Essays on Child Growth in Sri Lanka

An Empirical Analysis of the Effects of Sectors, Interventions and Natural Disasters

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Abstract

The United Nations Sustainable Development Goal (SDG) 3: 'Ensure healthy lives and promote well-being for all at all ages' is specifically designed to promote wholistic health and wellbeing, particularly among identified vulnerable population groups. Designed to follow the 4th, 5th and 6th Millennium Development Goals (MDG), the SDG has four key pillars, one of which focusses specifically on reproductive, newborn, child and maternal health. Even with years of dedicated focus, child malnutrition is a persistent issue especially in developing countries such as Sri Lanka. Sri Lanka is an upper middle income earning, developing country, with a total population of approximately 21 million people. Situated in the Bay of Bengal, south of the Indian subcontinent, Sri Lanka is an island nation, with a landmass of approximately 65,000 square kilometres. Centuries of colonisation, followed by decades of civil war and intermittent natural disasters including the 2004 Indian Ocean Tsunami, has left Sri Lanka, both economically and socially weak, the brunt of which is largely felt by the more vulnerable groups of society including children. Despite the many challenges faced, Sri Lanka has managed to make impressive developments in the areas of child and maternal mortality. However, high levels of child malnutrition remain a significant issue plaguing the country.

This thesis explores the state of child growth (among 0-5 year-old's) in Sri Lanka, along three separate axes. Constructed as three essays, the first essay explores regional variations in child growth focussing on the rural and estate sectors of Sri Lanka. The second essay looks at yet another interesting facet by exploring the impact of a nutrition intervention on child growth within the estate sector, while the final essay explores child growth in the backdrop of a natural disaster, focussing on the 2004 tsunami. Given the broad spectrum covered by the three essays, this thesis clearly contributes to existing child malnutrition literature in a number of ways. In addition to this, a significant methodological contribution is also made, especially through the calibrated application of methods and techniques

mainly used in epidemiology and clinical research, within the scope of modelling child growth.

As noted earlier, Essay 1 explores child growth within the rural and estate sectors of the country. The focus is specific to these two sectors, as these sectors record the highest under-5 stunting, wasting and underweight incidences in the country. Two waves of the Demographic and Health Survey, 10 years apart (2006 and 2016) are used to identify changes across time and sector. Both long-term and short-term child growth is considered, by looking at the height-for-age, weight-for-age and BMI-for-age of children. Using both linear and unconditional quantile regression (Re-centred Influence Function regression (RIF)), the essay identifies key determinants of child growth within each sector in each time period and factors that impact growth differentially across the growth distribution. Following this, the Blinder-Oaxaca decomposition method (with necessary extensions) is applied to identify the main drivers of the rural-estate growth differential at the mean and at different points of the growth curve. The decomposition methods are also extended to identify what drives growth improvements across time, focussing on the 10-year period between the two DHS surveys. The academic contribution of this work lies mainly in the fact that an analysis of this nature has not been attempted when modelling child growth in Sri Lanka. Together, the regional and temporal analysis will yield crucial insights and policy recommendations towards improving child growth within the rural and estate sectors of the country. The application of RIF regression decomposition to model child growth is also somewhat new, with only a handful of studies using this method.

The results suggest several key areas such as birthweight, breastfeeding practices, maternal health, maternal education and education of the HH head as being strong determinants both of child growth within the sectors and the growth differentials between them. A number of policy prescriptions are made around interventions for reducing low weight births, increasing awareness on breastfeeding and weaning practices and the provision of good quality child-care services in order to promote child growth within both the rural and estate sectors.

Essay 2 deals with a targeted analysis designed to evaluate a nutrition intervention programme operating within the estate sector of Sri Lanka. The programme under evaluation is a mid-day meals programme which provides a balanced meal to children below the age of 5 years attending child care centres in tea estates. Two distinct methods are used, first to evaluate the impact of access to the programme, and second, to evaluate the impact of continuous participation in the programme on the weight-for-age, height-for-age and BMI-for-age of children. Longitudinal data on child growth within treatment and control samples is used in the study. The former analysis which evaluates the growth impacts of access to the programme, is carried out using an Instrument Variable approach. Carefully thoughtout instruments are used to control for endogenous variables that confound treatment effects. The latter analysis which evaluates the impact of continuous programme attendance, deals with the issue of time-varying confounders on continuous valued treatments. A Marginal Structural Modelling approach with Inverse Probability Treatment Weights is used to control for it. Often used in epidemiological and clinical research to control for observed confounding of treatment effects, its application to a social science/field research setting is somewhat limited, and this work adds to that limited literature particularly within child nutrition and growth research. Results from both stages of the analysis show a clear positive impact of the programme on improving the growth of children, and based on the analysis, a number of recommendations are made, which could improve both the efficacy and equitability of the programme.

Essay 3 looks at a somewhat different context by focussing on the impacts of exposure to a natural disaster on the subsequent growth of children below the age of 5. Using Demographic and Health survey data collected two years post the 2004 Indian Ocean tsunami, the study focuses on two potential sources of exposure as individual and community exposure, to the tsunami, which could adversely impact child growth. Using a range of different controls, the study aimed at identifying if persistent adverse impacts of the tsunami on child growth existed two years post the exposure, and if present, whether these impacts originate from individual (or direct) exposure to the tsunami, community (or indirect) exposure to the tsunami, or both.

Results suggest that within affected provinces, the adverse growth impacts of exposure to the tsunami on children persits even two years after the event. However, these negative impacts were mainly as a result of community exposure to the tsunami, through living in/being born in a village which was impacted by the tsunami. The results signal the need for restructuring of current disaster management policies and procedures to facilitate and support community recovery in the aftermath of natural disasters.

Children are the most priceless asset of any society as they form the building blocks of the future. Through this thesis, I strive to give a brief glimpse of different deprivations faced by young children in Sri Lanka, with the hope that insights drawn through this work would be beneficial in reversing some of these adversities, for the betterment of their future.

Declaration

I declare that this thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes analyses carried out using both publicly available data issued by the Department of Census and Statistics in Sri Lanka, secondary data collected by the Plantations Human Development Trust-Sri Lanka, and primary data collected by the Author, with the approval of the Plantations Human Development Trust and the Merrill J Fernando Charitable Foundation. I hereby declare that all data has been used and protected in accordance with the terms and conditions for usage and protection of data outlined in the Memorandum of Understanding between the Author and the stated institutions.

Date: 16/6/2020

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Essay	Publication Title	Publication status	Nature and % of student contribution	Co-authors name(s) Nature and % of contribution
Essay 1	Exploring Distributional Changes in Growth Gaps between Rural and Estate Children in Sri Lanka [1]	Working paper	80% Concept, data analysis and writing first draft	(2) Inder, B. A. Concept and input in to manuscript (20%)
Essay 2	Midday Meals as an Early Childhood Nutrition Intervention: Evidence from Plantation Communities in Sri Lanka Estates	Under review – BMC Public Health	80% Concept, survey plan and implementation, data analysis and writing first draft, submission	(2) Inder, B. A. Survey plan, concept and input in to manuscript (20%)
Essay 3	Medium term effects of the Indian Ocean Tsunami on child health: Evidence from Sri Lanka	Working paper	80% Concept, data analysis and writing first draft	(2) Inder, B. A. Concept and input in to manuscript (20%)

[1] Awarded the Best Student Paper at the 16th International Conference on Business Management (Monash Business School)

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I acknowledge the Wurundjeri people of the Kulin Nations as the traditional owners of the land on which I stand, and pay my respects to their Elders past and present

“The wind beneath my wings”

‘It takes a village to raise a child’ they say. So, what does it take to complete a PhD thesis, over six long years, whilst raising a child, away from one’s motherland? What does it take to complete a thesis writeup amidst a global pandemic, which to date has infected over 6.4 million people and caused over 380,000 deaths around the world?

As I begin to write this section, with my two-year old son Gaveen perched on my lap, it occurs to me that this portion of the thesis is probably the most emotionally overwhelming piece of writing I have written, in a long time. The sheer enormity of the happiness and relief felt by the culmination of an intense academic experience spanning over 6 years, together with the incredible sadness felt by seeing the world gradually succumbing to an unseen enemy, one country after another, has left me with a myriad of conflicting emotions, some of which, I wish to document in these few pages. Coming back to my first question, ‘what does it take to wrap up a 6-year long PhD research, whilst raising a small boy, amid a global pandemic?’ The answer is that all the grit, determination and passion in the world would not be enough, if not for the love, understanding, support, loyalty and compassion of many, people upon whose shoulders I rested my weary head, many a time on this journey. This section is a tribute to them.

"A good teacher can inspire hope, ignite the imagination, and instil a love of learning"
~ Brad Henry

Over the last 6 years, my supervisor Prof. Brett Inder, has not just guided me with his mind, but also from his heart. He has been a mentor, life-counsellor, career-coach, friend, an avid listener of my never-ending political rhetoric and as a father of many daughters, a wonderful advisor to my husband and I, as we took our first steps into parenthood. As an Academic, he inspired me to push to learn better and understand better. As a person, he inspired me to become a better version of myself. Brett and Jenny have been part of our lives' most invaluable experience, of becoming parents, and their encouragement and advice has helped us in shaping our lives as new parents. I also acknowledge the many hours of mentorship provided by my co-supervisor, Prof. Ranjan Ray, throughout this journey. With a hearty smile a joyful greeting, and insightful academic advice, Prof. Ranjan has added significant value to my academic experience over the last 6 years. I am deeply grateful to both Prof. Brett Inder and Prof. Ranjan Ray, for their unwavering support and guidance, without whom, this PhD journey would not have reached its completion. I also wish to acknowledge Monash University, Faculty of Business and Economics and the Department of Econometrics and Business Statistics for providing me with both the Monash International Graduate Research Scholarship and the Dean's Excellence Award, which enabled me to carry out my studies, unhindered by financial burdens. I also gratefully appreciate Monash University for funding the MJF Mid-Day Meals Survey which formed a crucial part of my PhD research. I also wish to thank Prof. Gael Martin, Prof. Lisa Cameron, Prof. Xueyan Zhao, Prof. Pushkar Maitra and Mrs. Elke Blaedel for their advice and encouragement throughout my time at Monash University.

I also take this opportunity to sincerely thank all my lecturers at the Department of Statistics, University of Colombo, and my teachers at Methodist College, Colombo-3, for instilling in me, the passion to seek out new knowledge, to push the boundaries, and to never give up in my academic pursuit. I would not be here, if not for them!

‘Families are the compass that guides us. They are the inspiration to reach great heights, and our comfort when we occasionally falter.’ ~ Brad Henry

Family, that unwavering bond, which guides and shields us through ups and downs in life. My mother and father have been the steady pillars which raised me to be the woman I am today. Their unwavering support throughout the last six years, has been a guiding light for me throughout this journey. Growing up in a middle-income family, my brother and I saw our parents go through innumerable financial challenges through different stages of our lives. Yet, the one thing they did not hesitate to invest in, was our education, the returns of which both I and my brother enjoy today.

My husband Yasanga, has been an inspiration to me through the last decade if not more of my life. His life has been one of extreme courage in the face of tragedy and loss, and being part of his life journey, has provided me with the strength and courage to face my own challenges, over the years. A typical PhD journey tends to be a long string of lonely (and in Australia, often cold) nights, and having Yass to share this experience with, day-in day-out has been a true blessing.

The second youngest member of my family and a clear height outlier in our family photos is my brother Jayal, who has been a permanent (sometimes annoying) fixture in my life story. His contribution towards my success is something which humbles me every single day. Being the younger and not-too-academically-inclined sibling to a far-too-academically-inclined older sister, meant being constantly compared and harassed by parents and relatives, to perform better in school. Yet my brother took it on the cuff and never complained. Spending many months alone, in lockdown, trapped in an empty house, during a pandemic is not an easy burden to bear, and my brother has been going through this for the better part of the last three months. A sacrifice made so that I could have my parents here in Australia, as I run the last mile of my PhD journey. I am eternally grateful for the countless words of strength and courage I have received from my parents, husband

and brother, throughout this journey. They are and always will be the ‘wind beneath my wings’.

A child gives birth to a mother. I became a mother on the 15th of February 2018. Born 5 weeks premature with a weight of only 2.36 kg, Gaveen needed a bit of extra support, to catch-up in growth. Yet, he brought with him, an abundance of courage, confidence and constant cheekiness. These traits have inspired me every single day, not just to be a better mother, but to find new meaning and passion for the research I do on children. Children are the foundation of life and as academics and researchers in this field, it is our job to work collectively with policy and change-makers, to make their lives better.

I also take this opportunity to sincerely thank my uncle and aunt, Theja and Harsha Kariyawasam, who, when I first landed in Melbourne, in 2014, received me with love and warmth, opening their hearts and home to me. Dilan and Chaminda, my cousin brothers, and alumni of Monash, dropped me to campus on the very first day, and walked me to the Menzies Building. They also helped me with an array of time-consuming settling-in activities, such as shopping around for a laptop, getting miki-cards etc. If not for their help and support, the start of my PhD journey would not have been as smooth.

“Good company in a journey makes the way seem shorter” ~ Izaak Walton

I still remember the first day I stepped in to the Department of Econometrics and Business Statistics on the 7th of March 2014. I stood at the door to the PhD student room and gazed down at the long row of desks, with students, pouring over books or staring at screens. And then a familiar and friendly face looked back at me with a smile. Shanika Wickramasuriya, someone I share my second name (Shanika) and my tertiary alma-mater (Department of Statistics-University of Colombo), had started her PhD studies at Monash EBS a few years back. Shanika was a constant source of strength to me throughout the years. Sharing rooms, books, papers and gossip. Sharing frustrations and vexations. The journey was lighter and

happier, with her by my side. Kanchana Nadarajah, Puwasala Gamakumara, Miriam Marembo, Diana Contreras Suarez, are a few of the many friends at Monash EBS, who each added value to my academic experience. A special thanks goes to Kanchana Nadarajah for her invaluable assistance in translating the questionnaires used in the field study, to Tamil.

Two months into my stay in Melbourne, I rented a tiny 1-bedroom apartment close to Monash, and a month from then, a couple and their little baby boy moved in to the apartment next door. From all the countries in the world they could have been from, our new neighbours were from Sri Lanka and with them they brought that familiar warmth and love which we craved for, ever since we moved to Melbourne. Sanjeewani and Manoj Widanapathirana and their beautiful baby boy Hiruka, became like family away from home. I especially treasure the all too familiar knock on the door that used to come whenever Sanji made something fabulous for lunch or dinner. These dishes were a blessing to Yass and me as they seem to arrive when we were most hungry and craving for a home-cooked meal, which we were both unwilling to cook for ourselves. This journey would have been that much harder, if not for their support and friendship. Thilini Weerasuriya, Thilan Balauriya, Durga and Manora Bandara; friends without whom, life in Australia would have been a solitary experience. I am eternally grateful to all my friends both here and in Sri Lanka, who have supported me throughout this journey.

In June of 2016, on the very same day of my mid-candidature milestone, I also had another important meeting. An interview for an academic position at the School of Economics Finance and Marketing at RMIT University. There I met Prof. Tim Fry, the then Head of School, and coincidentally an old student of my co-supervisor back from his days in the UK. I also met Assoc Prof. Angela Dobele who subsequently became my first ever line manager, friend and mentor at RMIT. Tim and Angela have had a significant positive influence on my academic journey over the last few years. Angela in particular, has been a friend and a mentor and fundamentally reshaped the way that I look at academia as a woman. The School of Economics Finance and Marketing at RMIT has been a pivotal part of my life and my growth as an academic over the last four years. Prof. Jason Potts, Prof. Lisa Farrell, Assoc Prof. Ashton De Silva and Prof. Simon Feeny in their capacities as my line managers from 2017- to present, have each had a significant influence in shaping me to become a better researcher and academic. In particular, Lisa has been a true inspiration, mentoring me and guiding me through the challenge of re-establishing and reinventing myself as a researcher, post an 8-month career interruption after childbirth. Seeing her reach the heights she has, while mothering two beautiful daughters, has given me the faith that despite the many challenges that I will face in years to come, I too will have the strength to achieve my academic dream someday.

As a PhD student, the most prized academic association I made at RMIT was with Jane Fry. I consider Jane to be my STATA-Guru as she single-handedly elevated me from being a novice menu-dependent STATA practitioner to the STATA-coder I am today. I credit every piece of elegant STATA coding that I have written over the last 4 years, to Jane’s brilliant teaching of STATA. Dr. Leonora Risse, Dr. Janneke Blijlevens, Dr Avni Misra and Dr. Kathleen Elizabeth, all friends and colleagues from RMIT, have supported, counselled and cheered me on as I navigated through the work-study-life labyrinth over the last few years. If not for their warmth and support, this journey would have been ever so difficult. I would also like to thank Prof. Heath McDonald, current Dean of the School of Economics Finance and Marketing, who willingly supported my application for the RMIT-College of Business and Law Staff Doctoral Completion Grant. I also graciously acknowledge and thank the College of Business and Law for presenting me with this grant which allowed me to go on research leave over the last 6 months, to complete my thesis. RMIT has been as much a part of my PhD journey as Monash, and I am incredibly privileged to be associated with both Monash and RMIT universities; two great pillars of Australian Higher Education.

Any seasoned development economist would readily agree that field studies in developing countries are not easy to implement. For a budding researcher in this area, it was doubly difficult to make this happen. My field work in Sri Lanka would not have been possible if not for the help of many people from different institutions across the country who came together to support me in this venture. Three people instrumental in the successful implementation and completion of the survey were, the founder and chairman of the MJF Charitable Foundation Mr. Merrill J. Fernando, MJF Charitable Foundation Project Coordinator Mr. Kamal Subramaniam, and Director of Health/Plantations Human Development Trust (PHDT) Dr. Ravi Nanayakkara. If not for their guidance and support the field survey would not have been a possibility. I also acknowledge the support given by the estate managers, estate medical officers, estate midwives and child development officers at the Bearwell, Holyrood, Dessford and Craighead estates throughout the survey period. It is also important to acknowledge the estate manager of Palmerston estate, Mr. Usheera Udawatte and his lovely wife Asanthi De Silva (coincidentally also an old girl of Methodist College), for welcoming us to their estate home, and providing us with food throughout the period of the survey. A special mention to Thanuka Parami, who assisted me throughout the field survey. Her skills and field expertise were vital in the success of the field survey. A special thank you also goes to Dr Renuka Jayatissa for her expert opinion and support during the initial stages of my PhD study, and the Department of Census and Statistics, Sri Lanka, for providing me with the necessary DHS datasets. A special thank you to former Director General of the Department of Census and Statistics (and incidentally also my aunt) Mrs. Priyanthi Vidyaratne, whose advise significantly helped me during the initial stages of my PhD.

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Abbreviations and Acronyms

ADA – American Dietetic Association
AR – Autoregressive
BF – Breastfeeding
BMI – Body Mass Index
BO Decomposition – Blinder-Oaxaca Decomposition
BW – Birthweight
CDC – Child Development Centre
CDF– Cumulative Density Function
CDO– Child Development Officer
CEPA – Centre for Poverty Analysis
CIAF – Composite Index of Anthropometric Failure
DAG – Directed Acyclic Graphs
DCS– Department of Census and Statistics
DHS – Demographic and Health Survey
DS division – Divisional Secretariat division
EA – Enumerator Areas
EBS – Economics and Business Statistics
ECD – Early Childhood Development
EMO – Estate Medical Officer
FE – Fixed Effects
FFE – Food for Education
G2SLS – Generalised Two–Stage Least Squares
GCE(A/L) – General Certificate in Education (Advanced Level)
GCE(O/L) – General Certificate in Education (Ordinary Level)
GEE – Generalized Estimating Equations
GLS – Generalized Least Squares
GN division – *Grama Niladari* division
HH – Household
HRD – Human Resource Development
ICDS – Integrated Child Development Services
IDP – Internally Displaced Persons
INP – Integrated Nutritional Package
IPTW – Inverse Probability Treatment Weights
ITT – Intention to Treat
IV – Instrument Variable
MAM – Moderate Acute Malnutrition
MDG – Millennium Development Goals
MDMS – Mid-Day Meals Scheme
MJF – Merrill J. Fernando
MJFCF – Merrill J. Fernando Charitable Foundations
MSM – Marginal Structural Models
MUHREC – Monash University Human Research Ethics Committee
NGO – Non-Governmental Organisations
OLS – Ordinary Least Squares
PDF – Probability Density Function
PHDT – Plantations Human Development Trust

PHSWT – Plantation Housing and Social Welfare Trust
PNIP – Participatory Nutrition Intervention Project
PSU – Primary Sampling Unit
RA – Research Assistant
RE – Random Effects
RIF – Recentered Influence Function
RPC – Regional Plantation Company
SAARC – South Asian Association for Regional Cooperation
SAM – Severe Acute Malnutrition
SD – Standard Deviation
SDG – Sustainable Development Goal
SES – Socioeconomic Status
SL – Sri Lanka
SLDHS – Sri Lanka Demographic and Health Survey
SNM – Structural Nested Models
TTEL – Talawakelle Tea Estates Limited
UN – United Nations
UNICEF – United Nations Children's Fund
USAID – United States Agency for International Development
WFP – World Food Programme
WHO – World Health Organisation
WIC – Women, Infants and Children

Chapter 1: Introduction and Overview of the Thesis

"We are guilty of many errors and many faults, but our worst crime is abandoning the children, neglecting the foundation of life."
Gabriela Mistral (1948)

On 20th November 1959, the first UN Declaration of the Rights of the Child was adopted unanimously by all members of the UN General Assembly. The declaration set out ten Principles, the 4th of which outlined the right of the child to 'adequate nutrition, housing and medical service' (Jonsson, 1993). The past decades have seen major developments in attempts to combat child hunger and malnutrition globally. The Millennium Declaration in 2000 paved the path for many developing countries to make significant improvements on many fronts. With most countries signing the Millennium Declaration, the focus of governments and aid agencies around the world was to work towards achieving the Millennium Development Goals (MDG) by 2015. A central focus of MDGs was poverty reduction, improvement of child and maternal health and universal education. Most developing countries have managed to make considerable improvements in the key areas of concern through effective policy change and targeted interventions. Sri Lanka and the Indian State of Kerala, are considered two key child and maternal health success stories in South Asia (Kumar, 1993; United Nations, 2015). Sri Lanka is particularly praised for its impressively low child and maternal mortality rates compared to its other Asian counterparts. This has much to do with the universal free access to government provided healthcare available in Sri Lanka since the 1930s (Smith, 2018) and the targeted poverty reduction initiatives undertaken by both government and private stakeholders (United Nations Sri Lanka, 2015). Together, these initiatives have led to a drastic reduction in child and maternal mortality rates. Yet according to the Sri Lanka Millennium Development Goals Country Report (United Nations Sri Lanka, 2015), child malnutrition and morbidity continues to be a pertinent issue hindering progress. Continuing from the MDGs, post 2018, efforts have been focused on progressing towards the third goal of the UN Sustainable Development Goals: Ensure healthy lives and promote well-being for all at all ages.

Child malnutrition is a multi-dimensional problem which should be combatted on different fronts in Sri Lanka (Shekar, Somanathan and Du, 2007; Wickramasingha, Jayatissa and Gunawaradana, 2015). Despite continuous efforts, as of 2016, the prevalence of stunting, wasting and underweight among children under 5, was reported to be 17.3%, 15.1% and 20.5% (Department of Census and Statistics-Sri Lanka, 2017a). These statistics show little change or improvement particularly over the last decade (stunting, wasting and underweight reported as 17.3%, 14.7% and 21.1% in 2006 (Department of Census and Statistics-Sri Lanka, 2017a), raising questions on the effectiveness of some of the nutrition policies implemented over that period. As a developing country and signatory to the Millennium declaration, Sri Lanka has seen many policy evaluations and research specifically targeting child malnutrition, over the last few decades. This has given rise to a significant pool of research on child growth and malnutrition. Nevertheless, given the complex and dynamic nature of malnutrition, and its sensitivity to emerging challenges (climate change, natural disasters, changing population trends), there are and will always exist, many facets of child malnutrition, that would demand study.

This thesis seeks to explore child malnutrition in Sri Lanka, as three distinct yet complimentary analytical essays. The first essay explores child malnutrition in context of the varied regional population of Sri Lanka. Sri Lanka is administratively divided in to 9 provinces and 25 districts. Based on key social and structural characteristics including the spread of the population, Sri Lanka is also divided in to three sectors as, urban, rural and estate. According to the Department of Census and Statistics, all areas administered by Municipal/ Urban councils are defined as ‘urban’ while all plantations (tea/rubber/coconut etc.) which are 20 acres or more in area and employees ten or more resident labourers is defined as ‘estate’. All other areas are considered ‘rural’ (Department of Census and Statistics, 2010). These areas are clearly demarcated for administrative purposes.

Given key differences in both population characteristics and economic parameters at the district and sector levels, districts and sectors often form the basis for malnutrition research.

However, from a malnutrition perspective, sectors are also of particular interest, as sector variations are often present within the same district. For example, districts belonging to the central province predominantly consist of estate areas, but also include urban and rural regions within them. This gives rise to heterogenous population groups living within the same district. The first essay dwells deeper in to these sector level variations focussing on child growth. Changing trends over time and across the growth distributions are analysed for major anthropometric measures, using data from nationally representative population surveys 10 years apart. Empirical econometric models are built to identify relationships between different growth outcomes and key variables of interest within sectors, to explore how the relationships change across the growth distributions, to analyse gaps in growth outcome between sectors and across growth distributions and finally to explore changes across time. Whilst largely exploratory, this essay hopes to answer a few key questions: To what extent do certain factors impact growth within rural and estate sectors across the two considered time periods? To what extent did the sector growth gaps change over the considered period? To what extent did growth improve/decline over the considered period, within each sector? Did the growth gap change due to changes in observed characteristics or due to changes in the returns to these characteristics? Finally, how do these results vary over the growth distribution? The next chapter serves as an introductory chapter to Essay 1 and outlines the background and relevant literature. Chapter 3 provides a detailed description of data used, econometric methods and models and analytical issues. Chapters 4 and 5 provide the main results and discussion.

The second essay explores yet another facet of child malnutrition, concentrating particularly on the estate sector of Sri Lanka. With a long history of discrimination and exclusion stemming from the deprivation of citizenship rights the estate sector is generally marked by high levels of poverty and malnutrition (Jayawardena, 1984). Owing to its vulnerable history, the sector also attracts various interventions, which target the health and wellbeing of residents. Essay 2 focusses on reviewing and analysing one such nutrition intervention operational within certain tea estates in the country. The aim of the intervention is to improve the growth of children below the age of 5, by providing a balanced mid-day meal through child development centres (CDC) in tea estates. Initiated in 2007, the programme has since grown and currently benefits over 2000 children, living within several tea estates in the country. Our study was aimed at evaluating the effectiveness of the programme in improving the growth of participating children. The study consists of quantitative and qualitative components. The quantitative component uses panel data of children's weights and heights, together with several child and institutional level controls to assess the effectiveness of the programme. Suitable econometric methods are employed to overcome certain analytical complications, and to derive causal interpretations. The qualitative component presents an analysis of data collected via structured interviews of health and medical professionals of the sampled estates. Together, this essay focusses on presenting a comprehensive evaluation of the target intervention programme with recommendations on its potential to improve. Chapters 6 and 7 outline the relevant background, literature, survey plan and implementation. Chapters 8 presents the theoretical and conceptual frameworks, together with the methods used in the analysis. Chapter 9 presents the quantitative analysis together with a summary of qualitative results (qualitative analysis included in appendices), while Chapter 10 presents a concise summary and discussion of the main findings.

The third essay explores child malnutrition in Sri Lanka, within the context of a natural disaster. Significantly, different from the previous two essays, this part of the thesis focuses on exploring persistent impacts of natural disasters on child growth, by using the 2004 Indian ocean tsunami as a natural experiment. The Indian Ocean tsunami is the largest natural disaster faced by Sri Lanka in its recorded history. Given this, it is important to explore the nature of its effects on children. This essay analyses the impacts of exposure to the tsunami on children's growth, approximately 2 years after the event. The study particularly aims to distinguish between the individual and community effects of exposure to the tsunami, as appropriately defined for analytical purposes. Using the 2006 DHS dataset the analysis focusses on 2 years post the tsunami and exploits certain geographic tsunami markers embedded in the dataset to explore impacts on growth. Chapters 11 presents a brief introduction and review of relevant literature. This is followed by Chapter 12 and 13 which present the conceptual framework, data and methods used in the study. Chapter 14 presents the main results followed by Chapter 15 which draws on important findings to present policy insights. The thesis wraps up with a final chapter which provides a concise summary of the three essays. It should be noted that StataSE version 15 was used for all analytical purposes, while MS Excel was used for descriptive purposes.

Essay 1: Exploring Sectoral Variations in Child Growth across Sri Lanka

Chapter 2: Introduction and Review of Literature

Child malnutrition is a serious problem faced by many developing countries. According to UNICEF/WHO/World Bank joint estimates, 149 million children below the age of 5 were stunted while over 49 million children were wasted, in 2018 (UNICEF/WHO/World Bank Group, 2019). Malnutrition in children has been a phenomenon which, for many years, has garnered the attention of social scientists and economists around the world. Recognizing its true severity and depth, the UNICEF introduced its first conceptual framework to identify the root causes of child malnutrition, in 1990 (UNICEF, 1990, 2013). Since then, the framework has been refined with time, yet the basis has remained unchanged (UNICEF, 2013) . According to this framework child malnutrition is identified as a multi-sectoral problem and three categories of causes as 'Immediate', 'Underlying' and 'Basic' are identified. The framework also suggests a crucial link between poverty and malnutrition, with feedback loops forming the perpetuating cycle of poverty and malnutrition (UNICEF, 2013).

As mentioned earlier, Sri Lanka has performed relatively well in lowering child and maternal mortality but official statistics on child stunting and wasting and other research indicate significant regional variations in child malnutrition at sector and district levels (Department of Census and Statistics-Sri Lanka, 2009, 2017; Rajapaksa, Arambepola, and Gunawardena, 2011; Shekar et al., 2007). In the context of a developing country like Sri Lanka, combatting child malnutrition becomes a multi-pronged effort and given that regional variations in malnutrition exists, a successful approach would be to first level the playing field, by concentrating on, and mitigating the factors that cause these regional variations in malnutrition. This would require significant exploration of what causes these variations at the regional level. Apart from the two traditional urban and rural sectors, Sri Lanka has a third sector which evolved around the tea and rubber plantations introduced to the country during the colonization era. Given its roots in indentured labour, the estate sector has since shown relatively low growth in almost all socio-economic parameters be it income, health or education (Gunetilleke, Kuruppu and Goonasekera, 2008;

Jayawardena, 1984; Rajendran and Abhayaratne, 2008). From a child malnutrition perspective, research clearly indicates that the estate and rural sectors fare considerably poorly compared to the urban sector (Department of Census and Statistics-Sri Lanka, 2009, 2017; Gunatilaka, Wan, and Chatterjee, 2009; Gunetilleke et al., 2008). Whilst these two sectors report high rates of stunting and wasting among children, the factors that drive child growth and malnutrition within the sectors, as well as the factors that determine growth differentials between the two sectors can vary due to the structural and sociographic differences between them. The aim of this essay is to explore variations in child growth across the rural and estate sectors of Sri Lanka with the objective of understanding, firstly the nature and drivers of child growth within each sector and secondly, which factors drive the gaps in child growth between the two sectors. Child growth is measured using the weights, heights and body mass index (BMI) of children which are standardized using WHO recommendations. Accordingly, the three outcome variables used in the analysis are the standardized height-for-age, weight-for-age and BMI-for-age of children.

Given that national statistics clearly indicate that the rural and estate sectors fare considerably worse than the urban sector, the essay purposefully focuses on the rural and estate sectors alone. The essay is largely descriptive and does not aim to assign strict causality. However, by basing the analysis on two nationally representative demographic and health surveys, a decade apart, combined with suitable econometric techniques allows for the accurate estimation of key associations between biological and socio-economic factors and growth which leads to identifying key risk factors of child malnutrition. The analysis also expands further to look at the distribution of child growth, within both sectors as well as distributional changes in growth between the two sectors to try to understand how different factors influence growth at various points of the growth distribution. Given that the growth of estate children (according to the reported incidence of stunting, wasting and underweight) is observed to track well behind that of rural children (Department of Census and Statistics-Sri Lanka, 2009, 2017a), the analysis also looks at the factors that drive the rural-estate growth gap at the top, mid and bottom levels of the growth distribution.

As mentioned earlier, three key growth measures, namely length/height-for-age, weight-for-age and BMI-for-age of children below the age of 5, are used in the analysis. The length/height-for-age is considered as a measure of long-term health and growth. Low height-for-age, or stunting is a major long-term growth impediment for children below the age of 5 (UNICEF/WHO/World Bank Group, 2019), with potential to produce developmental and cognitive lags leading well in to adulthood (Crookston et al., 2010). Therefore, with regards to children, length/height-for-age is often given prominence so as to detect and control for potential risk factors in order to reverse harmful future effects.

Weight-for-age on the other hand, is a more composite measure which is difficult to interpret given it is influenced by both the height and weight of the child. Nevertheless, children with low weight-for-age are termed to be underweight and are said to reflect either 'wasting' (as indicated by low weight-for-height), or stunting, or both. Thus the measure is often used in conjunction with other measures such as weight-for-height or BMI-for-age, which control for the effect of height, and this allows for a reliable interpretation of the underlying causes of being underweight (WHO, 2010).

The use of weight-for-height and BMI-for-age has attracted much debate over the last few years. Whilst, both measures are similar to a great extent, studies have shown some distributional differences in the two measures (CDC, 2015; Flegal, Wei, and Ogden, 2002). Studies have argued certain advantages of using the BMI-for-age measure, particularly due to its consistency with adult BMI-for-age measures which makes it possible for the measure to be used from 2 years up to 20 years of age (Flegal et al., 2002). BMI is also a measure that can be used to track body size throughout a person's life cycle which makes it a consistent tool in monitoring body size (CDC, 2015). In addition to this, BMI is also useful in monitoring both underweight and obesity making it an effective screening tool.

However, a few studies have noted that BMI-for-age should generally be used after the age of 2 years, given the weak association between BMI at younger ages and adult BMI (CDC, 2015). Given that the three essays in this thesis focus on children between the ages of 0-5 years with no comparisons done with adult BMIs, and the considerable benefits of using BMI as an analytical tool noted in research, the BMI-for-age is used in place of weight-for-height in all three essays. However, as a measure of robustness, some of the main models were run on standardized weight-for-heights of children. These models yield similar results to the BMI-for-age models, further justifying the use of BMI-for-age in the analysis.

This essay aims to contribute to a couple of significant gaps that exist in child malnutrition research in Sri Lanka. When looking at the available literature, two main branches emerge. The first branch of research consists of those which look at child growth and malnutrition at a national level (Aturupane and Deolalikar, 2005; Aturupane, Deolalikar, and Gunewardena, 2011; Jayawardena, 2011, 2012). The second branch of research focuses on identified vulnerable regions (Jayawardena, 2014b; Naotunna et al., 2017; Ranathunga and Gibson, 2014). Whilst this broadly allows to identify the determinants of malnutrition both at the country and regional levels, it does not provide a systemic comparison of the gaps in growth and malnutrition between regions or the determinants which drive these gaps. Jayawardena (2012) tries to address the issue of inequality in child malnutrition by using a decomposition technique but focuses mainly on modelling the inequality across socio-economic groups and not geographic regions. Thus, a clear research gap exists with regards to identifying the varying behaviour of child growth, as measured by their weights and heights (height-for-age, weight-for-age and BMI-for-age) between the two main vulnerable sectors of the country; rural and estate. This essay aims to address this gap in research by establishing the factors that drive mean and distributional gaps in child growth between the rural and estate sectors, which according to prior research are the two most vulnerable regions in the country. Identifying these factors will help to design more targeted policies and treatments within sectors as well as within different bands of the growth distribution.

In addition to the sector analysis, the analysis also considers variation across a ten-year period (2006-2016). The factors that impact child growth and health inequalities tend to generally vary over time (Wagstaff, van Doorslaer and Watanabe, 2003). Given the somewhat volatile macro and microeconomic parameters of developing countries such as Sri Lanka, it is reasonable to assume that there would be significant variations in the socio-economic composition and growth gaps between sectors. To understand this time dynamic, DHS data from two separate time points ten years apart (2006 and 2016 DHS data) is considered. Attention has been paid to identify and mitigate any potential issues that may exist in combining data over two waves of DHS surveys, when carrying out the analysis.

In order to explore the contribution of individual (groups of) characteristics, the decomposition analysis of the rural-estate growth gap in 2006 and 2016 is carried out. The analysis is then further extended to decompose the changes in growth between 2006-2016 for the rural and estate sectors separately. Both mean and distributional decompositions are used to explore changes in the growth differential across the growth distribution.

As noted earlier, this essay aims to explore a number of research questions. Firstly, to what extent do certain factors impact growth within the rural and estate sectors across the two considered time periods? Secondly, to what extent did the rural-estate growth gap change over the period 2006-2016? Also, to what extent did growth improve/decline from 2006-2016 within each sector? Did the growth gap change due to changes in observed characteristics between the two sectors or due to changes in the returns to these characteristics? Finally, how do these results vary over the growth distribution?

2.1. Child malnutrition- A brief review

That child malnutrition is a global burden is evident by the myriad of research that has been focused on it, over decades. This section presents a review of some of the recent studies which have influenced this analysis. Starting with an overview of the nature of the global child malnutrition problem, the section then reviews research which explore regional and socioeconomic inequalities in malnutrition. This is followed by a brief review on the status of child malnutrition in Sri Lanka.

2.1.1. The global burden of child malnutrition and prevalence in Sri Lanka

A large base of research on child malnutrition exists. Whilst it is not possible to review this literature in its entirety, this section reviews some of the related and recent papers on malnutrition which focus on developing countries and hence applies to this essay. As mentioned earlier, joint estimates by the UNICEF, WHO and World Bank indicated that an estimated 22% or 149 million children below the age of 5 years, globally, suffered from stunting in 2018. An estimated 8% or 49 million children in the same age group, suffered from moderate or severe wasting around the world. The bulk of this is borne by Asia and Africa, with more than half of all stunted children and more than two thirds of all wasted children living in Asia. When considering the sub-regions of Asia, Southern Asia again performs relatively poorly with regards to child malnutrition, with an estimated 57.9 million or 2 in 5 stunted children being from Southern Asia (UNICEF/WHO/World Bank Group, 2019). Given this dismal outlook, it is no surprise that, Asia and Africa are foci of a significant portion of the malnutrition literature.

Bhutta (2000) reviews the causes behind South Asia's slow improvement in child and maternal health. He accounts the poor health of children and mothers to the poor status of women in society and to economic inequity. The study also notes the scarcity of research programmes aimed at understanding the basic determinants of health. Bhutta et al. (2004) reviews available information on the state of maternal and child health in key South Asian countries (i.e. SAARC countries) and Afghanistan. They review estimates provided by the WHO, UNICEF and other organisations and deduce that underlying determinants such as female illiteracy, poverty, and lack of female empowerment are major barriers to improving child and maternal health. The paper also notes successful interventions focused on providing low cost primary care strategies have been effective in certain areas and highlight the need for such programmes to be implemented across the health care system. Black et al. (2008) reviews regional patterns of maternal and child undernutrition in three world regions Africa, Asia and Latin America. The research attributes maternal and child undernutrition as underlying causes of 3.5 million deaths with 35% of the disease burden in children younger than 5 years. Vitamin A and Zinc deficiencies are identified as main risk factors which promote disease. Van De Poel, Hosseinpoor, Speybroeck, Van Ourti, and Vega (2008) is a key research that utilises 47 DHS from developing countries across the world to explore socioeconomic inequality in malnutrition. The research reports some seminal results, firstly with regards to there being no clear relation between socioeconomic inequality in stunting/wasting and average levels of stunting and wasting. This in turn implies that reducing overall rates of malnutrition may not necessarily lead to a decline in inequality in malnutrition.

Apart from the above research which focus on wide regions of the world, there is a significant pool of research which focus on individual countries or a group of countries. Chowdhury et al. (2016) looks at risk factors of child malnutrition in Bangladesh using a multilevel analysis technique. Amongst others, the report finds age, sex, mother’s BMI, mother’s educational status, father’s educational status, place of residence and socioeconomic status as significant risk factors. Dancer, Rammohan, and Smith (2008) also focus on Bangladesh exploring the link between infant mortality and child nutrition. The study uses a copula approach to model for child nutrition in the presence of selection due to mortality, and contrary to previous research, show female children to have a higher likelihood of surviving. However, surviving male children are reported to show better growth as measured by their height-for-age. Grace, Davenport, Funk, and Lerner (2012) explores the link between child malnutrition and climate in Kenya and find that high levels of warming and drying experienced by Kenya due to climate change, results in an increase in malnutrition rates. They propose that investing in infrastructure and expanding education may mitigate these negative impacts. Harpham, Huttly, De Silva, and Abramsky (2005) focus on four developing countries; Ethiopia, India, Vietnam and Peru to test the link between maternal mental health and child nutrition. They report a relationship between high maternal common mental disorders and poor child nutrition in the two Asian countries (India and Vietnam) whilst a clear link is not established in the other two countries. Inequities in under-five child malnutrition in South Africa is explored by Zere and McIntyre (2003) where stunting was found to be the main form of malnutrition. The research reports considerable pro-rich inequalities in the distribution of the prevalence of underweight and stunting. Inequalities in malnutrition are also not reported among white children while the highest pro-rich inequalities are observed among children of colour.

2.1.2. Regional and socioeconomic inequalities in child malnutrition

Apart from risk factors that promote child malnutrition, another key area of concern is the growing inequality in the distribution of malnutrition across and within countries. Socioeconomic and regional inequalities in malnutrition pose a significant hindrance to implementing malnutrition alleviation policies. For example Van De Poel et al. (2008) points out that according to the differing patterns with which socioeconomic inequality in stunting occur, it may either be classified as mass deprivation or exclusion. Accordingly, the research notes the need to apply different policies for alleviating malnutrition, based on the nature of the inequality present. Given this, a considerable branch of research on inequality of malnutrition has also arisen in recent years. Inequalities in child malnutrition has been researched on various fronts. The most common line of research has been to explore the socioeconomic inequality of malnutrition. Research in this area commonly uses methods such as the concentration index (Kakwani, 1977) and Erreyger's index (Erreygers, 2009) widely used for measuring inequalities in health outcomes such as chronic disease and mortality. Wagstaff, van Doorslaer, and Watanabe (2003) is a seminal paper which adopts the concentration index technique together with an Oaxaca type decomposition (Oaxaca, 1973) to explore malnutrition inequalities in Vietnam between 1993 and 1998. The paper, whilst mainly theoretical, suggests that inequalities in stunting amongst young children were largely due to inequalities in household consumption and inequalities in unobserved determinants at the commune level in both 1993 and 1998. Kien et al. (2016) is similar research which looks at socioeconomic inequalities in malnutrition in Vietnam using a multiple indicator cluster survey from 2000 and 2011. They report an increase in inequality between 2000 and 2011, even though the overall rate declined. Mazumdar (2010) uses the concentration and wealth indices to explore the link between inequality in malnutrition and poverty in India. The results indicate that poverty accounts for half of the inequality in malnutrition, providing yet another example of the linkage between poverty and malnutrition. Van de Poel, Hosseinpoor, Jehu-Appiah, Vega, and Speybroeck (2007) looks at the socioeconomic inequality in child stunting in Ghana using the 2003 DHS data and presents poverty, access to health care and regional disparities as the main factors driving the inequality.

Another widely researched area of inequality in malnutrition deals with regional inequalities. This encompasses many studies which looks at the urban-rural decomposition or poor-non poor decomposition of malnutrition. Menon, Ruel and Morris (2000) looks at DHS data for 11 countries to explore intra-urban and intra-rural differentials in the prevalence of stunting. The study reports intra-urban differentials in stunting to be higher than intra-rural differentials for most countries in the sample data. Fotso (2006) is a similar study which uses DHS data for 15 African countries. The study reports intra-urban differentials in child malnutrition to be larger than urban-rural differentials. A related study by the same author explore the rural-urban differentials in malnutrition and attributes the narrowing/widening gaps to the sharp increase/decline in urban malnutrition respectively (Fotso, 2007). The author draws attention to the need for interventions that target the urban poor. Van de Poel, O'Donnell, and Van Doorslaer (2007) looks at the urban-rural disparity in child malnutrition using DHS data from 47 developing countries. The results again generally suggest a need for targeted policy interventions for the urban poor.

When considering the South Asian region, India has attracted a significant portion of malnutrition decomposition research owing to large regional and caste disparities in malnutrition across the country. Nie, Rammohan, Gwozdz, and Sousa-Poza (2019) is a recent study which explores changes in child nutrition in India using a decomposition analysis approach. The study looks at changes in stunting, underweight and the Composite Index of Anthropometric Failure (CIAF) of children below the age of 5 years between 2005 and 2012. Using three different decomposition techniques the study identifies the main socio-economic factors that drive changes. The study identifies household wealth, maternal BMI and education as significant factors that drive improvements in child nutrition across time. Kumar and Singh (2013) decomposes the gap in child undernutrition between the poor and non-poor population in urban India. Underutilization of health care facilities, poor maternal health and low levels of parental education among the poor are found to be the main factors driving the gaps. Bhalotra, Valente, and van Soest (2010) analyses the conundrum between the socioeconomic status (SES) and child survival rates and child nutrition of Indian Muslims and Hindus. They find that, while Indian Muslims show relatively lower SES than Hindus in general, Muslim children tend to show better survival rates compared to Hindus. However, with respect to stunting and wasting, Muslim children report relatively higher rates of stunting and wasting compared to high-caste Hindu children and the differential is observed to be driven by factors such as parental education and birth order. Van de Poel and Speybroeck (2009) looks at malnutrition inequalities between scheduled castes and tribes and the remaining Indian population using the Blinder-Oaxaca decomposition technique. The results suggested that the gaps were due to lower wealth, education and access to health care among the scheduled castes and tribes. Srinivasan, Zanello, and Shankar (2013) explore rural-urban disparities in malnutrition in Nepal and Bangladesh using a regression based counterfactual decomposition technique and do not find any fundamental differences between urban-rural characteristics that drive child nutrition outcomes. The Blinder-Oaxaca decomposition is widely used in modelling disparities in child malnutrition for continuous outcomes (Liu, Fang and Zhao, 2013; Sharaf and Rashad, 2016). Literature also has many examples of other types of decompositions used, based on the nature of the outcome variable. Mussa (2014) uses a matching decomposition technique to explore rural-urban differences in malnutrition in Malawi while Chauhan, Chauhan and Chaurasia (2019) applies a non-linear decomposition technique to model the poor-nonpoor malnutrition gaps in Sierra Leone. This suggests that similar to the choice of index used for measuring inequality, attention also needs to be paid towards picking suitable decomposition techniques when modelling regional gaps in child malnutrition.

2.1.3. Prevalence of child malnutrition in Sri Lanka

The status of child growth and nutrition in Sri Lanka has received significant attention over the last few decades. Sri Lanka has shown good progress in reducing child and maternal mortality since the signing of the Millennium Declaration in 2000. With regards to child and maternal malnutrition, Sri Lanka again performs better than its counterparts in South East Asia (UNICEF ROSA, 2019). Since 2000, the evolution of child and maternal health and growth in Sri Lanka has been the subject of periodic reviews (Department of Census and Statistics-Sri Lanka, 2017a; United Nations Sri Lanka, 2015). Given Sri Lankas status as a developing country often funded by international donor agencies such as the UNDP, UNICEF and World Vision, these organisations also carry out periodic reviews of implemented programmes. Apart from this, various independent research utilising secondary data sources such as the DHS, has also been done on the prevalence and causes of child malnutrition in the country. A key theme appearing across much of these reports is the large regional variations in child and maternal malnutrition at the district and sector levels. Despite the overall prevalence of childhood stunting and wasting is generally low compared to other countries in the region regional variations suggest rates of stunting as high as 30% in certain regions (Department of Census and Statistics-Sri Lanka, 2017a).

As mentioned earlier, two main branches of malnutrition research can be identified; those which broadly address the issue of child malnutrition at a national level and those that focus on specific areas within the country. Most research tend to cover child malnutrition at a national level (Aturupane and Deolalikar, 2005; Aturupane, Deolalikar, and Gunewardena, 2011; Jayatissa, 2012; Jayatissa, Wickramasinghe, and Bekele, 2006; Shekar et al., 2007) with a few focussing their attention on vulnerable regions of the country. Aturupane and Deolalikar (2005) is a key report which looked at Sri Lanka attaining the MDGs. The report reviewed the numerical goals that had been met as of 2005, which included universal primary school enrolment and completion and reducing under 5 mortality. The report also highlighted key areas of concern including quality of education, poverty reduction and child malnutrition. The paradox of low infant and child mortality vs high malnutrition is given much consideration and is partially attributed to social and cultural norms. Jayatissa et al. (2006) and Jayatissa and Fernando (2011) are two research reports issued by the Medical Research Institute, respectively in collaboration with the UNICEF and WHO. Both reports highlight maternal and child undernutrition as a key public health problem. The first report uses data from the 2000 DHS and 2003 UNICEF child welfare surveys to identify causal channels of child malnutrition. Low birthweight, respiratory tract infections, supplementary food intake, total number of children in the family, maternal/paternal education, quality of antenatal care, socioeconomic status and hygiene practices are identified as significant predictors of child under nutrition. The second report is a landscape analysis to identify the readiness to accelerate actions to reduce child and maternal undernutrition. The report makes several prescriptions including the need to streamline the allocation of funds for nutrition related activities within the health sector. The report also identifies wide variations at the province and district level policies pertaining to nutrition which causes problems in the implementation of programmes. Rajapaksa et al. (2011) provides a detailed review of research findings on child nutrition, the determinants of malnutrition and intervention programmes. The review identified some key issues and areas needing improvement including a committed political leadership, strengthening and mainstreaming of nutrition interventions both centrally and at the sub-national levels and building in strong monitoring and evaluation systems in to intervention programmes at the programme planning stage. Aturupane et al. (2011) is another recent study which looks at determinants of heights and weights of children in Sri Lanka. Using conditional quantile regression, the study identifies key characteristics that influence child growth at various points of the growth distribution. Results suggest significant gender discrimination at the lower end of the growth distribution, indicating that, among children at higher risk of malnutrition, girls tend to be more disadvantaged than boys. Similarly, the positive effects of income on growth is also seen to be significant, at the upper end of the conditional growth distribution.

Official statistics indicate certain regions of the country which are particularly vulnerable with regards to child nutrition. These include the rural and estate sectors and districts belonging to the Central, Northern, Eastern and Uva provinces. This has led to malnutrition research specifically targeting these areas. The estate sector in particular has attracted much research owing to its history of poverty and malnutrition (Dawood, 1980; Galgamuwa, Iddawela, Dharmaratne, and Galgamuwa, 2017; Gunetilleke, Kuruppu, and Goonasekera, 2008; Jayawardena, 2011). Broadly, these studies identify a unique set of determinants that influence child malnutrition within the estate sector such as poor food diversity, alcoholism and tobacco abuse and low levels of maternal education. Apart from the estate sector, research has been carried out on the state of nutrition and interventions in other areas. Jayatissa, Bekele, Kethiswaran, and De Silva (2012) is a study which looks at a community-based nutrition intervention programme (Nutrition Rehabilitation Programme) implemented in Jaffna (Northern province district). The study reports a significant decline in the prevalence of global acute malnutrition and severe acute malnutrition within the study period. Peiris and Wijesinghe (2010) is a similar research which looks at the nutrition status of under five-year old’s in the Weeraketiya divisional secretariat division (an area of the Southern province). The study looks at the relationship between the nutrition status of children and the level of knowledge of mothers regarding nutrition, in the area. The study reports the knowledge of mothers on micronutrients such as vitamin A and iron, knowledge on managing illnesses (e.g. diarrhoea) and feeding during illness to be inadequate. The rural sector has also attracted significant research especially on poverty (Anulawathie Menike, 2015; Bandara, 1997; Naotunna et al., 2017). However notably, not many studies focus on regional and social inequalities in child growth and malnutrition, to identify factors that drive these differences.

Jayawardena (2012) is a unique study which addresses the above gap to a certain extent by exploring the socioeconomic inequalities in child malnutrition in Sri Lanka. The concentration index together with the Wagstaff decomposition (Wagstaff et al., 2003) has been used in the study. The study reports the continuous life-cycle of malnutrition and intergenerational transmission as major causes of the continuing malnutrition within the lower socioeconomic classes of the country. However, no attention is paid to regional variations in malnutrition.

It is clear that a considerable gap exists in research targeting regional and sectoral variations in malnutrition in Sri Lanka. As noted, research indicates specific household and community level variables such as alcoholism, cultural norms and lack of food diversity as factors that impact child growth within the estate sector. Others indicate issues around lack of knowledge on nutrients and maternal education as factors that could impact child growth in rural areas such as Weeraketiya. However, it is vital to explore what drives differences in child growth within these two vulnerable sectors: rural and estate. This essay hopes to contribute to this gap in knowledge and will enable identifying risk factors that drive child malnutrition in this context.

Chapter 3: Data and Methodology

This study uses data from two nationally representative Demographic and Health Surveys (DHS), conducted in 2006 and 2016, in Sri Lanka. Traditionally, a DHS is carried out every 5 years, however, various factors including civil unrest, political uncertainty, and lack of funding, delayed the DHS round by 5 years, causing a 10-year gap between the two successive surveys. The following is a brief overview of the DHS survey set up including the sample design and type of data collected.

3.1. The DHS Programme and the Sri Lankan Demographic and Health Survey

The Demographic and Health Survey Program was initiated by ICF International and the United States Agency for International Development (USAID) in 1984 (ICF International Inc., 2020). With the primary intention of improving the collection, analysis, and dissemination of population, health and nutrition data and encouraging the use of data for policy-making and program management, the programme has since supported the implementation of surveys in many countries (ICF International Inc., 2020).

The DHS survey tool is used in many countries, to collect and update information on a range of demographic, social, health and economic factors at an individual and household level. Countries often receive funding from donor agencies such as the World Bank, USAid and UNICEF to carry out the surveys. The Sri Lankan Demographic and Health Survey (SLDHS) is regularly conducted by the Department of Census and Statistics (DCS) in Sri Lanka, usually in collaboration with the World Bank. The objective of the survey is to collect data required to monitor and evaluate impacts of various population, health and nutrition interventions implemented in Sri Lanka. Initiated in 1987, Sri Lanka has seen periodic DHS being conducted, a trend which was intermittently disrupted due to insurgencies and civil unrest prevailing in the country at certain time periods. Following the signing of the Millennium Declaration in 2000, DHS became a powerful tool used to road map the progress of achieving the development indicators (Department of Census and Statistics-Sri Lanka, 2009).

The DHS is typically designed to be representative at national and regional levels of a country. In the Sri Lankan context, the survey is designed to be representative nationally, at district level and at the sector level. Oversampling of certain areas have been done on occasion, when additional information is required in certain contexts. For example, following the Indian Ocean tsunami disaster in 2004, the 2006 DHS introduced questions related to exposure to the tsunami, and hence the survey oversampled in tsunami affected regions. Similarly, certain areas of the country have also been excluded in some of the surveys, due to the prevailing political climate of the country (e.g. the Northern province has been excluded in a few DHS surveys prior to 2008, due to the civil unrest that was prevalent in the area).

The DHS questionnaire is designed to collect information from households and eligible women through face-to-face interviews. The core sections are designed in line with standard set of questions included in the ICF DHS questionnaire. In addition to this country specific questions are also periodically added to the survey whenever deemed necessary. The questionnaire is structured as two main sections: the household and women and children sections. Under the household section all residents of sampled households are listed (including visitors), and details on age, gender, relationship to household head, education, marital status and school attendance (where applicable) is recorded. In addition to these questions, the household section also collects details on household facilities including main source of drinking water, toilet facilities, source of lighting, type of cooking fuel, material on roof, walls and floors and general household assets. Details on non-communicable diseases, mental health and substance use in household (tobacco, alcohol and drugs) is also collected. The household section also identifies all eligible women (ever-married women aged 10-49), eligible children (0 – 59 month old) and women eligible to complete the domestic violence section of the survey. Eligible women are then further interviewed, and data recorded under the women and children section of the survey. Under this section, women are asked a series of questions on their background (age, education, religion, ethnicity, marital status, etc.), reproductive history, pregnancy and postnatal care, use of family planning methods, child immunization, health and nutrition etc. In addition to this, the health officers in each survey team measures the height and weight of all eligible women and children in the HH. Blood samples are also taken from eligible women and children to test for haemoglobin levels to estimate the prevalence of anaemia. Following each round of the survey, the DCS issues a detailed report which includes estimates of major demographic and health indicators at the national, district and sector levels and also releases data to relevant authorities and individual researchers (Department of Census and Statistics-Sri Lanka, 2017a).

3.2. DHS Sampling Procedure

The DHS uses a two-stage stratified area probability sample design. In the first stage 2500 census blocks or Enumerator Areas (EA) are selected as the Primary Sampling Unit (PSU). Census blocks or EAs are selected using the census maps created through the most recent census survey. Accordingly, the 2006 DHS was based on the 2001 census survey whilst the 2016 DHS was based on the 2012 census survey. A census block/ EA is typically defined as a subdivision of a *Grama Niladari* division (GN division) which is the smallest administrative unit of the country. Often viewed as a village, the definition of a GN division has also evolved over time. For example, the 2016 SLDHS report defines a GN division as an administrative unit which includes around 150 building units (Department of Census and Statistics-Sri Lanka, 2017a), whilst the 2006/07 SLDHS defines it as an administrative area which includes around 80 housing units in urban areas and 65 units in rural or estate areas (Department of Census and Statistics-Sri Lanka, 2009). However, an EA is typically defined for survey purposes such that one field officer can visit all units within the EA, within six hours to take a count of all the units and the people residing within it. The second stage of sampling in the DHS sampling procedure consists of systematically sampling between 10-12 household from each of the EAs selected as PSUs.

Looking at the 2006 DHS, of the initially selected 2500 EAs, information was collected from 2,106 EAs. The 394 EAs not covered were from the Northern province which was inaccessible due to civil unrest. 21,060 housing units were selected in stage 2, of which 19,862 households were interviewed (Department of Census and Statistics-Sri Lanka, 2009). As mentioned earlier, tsunami affected areas were oversampled in the survey as this was the first major country-wide survey carried out after the 2004 Indian Ocean tsunami disaster. Sampling weights were included in the analysis to account for this. The 2016 DHS initially selected 28,720 sampling units of which 27,210 households were interviewed for the final sample.

3.3. Data Considerations

As indicated earlier, data from the 2006 and 2016 SLDHS is used in this essay. The DHS by design is representative at the national, district and sector levels and as explained above, a similar sampling procedure was used for both surveys. However, a few key differences also exist. Firstly, as explained in the previous section, the 2006 DHS was based on EAs created by the 2001 population census, while the 2016 DHS was based on the EAs created for the 2012 population census. Combining two or more waves of DHS surveys usually requires adjusting for the possibility of non-independence of sampling units between the surveys. This arises due to the possibility that successive DHS surveys may use census blocks derived from the same population census survey, at the sampling stage. However, given that the two surveys use census blocks created by two different population census datasets, this significantly reduces if not eliminates the possibility of non-independence of sampling units. Therefore, I do not adjust for this effect.

Another difference between the two datasets is the coverage of the 2006 DHS. Due to the civil unrest prevailing in the country at the time, the 2006 DHS did not cover the Northern province of the country. This is noted as a possible data related issue, which is beyond the control of the researcher. All provinces and districts were covered in the 2016 DHS. As a robustness check, models were run excluding Northern province districts in the 2016 DHS data as well. Estimates did not show significant changes.

3.4. Theoretical and conceptual model

The conceptual framework used in this study closely follows the UNICEF theoretical framework of determinants of child and maternal malnutrition (Figure 3-1 below). As noted earlier the framework is built on three layers of causes: immediate, underlying and basic. Inadequate diet and disease are identified as the immediate causes that directly result in malnutrition. These are influenced by underlying causes such as food insecurity, inadequate care practices and unhealthy environmental factors. An array of economic and social factors forms the basic causes, with poverty being a key driver. This framework is regularly used in malnutrition research. The usual practice is to consider individual research questions in the context of this framework to identify the level at which they link with the framework.

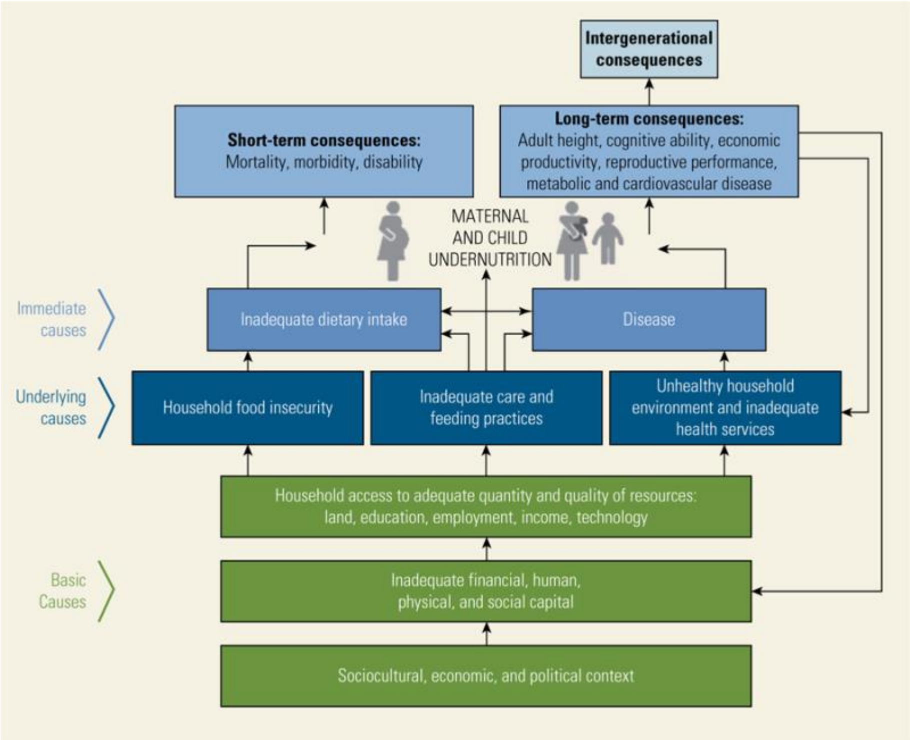


Figure 3-1:UNICEF Conceptual Framework of Determinants of Child and Maternal Undernutrition [Source: Black et al. (2016) adopted from (UNICEF, 2013)]

This study introduces a location dimension to the above framework, in the form of sectors (rural and estate), to understand how the basic, underlying and immediate causes explained in the UNICEF framework are impacted by the location in which children reside. Location would link into the model at different levels. Firstly, given the established variations in poverty between sectors in Sri Lanka (Anulawathie Menike, 2015; Dawood, 1980; Kumanayake, Estudillo and Otsuka, 2014; Ranathunga and Gibson, 2014; Vijayakumar and Olga, 2012), it is clear that location would link to the framework through poverty at the basic level. However, it is important to disentangle variations in socio-economic factors that form this link. Another possible link is via the underlying causes such as HH food security, inadequate care practices and access to health care facilities which may vary based on location. Varying environmental conditions across sectors may also be a possible link through which location is linked to the model. Key climatic differences exist between sectors with the rural sector often marked by periods of arid weather conditions and periods of predictable rains during the two monsoon seasons. On the other hand, much of the estate sector is concentrated towards the centre of the country and is marked by a relatively cool and wet climate throughout the year. Environmental conditions can be linked to the spread of diseases such as respiratory infections, fever, diarrhoea, and mosquito borne diseases like dengue. They can also influence food supply given the heavy dependence on agriculture especially within the rural sector. While short and non-frequent stints of disease is usually not considered as a direct predictor of long-term growth, food supply is considered to have a considerable impact. Given these interdependencies, suitable proxies were used where necessary to control for these channels.

Having conceptualised some of the possible ways through which location links into the theoretical framework, it is also necessary to conceptualise possible ways in which the impacts of location (i.e. sector) on child growth could manifest. Official statistics clearly indicate stunting and wasting to be high in both the rural and estate sectors, with the estate sector being worse off. However, given some of the structural differences noted between the rural and estate sectors above, it is possible that growth may be driven by different factors between the two sectors. For example, a child living in a rural village may also be better off, compared to a similar child living in an estate, due to having access to quality produce during the harvesting seasons (as mentioned earlier, a considerable portion of rural households are involved in agriculture-based industries and it is reasonable to assume that these households would have higher income and access to food, during the harvesting seasons). Another impact may be through cultural norms and feeding practices which are significantly different within the estate sector compared to the rural sector. Much of the estate sector population consist of Indian Tamils who are known to have specific cultural norms which influence the type of food they consume (Jayawardena, 2014a).

As is evident by the above examples, there can be many complementary and confounding factors that drive child malnutrition within the rural and estate sectors. The aim of this essay is to disentangle some of these associations, to better understand what drives child growth within the two sectors and to understand the factors that drive the rural-estate growth gap and whether these factors vary over time and across the growth distribution.

3.5. Variables, Assumptions and other Data Considerations

Prior to presenting the econometric model, it is necessary to discuss variables used, potential analytical challenges and steps taken to overcome them. The main outcome variables considered are height/length-for-age, weight-for-age and BMI-for-age of children, standardized following WHO guidelines (WHO Multicentre Growth Reference Study Group, 2006). Standardization is done using the using WHO *igrowup* macros which use the WHO Multicentre Growth Reference Study Group of published in 2006. As explained earlier, height-for-age is generally considered as a measure of long-term health and growth and therefore is considered less susceptible to sudden health or income shocks such as acute food shortage or disease. However, it will capture more chronic conditions such as continuous bouts of disease, and chronic food shortage.

In contrast, the BMI-for-age and weight-for-age tend to be more sensitive to acute unfavourable conditions such as sudden economic shocks, acute food shortage and disease. However, weight-for-age is also considered to be sensitive to chronic conditions, through its relationship with height. Therefore weight-for-age is generally interpreted together with the height-for-age and BMI-for-age measures. For example, in the absence of significant wasting, weight-for-age generally reflects long-term growth conditions whilst in the presence of significant wasting it would reveal a compound effect between short and long-term growth (de Onis and Blössner, 1997). Therefore, together these three measures can be expected to reveal some important patterns with respect to child growth.

Data from the two DHS are combined along with a year indicator to identify the wave. The overall sample is split into subsamples based on sector and year. As mentioned earlier, the urban sector is excluded from the analysis. A range of child, maternal and household level variables were included as controls in the model. The controls used in the model are in line with those commonly used in malnutrition literature (Black et al., 2008; Dancer et al., 2008; Jayawardena, 2012; Mazumdar, 2010; Shekar et al., 2007; UNICEF/WHO/World Bank Group, 2019). Accordingly, the child's birthweight, birth order, age, gender, breastfed duration, antenatal care and whether the birth was supervised were included as child-level variables. Age and breastfed duration are also added as quadratic terms into the models. The nonlinear relationship between the age of children and their growth in developing countries has been well documented in other research (Van de Poel, Hosseinpoor, et al., 2007). The relationship between breastfed duration and growth is somewhat complex with research reporting both positive and negative impacts on growth (Delgado and Matijasevich, 2013; Van de Poel, Hosseinpoor, et al., 2007). In addition to this, a visual analysis of the data showed a possible nonlinear relationship between the breastfed duration and growth. A quadratic term of the breastfed duration was added to account for this. Mother's age, height, BMI, education, and employment are added as maternal-level variables. HH wealth quintile, characteristics of the head of the HH, substance use in HH and variables on facilities and care practices are included as HH level variables. Province is added to control for wider spatial effects.

Apart from these generic characteristics, a few variables have also been included to account for some of the key pathways by which sector may impact child growth. As identified in the previous section, poverty, HH food security and care practices, access to health care, environmental conditions and cultural norms are some of the potential paths through which sector could influence child growth. HH wealth is used as a direct control for HH income and thus controls for the link between poverty and growth. Care practices at home are identified using a range of care variables (improved drinking water source, hand hygiene of mother and toilet facilities) while antenatal care and supervision of birth also play the role of proxies for access to health care services. Given cultural norms and related feeding practices are often closely tied with ethnicity, ethnicity is added as a control to represent this pathway.

Controlling for HH food security and environmental factors is not as straightforward. HH food security broadly refers to the access to the necessary quantities of quality food, within the HH. Environment factors refer to factors that operate at the HH level, which impact child growth yet is not under the direct control of the individuals of the HH. A number of proxies are used to control for each of these pathways and these will be discussed later in the section. In addition to these variables, the weight-for-age and BMI-for-age models also include indicators for disease, particularly fever and diarrhea in children.

When considering some of the analytical challenges, selection bias due to mortality is an inherent challenge that arises when using survey data to assess health outcomes of individuals (Pitt, 1997). As noted above, child mortality in Sri Lanka is low and comparable to that of developed countries, especially among children below the age of 5 years. A quick analysis of both the surveys also yielded a considerably low percentage of deceased children in the considered age groups (the under 5 years mortality rates calculated using

2006 and 2016 DHS data is 3% and 2% respectively). Nevertheless, the Heckman selection model was used to account for selection due to mortality in the rural and estate sectors, as a robustness check.

The second analytical challenge is due to possible endogeneity of controls used in the models. Previous research has shown that most of the general controls used in child growth and malnutrition models have direct and unconfounded paths that link them to the outcome (Wagstaff et al., 2003). However, there are a few select controls which could impact the outcome in multiple ways. One such point of contention is the measurement of HH food security. As mentioned earlier, HH food security is a clear pathway through which sector could influence child growth, especially given the dependence on agriculture within the rural and estate communities. Unlike other factors, HH food security is more difficult to control for, as the DHS data does not have a direct measure of HH food security. To overcome this issue, HH wealth and the total number of children in the HH are used as proxy variables for measuring HH food security (Jayawardena, 2012; Shekar et al., 2007). Household wealth is considered a valid proxy for food security in Sri Lanka given the relatively high food ratio particularly within the rural and estate sectors (Department of Census and Statistics-Sri Lanka, 2017b). The food ratio refers to the average percentage of HH disposable income spent on food. Whilst the interaction between sector and wealth would reveal any sectoral differences that may exist in HH food security, there is also a possibility that the effect of wealth on child health and growth may arise through other channels apart from food security. For example, higher HH wealth may also signal a better employment status and education of HH members including the mother which is a key factor that is thought to influence child health and growth.

A higher HH wealth could also signal a cleaner HH environment which will lower disease, in turn reducing the risk of malnutrition. Therefore, the interaction between HH wealth and sector may also encompass sectoral differences in employment, education, and other environmental factors. In order to isolate the impact of HH wealth as a proxy for food security alone, as many of these confounding effects need to be controlled in the models. Accordingly, the main employment in the HH and the mother's employment are both added as controls to the models. In addition to this, the mother's education as well as the education level of the head of the HH are also added as controls.

3.6. Empirical Strategy

As noted earlier, the analysis aims to address a few analytical questions. Firstly, to what extent do different socio-economic and demographic factors impact growth within the rural and estate sectors in 2006 and 2016, and how does the rural-estate growth gap change over this time period? Secondly, are differences in rural-estate growth caused by changes in the observed characteristics, or are they driven by changes in returns to the observed characteristics? Thirdly, what drives rural-estate growth differentials at different points of the growth distribution and what drives the improvement/deterioration of growth over time? This section briefly outlines the empirical strategy used to answer the above questions.

3.6.1. Intra-sector analysis within each time period

Ordinary least squares estimation with sample weights and robust standard errors is used in this initial stage of modelling. The dataset is split by sector (rural and estate) and year (2006 and 2016) which yields four subsamples. The following linear model is fitted within each subsample, for each outcome (standardized height-for-age, weight-for-age and BMI-for-age), using the OLS estimation method.

$$E[Y_{ist}|X_{ist}] = X'_{ist}\beta_{st} \qquad (3.1)$$

Where, Y_{ist} is the standardised anthropometric measure of child i in sector *s* (*s=rural/estate*) in time period *t* (*t=2006/2016*). X_{ist} refers to the observed characteristics (i.e. child, maternal and HH controls and the province) including constant. All categorical variables are included as indicator variables for ease of interpretation. β_{st} are sector-time specific coefficients and are estimated using ordinary least squares estimation with robust standard errors and sampling weights.

Following this, the Generalised Hausman specification test (using *suest* Stata command) is used to compare the estimated coefficients of control variables across the sector-year models, to identify the effects which significantly differ across models. The Generalised Hausman test is based on the popular Hausman specification test which uses the Hausman statistic to compare coefficients across two nested models or models fitted across different subsamples. The statistic is based on the difference between the estimated coefficients in the two models (b and B) scaled by the estimated variance of the difference (V[b-B]). The difference between the Hausman method and the Generalised Hausman method is based on the estimation of V[b-B]. The Hausman method estimates V[b-B] by V[b]-V[B], which often violates the positive definite condition. This renders the test to be undefined in these cases. Alternatively, the Generalised Hausman method estimates the same as, V[b] – cov[b, B] – cov [B, b] + V[B]. This estimate is always admissible hence the test would always be well defined. However, the method also has certain drawbacks, such as the non-compatibility with sample weights, and requirements to maintain the same base category for categorical variables in all models. Given that the specification test is used only as a precursor to the decomposition models which further explore sector and year differences with respect to the child, maternal, HH and care controls, the Generalised Hausman specification test is run excluding sample weights, and base categories for categorical variables are redefined, if conflicts occur.

3.6.2. Decomposition of the mean growth differential

The Blinder-Oaxaca decomposition technique was simultaneously introduced by Blinder (Blinder, 1973) and Oaxaca (Oaxaca, 1973) in 1973. The technique was introduced as a method for identifying and quantifying discrimination in wage structures. Whilst Oaxaca concentrated on the sex differential of wages by looking at male vs. female workers, Blinder concentrated on decomposing the wage differential between both white vs. black and male vs. female workers. In context, discrimination was said to occur when an individual similar to another, who only differed with respect to race, sex or other such personal characteristic, received lesser treatment (as identified by the outcome variable) for reasons not directly linked to their performance. Though this technique was traditionally used for the purpose of exploring wage-gaps, the method has, in recent years, been used to explore other gaps, including gaps in malnutrition and growth (Chauhan et al., 2019; Sharaf and Rashad, 2016). Accordingly, the Blinder-Oaxaca (BO) decomposition with extensions to unconditional quantile regression decompositions (Firpo, Fortin and Lemieux, 2018), is used to model growth differentials between the rural and estate sectors, between the two time-periods and at various stages of the growth distribution.

Consider the growth differential between two groups *j* = (0,1). Within each group, the outcome Y_{ij} and a set of characteristics X_{ij} for each child *i* in group *j* are observed. Similar to the intra-sector model, assume that the conditional expectation of Y_j given X_j can be presented as a linear model,

$$E\left[Y_{ij} \middle| X_{ij}\right] = X_{ij}'\beta_j \ , \qquad j = 0{,}1 \qquad (3.1)$$

Accordingly, the raw growth differential (R) can be written as follows:

$$R = E(Y_1) - E(Y_0) = E(X_1)'\beta_1 - E(X_0)'\beta_0 \qquad (3.2)$$

$$= [\ E(X_1) - E(X_0)\ ]'\beta^* + E(X_1)'(\beta_1 - \beta^*) + E(X_0)'(\beta^* - \beta_0) \qquad (3.3)$$

Where the reference vector β^* is given by the following linear form,

$$\beta^* = \Lambda\beta_1 + (I - \Lambda)\beta_0 \qquad (3.4)$$

In equation (3.3) the term $[\ E(X_1) - E(X_0)\ ]'\beta^*$ is referred to as the ‘endowment effect’ and can be interpreted as the portion of the raw differential that may be explained by differences in observed characteristics between the two groups. The two remaining terms are referred to as the ‘coefficient’ and ‘interaction’ effects, both indicating the portion of the differential attributable to the varying returns to observed characteristics, between the two groups. Given the linearity assumption, equation (3.3) can be estimated by using the OLS estimates of the parameter vectors (β_0 and β_1) and replacing the expected value of the covariates with their sample averages (Firpo et al., 2018).

The BO decomposition method outlined above is used to first model the rural-estate differential in each of the two considered time periods (2006 and 2016). The same method is then used to model the 2006-2016 differential within the rural and estate sectors separately. This provides a decomposition of the growth differential both across sectors and time and allows for a broader analysis of the underlying changes in child growth patterns in the sample.

The standard BO decomposition has a few noted limitations. Firstly, in the presence of categorical covariates, the decomposition is sensitive to the base category selected. Secondly, the decomposition provides consistent estimates only under the assumption of linear conditional expectations which yields $E_X[E(Y_{ij}|X_{ij})] = E(Y_{ij}) = E(X_{ij})'\beta_j$.

A potential solution to the first limitation is to apply the deviation contrast transformation to the sets of dummy variables representing each categorical variable. The group models are estimated using the standard dummy coding and the coefficient vector is later transformed to reflect the deviations from the grand mean. This allows for the redundant coefficient of the base category to be estimated. The transformation makes the results of the decomposition invariant to the choice of the base category (Jann, 2008b). The second limitation becomes problematic in cases where it is reasonable to expect a non-linear relationship between the outcome variable and controls. In this case, potential solutions could be to estimate conditional expectations using a non-parametric estimation technique or to perform the decomposition using a non-parametric reweighting approach (DiNardo, Fortin and Lemieux, 1996). This however, is not an issue in this scenario, given the well-established linear relationship between child growth and most determinants (R E Black et al., 2008). Therefore, the standard BO decomposition together with the deviation contrast transformation, is used to model the mean growth differentials.

3.6.3. Unconditional Quantile Regression and Decomposition

Unconditional quantile regression provide an analytical method for modelling effects of explanatory variables on the quintiles of the unconditional marginal distribution of an outcome variable (Firpo, Fortin and Lemieux, 2009). The method extends the concept of Influence Function (IF) commonly used in econometric modelling. The IF function $IF(Y; v, F_Y)$, is a distributional function of a statistic $v(F_Y)$ which yields the influence of an individual observation on that statistic. The Recentered Influence Function (RIF) is constructed by add the statistic $v(F_Y)$ back to the IF. When considering quantiles, the IF for the τth quantile can be given as,

$$IF(Y; q_\tau, F_Y) = \frac{\tau - 1\{Y \leq q_\tau\}}{f_Y(q_\tau)} \qquad (3.5)$$

Where, F_Y and f_Y represent the CDF and PDF respectively. Accordingly, the RIF for τth quantile can be given as,

$$RIF(Y; q_\tau, F_Y) = q_\tau + (\tau - 1\{Y \leq q_\tau\})/f_Y(q_\tau) \qquad (3.6)$$

The conditional expectation of $RIF(Y; q_\tau, F_Y)$ can be modelled as a linear function of a set of explanatory variables (also known as RIF regression) in the following manner.

$$E[RIF(Y; q_\tau, F_Y)|X] = X'\beta_{q_\tau} \qquad (3.7)$$

According to Firpo et al. (2009), with the dependent variable set as $RIF(Y; q_\tau, F_Y)$, the above model can be estimated using OLS estimation among others. Given that the

$RIF(Y; q_\tau, F_Y)$ satisfies the assumption of linearity of conditional expectations, Firpo et al. (2018) also extends the RIF regression method within the BO decomposition framework. Accordingly, under the assumption that $E[RIF(Y; q_\tau, F_Y)|X]$ is linear in X, the estimated differential at the τth quantile, $R(\tau)$ can be decomposed as:

$$R(\tau) = E(X_1)'\beta_{1(\tau)} - E(X_0)'\beta_{0(\tau)} \qquad (3.8)$$

$$= [E(X_1) - E(X_0)]'\beta^*_{(\tau)} + E(X_1)'\left(\beta_{1(\tau)} - \beta^*_{(\tau)}\right) + E(X_0)'\left(\beta^*_{(\tau)} - \beta_{0(\tau)}\right) \qquad (3.9)$$

Where $\beta^*_{(\tau)} = \Lambda_{(\tau)}\beta_{1(\tau)} + \left(I - \Lambda_{(\tau)}\right)\beta_{0(\tau)}$, and $\beta_{1(\tau)}$ and $\beta_{0(\tau)}$ are parameters of the unconditional quantile regression model at the τth quantile. Similar to the mean decomposition, $[E(X_1) - E(X_0)]'\beta^*_{(\tau)}$ represents the 'endowment' effect while the remainder of equation (3.9) represents the 'coefficient' and 'interaction' effects.

The advantage of using unconditional quantile regression over conditional quantile regression is outlined in Firpo et al. (2009). The unconditional quantile regression is often considered to be of economic and policy interest over the conditional quantile regression, as it provides direct estimates of the partial effect of a covariate on the unconditional quantile of the outcome variable. Hence unconditional quantile regression and decomposition is used in this analysis.

3.6.4. Choice of the Reference Parameter Vector

Both the mean and quantile decomposition models above depend on estimating suitable reference parameter vectors β^* and $\beta^*_{(\tau)}$. While the standard BO decomposition uses the parameter vector estimated for either the disadvantaged group ($\beta^* = \beta_0$) or the advantaged group ($\beta^* = \beta_1$) this choice has been criticised in later research. One alternative suggested by Reimers (1983) is to average coefficients estimated for the two groups. Cotton (1988) suggested using group sizes as weights in estimating the reference parameter vector. Another widely used alternative is to approximate the reference parameter vector using a pooled regression across both samples (Neumark, 1988). This method, whilst widely adapted, is also criticised for the potential omitted variable bias arising from the exclusion of group specific intercepts in the model (Fortin, 2008; Jann, 2008a; Kassenboehmer and Sinning, 2014). Alternative models accounting for group specific intercepts are used in a number of later studies, to overcome this bias (Fortin, 2008; Kassenboehmer and Sinning, 2014).

In this study, the method outlined in Kassenboehmer and Sinning (2014) is followed in order to fit the RIF regression decomposition. Given both the sector and year dynamics in the dataset, the method outlined in Kassenboehmer and Sinning (2014) is applicable for the data. However, instead of the extension to (Neumark, 1988) used in their work, the rural sector parameter estimates are used as the reference parameter vector in this study, under the assumption that children in the estate sector are likely to face additional disadvantage compared to rural sector children, from a growth perspective. This assumption is somewhat justified, given the historic roots of the estate sector. Sri Lanka's estate sector has a long history of discrimination and exclusion stemming from the deprivation of citizenship rights for estate communities due to their status as immigrant indentured labour from India. This meant that the estate sector was excluded from many of the country's social and economic development projects (Jayawardena, 1984). Therefore, the assumption of negative discrimination towards the estate sector is justifiable in this case. Other estimations of the reference parameter vector will be explored as a measure of robustness.

Chapter 4: Analysis and Results

This chapter presents the main results of the analysis carried out under this essay. The chapter will be structured in the following manner. As indicated earlier the intention of this essay is to analytically explore child growth within the rural and estate sectors of Sri Lanka. As highlighted in the empirical strategy, a series of analytical steps are followed to address the key research questions. This chapter is structured to highlight each of these research questions. Section 4.1 provides a detailed descriptive analysis of the main outcome and control variables used in the models. The section descriptively explores differences between the rural and estate sectors as well as changes across time, in the outcome and control variables.

Section 4.2 aims to answer part of the first analytical question on identifying the main factors that impact child growth within the rural and estate sectors across the two considered time periods particularly focusing on the long-term growth of children (height-for-age). Results of the intra-sector OLS regression models and the unconditional quantile regression models outlined in section 3.6. is presented in this section. This is followed by the decomposition analysis of long-term growth differentials across the two sectors and two time periods using the Blinder-Oaxaca method. A sensitivity analysis is carried out, to further explore some of the patterns observed in the analysis.

Section 4.3 carries out a similar analysis, focussing on the short-term growth parameters (weight-for-age and BMI-for-age), to identify the factors that drive short-term growth within each sector and time period. The intra-sector models are followed by the decomposition analysis which looks at short-term growth differentials across sector and time.

4.1. Descriptive Analysis

Table 4-1 provides an overview of the outcome variables (standardized height-for-age (*HAZ*), weight-for-age (*WAZ*) and BMI-for-age (*BMIZ*)) for the rural and estate sectors in 2006 and 2016. Two-sample t-tests assuming equal variance is conducted on calculated weighted means to statistically assess the differences in average outcomes across time and sectors. On average the standardised height-for-age has improved from 2006-2016 across both sectors and the change is statistically significant. However, the improvement is larger for the estate sector than rural (0.58 standardized units in the estate sector as opposed 0.24 units in the rural sector). When looking at changes across the distribution, much of the rural sector improvement can be attributed to improvements at the 70^{th} and 90^{th} deciles. In contrast the estate sector seems to show a more uniform improvement across much of the growth distribution apart from Q10, which is comparatively low at 0.28 standardized units. The improvement is markedly large at 0.81 standardized units at the 90^{th} decile, where *HAZ* has improved from negative to positive over the considered time period.

The standardized weight-for-age has also improved on average from 2006 to 2016 and this change is statistically significant. However, unlike the pattern seen in height-for-age the improvement is quantitatively similar, but slightly more for the rural sector (0.19 standardized units in the rural sector and 0.16 units in the estate sector). Looking across the distribution, the rural sector improvement can again be attributed to improvements at the 70^{th} and 90^{th} deciles. In the estate sector, improvements across 30^{th}-70^{th} deciles are considerably low. The 10^{th} and 90^{th} deciles show large and quantitatively similar improvements in weight-for-age (0.32 and 0.33 standardized units at Q10 and Q90 respectively). Once again, a significant change (from negative to positive) in *WAZ* from 2006-2016 is seen at the 90^{th} decile. The behaviour of BMI-for-age is considerably different to the behaviour of weight-for-age and height-for-age. Whilst the average standardized BMI-for-age has improved by 0.09 standardized units in the rural sector, it has declined by 0.28 standardized units in the estate sector. Quantitatively, the largest declines are seen at the 70^{th} and 30^{th} deciles. It is also noticeable that *BMIZ* changes from positive to negative at the 70th decile. Considering the rural sector, the largest improvement in *BMIZ* is seen at the 90th decile. It is also noticeable that the *BMIZ* has declined by 0.07 standardized units at the 10th decile. The behaviour of BMI suggests that the distribution of standardized BMI-for-age may have shifted further away from a standard normal curve over time. Figure 4-1 to 4-2 present the histograms and estimated density curves of the outcome distributions by sector and by time-period to visually gauge these results.

Table 4-1: 2016-2006 difference in average growth within each sector

Height-for-age	Rural			Estate		
(*HAZ*)	2006	2016	change	2006	2016	Change
Mean	-1.02	-0.78	0.24**	-1.75	-1.17	0.58**
Std. Dev.	1.17	1.45		1.34	1.86	
Quantile						
Q10	-2.42	-2.29	0.13	-3.21	-2.93	0.28
Q30	-1.57	-1.44	0.13	-2.45	-1.92	0.53
Q50	-1.05	-0.85	0.20	-1.76	-1.35	0.41
Q70	-0.48	-0.25	0.23	-1.14	-0.70	0.44
Q90	0.38	0.84	0.46	-0.2	0.61	0.81
N	3643	5204		417	393	

Weight-for-age	Rural			Estate		
(*WAZ*)	2006	2016	change	2006	2016	Change
Mean	-1.23	-1.04	0.19**	-1.48	-1.32	0.16*
Std. Dev.	1.06	1.19		1.14	1.30	
Quantile						
Q10	-2.49	-2.42	0.07	-3.00	-2.68	0.32
Q30	-1.78	-1.65	0.13	-2.03	-1.90	0.13
Q50	-1.28	-1.11	0.17	-1.46	-1.41	0.05
Q70	-0.75	-0.51	0.24	-0.97	-0.83	0.14
Q90	0.09	0.39	0.30	-0.08	0.25	0.33
N	3638	5201		416	392	

BMI-for-age	Rural			Estate		
(*BMIZ*)	2006	2016	change	2006	2016	Change
Mean	-0.89	-0.80	0.09**	-0.54	-0.82	-0.28**
Std. Dev.	1.13	1.46		1.30	1.59	
Quantile						
Q10	-2.19	-2.26	-0.07	-2.22	-2.31	-0.09
Q30	-1.43	-1.41	0.02	-1.14	-1.43	-0.29
Q50	-0.92	-0.86	0.06	-0.57	-0.8	-0.23
Q70	-0.38	-0.26	0.12	0.13	-0.22	-0.35
Q90	0.44	0.78	0.34	1.09	0.98	-0.11
N	3638	5201		416	392	

**1%, *5%, + 10% significance. NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

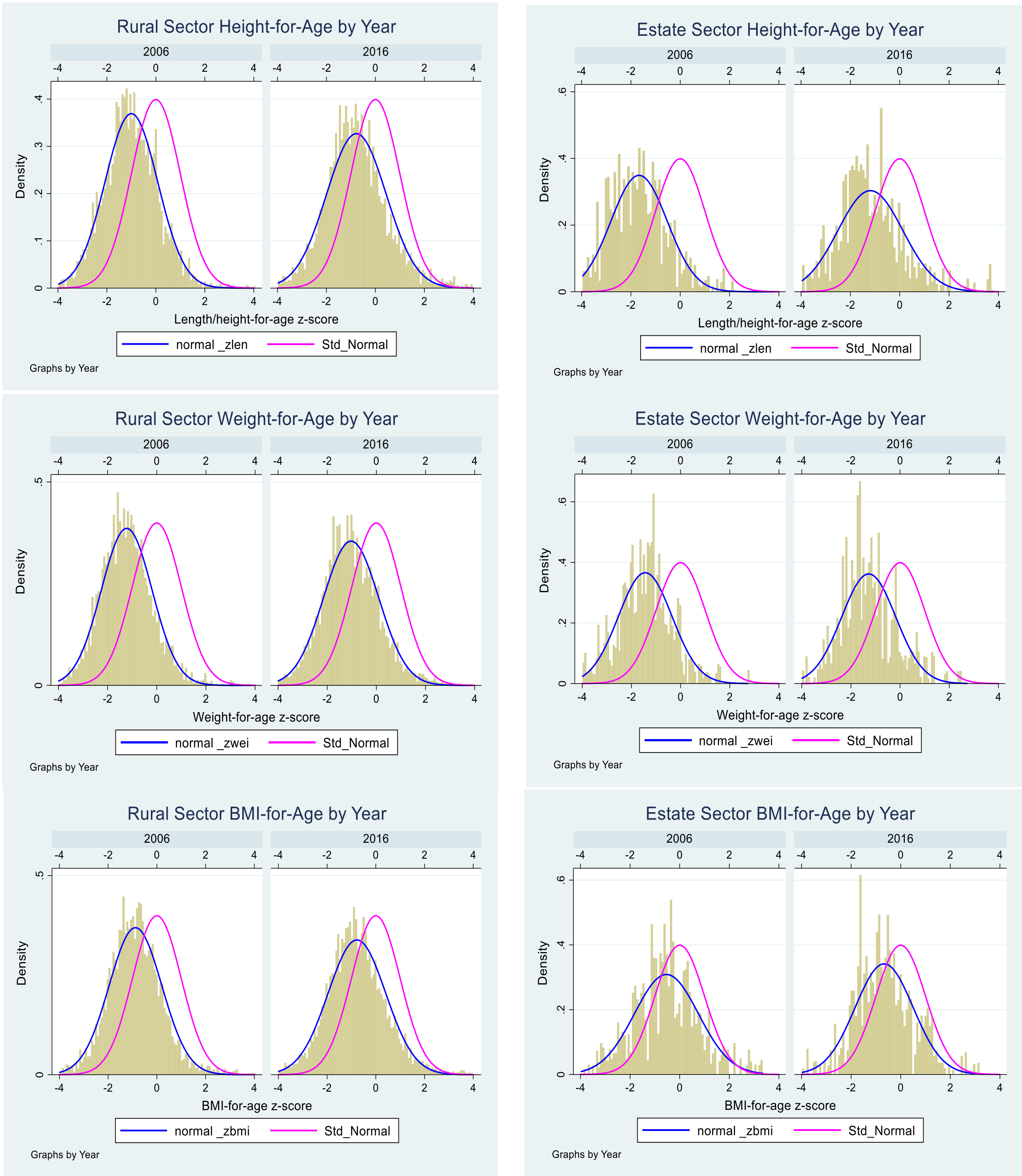
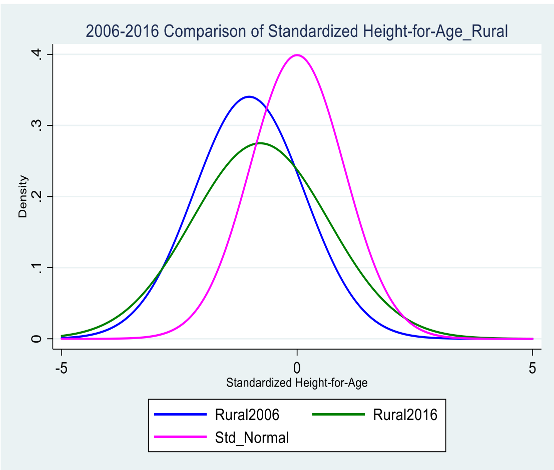
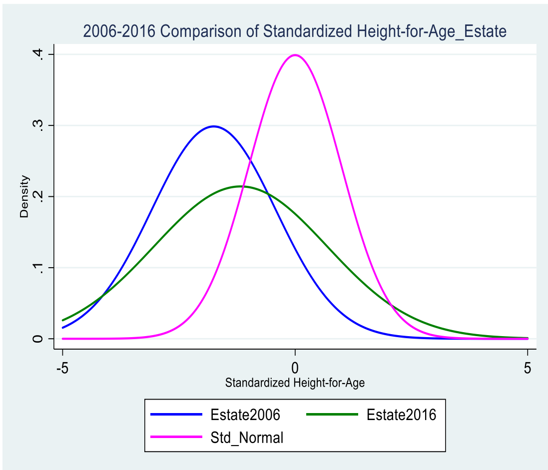


Figure 4-1: Histograms of Rural and Estate Sector *HAZ*, *WAZ* and *BMIZ* by Year

Figure 4-1 indicates the distribution of the outcome variables across the two time periods within each sector. The left panel presents the change across time for the rural sector while the right panel presents the same graphs for the estate sector. Whilst it is visually difficult to detect clear patterns in most of the graphs, a clear observation can be made with regards to the estate sector graphs which show a relatively larger spread compared to the rural sector graphs, particularly with regards to height-for-age. The 2016 distributions are generally seen to deviate less from the standard normal than the 2006 distributions, across the rural sector. In comparison the height-for-age graphs in the estate sector (right panel) show the distribution in 2016 to be somewhat closer to the standard normal, than the 2006 distribution, while the BMI-for-age graphs show the 2006 distribution to be marginally closer to the standard normal curve than the 2016 distribution, especially at the upper tail of the distribution (i.e. a larger area of the upper tail of the 2006 distribution lies within the standard normal curve, as opposed to the 2016 distribution). A pattern is not very evident with weight-for-age graphs in the estate sector, where distributions across 2006-2016 appear to be very similar.

The following graphs plot the estimated density curves of the outcome variables (standardised height-for-age, weight-for-age and BMI-for-age) for the two sectors, together with the standard normal density curve in a single plot for comparison purposes. The patterns noted above are clearly evident in the graphs below, where a general improvement over time in the measured outcomes is evident within the rural sector. In contrast, the distribution of height-for-age and BMI-for-age are somewhat flattened in 2016, within the estate sector, and the BMI-for-age distribution is also seen to deviate more from the standard normal curve, in 2016. Overall, results suggest that though outcomes have, on average improved from 2006 to 2016, some important exclusions exist, especially within the estate sector.





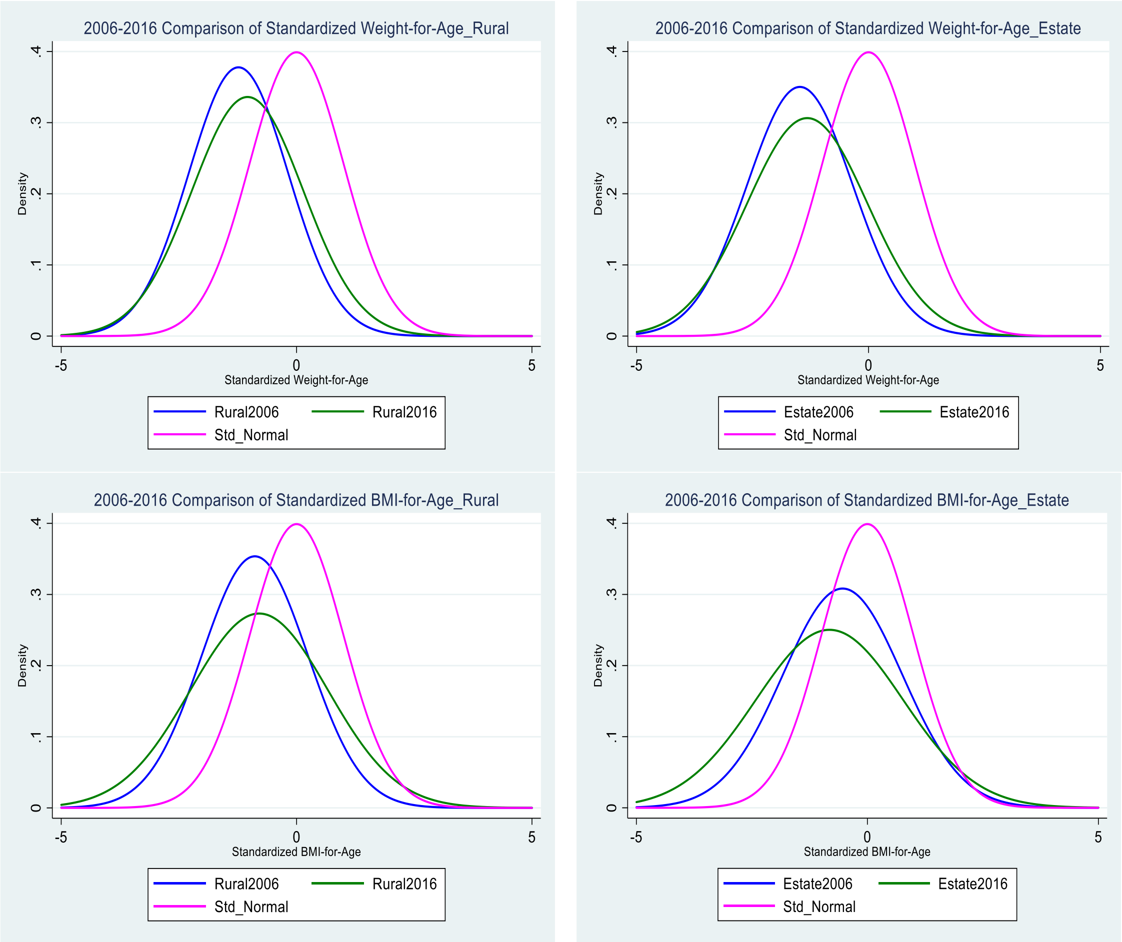


Figure 4-2: Density Curves for 2006-2016 *HAZ*, *WAZ* and *BMIZ* by Sector

A possible reason for the results with regards to the BMI-for-age distributions within the estate sector, could be the relatively higher spread of the height-for-age distribution in 2016, coupled together with the weight-for-age distribution which has not significantly changed over time. This suggests that the BMI-for-age may have deteriorated over time, within the estate sector.

The table below compares the difference between weighted mean outcomes (*HAZ*, *WAZ* and *BMIZ*) between the rural and estate sectors in each time period. The mean height-for-age and weight-for-age is higher in the rural sector than the estate sector in both time periods, and the differences are statistically significant. However, with regards to the BMI-for-age, the weighted mean is higher in the estate sector than the rural sector in 2006, and the difference is statistically significant. There is no significant difference in the BMI-for-age between the two sectors in 2016.

Table 4-2: Rural-Estate difference in average growth within each year

HAZ	2006			2016		
	Rural	Estate	change	Rural	Estate	change
Mean	-1.02	-1.75	0.73**	-0.78	-1.17	0.39**
Std. Dev.	1.17	1.34		1.45	1.86	
N	3643	417		5204	393	

WAZ	2006			2016		
	Rural	Estate	change	Rural	Estate	change
Mean	-1.23	-1.48	0.25**	-1.04	-1.32	0.28**
Std. Dev.	1.06	1.14		1.19	1.30	
N	3638	416		5201	392	

BMIZ	2006			2016		
	Rural	Estate	change	Rural	Estate	change
Mean	-0.89	-0.54	-0.35**	-0.80	-0.82	0.02
Std. Dev.	1.13	1.30		1.46	1.59	
N	3638	416		5201	392	

**1%, *5%, + 10% significance.
NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

Figure 4-3 portrays the above results graphically by presenting the distributions of *HAZ*, *WAZ* and *BMIZ* across sectors (left panel) and across the two time periods (right panel). Looking at the left panel, the height-for-age and weight-for-age distributions for the estate sector visually deviates more from the standard normal curve than in the rural sector. This is also evident in the top panel graph of Figure 4-4 and 4-5, where the estimated height-for-age and weight-for-age density curves for the rural sector, tend to be closer to the standard normal, than those of the estate sector. Figure 4-4 also suggests that the distributional gap in height-for-age between the two sectors was wider in 2006 compared to 2016, while the gap remains more or less the same between 2006 and 2016, with regards to weight-for-age (Figure 4-5). In contrast the distributions of BMI-for-age between the rural and estate sectors are seen to deviate by similar measures from the standard normal curve.

However, looking across the two time periods (right panel in Figure 4-3), it is noticeable that the deviation from the standard normal curve is visually similar across the two time periods for all three outcome measure. This may be due to the change in distribution of outcome variables being different for the two sectors.

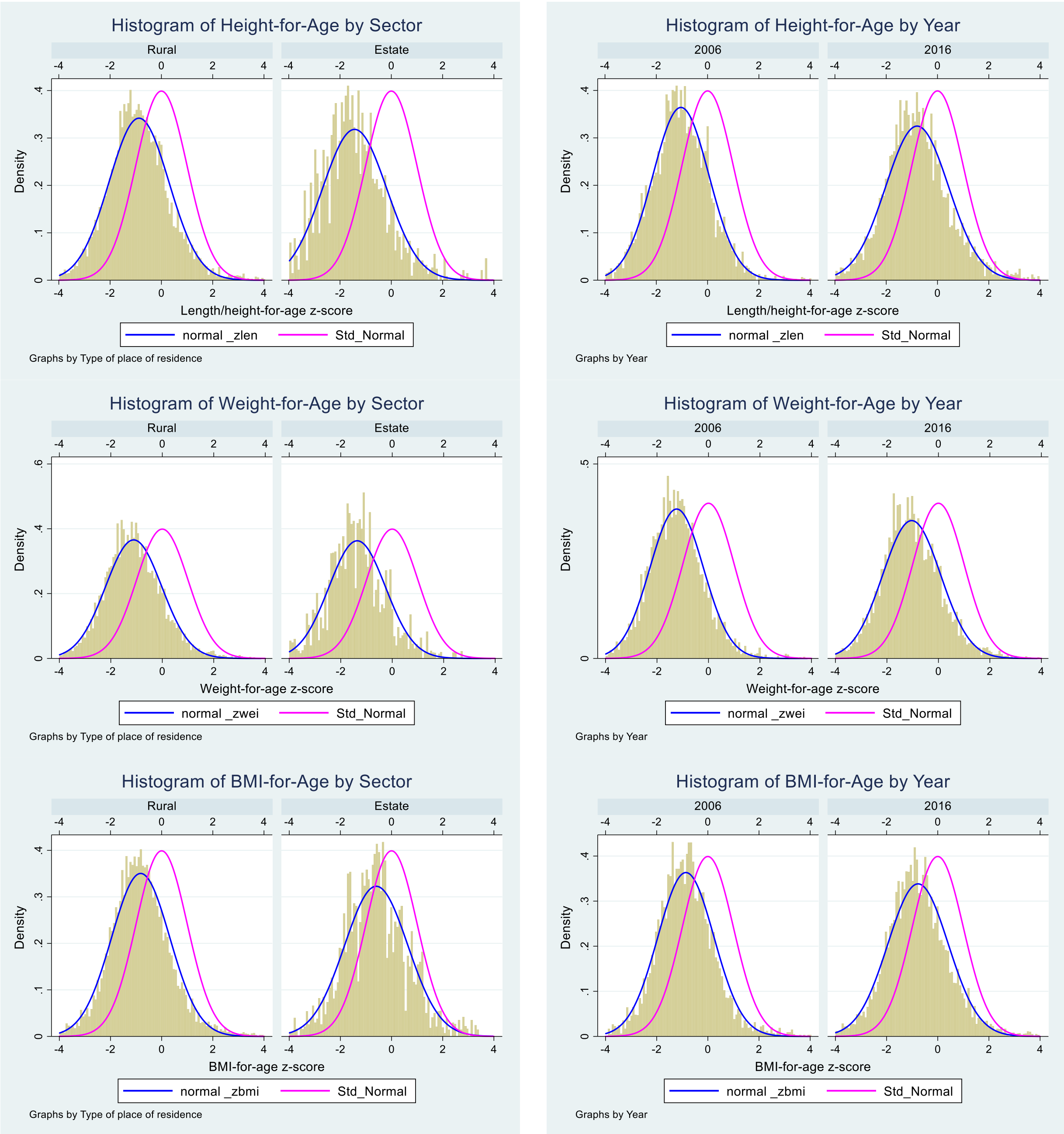


Figure 4-3: Histograms *HAZ*, *WAZ* and *BMIZ* by Sector and Year

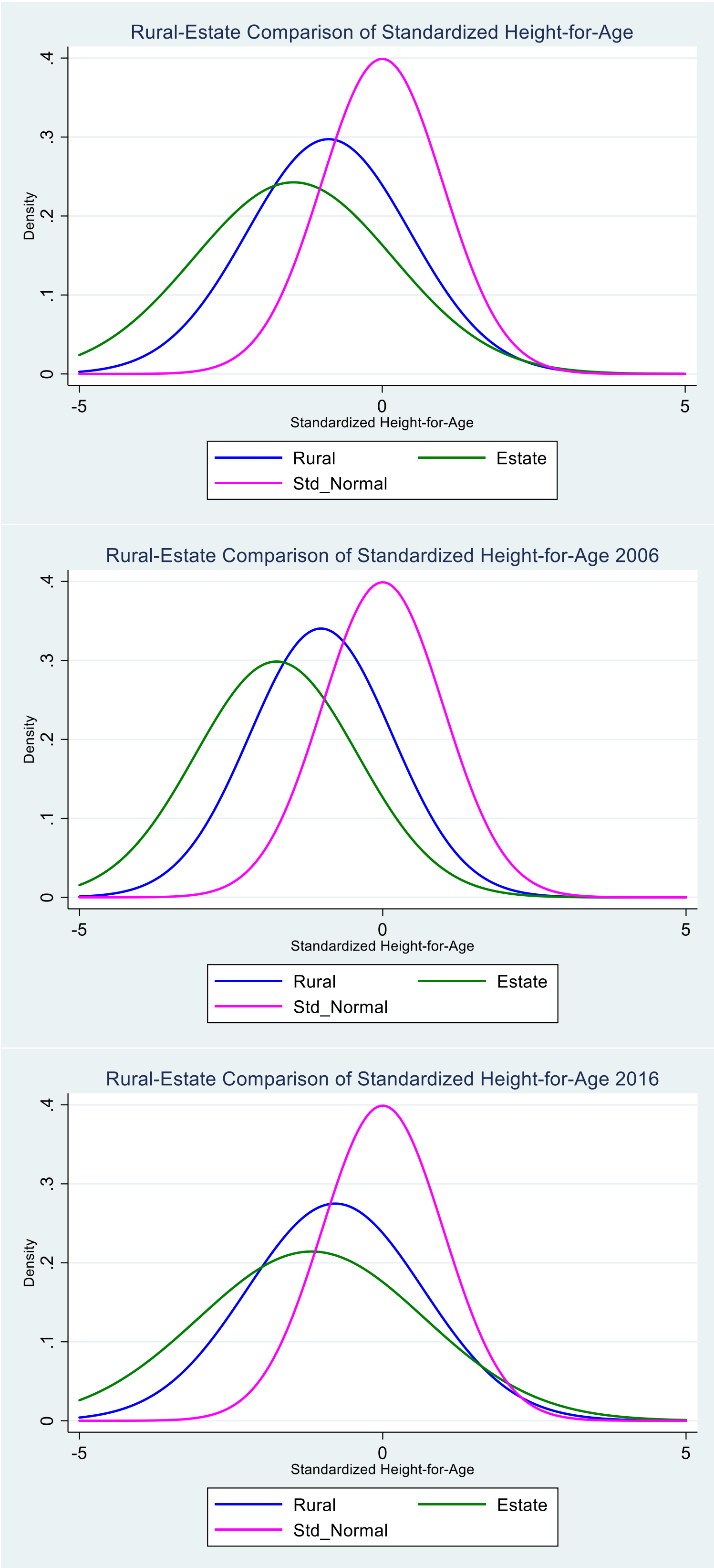


Figure 4-4: Density curves for *HAZ*: Overall, 2006 and 2016 samples

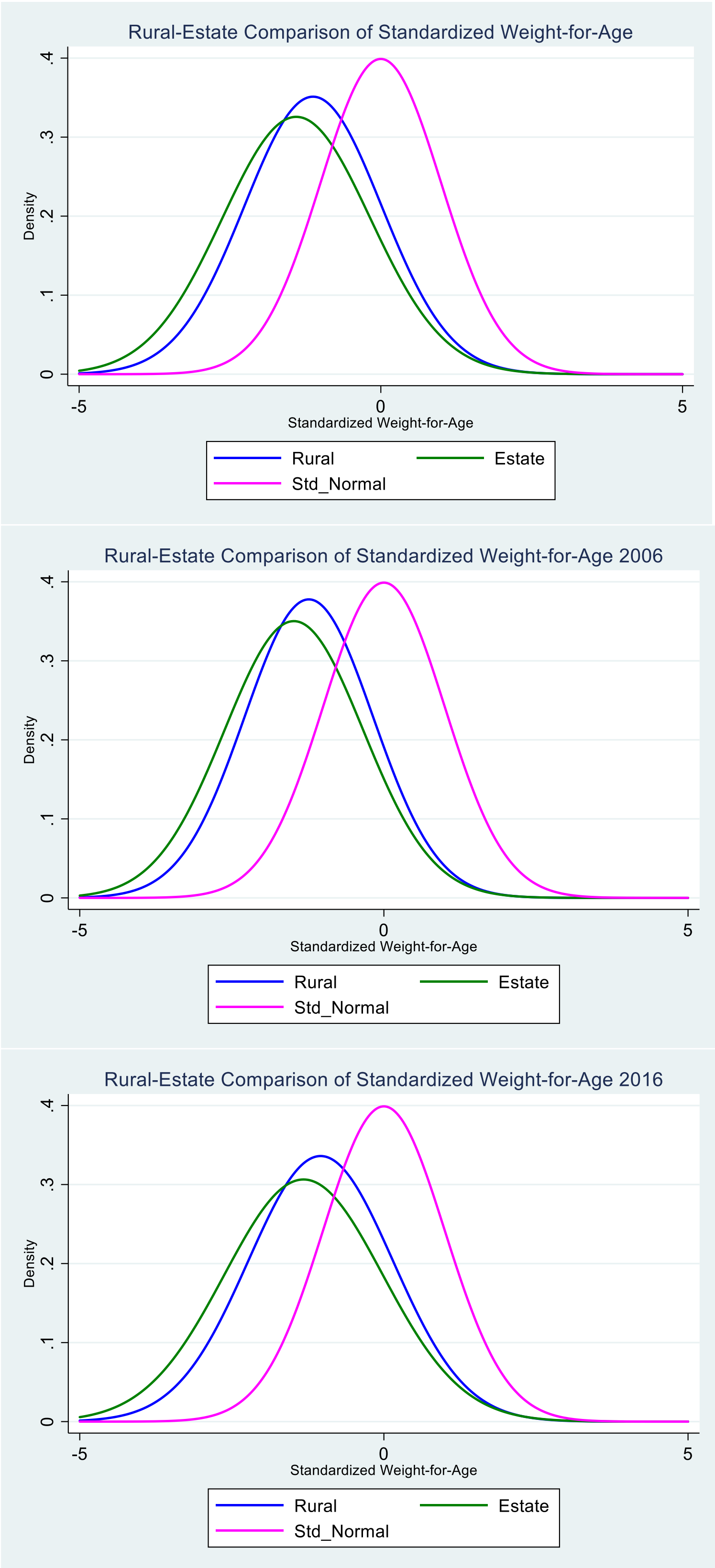


Figure 4-5: Density curves for *WAZ*: Overall, 2006 and 2016 samples

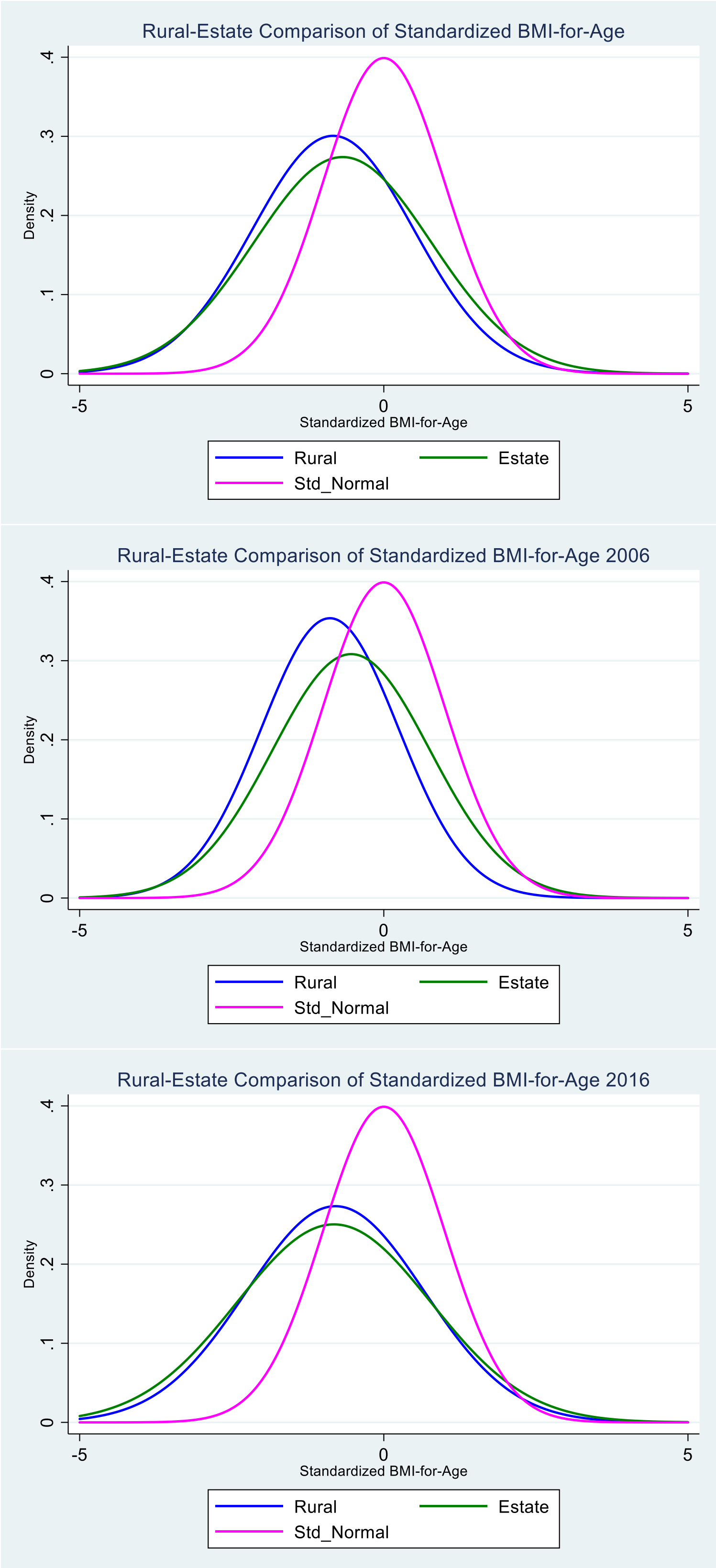
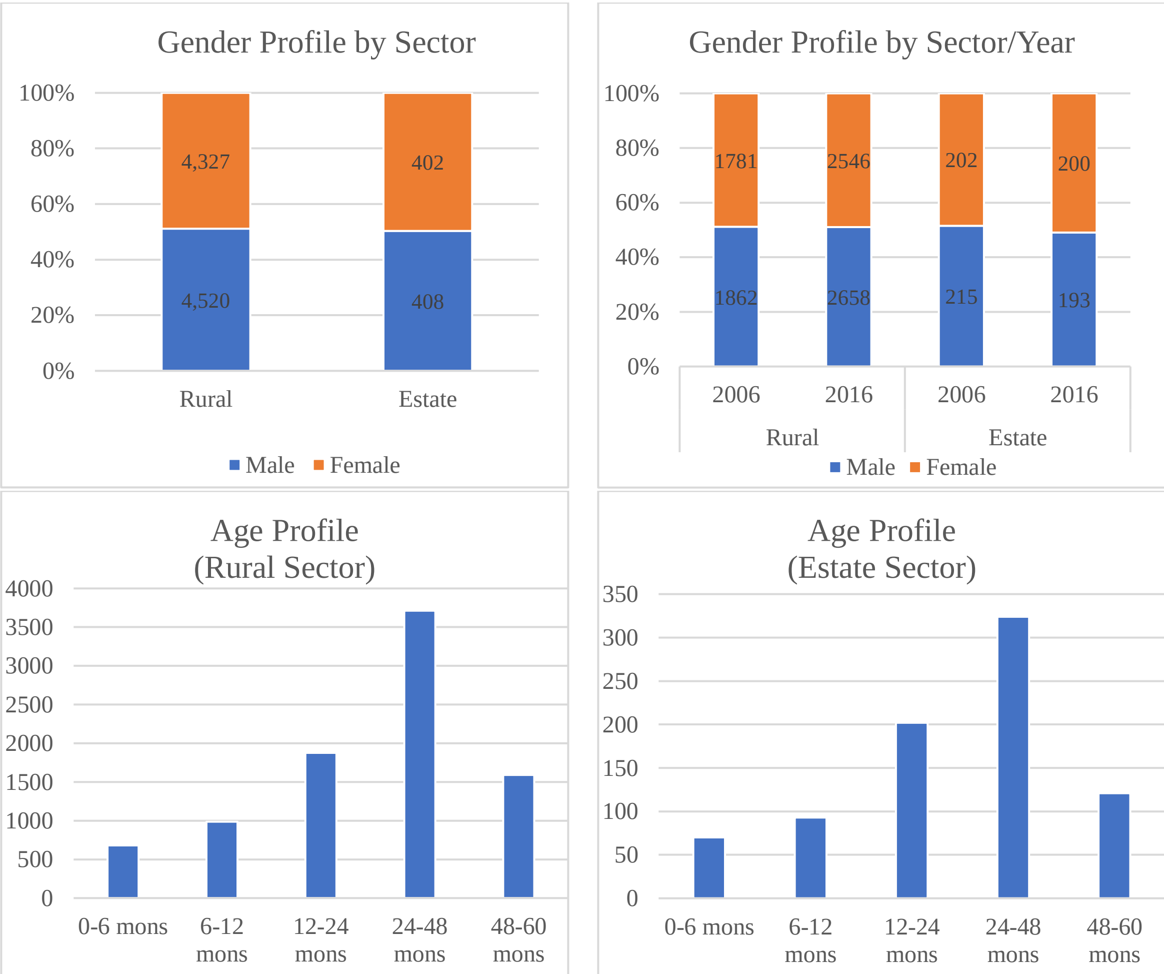


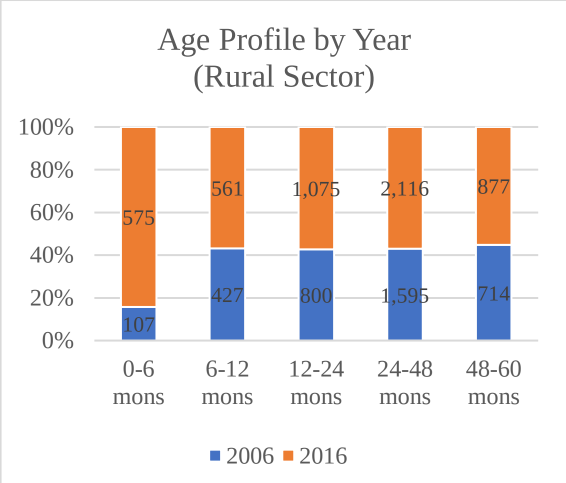
Figure 4-6: Density curves for *BMIZ*: Overall, 2006 and 2016 samples

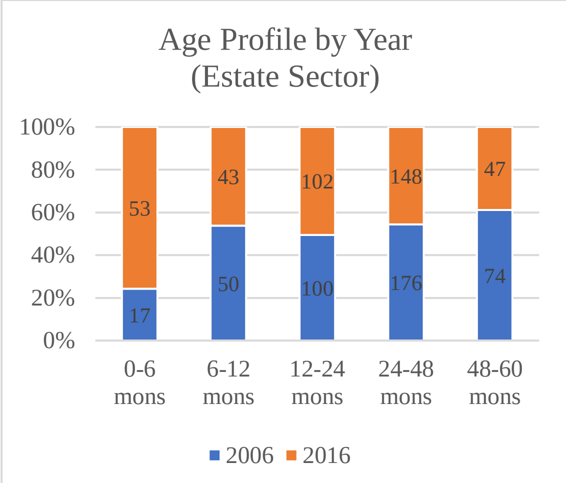
4.1.1. Distribution of control variables across sector and time

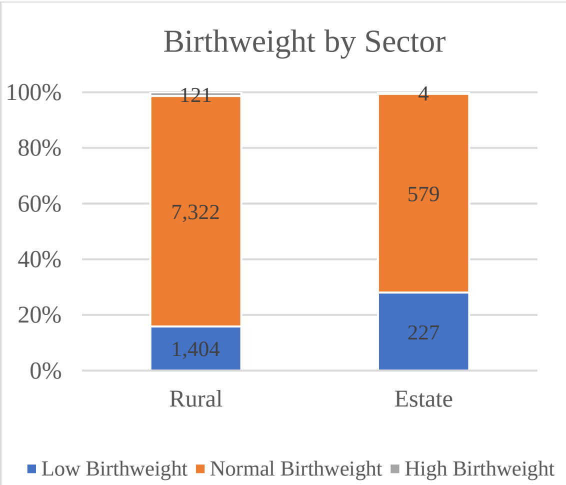
This section presents a descriptive analysis of the sector and temporal changes in the child, maternal HH and environmental variables used as controls in the models. Given that most variables are categorical in nature, indicator variables are used to run descriptive tests (e.g. t-tests).

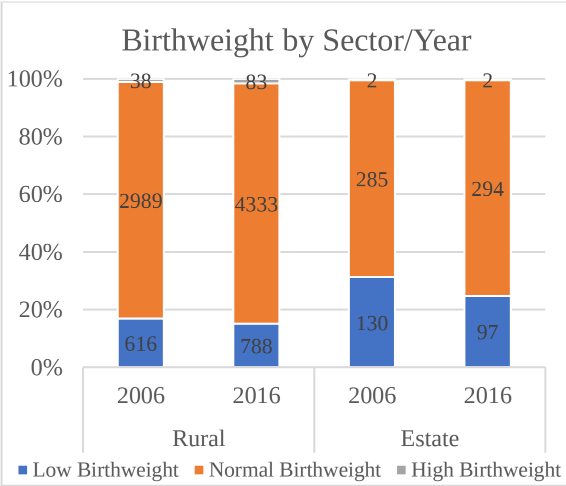
a) Sample Profile

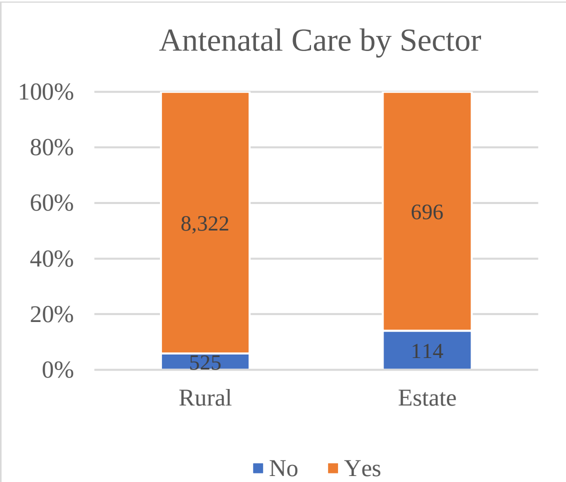


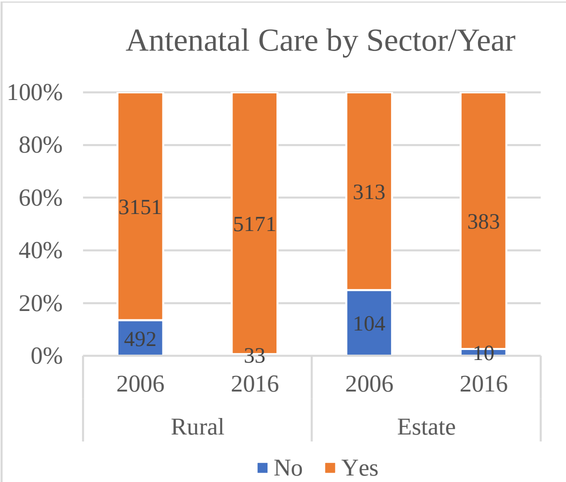

Age Profile by Year
(Rural Sector)
100%
80%
60%
40%
20%
0%
575
107
561
427
1,075
800
2,116
1,595
877
714
0-6 mons
6-12 mons
12-24 mons
24-48 mons
48-60 mons
2006
2016


Age Profile by Year
(Estate Sector)
100%
80%
60%
40%
20%
0%
53
17
43
50
102
100
148
176
47
74
0-6 mons
6-12 mons
12-24 mons
24-48 mons
48-60 mons
2006
2016


Birthweight by Sector
100%
80%
60%
40%
20%
0%
121
7,322
1,404
4
579
227
Rural
Estate
Low Birthweight
Normal Birthweight
High Birthweight


Birthweight by Sector/Year
100%
80%
60%
40%
20%
0%
38
2989
616
83
4333
788
2
285
130
2
294
97
2006
2016
2006
2016
Rural
Estate
Low Birthweight
Normal Birthweight
High Birthweight


Antenatal Care by Sector
100%
80%
60%
40%
20%
0%
8,322
525
696
114
Rural
Estate
No
Yes


Antenatal Care by Sector/Year
100%
80%
60%
40%
20%
0%
3151
492
5171
33
313
104
383
10
2006
2016
2006
2016
Rural
Estate
No
Yes

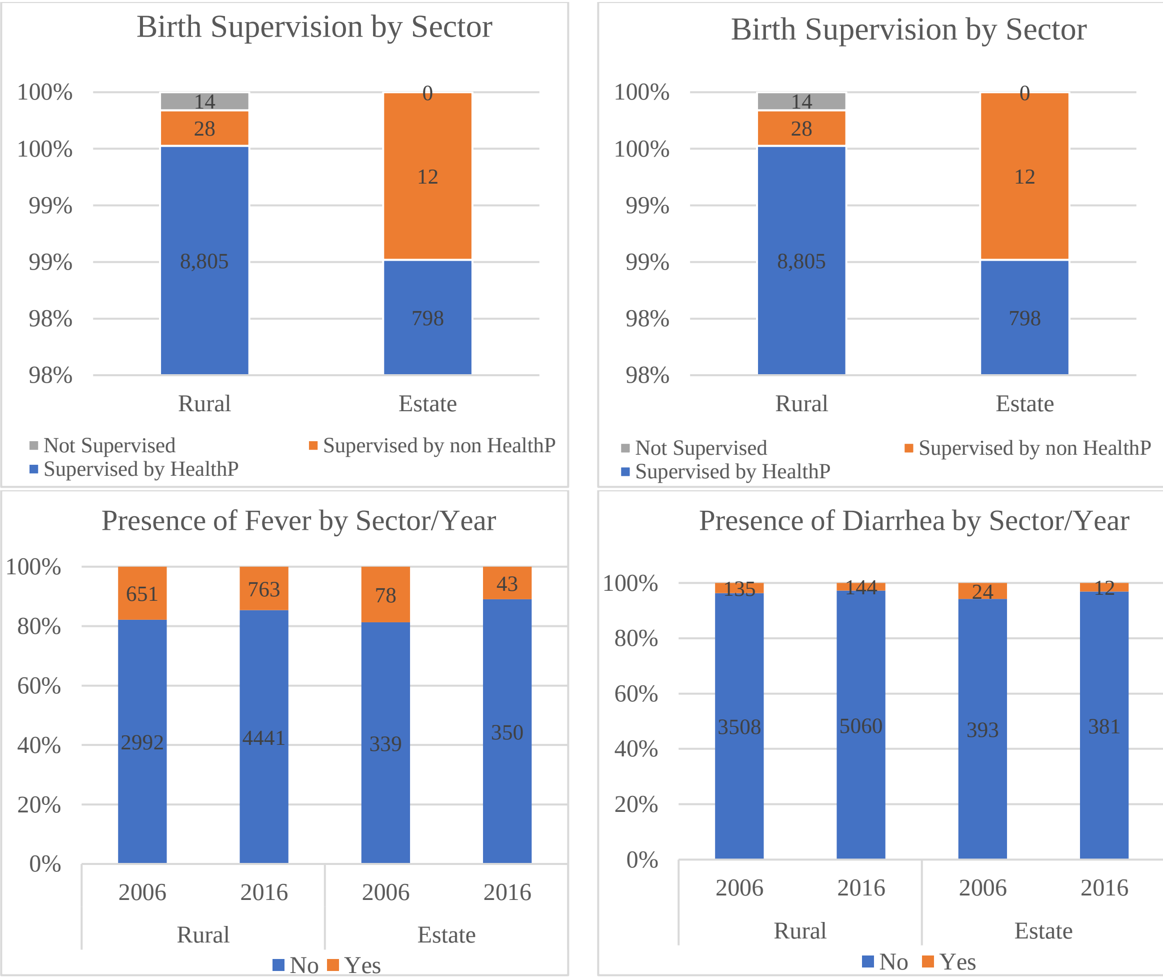


Figure 4-7: Sample Profile by Sector and Year
Base: Rural (8847) Estate (810), Rural 2006/2016 (3643/5204), Estate 2006/2016 (417/393)

The sample used for modelling has an even gender split and age distribution across sectors. Gender is also evenly split across the two time periods within each sector. With regards to age, the sample shows similar percentages across the two time periods in all age groups between 6-48 months. The percentage of children in the 0-6 months age group is significantly lower in the 2006 sample compared to 2016 sample in both sectors. The percentage of children in the 48-60 months age group is slightly higher in the 2016 sample than the 2006 sample in the estate sector.

Most children recorded normal birthweights in both sectors whilst the percentage of children recording low birthweight was slightly higher in the estate sector in both time periods. With regards to antenatal care, most mothers in both sectors have received antenatal care during pregnancy. The percentage of mothers not receiving antenatal care was higher in 2006 than in 2016 in both sectors. The percentage of mothers not receiving antenatal care was slightly higher in the estate sector than the rural sector in 2006. With regards to the supervision of birth, it is clearly noticeable that close to 99% of all births were supervised by health persons in both sectors. However, the percentage of births supervised by non-health personnel was slightly higher in the estate sector (1.5%) than the rural sector (0.3%). No births in the estate sector were unsupervised as opposed to the rural sector sample which had (0.2%) births which were unsupervised. Considering the presence of disease, fever is seen to be clearly more prevalent than diarrhea in both sectors in both time periods and prevalence of fever is seen to be marginally higher within the rural sector in both years.

b) Child-level variables

Table 4-3 presents mean comparison results for some key child-level variables for the rural and estate sectors. This is followed by a more detailed comparison by sector and year in Table 4-4. As indicated in Table 4-3, average birthweight is significantly higher in the rural sector than the estate sector. Average proportion of mothers receiving antenatal care and the average duration of breastfeeding is also significantly higher within the rural sector (except for antenatal care in 2006) as opposed to the estate sector.

According to Table 4-4, birthweight shows a significant improvement from 2006 to 2016 within both sectors. A significant increase is observed in the proportion of mothers receiving antenatal care in the rural sector from 2006-2016. However, no significant change can be observed in the estate sector. With regards to the supervision of the birth of the child, it is noticeable that most births were supervised by a health person in both sectors and in both time periods. A significant decline in the proportion of births supervised by non-health personnel is also observed in both sectors. The duration of breastfeeding has significantly increased from 2006-2016 in the estate sector. Looking at proportions of children being breastfed over 1 month and 6 months, it is noticeable that the proportions show a decline from 2006 to 2016 within both sectors. However, the calculated percentages are still significantly high, with over 90% of children being breastfed beyond 1 month, and over 80% being breastfed beyond 6 months, in both sectors in 2016. It is also interesting to note that, contrary to these results, the proportion of children breastfed beyond 2 years has increased over time within both sectors. This may signal potential gaps in awareness regarding the importance of exclusive breastfeeding, given the small but significant decline in the percentages of exclusive breastfeeding within both sectors.

The prevalence of diseases such as fever and diarrhea are another key factor which impede child growth, especially impacting their weight and BMI. Two disease indicators, for fever and diarrhea are hence used in the weight-for-age and BMI-for-age models, to control for these effects. The frequency distribution showed that the proportion of children suffering from fever and those suffering from diarrhea have declined over time within both sectors. Comparing the prevalence within the two sectors, the rural sector showed a significantly higher proportion of children suffering from fever, than the estate sector, in both years, while the estate sector showed a higher proportion of children suffering from diarrhea in 2006.

Table 4-3: Rural-Estate difference in key average child-level variables

	Total			2006			2016		
	Rural	Estate	Change	Rural	Estate	Change	Rural	Estate	Change
Birthweight (g)									
Mean	2911.1	2705.5	205.6**	2900	2635	265**	2920	2777	143**
Std. Dev.	528	569		475	496		564	627	
Birth order									
Mean	1.96	2.05	-0.09**	1.95	2.00	-0.05	1.96	2.10	-0.14**
Std. Dev.	1.01	1.04		1.09	1.09		0.94	0.99	
Birth order cat									
1st									
Mean	0.38	0.36	0.02	0.41	0.40	0.01	0.36	0.32	0.04^{+}
Std. Dev.	0.48	0.48		0.49	0.49		0.48	0.47	
2nd									
Mean	0.37	0.36	0.01	0.35	0.34	0.01	0.39	0.37	0.02
Std. Dev.	0.48	0.48		0.48	0.48		0.49	0.48	
3rd or higher									
Mean	0.25	0.28	-0.03*	0.24	0.26	-0.02	0.25	0.31	-0.06**
Std. Dev.	0.43	0.45		0.43	0.44		0.43	0.46	

Table 4-3 *ctd*.

	Total			2006			2016		
	Rural	Estate	Change	Rural	Estate	Change	Rural	Estate	Change
Antenatal care									
Mean	0.94	0.86	0.08**	0.86	0.98	-0.12**	0.99	0.99	0
Std. Dev.	0.24	0.35		0.34	0.14		0.08	0.08	
Birth sup by:									
Health P.									
Mean	0.99	0.99	0.0	0.99	0.98	0.01*	0.99	0.99	0
Std. Dev.	0.07	0.11		0.08	0.14		0.06	0.08	
Non-Health P.									
Mean	0.003	0.01	-0.01**	0.01	0.02	-0.01*	0.002	0.01	-0.004
Std. Dev.	0.06	0.11		0.07	0.14		0.05	0.08	
Breastfed duration									
Mean	22.82	18.63	4.19**	22.93	17.51	5.42**	22.73	19.77	2.96**
Std. Dev.	13.20	12.05		12.3	11.56		13.85	12.44	
Fever									
Mean	0.163	0.143	0.02+	0.178	0.177	0.001	0.15	0.109	0.041*
Std. Dev.	0.369	0.351		0.383	0.382		0.358	0.313	
Diarrhea									
Mean	0.032	0.045	-0.013*	0.037	0.059	-0.022*	0.028	0.03	-0.002
Std. Dev.	0.175	0.207		0.188	0.237		0.165	0172	
N	8847	810		3643	417		5204	393	

**1%, *5%, + 10% significance. NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

Table 4-4: 2016-2006 difference in average child-level variables within each sector

	Rural			Estate		
	2006	2016	change	2006	2016	change
Birthweight (g)						
Mean	2900	2920	20*	2635	2777	142**
Std. Dev.	475	564		496	627	
Birth order						
Mean	1.95	1.96	0.01	2.00	2.10	0.1^{+}
Std. Dev.	1.09	0.94		1.09	0.99	
Birth order cat						
1^{st}						
Mean	0.41	0.36	0.05**	0.40	0.32	0.08**
Std. Dev.	0.49	0.48		0.49	0.47	
2^{nd}						
Mean	0.35	0.39	-0.04**	0.34	0.37	-0.03
Std. Dev.	0.48	0.49		0.48	0.48	
3rd or higher						
Mean	0.24	0.25	-0.01	0.26	0.31	-0.28^{+}
Std. Dev.	0.43	0.43		0.44	0.46	

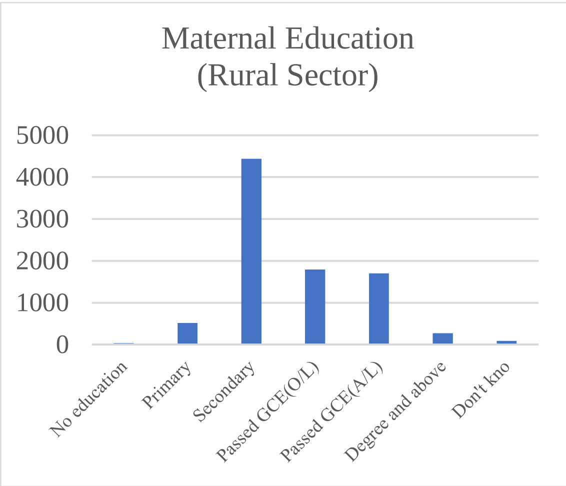
Table 4-4 *ctd*.

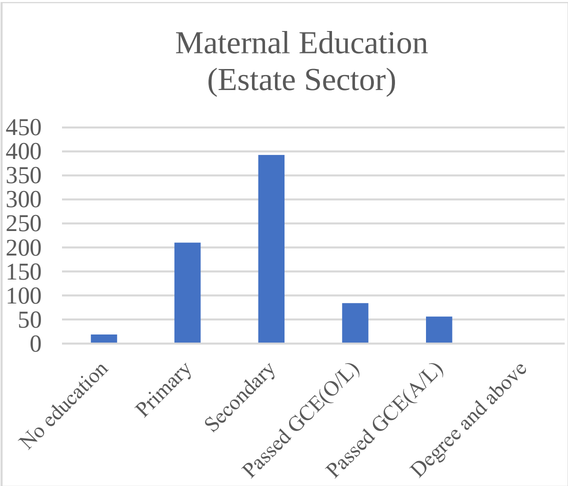
	Rural			Estate		
	2006	2016	change	2006	2016	Change
Antenatal care						
Mean	0.86	0.99	0.13**	0.98	0.99	0.01
Std. Dev.	0.34	0.08		0.14	0.08	
Birth supervised by:						
Health P.						
Mean	0.99	0.99	0.0	0.98	0.99	0.01
Std. Dev.	0.08	0.06		0.14	0.08	
Non-Health P.						
Mean	0.01	0.002	-0.008**	0.02	0.01	-0.01*
Std. Dev.	0.07	0.05		0.14	0.08	
Not Supervised						
Mean	0.001	0.002	0.001	0.0	0.0	0.0
Std. Dev.	0.04	0.04		0.0	0.0	
Breastfed duration						
Mean	22.93	22.73	-0.2	17.51	19.77	2.26**
Std. Dev.	12.3	13.85		11.56	12.44	
BF > 1 mon						
Mean	0.99	0.96	-0.03**	0.98	0.92	-0.06**
Std. Dev.	0.07	0.20		0.13	0.27	
BF > 6 mons						
Mean	0.94	0.85	-0.09**	0.84	0.8	-0.04+
Std. Dev.	0.25	0.36		0.37	0.4	
BF > 12 mons						
Mean	0.76	0.72	-0.04**	0.58	0.68	0.1**
Std. Dev.	0.43	0.45		0.5	0.47	
BF > 24 mons						
Mean	0.4	0.42	0.02*	0.21	0.32	0.11**
Std. Dev.	0.49	0.49		0.41	0.47	
BF > 36 mons						
Mean	0.13	0.15	0.02**	0.06	0.08	0.02
Std. Dev.	0.34	0.36		0.24	0.27	
Fever						
Mean	0.178	0.15	-0.028**	0.177	0.109	-0.068**
Std. Dev.	0.383	0.358		0.382	0.313	
Diarrhea						
Mean	0.037	0.028	-0.009**	0.059	0.03	-0.029*
Std. Dev.	0.188	0.165		0.237	0.172	
N	3643	5204		417	393	

**1%, *5%, + 10% significance. NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

c) Maternal-level variables

The following figure presents maternal education and employment by sector and year. In general mothers were observed to have secondary or lower education in both sectors. However, it is noticeable that the percentage of primary educated mothers is relatively high in the estate sector compared to the same percentage in the rural sector. The percentage of mothers who have passed GCE(O/L) or GCE(A/L) within the rural sector is relatively higher than the same percentage within the estate sector. Looking across the two time periods, it is noticeable that the percentage of secondary educated mothers has decreased by over 10% in the rural sector, while the same percentage has increased by 7% in the estate sector, from 2006 to 2016. A positive trend is also seen with regard to the percentage of mothers completing GCE(O/L) and GCE(A/L) which has increased between 2006 to 2016, within both sectors. Looking at maternal employment, a significantly high percentage of rural sector mothers in the sample are not working, while a relatively high percentage of estate sector mothers were either non-working or were employed as unskilled workers. Looking across the two time periods, a somewhat startling observation is the significant increase in the percentage of non-working mothers (from 35% to 59%) and decrease in the percentage of mothers doing unskilled work (59% to 22%). In contrast, the rural sector does not show major changes in maternal employment between 2006-2016.





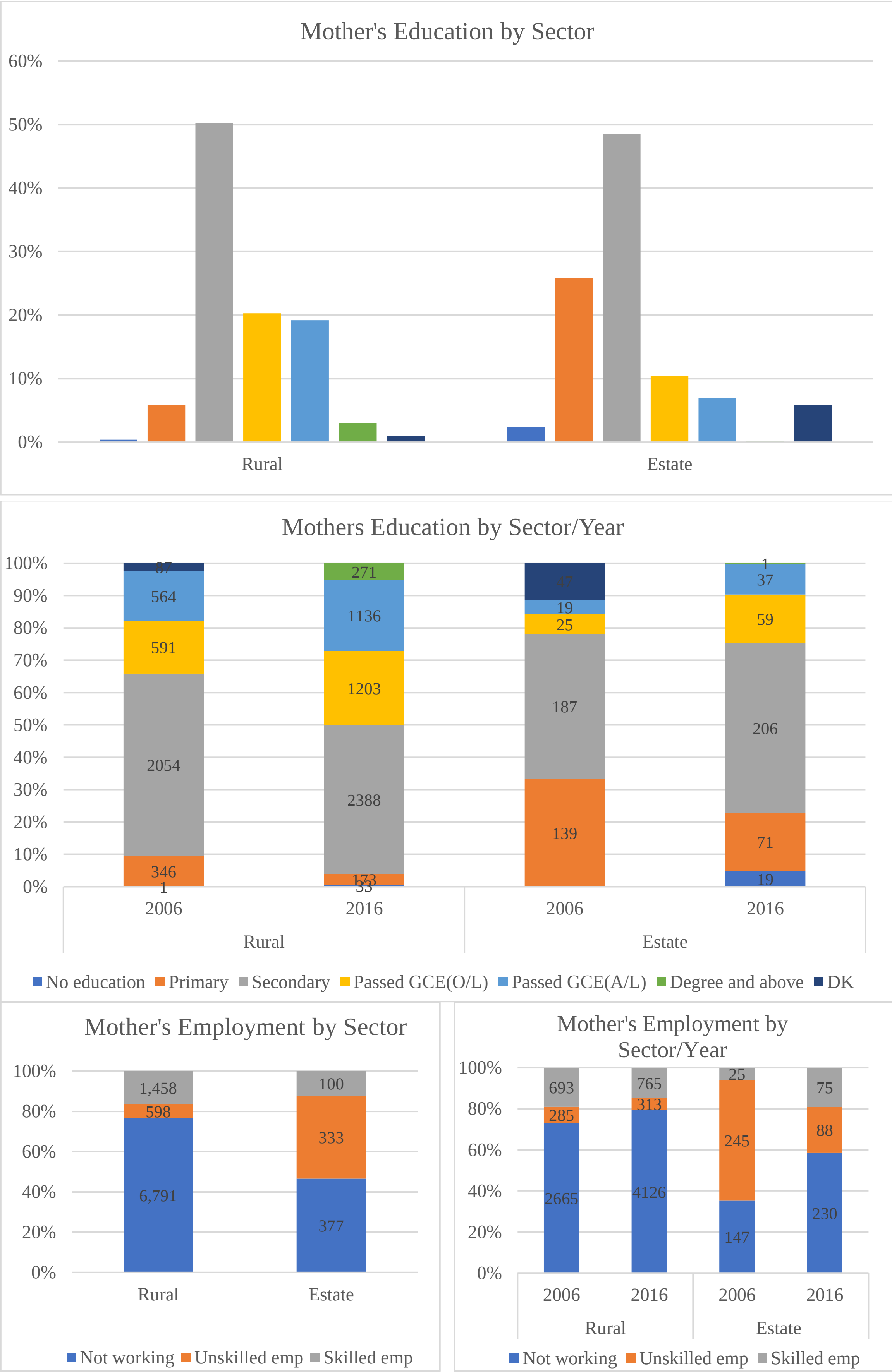


Figure 4-8: Maternal Characteristics by Sector and Year
Base: Rural (8847) Estate (810), Rural 2006/2016 (3643/5204), Estate 2006/2016 (417/393)

Table 4-5 and 4-6 presents mean comparison results for maternal variables across sectors and time. Maternal age at birth of the child is significantly higher, on average, in the rural sector compared to the estate sector. This coupled together with the higher average birth order of children within the estate sector (results in Table 4-3) may be indicative of estate women becoming mothers at a relatively younger age than rural women. Average maternal height and BMI are both significantly higher in the rural sector than the estate sector. Maternal BMI shows a significant improvement across time, within both sectors. However maternal height shows a significant improvement across time, only within the rural sector. Looking at maternal education, the average proportion of mothers with relatively low education (i.e. no education or primary education) was significantly higher in the estate sector that the rural sector, while average proportions of mothers with relatively higher levels of education (i.e. GCE(O/L), GCE(A/L) or degree) was significantly higher in the rural sector compared to the estate sector. The average proportions of mothers with higher levels of education has also increased over time, within both sectors, while the average proportion of mothers with primary education has declined over time within both sectors. However, it is also noticeable that average proportion of mothers with no education also shows a significant increase over time in both sectors. Maternal employment also showed some significant patterns. The average proportion of mothers who are unemployed or doing unskilled work is significantly higher in the estate sector than the rural sector. The average proportion shows a significant increase in the rural sector and a significant decrease in the estate sector, over time.

Table 4-5:Rural-Estate difference in key average maternal-level variables

	Total			2006			2016		
	Rural	Estate	Change	Rural	Estate	Change	Rural	Estate	Change
M Age									
Mean	30.93	29.40	1.53**	30.49	28.66	1.83**	31.26	30.14	1.12**
Std. Dev.	5.92	5.55		5.99	5.67		5.84	5.33	
Age at Birth									
Mean	28.62	27.22	1.40**	28.38	26.59	1.79**	28.81	27.85	0.96**
Std. Dev.	5.74	5.31		5.87	5.41		5.64	5.14	
M Height									
Mean	152.81	151.16	1.65**	152.32	151.12	1.2**	153.19	151.21	1.98**
Std. Dev.	6.10	5.88		5.68	6.1		6.37	5.65	
M BMI									
Mean	23.35	21.32	2.03**	22.53	20.54	1.99**	23.98	22.1	1.88**
Std. Dev.	4.67	4.57		4.25	4.71		4.88	4.29	
M Edu									
No Edu									
Mean	0.004	0.025	-0.021**	0.0004	0	0.0004	0.01	0.05	-0.04**
Std. Dev.	0.06	0.16		0.02	0		0.08	0.22	
Primary									
Mean	0.06	0.26	-0.2**	0.09	0.34	-0.25**	0.03	0.18	-0.15**
Std. Dev.	0.23	0.44		0.29	0.48		0.17	0.39	
Secondary									
Mean	0.50	0.48	0.02	0.56	0.44	0.12**	0.45	0.52	-0.07**
Std. Dev.	0.50	0.50		0.5	0.5		0.5	0.5	
GCE(O/L)									
Mean	0.20	0.11	0.09**	0.17	0.06	0.11**	0.23	0.16	0.07**
Std. Dev.	0.40	0.31		0.37	0.23		0.42	0.36	
GCE(A/L)									
Mean	0.20	0.07	0.13**	0.17	0.04	0.13**	0.23	0.09	0.14**
Std. Dev.	0.40	0.25		0.37	0.2		0.42	0.29	
Degree									
Mean	0.03	0.002	0.028**	0	0	0	0.06	0.003	0.057**
Std. Dev.	0.17	0.04		0	0		0.23	0.06	
M Emp									
Not emp.									
Mean	0.76	0.43	0.33**	0.73	0.32	0.41**	0.79	0.54	0.25**
Std. Dev.	0.42	0.49		0.44	0.46		0.41	0.50	
Unskilled_emp									
Mean	0.07	0.44	-0.37**	0.08	0.63	-0.55**	0.06	0.24	-0.18**
Std. Dev.	0.25	0.50		0.27	0.48		0.24	0.43	
Skilled_emp									
Mean	0.17	0.13	0.04**	0.19	0.05	0.14**	0.15	0.21	-0.06**
Std. Dev.	0.37	0.34		0.39	0.23		0.36	0.41	
N	8847	810		3643	417		5204	393	

**1%, *5%, + 10% significance. NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

Table 4-6: 2016-2006 difference in average maternal-level variables within each sector

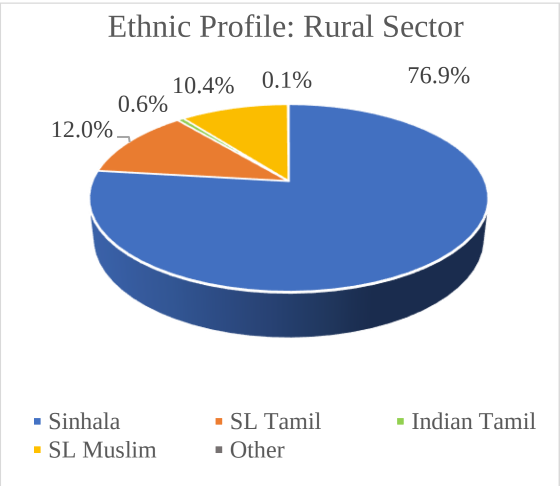
	Rural			Estate		
	2006	2016	change	2006	2016	change
M Age						
Mean	30.49	31.26	0.77**	30.14	28.66	1.48**
Std. Dev.	5.99	5.84		5.33	5.67	
Age at Birth						
Mean	28.38	28.81	0.43**	26.59	27.85	1.26**
Std. Dev.	5.87	5.63		5.41	5.14	
M Height						
Mean	152.32	153.19	0.87**	151.12	151.21	0.09
Std. Dev.	5.68	6.37		6.10	5.65	
M BMI						
Mean	22.53	23.98	1.45**	20.54	22.1	1.56**
Std. Dev.	4.25	4.88		4.71	4.29	
M Edu						
No Edu						
Mean	0.0004	0.01	0.0096**	0	0.05	0.05**
Std. Dev.	0.02	0.08		0	0.22	
Primary						
Mean	0.09	0.03	-0.06**	0.34	0.18	-0.16**
Std. Dev.	0.29	0.17		0.48	0.39	
Secondary						
Mean	0.56	0.45	-0.11**	0.44	0.52	0.08*
Std. Dev.	0.50	0.50		0.50	0.50	
GCE(O/L)						
Mean	0.17	0.23	0.06**	0.06	0.16	0.10**
Std. Dev.	0.37	0.42		0.23	0.36	
GCE(A/L)						
Mean	0.17	0.23	0.06**	0.04	0.09	0.05**
Std. Dev.	0.37	0.42		0.20	0.29	
Degree						
Mean	0	0.06	0.06**	0	0.003	0.003
Std. Dev.	0	0.23		0	0.06	
M Emp						
Not emp.						
Mean	0.73	0.79	0.06**	0.32	0.54	0.22**
Std. Dev.	0.44	0.41		0.46	0.50	
Unskilled_emp						
Mean	0.08	0.06	-0.02**	0.63	0.24	-0.39**
Std. Dev.	0.27	0.24		0.48	0.43	
Skilled_emp						
Mean	0.19	0.15	-0.04**	0.05	0.21	0.16**
Std. Dev.	0.39	0.36		0.23	0.41	
N	3643	5204		417	393	

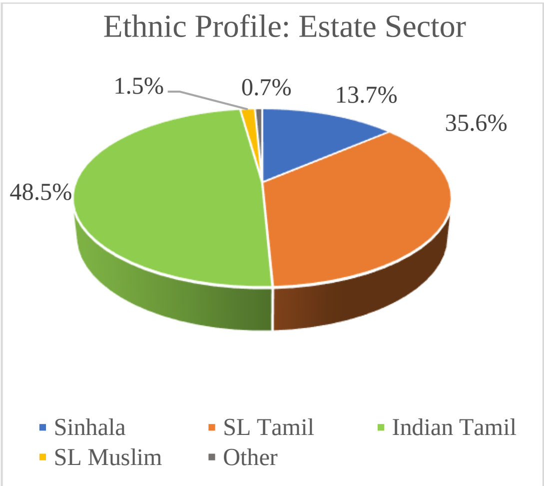
**1%, *5%, + 10% significance. NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

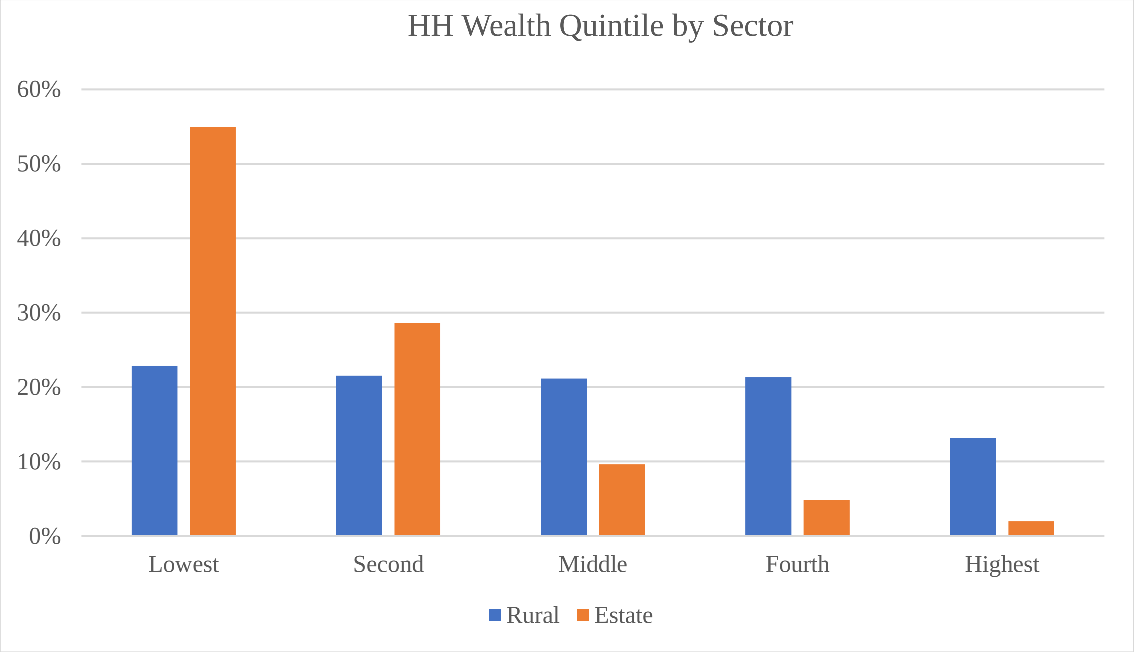
d) Household-level variables

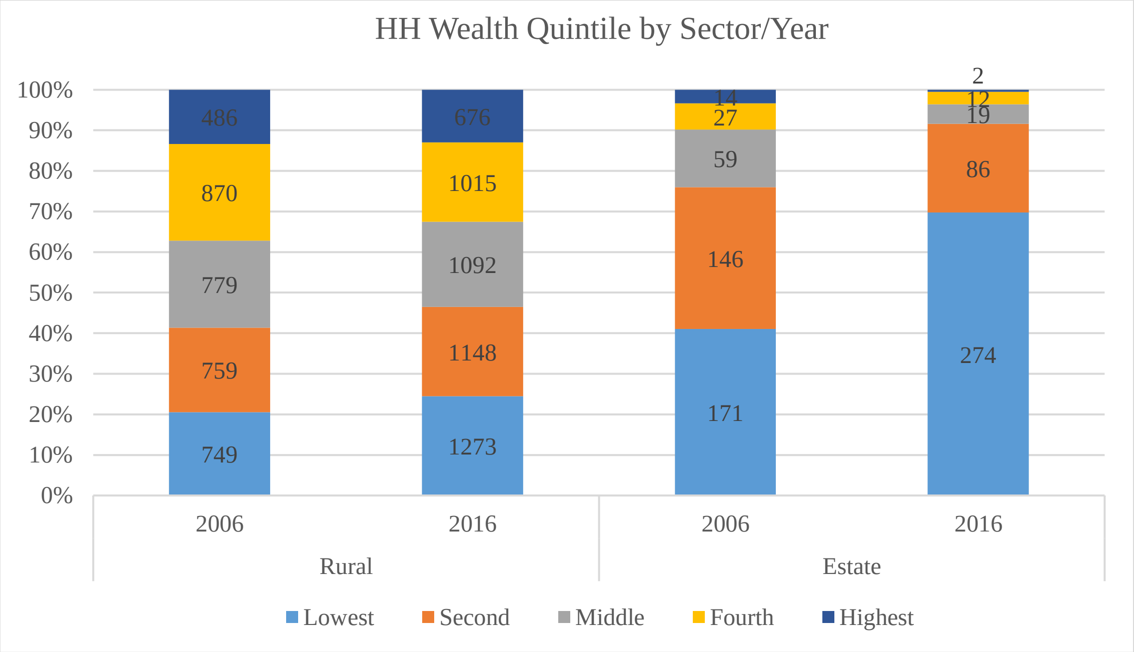
Figure 4-9 below gives a snapshot of the main HH-level variables in the sample. Looking at the ethnic profile within the two sectors, Sinhala is seen to form the clear majority in the rural sample while Indian Tamil forms a clear majority within the estate sector. Most HHs within the estate sector fall within the lowest wealth quintile, while the rural sector shows a more even spread of HHs across the wealth quintiles. While the rural sector does not show observable changes across time, a clear increase in the number of HHs falling within the lowest wealth quintile can be observed in the estate sector. It is also noteworthy that the number of HHs falling within the 2nd-5th wealth quintiles have decreased over time within the estate sector. This could be indicative of worsening economic conditions of estate households over time, which needs to be further explored.

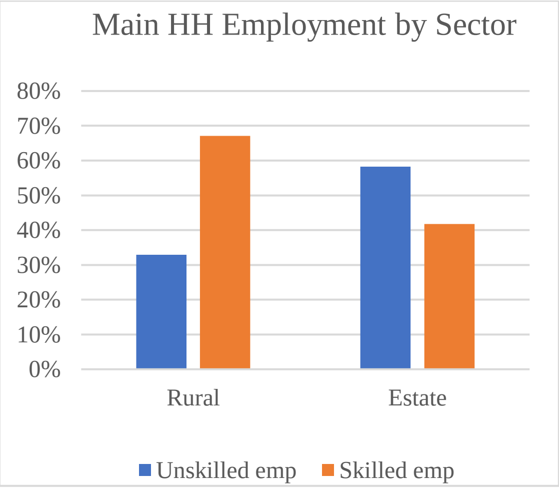
Average proportion of HHs whose main employment involves skilled work, is higher in the rural sector than the estate sector. However, counter intuitively, this proportion has increased over time, within the rural sector, while it has decreased over time within the estate sector. Another significant observation is in the proportion of HHs reporting substance use (alcohol, tobacco or drugs), which is high in both sectors, particularly within the estate sector (70%). These proportions do not appear to show significant changes across time. Most HHs report having male HH heads.

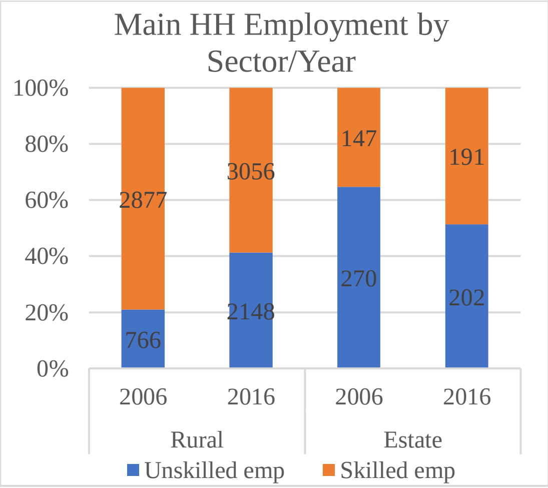





HH Wealth Quintile by Sector
60%
50%
40%
30%
20%
10%
0%
Lowest
Second
Middle
Fourth
Highest
Rural
Estate


HH Wealth Quintile by Sector/Year
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
486
870
779
759
749
676
1015
1092
1148
1273
14
27
59
146
171
2
12
19
86
274
2006
2016
2006
2016
Rural
Estate
Lowest
Second
Middle
Fourth
Highest


Main HH Employment by Sector
80%
70%
60%
50%
40%
30%
20%
10%
0%
Rural
Estate
Unskilled emp
Skilled emp


Main HH Employment by Sector/Year
100%
80%
60%
40%
20%
0%
2877
766
3056
2148
147
270
191
202
2006
2016
2006
2016
Rural
Estate
Unskilled emp
Skilled emp

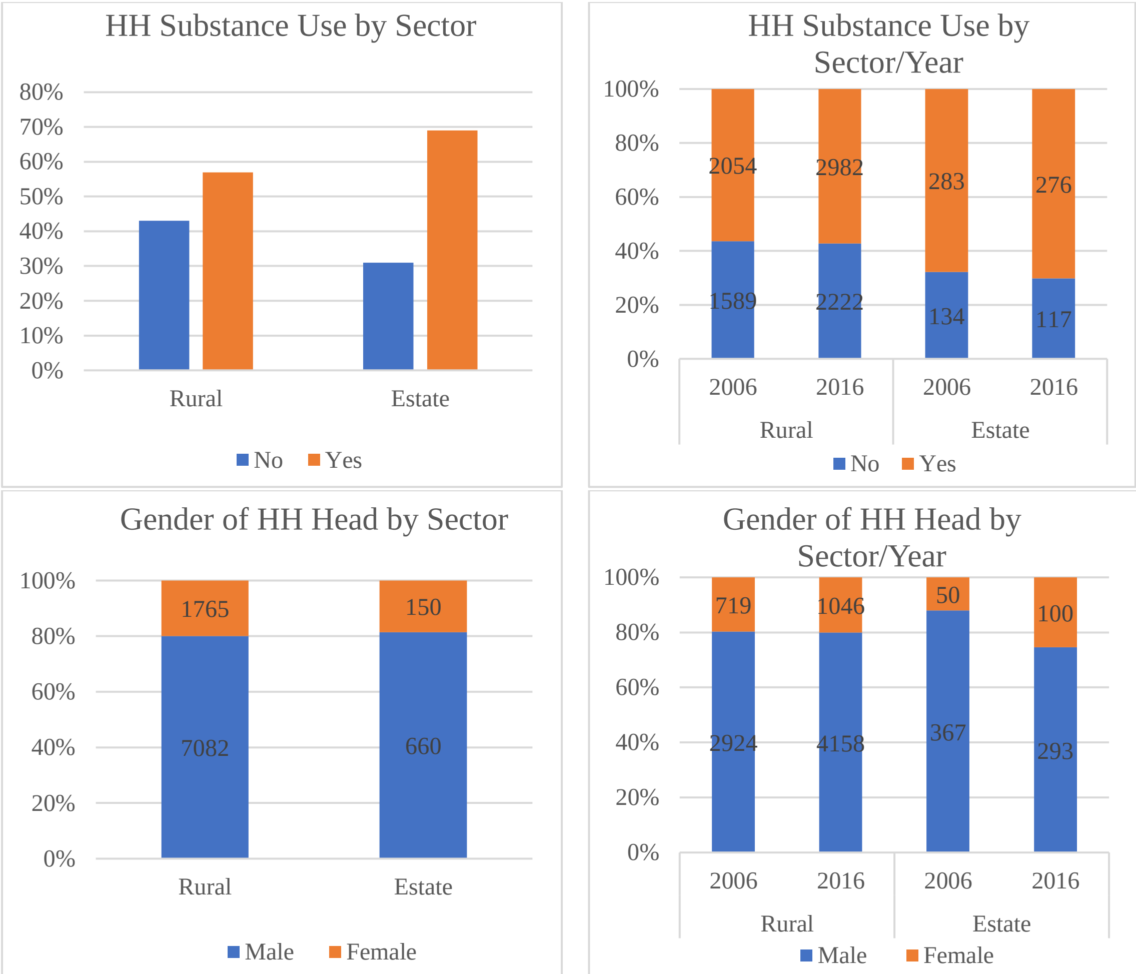


Figure 4-9: HH Characteristics by Sector and Year
Base: Rural (8847) Estate (810), Rural 2006/2016 (3643/5204), Estate 2006/2016 (417/393)

The mean comparison results below verify some of the key observations in Figure 4-9. The average proportion of HHs falling within the lowest and second lowest wealth quintiles is significantly higher in the estate sector than in the rural sector, while the average proportion of HHs falling within the 3^{rd}-5^{th} wealth quintiles is significantly higher in the rural sector compared to the estate sector. The average proportion of estate sector HHs falling within the lowest wealth quintile has significantly increased from 2006-2016, while the proportions of estate sector HHs falling within the 2^{nd}-5^{th} wealth quintiles have significantly decreased over time. A similar but slightly weaker pattern can also be observed within the rural sector where the combined proportion of HHs falling within the two lowest wealth quintiles shows a significant increase over time, while the proportion of HHs falling within the two highest wealth quintiles shows a significant decrease over time. The mean comparison also verifies the pattern seen with regards to skilled employment where the rural sector shows a significant decline in the average proportion of HHs with skilled employment listed as the main HH employment, while the estate sector shows a significant increase in the same proportion over time. The average number of children in a HH is significantly higher within the estate sector than the rural sector., with the average within each sector significantly declining over time. The average proportion of HHs reporting substance use is significantly higher within the estate sector than the rural sector. This proportion also shows a significant increase over time, within the rural sector.

Table 4-7: Rural-Estate difference in key average HH-level variables

	Total			2006			2016		
	Rural	Estate	Change	Rural	Estate	Change	Rural	Estate	Change
Wealth Q.									
Lowest (Q1)									
Mean	0.20	0.56	-0.36**	0.19	0.43	-0.24**	0.19	0.69	-0.5**
Std. Dev.	0.39	0.50		0.4	0.5		0.39	0.46	
Second (Q2)									
Mean	0.21	0.29	-0.08**	0.21	0.36	-0.15**	0.22	0.22	0
Std. Dev.	0.41	0.45		0.41	0.48		0.41	0.42	
Middle (Q3)									
Mean	0.22	0.09	0.13**	0.22	0.12	0.1**	0.22	0.05	0.17**
Std. Dev.	0.41	0.28		0.41	0.33		0.42	0.22	
Fourth (Q4)									
Mean	0.23	0.05	0.18**	0.24	0.06	0.18**	0.22	0.03	0.19**
Std. Dev.	0.42	0.21		0.43	0.23		0.41	0.18	
Highest (Q5)									
Mean	0.14	0.02	0.12**	0.14	0.03	0.11**	0.15	0.003	0.147**
Std. Dev.	0.35	0.14		0.34	0.18		0.35	0.06	
Low WQ (Q1, Q2)									
Mean	0.41	0.85	-0.44**	0.4	0.79	-0.39**	0.42	0.91	-0.49**
Std. Dev.	0.49	0.36		0.49	0.41		0.49	0.28	
High WQ (Q4, Q5)									
Mean	0.37	0.07	0.30**	0.38	0.09	0.29**	0.36	0.03	0.33**
Std. Dev.	0.48	0.25		0.48	0.29		0.48	0.18	
HH Emp Skilled									
Mean	0.69	0.42	0.27**	0.79	0.34	0.45**	0.61	0.49	0.12**
Std. Dev.	0.46	0.49		0.40	0.47		0.49	0.50	

Table 4-7 *ctd.*

	Total			2006			2016		
	Rural	Estate	Change	Rural	Estate	Change	Rural	Estate	Change
Total children									
Mean	2.02	2.19	-0.17**	2.08	2.27	-0.19**	1.96	2.1	-0.14**
Std. Dev.	1.04	1.04		1.14	1.08		0.94	0.99	
Substance use									
Mean	0.58	0.69	-0.11**	0.57	0.68	-0.11**	0.59	0.69	-0.1**
Std. Dev.	0.49	0.46		0.49	0.47		0.49	0.46	
Head age	45.03	44.19	0.84	43.85	42.70	1.15	45.93	45.71	0.22
	14.84	14.30		14.75	13.76		14.85	14.68	
Head Edu									
No Edu									
Mean	0.02	0.05	-0.03	0.0003	0	0.0003	0.03	0.11	-0.08**
Std. Dev.	12.6	0.23		0.02	0		0.17	0.31	
Primary									
Mean	0.14	0.33	-0.19**	0.09	0.34	-0.25**	0.17	0.32	-0.15**
Std. Dev.	0.34	0.47		0.29	0.47		0.37	0.47	
Secondary									
Mean	0.52	0.43	0.09**	0.56	0.44	0.12**	0.48	0.43	0.05+
Std. Dev.	0.50	0.50		0.50	0.50		0.50	0.49	
GCE(O/L)									
Mean	0.17	0.07	0.10**	0.17	0.05	0.12**	0.17	0.08	0.09**
Std. Dev.	0.38	0.26		0.37	0.23		0.38	0.28	
GCE(A/L)									
Mean	0.14	0.04	0.10**	0.16	0.04	0.12**	0.12	0.04	0.08**
Std. Dev.	0.34	0.20		0.37	0.20		0.32	0.20	
Degree									
Mean	0.01	0.003	0.007+	0	0	0	0.02	0.01	0.01
Std. Dev.	0.12	0.05		0	0		0.15	0.08	
N	8847	810		3643	417		5204	393	

**1%, *5%, + 10% significance. NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

Table 4-8: 2016-2006 difference in average HH-level variables within each sector

	Rural			Estate		
	2006	2016	change	2006	2016	Change
Wealth Q.						
Lowest (Q1)						
Mean	0.19	0.19	0.0	0.43	0.69	0.26**
Std. Dev.	0.40	0.39		0.50	0.46	
Second (Q2)						
Mean	0.21	0.22	0.01	0.36	0.22	-0.14**
Std. Dev.	0.41	0.41		0.48	0.42	
Middle (Q3)						
Mean	0.22	0.22	0.0	0.12	0.05	-0.07**
Std. Dev.	0.41	0.42		0.33	0.22	
Fourth (Q4)						
Mean	0.24	0.22	-0.02*	0.06	0.03	-0.03*
Std. Dev.	0.43	0.41		0.23	0.18	
Highest (Q5)						
Mean	0.14	0.15	0.01+	0.04	0.003	-0.037**
Std. Dev.	0.34	0.35		0.18	0.06	
Low WQ (Q1, Q2)						
Mean	0.40	0.42	0.02*	0.79	0.91	0.13**
Std. Dev.	0.49	0.49		0.41	0.28	
High WQ (Q4, Q5)						
Mean	0.38	0.36	-0.02+	0.09	0.03	-0.06**
Std. Dev.	0.48	0.48		0.29	0.18	
Main HH Emp						
Skilled						
Mean	0.79	0.61	-0.18**	0.34	0.49	0.15**
Std. Dev.	0.40	0.49		0.47	0.50	
Total children in HH						
Mean	2.08	1.96	-0.12**	2.27	2.1	-0.17*
Std. Dev.	1.14	0.94		1.08	0.99	
HH substance use						
Mean	0.57	0.59	0.02+	0.68	0.69	0.01
Std. Dev.	0.49	0.49		0.47	0.46	

Table 4-8 *ctd*.

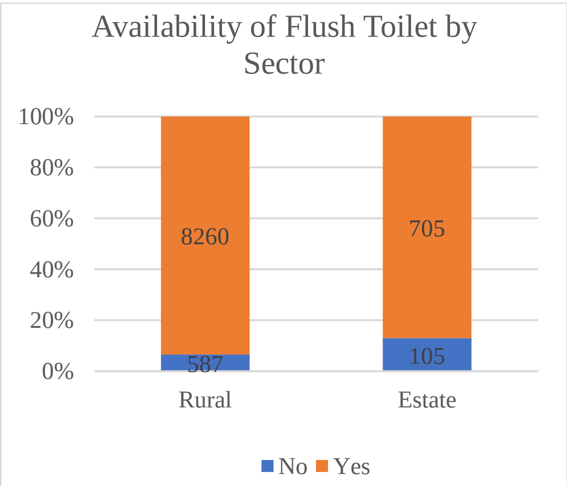
	Rural			Estate		
	2006	2016	change	2006	2016	Change
Low WQ (Q1, Q2)						
Mean	0.40	0.42	0.02*	0.79	0.91	0.13**
Std. Dev.	0.49	0.49		0.41	0.28	
High WQ (Q4, Q5)						
Mean	0.38	0.36	-0.02+	0.09	0.03	-0.06**
Std. Dev.	0.48	0.48		0.29	0.18	
Main HH Emp						
Skilled						
Mean	0.79	0.61	-0.18**	0.34	0.49	0.15**
Std. Dev.	0.40	0.49		0.47	0.50	
Total children in HH						
Mean	2.08	1.96	-0.12**	2.27	2.1	-0.17*
Std. Dev.	1.14	0.94		1.08	0.99	
HH substance use						
Mean	0.57	0.59	0.02+	0.68	0.69	0.01
Std. Dev.	0.49	0.49		0.47	0.46	
Head age	43.85	45.93	2.08**	42.70	45.71	3.01**
	14.75	14.85		13.76	14.68	
Head Edu						
No Edu						
Mean	0.0003	0.03	0.03**	0	0.11	0.11**
Std. Dev.	0.02	0.17		0	0.31	
Primary						
Mean	0.09	0.17	0.08**	0.34	0.32	-0.02
Std. Dev.	0.29	0.37		0.47	0.47	
Secondary						
Mean	0.56	0.48	-0.08**	0.44	0.43	-0.01
Std. Dev.	0.50	0.50		0.50	0.49	
GCE(O/L)						
Mean	0.17	0.17	0	0.05	0.08	0.03+
Std. Dev.	0.37	0.38		0.23	0.28	
GCE(A/L)						
Mean	0.16	0.12	-0.04**	0.04	0.04	0
Std. Dev.	0.37	0.32		0.20	0.20	
Degree						
Mean	0	0.02	0.02**	0	0.01	0.01*
Std. Dev.	0	0.15		0	0.08	
N	3643	5204		417	393	

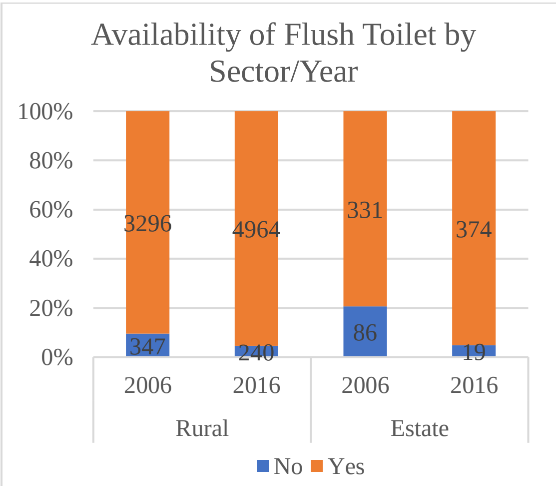
**1%, *5%, + 10% significance. NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

e) Facilities and Care variables

As indicated in Figure 4-10, a majority of HHs in both sectors report having flush toilets and adopting methods to improve drinking water for consumption. However, the former proportion is slightly higher within rural sector than the estate sector, whilst the latter proportion is clearly higher in the estate sector than the rural sector. With regards to hand hygiene practices of the mother, a significantly higher proportion of mothers in both sectors have indicated that they wash their hands after using the toilet. In contrast, the proportion of mothers indicating that they wash their hands before preparing food is comparatively lower in both sectors.

The mean comparison results presented in Table 4-9 and 4-10, further establish the above observations. The average proportion of HHs with flush toilets is significantly higher in the rural sector than the estate sector, and the proportions have significantly improved in both sectors, across time. The average proportion of HHs adopting methods for cleaning water prior to consumption is significantly higher within the estate sector. This proportion has also significantly decreased over time, within the rural sector. Maternal hand hygiene is also seen to be significantly better within the rural sector than the estate sector. And the proportion of mothers indicating that they wash their hands prior to preparing meals has also significantly increased over time, within both sectors.





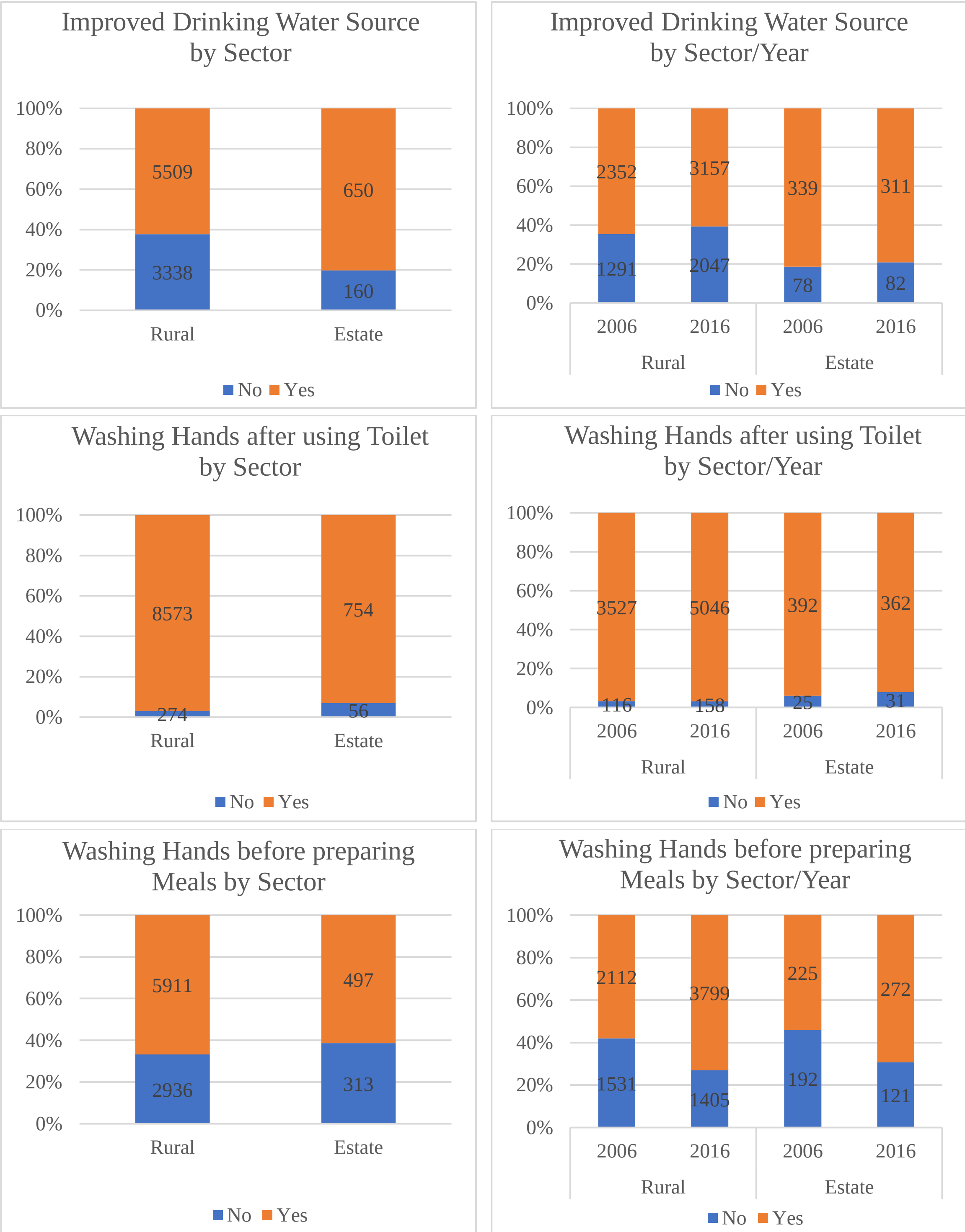


Figure 4-10: Sample Profile by Sector and Year
Base: Rural (8847) Estate (810), Rural 2006/2016 (3643/5204), Estate 2006/2016 (417/393)

Table 4-9: Rural-Estate difference in key average Care variables

	Total			2006			2016		
	Rural	Estate	Change	Rural	Estate	Change	Rural	Estate	Change
Flush Toilet									
Mean	0.94	0.86	0.08**	0.91	0.77	0.14**	0.96	0.95	0.01
Std. Dev.	0.24	0.35		0.29	0.42		0.20	0.22	
Improved Drinking Water									
Mean	0.64	0.81	-0.17**	0.65	0.83	-0.18**	0.62	0.80	-0.18**
Std. Dev.	0.48	0.39		0.48	0.38		0.49	0.40	
Hand Hygiene									
Aft Toilet Use									
Mean	0.97	0.93	0.04**	0.97	0.94	0.03**	0.97	0.92	0.05**
Std. Dev.	0.17	0.26		0.18	0.24		0.17	0.28	
Befr Meal Prep									
Mean	0.66	0.62	0.04*	0.58	0.55	0.03	0.72	0.70	0.02
Std. Dev.	0.47	0.49		0.49	0.50		0.45	0.46	
N	8847	810		3643	417		5204	393	

**1%, *5%, + 10% significance. NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

Table 4-10: 2016-2006 difference in average Care variables within each sector

	Rural			Estate		
	2006	2016	change	2006	2016	change
Flush Toilet						
Mean	0.91	0.96	0.05**	0.77	0.95	0.18**
Std. Dev.	0.29	0.20		0.42	0.22	
Improved Drinking Water						
Mean	0.65	0.62	-0.03**	0.83	0.80	-0.03
Std. Dev.	0.48	0.49		0.38	0.40	
Hand Hygiene						
Aftr Toilet Use						
Mean	0.97	0.97	0.0	0.94	0.92	-0.02
Std. Dev.	0.18	0.17		0.24	0.28	
Befr Meal Prep						
Mean	0.58	0.72	0.14**	0.55	0.70	0.15**
Std. Dev.	0.49	0.45		0.50	0.46	
N	3643	5204		417	393	

**1%, *5%, + 10% significance. NOTE- *ttesti* command is applied on the weighted mean and standard deviation values. Weighted mean and standard deviations calculated based on sample weights provided by the DHS.

4.2. Analysis of Long-Term Growth of Children

This section presents results of the intra-sector analysis (mean and quantile) of the height-for-age of children and analysis of the long-term growth differential across the two sectors (rural and estate) and time. As indicated earlier, the intra-sector analysis is carried out to identify the main drivers of children's height-for-age within each sector and time period. The Linear and Unconditional Quantile Regressions are followed by the Generalised Hausman specification tests to compare estimated coefficients across different models. Sampling weights and robust standard errors are used in each model.

4.2.1. Intra-Sector Analysis

The table below provides the OLS estimates of the linear regressions for the standardized height-for-age of children. The model includes child-level, maternal-level, HH-level, facilities and care variables discussed above. Age and breastfed duration are included with a quadratic term and the models also control for province fixed effects.

Results show significant impacts of child age and maternal height across both sectors. Birthweight has a significant positive impact on the height-for-age (*HAZ*) across all models except in the estate sector in 2016, while maternal BMI also has a significant positive impact within the rural sector in both time periods. The relationship is also marginally significant in the estate sector in 2016 but is not significant in 2006. The impact of age on *HAZ* takes the predicted U shape (Wagstaff et al., 2003). Given that a major portion of the sample report negative *HAZ* this pattern suggests that children tend to further deviate from the reference population as they grow older up to a particular inflection point after which the decline tapers off. The inflection point for the rural sector has remained the same, approximately at 34 months over the considered period. However, within the estate sector, the inflection point has increased from 29 months in 2006 to 49 months in 2016, which might make it more difficult for estate children to begin the catch-up process. Though significant, it should also be noted that the magnitude of these effects is considerably small compared to other significant effects.

A clear positive effect of maternal height on *HAZ* is observed. The magnitude of the estimated effect is approximately equivalent within the rural sector across the two time periods, while the magnitude has increased from 2006 to 2016 within the estate sector. With regards to the duration of breastfeeding, the significant coefficients on the quadratic term of the breastfed duration verifies the existence of a nonlinear relationship between breastfed duration and growth. The estimated coefficients also suggest that, longer duration of breast-feeding links to lower growth (up to an inflection point) within both sectors in both time periods, and the estimated relationship is statistically significant except in the estate sector in 2006. Though counter-intuitive at first, similar patterns between breastfeeding and height-for-age of children have been observed in other studies (Delgado and Matijasevich, 2013; Martin, 2001). The inflection points at which this negative relationship tapers off, is approximately 45 months, 34 months and 34 months within the 2006-rural, 2016-rural and 2016-estate subsamples. In comparison, a considerably shorter inflection point of 14 months is observed for the 2006-estate subsample. This may be indicative of longer durations of breastfeeding, particularly beyond 14 months, was relatively beneficial within the estate sector in 2006. Within the rural sector in both time periods, and the estate sector in 2016, the models suggest that a longer period of breastfeeding (beyond 36 months) would be required on average to produce a positive impact on growth[2].

Positive effects of HH wealth on *HAZ* is observed across 2006 and more so in 2016. However, these effects are only observed within the rural sector. Similarly, ethnicity also shows significant impacts on the outcome only in the rural sector. The models suggest that children from minority ethnic groups generally fare worse compared to similar children from the majority ethnic group, within the rural sector. Maternal education also has significant positive effects on growth within the rural sector in 2006. In comparison, the education level of the HH Head had a significant positive effect on child growth within the

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[2] For example, as per estimates, a child breastfed for a period of 36 months, will on average, show a standardized height-for-age 0.3 sds **lower** than a similar child breastfed only for 6 months, within the rural sector in 2006.

estate sector in 2016. The total number of children in the HH shows a significant negative effect only within the rural sector in 2006. Though consistently negative, this effect is not statistically significant in the other settings.

Table 4-11:OLS Estimation by sector and year - *HAZ*

HAZ		Rural		Estate	
		2006	2016	2006	2016
Birthweight	Normal	0.488**	0.611**	0.542**	0.246
		(0.053)	(0.051)	(0.143)	(0.21)
	High	0.789**	0.941**	2.009**	-1.043
		(0.152)	(0.201)	(0.626)	(0.801)
Birth order	2nd	-0.089+	-0.116	-0.221	0.386
		(0.053)	(0.079)	(0.185)	(0.479)
	>2nd	-0.111	-0.019	-0.298	0.047
		(0.096)	(0.151)	(0.291)	(0.884)
Gender	Female	0.035	0.039	0.049	0.027
		(0.036)	(0.039)	(0.127)	(0.177)
Age		-0.034**	-0.067**	-0.058**	-0.093**
		(0.007)	(0.006)	(0.018)	(0.027)
Age_sq		0.001**	0.001**	0.001**	0.001*
		(0.0001)	(0.0001)	(0.0003)	(0.0005)
Antenatal care	Yes	0.021	0.098	-0.125	0.725
		(0.069)	(0.329)	(0.192)	(0.668)
Birth supervision	Supervised_ NonH person	-0.498	0.337	0.285	0.731
		(0.388)	(0.304)	(0.38)	(0.735)
Breastfed duration		-0.019**	-0.028**	-0.028	-0.074*
		(0.007)	(0.006)	(0.018)	(0.031)
BF dur_sq		0.001*	0.0004**	0.001*	0.001*
		(0.0001)	(0.0001)	(0.0003)	(0.001)
Mother age(yr)		0.012**	0.005	0.008	0.006
		(0.004)	(0.004)	(0.013)	(0.016)
Mother height (cm)		0.052**	0.049**	0.035**	0.06**
		(0.004)	(0.004)	(0.013)	(0.019)
Mother BMI		0.018**	0.028**	-0.006	0.034+
		(0.005)	(0.004)	(0.012)	(0.019)
Mother edu.	Primary		-0.246	0.622*	0.277
			(0.276)	(0.248)	(0.475)
	Secondary	0.839**	-0.224	0.589**	-0.313
		(0.129)	(0.273)	(0.2)	(0.434)
	GCE(O/L)	0.874**	-0.158		-0.575
		(0.14)	(0.276)		(0.478)
	GCE(A/L)	0.929**	-0.111		0.035
		(0.154)	(0.276)		(0.457)
	Degree or above		-0.14		0.826
			(0.288)		(1.04)
	D/K	0.443**		0.704**	
		(0.158)		(0.244)	

Table 4-11 *ctd.*

HAZ		Rural		Estate	
		2006	2016	2006	2016
Mother emp.	Working_Unskilled	-0.106	-0.072	-0.427**	-0.096
		(0.068)	(0.079)	(0.157)	(0.267)
	Working_Skilled	-0.021	0.079	-0.117	-0.113
		(0.047)	(0.06)	(0.25)	(0.281)
WealthQ	Second	0.025	0.097+	0.104	0.366+
		(0.065)	(0.056)	(0.187)	(0.222)
	Middle	0.005	0.14*	0.105	0.27
		(0.066)	(0.061)	(0.223)	(0.321)
	Fourth	0.036	0.189**	0.206	-0.198
		(0.071)	(0.064)	(0.389)	(0.319)
	Highest	0.182*	0.185*	0.275	0.653
		(0.079)	(0.087)	(0.408)	(0.484)
HH emp	Skilled	0.053	-0.002	0.065	-0.15
		(0.052)	(0.044)	(0.148)	(0.212)
Total children		-0.096**	-0.047	-0.173	-0.121
		(0.03)	(0.063)	(0.115)	(0.416)
Substance use	Yes	-0.041	0.042	0.055	0.229
		(0.038)	(0.042)	(0.13)	(0.294)
Ethnicity	SL Tamil	-0.207	-0.06	-0.186	-0.0002
		(0.138)	(0.095)	(0.209)	(0.299)
	Indian Tamil	-0.181	-0.532**	-0.126	0.007
		(0.228)	(0.192)	(0.205)	(0.284)
	SL Moor	-0.222**	-0.088	-0.854+	0.206
		(0.073)	(0.084)	(0.443)	(0.824)
	Malay	0.551+	-1.471**	0.506	
		(0.305)	(0.125)	(0.4)	
	Burger				-0.395
		0.047	-0.6*		(0.487)
		(0.391)	(0.264)		
	Other	0.067			
		(0.115)			
Head age(yr)		0.002	0.001	-0.004	0.016+
		(0.001)	(0.002)	(0.005)	(0.009)
Head gender	Female	-0.016	0.034	0.13	0.187
		(0.049)	(0.048)	(0.179)	(0.218)
Head edu	Primary	0.764**	0.092		0.349
		(0.13)	(0.122)		(0.291)
	Secondary		0.15		1.031**
			(0.119)		(0.359)
	GCE(O/L)		0.105		0.847*
			(0.13)		(0.423)
	GCE(A/L)			0.358	
			0.196	(0.339)	1.272**
			(0.134)		(0.48)
	Degree or above		0.245		1.695**
			(0.194)		(0.527)
	D/K		-0.058		
			(0.384)		
Toilet	Flush toilet	-0.046	0.212*	-0.207	-0.172
		(0.084)	(0.091)	(0.231)	(0.341)
Improved drinking water	Yes	0.045	0.046	0.017	0.331
		(0.039)	(0.042)	(0.173)	(0.318)
Hand washing	Wash after toilet use	-0.07	-0.001	0.07	-0.193
		(0.104)	(0.145)	(0.24)	(0.387)
	Wash before cooking	0.029	-0.031	0.212	-0.294
		(0.039)	(0.044)	(0.14)	(0.235)

_cons	-9.666**	-8.693**	-5.677*	-10.832**
	(0.68)	(0.755)	(2.304)	(2.95)
N	3643	5204	417	393
R-sq	0.194	0.207	0.292	0.351

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.
Base categories (in parenthesis): Birthweight(Low), Gender/Head Gen(Male), ANcare(No), MotherEmp(Skilled work), WealthQ(First), Ethnicity(Sinhalese), Improved drinking water(No)
NOTES: ANcare is on the antenatal care received by mother. Breastfed duration records the total months the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the child's current age. Estimates for the 'Not Supervised' category of the Birth supervision variable is omitted for accuracy due to low counts. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

While the above results show general trends in factors that impact growth within the two sectors, further analysis is required to test how different the estimated effects are across models. The Generalised Hausman specification test (using *suest*) was used to compare estimated coefficients within each sector across the two time periods, as well as the estimated coefficients between the two sectors in each time-period. Estimated effect coefficients are approximately equivalent to those presented in Table 4-11. Table 4-12 presents a comparison of coefficients across the two time periods, for each sector, while Table 4-13 presents a comparison of estimated coefficients for the rural and estate sectors in each time period. The Generalised Hausman test reveals significant differences, across models.

Birthweight, age, maternal education and BMI, availability of flushable toilets, ethnicity and the HH head being primary educated show significant differences in estimated effects across the two time periods within the rural sector. Significant improvements in positive effects are observed in birthweight, maternal BMI and toilet facilities from 2006 to 2016, while the positive effects of maternal education seem to have diminished over the same period. The significant positive impact of belonging to the Malay ethnic group and the HH head being primary educated also seems to have diminished from 2006 to 2016. Looking at the estate sector, significant differences in estimated effects are observed for birthweight, maternal BMI, maternal secondary education, and education of HH head. Whilst the effect of high birthweight on growth has diminished over the 2006-2016 period, the effect of maternal BMI on growth has improved over time. The large positive impact of being secondary educated has also diminished over time. However, the positive returns to higher levels of education of the HH head was clearly larger in 2016 than 2006 within the estate sector.

Table 4-12: 2016-2006 difference in estimated effects within each sector - *HAZ*

Effect	Level	Rural		
		2006	2016	Chi2
Birthweight	Normal	0.488**	0.611**	2.81^{+}
Age		-0.034**	-0.067**	13.18**
Mother BMI		0.018**	0.028**	2.79^{+}
Mothers Edu	Secondary	0.839**	-0.224	12.52**
	GCE (O/L)	0.874**	-0.158	11.22**
Flush toilet		-0.046	0.212*	4.35*
Ethnicity	Malay	0.551^{+}	-1.471**	38.11**
Head Edu	Primary	0.764**	0.092	14.39**
N		3643	5204	
Effect	Level	Estate		
		2006	2016	Chi2
Birthweight	High	2.009**	-1.043	10.20**
Mother BMI		-0.006	0.034^{+}	3.69^{+}
Mothers Edu	Secondary	0.589**	-0.313	4.05*
Head Edu	Secondary		1.031**	9.42**
	GCE (O/L)		0.847*	4.57*
	GCE (A/L)	0.358	1.272**	2.74^{+}
	Degree or above		1.695**	11.83**
N		417	393	

**1%, *5%, + 10% significance. NOTE- Generalised Hausman Specification test is run using the *suest* command. Sample weights not compatible with command. Robust standard errors are derived. Estimates derived using *suest* are approximately equal to estimates in Table 4-11.

According to the results reported below, significant differences in estimated effects of high birthweight, maternal BMI, education, and unskilled employment of mother and primary education of the HH head exists between the rural and estate sectors in 2006. The impact of high birthweight is significantly larger and positive within the estate sector compared to the rural sector in 2006. Maternal BMI and mother completing GCE(O/L) both show positive and significant effects within the rural sector whilst the same variables yield negative and non-significant effects within the estate sector. The impact of mother working in the unskilled sector is also negative and significant within the estate sector. The primary education of the HH head also reports higher positive returns within the rural sector in 2006. Similarly, in 2016, birthweight, belonging to Indian Tamil ethnicity and education of the HH head show significant differences in the estimated effects between the rural and estate sectors. The estimated effects of normal and high birthweight are significant and positive within the rural sector whilst they are not significant within the estate sector. Belonging to an Indian Tamil ethnic background has a significant negative impact within the rural sector in 2016 while higher levels of education of the HH head has statistically significant positive returns within the estate sector. Overall, the highlight variables have significantly different effects on growth within the two sectors and the two time periods. These results, together with differences in the distribution of explanatory variables observed across sectors and time (in section 4.1.1.) justifies the need for a decomposition analysis to identify how these changes impact changes in average child growth between the rural and estate sectors and across time.

Table 4-13: Rural-Estate difference in estimated effects within each time-period - *HAZ*

Effect	Level	2006		
		Rural	Estate	Chi2
Birthweight	High	0.789**	2.009**	3.99*
Mother BMI		0.018**	-0.006	3.78+
Mothers Edu	Primary		0.622*	7.03**
	GCE (O/L)	0.874**		39.42**
Mothers Emp	Working_unskilled	-0.106	-0.427**	3.89*
Head Edu	Primary	0.764**		35.12**
N		3643	417	
Effect	**Level**	**2016**		
		Rural	Estate	Chi2
Birthweight	Normal	0.611**	0.246	3.22+
	High	0.941**	-1.043	6.55*
Ethnicity	Indian Tamil	-0.532**	-0.313	2.72+
Head Edu	Secondary	0.15	1.031**	6.14*
	GCE (O/L)	0.105	0.847*	3.17+
	GCE (A/L)	0.196	1.272**	5.28*
	Degree or above	0.245	1.695**	7.51**
N		5204	393	

**1%, *5%, + 10% significance. NOTE- Generalised Hausman Specification test is run using the *suest* command. Sample weights not compatible with command. Robust standard errors are derived. Estimates derived using *suest* are approximately equal to estimates in Table 4-11.

4.2.2. Distributional Analysis of Growth within Sectors

Prior to carrying out the decomposition analysis, it is necessary to explore factors that impact growth across the growth distribution within each sector and each time period. Whilst the linear regression models fitted above yield some important trends with regards to factors that impact growth on average, these effects may significantly differ at different points of the growth distribution. For example, the impact of certain factors on growth may differ for children displaying relatively good growth from those displaying relatively poorer growth. These differential effects can be further explored through an unconditional quantile regressions analysis which provides estimated effects of explanatory variables across different points of the outcome distribution. Table 4.14-4.15 below present estimates for the unconditional quantile regression models for each sector in each year.

Birthweight, age, breastfed duration, maternal height, and BMI are among the variables that are significant across most of the models. Birthweight positively impacts the height-for-age within the rural sector, and the impact is seen across the entire growth distribution. However, within the estate sector, the positive impact of birthweight on height-for-age is observed more at the lower end of the distribution (Q10 and Q50 in 2006 and Q10 in 2016), and not at the upper end of the distribution, in both years. Effects observed for high birthweight are considered spurious due to the low frequency of high birthweights observed within the estate sector.

Age and its quadratic terms were significant across both sectors in both years. However, no significant effects are observed at the lower end of the growth distribution (i.e. Q10) in the rural sector in 2006, and in the estate sector in both time periods indicating that the impact of age on growth is negligible among children of poor growth, particularly within the estate sector. The negative impact of extended breastfeeding durations on growth is a clear and significant within the rural sector in both years. The negative effects are seen to be more acute and significant towards the middle and upper ends of the distribution, in both years, while a marginally significant negative effect is observed at the lower end of the distribution only in 2006. Whilst, not as persistent, a somewhat similar relationship between breastfeeding duration and the growth distribution is also observed within the estate sector. However, effects are mostly marginal and are seen to be more acute at the lower end of the growth distribution in both years. Results suggest that there is a differential effect of breastfeeding duration, across the growth distribution as well as across sectors and years. A couple of possible explanations can be put forth to explain the negative relationship between breastfed duration and long-term growth. Longer durations of breastfeeding may be associated with children who show weaker growth as a result of selection, where mothers decide to breastfeed children longer, if they are perceived to be of poor health and growth. Another possibility is the replacement of balanced meals with breastmilk, especially in households with low access to nutritious food. Yet another possibility for the negative effect of breastfed duration on long-term growth, may be due to delays in the introduction of solid foods including protein rich foods, due to extended durations of breastfeeding. Whilst the data does not facilitate the untangling of these various mechanisms, this results clearly indicates the need for more focussed studies on the impacts of prolonged breastfeeding on child growth in Sri Lanka.

Maternal height has a clear positive impact on growth across most models. Within the rural sector, a clear positive impact is observed across the growth distribution in both years and the magnitude of the effect is largest at the upper end of the distribution. Similarly, positive impacts are also observed within the estate sector. However, the effects are not significant at the upper end of the growth distribution within the estate sector in both years. The relationship between a child's height and mothers height is known to encompass two main effects. Firstly, part of it could be accounted for as the 'genetic effect' which is theorised by short mothers giving birth to short children and tall mothers giving birth to tall children. It can be expected that the genetic height effect would not vary much across the growth distribution of children. Secondly, maternal height is also viewed as an indicator of favourable economic conditions. For example, it is often assumed that taller mothers come from relatively wealthier backgrounds with better assess to nutritious food. Thus, part of the relationship between child and maternal height could be via the mechanisms of HH wealth and food security (whilst proxy variables are used to control for HH wealth and food security, these are imperfect control, beyond which additional wealth effects could remain). If this were the case, the impacts of high maternal height on child heights could be expected to vary across the growth distribution, as well as show a positive impact on the weight-for-age and BMI-for-age of the children (explored in section 4.3.). Given that a differential effect of maternal height on child height is observed across the growth distribution in the estate sector, this may be suggestive that HH wealth and food security may be potential mechanism through which the relationship between maternal and child height manifests within the estate sector. However, this should be further validated by looking at the relationship between maternal height and the child's weight-for-age and BMI-for-age.

Maternal BMI follows a very similar pattern whereby a somewhat uniform positive effect of BMI on child growth is observed across the growth distribution within the rural sector in 2016. The magnitude of the effect is again seen to be larger at the upper end of the growth distribution. In contrast, maternal BMI is not seen to have a significant effect within the estate sector in both years, apart from a positive effect at Q10 in 2006.This again suggest that the relationship between maternal health variables and child growth within the rural sector maybe the 'genetic' effect.

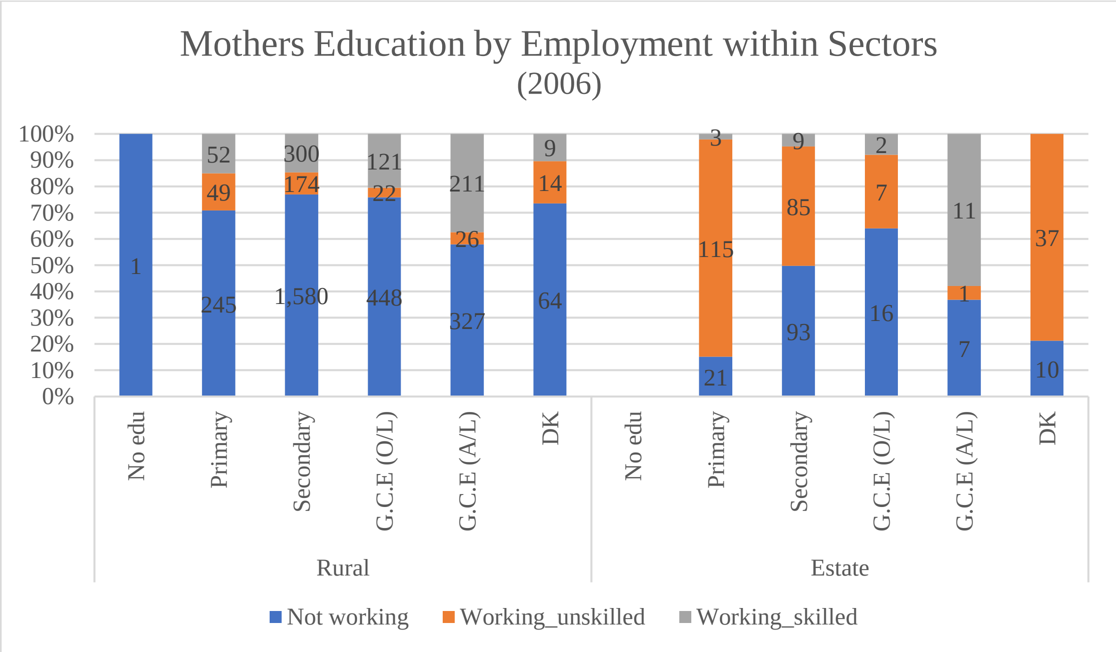
Apart from the above variable effects, a few other interesting patterns are also observed. With regards to higher maternal education, a differential effect across the growth distribution is observed within the rural sector in 2006. While higher maternal education is associated with significant negative returns at the lower end of the distribution (Q10), significant positive returns can be observed towards the middle and upper ends (Q50 and Q90). This suggests that higher maternal education tend to negatively impact long-term growth, of rural children who are at the lower tail of the growth spectrum, whilst the same would have a positive impact on the growth of children who are around the median or upper tails of the distribution. One possible reason for this observation could be with regards to the limited availability of skilled employment opportunities within the rural sector which may result in mothers with relatively higher levels of education having to either travel far for work, live away from home and work, or remain at home without working. While the first two options contribute to HH income, it could also result in the lack of attention and care towards children which, may drive out the positive impacts of increased HH income place and place an additional burden on children who already suffer from poor growth. Given their relatively poor growth, any additional income earned from mothers working away may not be enough to improve growth, leading to a further worsening of their growth due to lack of care. In the case of the third option where mothers decide not to work, the loss of an additional source of income could again be a plausible driver of poor growth in children.

Looking at children who display relatively good growth (i.e. middle and upper tails of the growth distributions), the impact of mothers travelling far for work, or living away from home for work, could again lead to a lack of care. However, given that they already display better growth, any negative impacts arising from the lack of care due to the mother not being present in the HH may be offset by positive effects of having a higher HH income, giving an overall positive effect. The significant positive impacts of maternal education on child growth in Q50 and Q90 models may also suggest that educated mothers whose children show good growth may choose to work even at a distance as opposed to not working.

Looking within the estate sector, a similar positive effect of higher maternal education on growth was observed in the middle and upper tail ends of the growth distribution. However, no negative impacts are seen, at the lower end of the growth distribution suggesting an overall positive impact (though limited to the middle and upper tail ends of the growth distribution) of maternal education on child growth. Again, this result would be consistent with the maternal employment story presented above, where mothers with higher education levels, whose children also display relatively good growth may be choosing to find skilled employment, away from home.

As explained above, it is highly plausible that employment away from home, is a valid mechanism through which maternal education impacts child growth within the rural and estate sectors of the country. Given the high dependence of agriculture-based industries (rice and tea) within the two sectors, the bulk of the available employment opportunities within these sectors tend to be unskilled labour-intensive employment. As a result, most females who are relatively better educated, tend to move to urban areas, to work in garment factories or within other fields which offer relatively better pay. A significantly large number of women, especially from rural areas, also opt to migrate overseas mainly to Middle-Eastern countries for employment, as semi-skilled domestic and factory workers (Shaw, 2010; Ukwatta, 2010). However, this would not be caught in these models, as it is unlikely that such mothers were captured in the survey, due to their residence overseas. The survey, however, would have captured mothers who work away from home within Sri Lanka, given that Sri Lanka is a relatively small country and people are able to easily travel between sectors, districts and provinces within a space of a few hours. To the extent that education forms a proxy for employment away from home, both the fact that skilled/semi-skilled employment often requires a minimum education level, and the fact that the maternal employment variables in the models did not show any significant effects across the growth distribution in the rural sector is another indication that maternal education impacts child growth through employment (or decision to not work) especially within the rural sector of Sri Lanka. However, it should also be noted that this pattern was not present in 2016 suggesting that the interplay between maternal education, employment and growth of children has not been persistent across the ten-year period considered.

The following figures present a breakdown of maternal education and employment status within the two sectors in 2006 and 2016. What is immediately evident in the rural sector in both years is the relatively high percentage of non-working mothers. In contrast the estate sector shows a relatively higher level of unskilled employment which is justified given the labour structure with the sector. Particularly, in the 2006 graph within the estate sector, an increasing trend in the percentage of non-working mothers can be seen with increasing education up to the GCE(O/L). The GCE(A/L) qualification shows a relatively high proportion of mother in skilled employment. In contrast within the rural sector in 2006, high percentage of non-working mothers are seen across all levels of education, and the proportions do not change much across primary, secondary and GCE(O/L) levels. However, the proportion of mothers in skilled employment is seen to progressively increase, while the proportion of mothers in unskilled employment is seen to progressively decrease with education. This suggests that as maternal education increases, more mothers do tend to be employed in skilled work or choose to be unemployed. This further verifies the reasoning given above regarding the interplay between maternal education and employment.



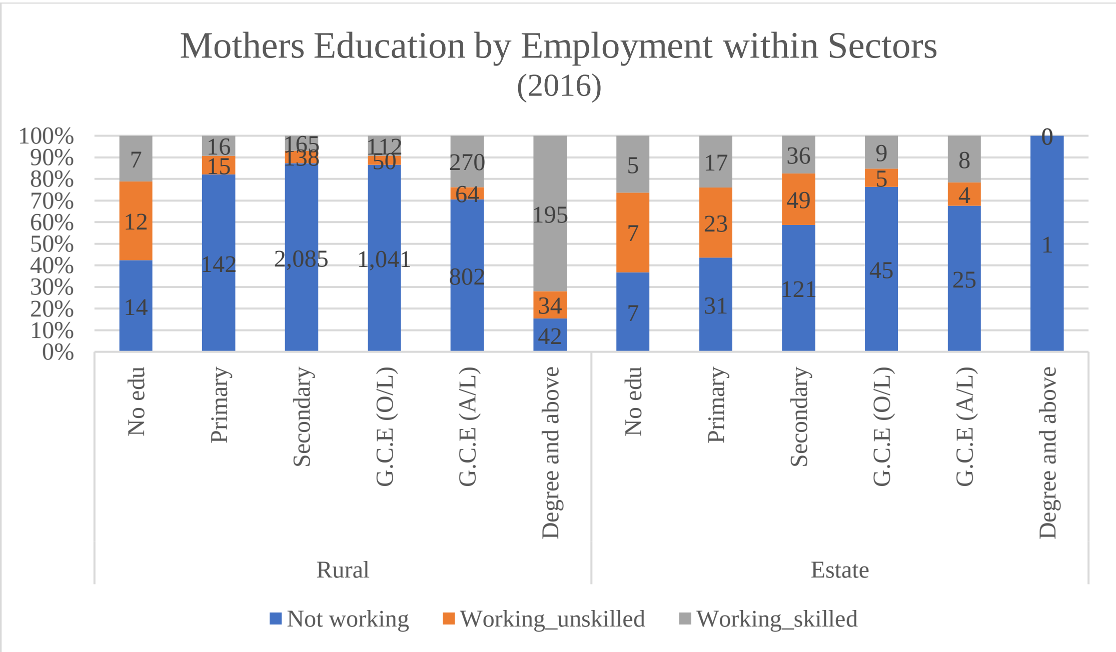


Figure 4-11: Maternal Education and Employment by Sector and Year
Base: Rural (8847) Estate (810), Rural 2006/2016 (3643/5204), Estate 2006/2016 (417/393)

Birth order was not a significant contributor to growth in the main models, whilst the total number of children in the HH showed a significant negative effect on child growth within the rural sector in 2006 but was not statistically significant in any other cases. Looking across the distributions the birth order showed a differential effect across the years within the rural sector. Whilst the negative effects were significant at the lower end of the growth distribution in 2006 whilst they were significant at the upper end of the distribution in 2016.In contrast birth order did not show any consistent patterns within the estate sector. The total number of children in the HH showed a negative effect on growth within the rural sector only in 2006.

Overall results presented in Table 4-14 and 4-15 do suggest some heterogeneity in the effects of growth determinants between the two sectors in both years. Coupled together with difference in the levels of controls observed in section 4.1., this justifies the need to carry out a more detailed analysis into what contributes to the rural-estate growth gap in each time period as well as well as the growth gap over time within each sector. The following section provides a detailed decomposition analysis which explores this further.

Table 4-14: RIF Regression Estimation for the Rural sector 2006-2016 - *HAZ*

HAZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Child-level							
Birthweight	Normal	0.633**	0.461**	0.391**	0.711**	0.582**	0.54**
		(0.11)	(0.056)	(0.075)	(0.109)	(0.054)	(0.082)
	High	0.661*	0.643**	0.714	0.516*	1.045**	1.951**
		(0.274)	(0.202)	(0.455)	(0.23)	(0.138)	(0.452)
Birth order	2nd	-0.178+	-0.026	-0.128	0.077	-0.146*	-0.393**
		(0.095)	(0.06)	(0.097)	(0.131)	(0.074)	(0.148)
	>2nd	-0.42*	0.025	-0.07	0.318	-0.128	-0.561*
		(0.184)	(0.102)	(0.15)	(0.256)	(0.137)	(0.274)
Gender	Female	0.148*	-0.004	-0.082	0.158**	0.047	0.015
		(0.06)	(0.042)	(0.071)	(0.059)	(0.04)	(0.078)
Age		-0.014	-0.03**	-0.056**	-0.03**	-0.052**	-0.155**
		(0.011)	(0.008)	(0.015)	(0.009)	(0.007)	(0.013)
Age_sq		0.0002	0.0004**	0.001**	0.001**	0.001**	0.002**
		(0.0002)	(0.0001)	(0)	(0.0001)	(0.0001)	(0.0002)
Antenatal care	Yes	0.158	-0.071	-0.047	0.139	0.079	-0.466
		(0.127)	(0.079)	(0.12)	(0.386)	(0.23)	(0.533)
Birth supervision	Supervised_	0.355	-0.437	-0.448*	0.057	0.392	1.85+
	NonH person	(0.649)	(0.316)	(0.205)	(0.447)	(0.285)	(1.06)
Breastfed duration		-0.02+	-0.019*	-0.035*	-0.014	-0.021**	-0.04**
		(0.012)	(0.008)	(0.014)	(0.01)	(0.007)	(0.012)
BF dur_sq		0.0003	0.0002+	0.001*	0.0002	0.0003*	0.001**
		(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0002)

Table 4-14 *ctd*.

HAZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Maternal-level							
Mother age(yr)		0.014*	0.008+	0.015*	0.001	0.005	0.013
		(0.007)	(0.005)	(0.007)	(0.007)	(0.005)	(0.009)
Mother height (cm)		0.047**	0.053**	0.058**	0.051**	0.05**	0.067**
		(0.006)	(0.004)	(0.008)	(0.005)	(0.003)	(0.007)
Mother BMI		0.011	0.02**	0.013	0.029**	0.025**	0.042**
		(0.007)	(0.005)	(0.009)	(0.006)	(0.005)	(0.009)
Mother edu.	Primary				0.815	-0.401	-0.899+
					(0.639)	(0.256)	(0.541)
	Secondary	-1.042**	1.034**	0.847**	0.504	-0.385	-0.745
		(0.204)	(0.132)	(0.235)	(0.625)	(0.248)	(0.54)
	GCE(O/L)	-1.057**	1.095**	0.896**	0.65	-0.344	-0.699
		(0.221)	(0.145)	(0.255)	(0.627)	(0.252)	(0.549)
	GCE(A/L)	-1.092**	1.102**	1.189**	0.644	-0.281	-0.663
		(0.234)	(0.153)	(0.273)	(0.628)	(0.254)	(0.553)
	Degree or				0.749	-0.219	-0.78
	above				(0.641)	(0.269)	(0.593)
	D/K	-1.909**	0.76**	0.601*			
		(0.372)	(0.175)	(0.264)			
Mother emp.	Working_	-0.096	-0.157+	-0.159	-0.099	-0.051	-0.361**
	Unskilled	(0.128)	(0.08)	(0.101)	(0.13)	(0.085)	(0.133)
	Working_	0.012	-0.064	-0.043	-0.002	0.076	0.071
	Skilled	(0.075)	(0.058)	(0.1)	(0.092)	(0.066)	(0.133)

Table 4-14 *ctd*.

HAZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
HH-level							
WealthQ	Second	0.065	0.098	-0.167	0.137	0.088	0.116
		(0.115)	(0.07)	(0.108)	(0.109)	(0.063)	(0.109)
	Middle	-0.067	0.018	-0.118	0.222*	0.144*	0.086
		(0.122)	(0.074)	(0.118)	(0.11)	(0.067)	(0.119)
	Fourth	-0.058	0.094	-0.067	0.241*	0.229**	0.165
		(0.123)	(0.078)	(0.128)	(0.112)	(0.071)	(0.131)
	Highest	0.11	0.206*	0.326+	0.179	0.161+	0.396*
		(0.128)	(0.091)	(0.166)	(0.129)	(0.089)	(0.177)
HH emp	Skilled	0.098	0.03	0.048	-0.102	-0.028	0.062
		(0.092)	(0.056)	(0.087)	(0.068)	(0.046)	(0.089)
Total children		0.019	-0.129**	-0.103*	-0.165	-0.029	0.078
		(0.063)	(0.031)	(0.044)	(0.111)	(0.055)	(0.109)
Substance use	Yes	-0.077	-0.04	-0.081	0.085	0.01	0.089
		(0.063)	(0.045)	(0.074)	(0.065)	(0.044)	(0.086)
Ethnicity	SL Tamil	-0.243	-0.166	-0.112	-0.286	0.054	0.197
		(0.215)	(0.129)	(0.235)	(0.175)	(0.1)	(0.201)
	Indian Tamil	-0.123	-0.389+	0.164	-0.532	-0.602**	-0.549+
		(0.523)	(0.22)	(0.303)	(0.583)	(0.229)	(0.286)
	SL Moor	-0.398**	-0.2*	-0.22+	-0.28*	-0.042	-0.029
		(0.128)	(0.08)	(0.132)	(0.136)	(0.079)	(0.156)
	Malay	0.38+	0.403	0.678	0.129	-1.911**	-1.612**
		(0.193)	(0.411)	(0.987)	(0.197)	(0.203)	(0.315)
	Burger	0.399**	-0.033	1.09	-0.746	-0.254	-0.817**
		(0.152)	(0.682)	(1.599)	(1.149)	(0.806)	(0.286)
	Other	0.65**	-1.037**	-0.084			
		(0.201)	(0.134)	(0.212)			

Table 4-14 *ctd*.

HAZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Head age(yr)		0.002	0.002	0.0001	0.003	0.0004	-0.005
		(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
Head gender	Female	-0.065	-0.021	0.042	0.077	0.015	0.081
		(0.077)	(0.055)	(0.097)	(0.073)	(0.052)	(0.103)
Head edu	Primary	-1.085**	0.947**	0.746**	0.077	0.064	0.097
		(0.216)	(0.139)	(0.23)	(0.214)	(0.122)	(0.217)
	Secondary				0.297	0.052	0.067
					(0.208)	(0.12)	(0.217)
	GCE(O/L)				0.155	0.03	0.057
					(0.219)	(0.132)	(0.248)
	GCE(A/L)				0.362	0.129	-0.122
					(0.224)	(0.141)	(0.262)
	Degree or				0.106	0.085	0.242
	above				(0.287)	(0.185)	(0.417)
	D/K				-0.497	-0.007	0.86
					(0.578)	(0.303)	(0.678)

Table 4-14 *ctd*.

HAZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Care/Facilities							
Toilet	Flush toilet	0.155	0.035	-0.097	0.304	0.107	0.308+
		(0.146)	(0.082)	(0.129)	(0.188)	(0.099)	(0.161)
Improved drinking	Yes	0.079	0.024	0.088	0.105	0.061	0.028
water		(0.069)	(0.047)	(0.077)	(0.068)	(0.043)	(0.088)
Hand washing	Wash after	0.328	-0.076	-0.148	0.298	0.046	-0.346
	toilet use	(0.209)	(0.12)	(0.205)	(0.227)	(0.111)	(0.228)
	Wash before	-0.066	0.057	-0.003	-0.026	-0.045	0.043
	cooking	(0.063)	(0.045)	(0.076)	(0.071)	(0.048)	(0.091)
_cons		-9.813**	-10.069**	-8.313**	-12.8**	-8.719**	-7.36**
		(0.969)	(0.71)	(1.249)	(1.144)	(0.659)	(1.342)
Sample mean		-2.408	-1.050	0.390	-2.293	-0.847	0.845
R-sq		0.088	0.158	0.091	0.087	0.168	0.167
N		3643			5204		

*1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.

Base categories (in parenthesis): Birthweight(Low), Gender/Head Gen(Male), ANcare(No), MotherEmp(Skilled work), WealthQ(First), Ethnicity(Sinhalese), Improved drinking water(No)

NOTES: ANcare is on the antenatal care received by mother. Breastfed duration records the total months the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the child's current age. Estimates for the 'Not Supervised' category of the Birth supervision variable is omitted for accuracy due to low counts. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Table 4-15: RIF Regression Estimation for Estate sector 2006-2016 - *HAZ*

		Estate					
HAZ		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Child-level							
Birthweight	Normal	0.854**	0.524**	0.242	0.683+	0.214	0.294
		(0.22)	(0.164)	(0.24)	(0.367)	(0.183)	(0.423)
	High	1.156*	-0.084	4.242	3.252*	-1.39+	-1.439
		(0.535)	(0.511)	(3.03)	(1.359)	(0.708)	(1.662)
Birth order	2nd	-0.066	-0.135	-0.51	-0.549	0.543+	0.301
		(0.367)	(0.224)	(0.327)	(0.671)	(0.327)	(0.677)
	>2nd	0.603	-0.051	-0.948*	-1.453	0.649	-0.235
		(0.766)	(0.405)	(0.426)	(1.359)	(0.622)	(1.273)
Gender	Female	0.464**	0.173	-0.173	0.058	-0.012	0.015
		(0.177)	(0.155)	(0.243)	(0.269)	(0.162)	(0.37)
Age		0.002	-0.072**	-0.107*	-0.009	-0.081**	-0.263**
		(0.024)	(0.023)	(0.043)	(0.038)	(0.02)	(0.057)
Age_sq		-0.0001	0.001**	0.001*	0.0001	0.001**	0.003**
		(0.0004)	(0.0004)	(0.001)	(0.001)	(0.0003)	(0.001)
Antenatal care	Yes	-0.696+	-0.227	-0.21	0.838	0.703	0.42
		(0.417)	(0.248)	(0.336)	(1.328)	(0.535)	(1.293)
Birth supervision	Supervised_		0.247	0.508	1.19*	1.028	1.702
	NonH person	0.1 (0.699)	(0.664)	(0.821)	(0.577)	(1.131)	(2.267)
Breastfed duration		-0.049*	-0.042+	-0.021	-0.072+	-0.013	-0.102+
		(0.023)	(0.023)	(0.039)	(0.039)	(0.023)	(0.058)
BF dur_sq		0.001**	0.001**	0.001	0.001	0.0004	0.002
		(0.0004)	(0.0005)	(0.001)	(0.001)	(0.001)	(0.001)

Table 4-15 *ctd*.

HAZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Maternal-level							
Mother age(yr)		0.004	0.026	0.023	0.035	0.009	0.012
		(0.019)	(0.017)	(0.026)	(0.029)	(0.018)	(0.034)
Mother height (cm)		0.033*	0.044**	0.033	0.075**	0.094**	0.033
		(0.014)	(0.014)	(0.023)	(0.023)	(0.013)	(0.032)
Mother BMI		0.032**	0.012	-0.027	0.048	0.027	0.02
		(0.012)	(0.02)	(0.019)	(0.033)	(0.018)	(0.047)
Mother edu.	Primary	-0.058	0.605+	1.671**	1.623	0.143	-0.161
		(0.381)	(0.335)	(0.416)	(1.077)	(0.385)	(0.768)
	Secondary	-0.088	0.746*	1.5**	1.426	-0.28	-0.233
		(0.345)	(0.305)	(0.378)	(1.082)	(0.362)	(0.687)
	GCE(O/L)				1.682	-0.486	-0.94
					(1.134)	(0.413)	(0.833)
	GCE(A/L)				1.901+	0.11	0.381
					(1.1)	(0.497)	(1.111)
	Degree or				-0.344	-0.117	0.282
	above				(1.907)	(1.056)	(2.517)
	D/K	0.703+	0.533	1.445**			
		(0.41)	(0.391)	(0.538)			
Mother emp.	Working_	-0.529**	-0.245	-0.492	-0.261	-0.311	-0.278
	Unskilled	(0.167)	(0.215)	(0.377)	(0.406)	(0.197)	(0.484)
	Working_	-0.018	-0.116	-0.234	-0.122	-0.03	-0.294
	Skilled	(0.272)	(0.319)	(0.68)	(0.463)	(0.242)	(0.558)

Table 4-15 *ctd*.

HAZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
HH-level							
WealthQ	Second	0.08	0.083	-0.063	0.014	0.04	0.408
		(0.236)	(0.196)	(0.293)	(0.295)	(0.214)	(0.491)
	Middle	-0.238	-0.081	0.54		0.422	-0.758
		(0.319)	(0.267)	(0.485)	0.3 (0.393)	(0.349)	(0.977)
	Fourth	-0.415	0.35	0.316	-0.926	-0.29	1.534
		(0.487)	(0.431)	(0.544)	(0.611)	(0.356)	(1.138)
	Highest	-0.265	0.559	0.502	-0.71	0.585	-0.581
		(0.395)	(0.456)	(0.98)	(0.652)	(0.531)	(0.9)
HH emp	Skilled	0.265	0.06	-0.093	-0.316	-0.296+	-0.536
		(0.206)	(0.191)	(0.297)	(0.293)	(0.179)	(0.487)
Total children		-0.47	-0.254+	-0.02	0.272	-0.324	0.117
		(0.3)	(0.14)	(0.141)	(0.541)	(0.252)	(0.526)
Substance use	Yes	-0.078	0.221	0.315	0.016	0.024	0.327
		(0.194)	(0.18)	(0.249)	(0.392)	(0.19)	(0.499)
Ethnicity	SL Tamil	0.004	-0.738*	0.313	-0.407	0.293	-0.41
		(0.304)	(0.29)	(0.435)	(0.353)	(0.275)	(0.662)
	Indian Tamil	0.322	-0.755**	0.344	0.201	-0.072	-0.621
		(0.282)	(0.268)	(0.421)	(0.37)	(0.288)	(0.619)
	SL Moor	-0.564	-1.318+	-0.173	0.572	-1.083	1.639
		(0.757)	(0.683)	(0.658)	(0.871)	(0.741)	(2.667)
	Malay	1.69**	0.077	-0.147			
		(0.569)	(1.014)	(0.792)			
	Burger				-0.941	-0.845+	1.55
					(0.972)	(0.488)	(1.255)
	Other						

Table 4-15 *ctd*.

HAZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Head age (yr)		-0.003	-0.009	0.002	0.005	0.006	0.016
		(0.007)	(0.006)	(0.008)	(0.012)	(0.007)	(0.016)
Head gender	Female	0.605**	0.124	0.05	0.299	0.105	-0.225
		(0.192)	(0.234)	(0.375)	(0.342)	(0.181)	(0.41)
Head edu	Primary				-0.602	0.21	1.407*
					(0.506)	(0.279)	(0.584)
	Secondary				0.208	0.254	1.389*
					(0.557)	(0.299)	(0.624)
	GCE(O/L)				0.18	-0.039	0.707
					(0.603)	(0.388)	(0.838)
	GCE(A/L)	-0.03	-0.207	1.464*	0.056	0.51	1.059
		(0.34)	(0.426)	(0.691)	(0.642)	(0.485)	(1.131)
	Degree or				-0.694	1.899**	1.235
	above				(0.912)	(0.626)	(1.121)
	D/K						

Table 4-15 *ctd*.

HAZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Care/Facilities							
Toilet	Flush toilet	-0.257	-0.186	-0.254	0.748	-0.24	-1.591+
		(0.226)	(0.218)	(0.313)	(0.853)	(0.334)	(0.896)
Improved drinking water	Yes	-0.093	-0.053	0.204	-0.081	0.372+	-0.214
		(0.262)	(0.223)	(0.343)	(0.433)	(0.208)	(0.514)
Hand washing	Wash after toilet use	-0.139	-0.103	0.578	0.729	-0.172	-0.083
		(0.344)	(0.336)	(0.588)	(0.662)	(0.333)	(0.7)
	Wash before cooking	0.389*	0.087	0.063	-0.006	-0.096	-0.08
		(0.186)	(0.169)	(0.246)	(0.307)	(0.194)	(0.42)
_cons		-7.086*	-6.615*	-4.478	-18.648**	-15.116**	0.312
		(2.752)	(2.664)	(4.005)	(4.206)	(2.31)	(5.517)
Sample mean		-3.207	-1.777	-0.199	-2.924	-1.349	0.585
R-sq		0.247	0.282	0.139	0.204	0.343	0.330
N		417			393		

*1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.
Base categories (in parenthesis): Birthweight(Low), Gender/Head Gen(Male), ANcare(No), MotherEmp(Skilled work), WealthQ(First), Ethnicity(Sinhalese), Improved drinking water(No)
NOTES: ANcare is on the antenatal care received by mother. Breastfed duration records the total months the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the child's current age. Estimates for the 'Not Supervised' category of the Birth supervision variable is omitted for accuracy due to low counts. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

4.2.3. Differentials in Long-Term Growth across Sector and Time

The descriptive and intra-sector analysis revealed some interesting trends with regards to the impact of control variables on long-term growth of children in each time period and within each sector. The significant sector-time differences in the levels of child, maternal, HH and care variables observed in the descriptive analysis (t-test results) and significant differences in estimated effects of these variables on growth as evidenced by the OLS and RIF regression and Generalised Hausman test results indicate that the growth differentials between the rural and estate sectors could be due to differences in characteristics (as indicated by endowment effects) or due to differences in returns to control variables (as indicated by coefficient effects), or both. A detailed decomposition analysis was carried out, on mean and quantile differentials, using the Blinder-Oaxaca decomposition technique, in order to further explore these effects. This section presents results of two different decomposition analyses: decomposition of growth differential between the two sectors and two time periods.

a) Rural-Estate Height-for-Age Differentials

This section analyses the rural-estate height-for-age differential in each time period. Panel A in Table 4-16 and panel B in Table 4-18 presents results for the mean and quantile growth differentials between the rural and estate sectors in 2006 and 2016 respectively. The average differential was 0.733 standardised units in 2006. Looking across the growth distribution, the rural-estate gap is clearly larger at the lower end of the distribution (0.798 at Q10) and gradually decreases towards the middle and upper tails of the distribution (0.589 at Q90). This implies that, on average growth gap between rural and estate children tend to be larger among children displaying poorer growth, while the gap is relatively smaller among children displaying better growth. The same pattern is also evident in 2016 (Table 4-18) with an average rural-estate growth differential of 0.390 standardized units. The gap is again wider at the lower end of the distribution (0.631 units at Q10) and narrows towards the middle and upper ends (0.260 units at Q90).

The BO decomposition analysis also reveals information and estimates of factors that contribute towards this rural-estate growth differential. According to the results presented in Table 4-16, the endowment effect is seen to significantly contribute to the mean growth differential (explains 72.2%) in 2006. The endowment effect is also significant at Q50, whilst none of the three effects (endowment, coefficient, or interaction) are seen to significantly contribute to the Q10 and Q90 differentials. Given that this may occur due to offsetting effects of variables, an initial breakdown of groups of controls as child, maternal, HH, facilities/care and Province followed by a more detailed variable level breakdown is considered, in order to identify the groups and individual variables within groups, that significantly contribute towards the rural-estate growth gap. Table 4-16 also presents a breakdown of endowment and coefficient effects by groups of controls (i.e. child, maternal, HH, facilities/care, and province). Looking at endowment effects, child variables show significant positive endowment effects across the mean while maternal variables show a significant endowment effect at Q10. HH variables significantly contribute to the Q50 growth differential. It is also noteworthy that, even though the overall coefficient effect was not statistically significant across the mean and quantile models, a significant coefficient effect is observed for child level variables and facilities/care variables at the mean and Q10 differentials respectively. Interaction effects are excluded from the tables below as none of the variable groups present significant effects.

Analysis of individual variables across the mean and quantile differentials reveal a few key differences in average endowments of controls that significantly contribute towards the rural-estate growth differential in 2006. Differences in the average proportion of low\normal birthweight, maternal height, maternal education, and employment significantly contribute towards the mean rural-estate growth gap. Differences in the average levels of low birthweight proportions, maternal height, proportion of mothers with secondary education and the proportion of mothers employed in the unskilled sector are seen to positively contribute towards the gap while the GCE(O/L)/GCE(A/L) educated mothers effectively reduces the gap. The observed effects are justified when considering descriptive results and the estimated effects in the intra-sector analysis. The average maternal height, proportion of mothers with secondary education and proportion of non-working mothers were higher in the rural sector than the estate sector in 2006, while the proportion of children born with low birthweight, proportion of mothers with primary education and the proportion of mothers in unskilled employment were higher in the estate sector. The proportion of HH with primary educated heads was higher within the estate sector while all other education levels showed a higher proportion within the rural sector. As noted in section 3.6., the BO decomposition transforms the coefficient vector to express effects as deviations from the grand mean (to estimate redundant coefficients for the base categories). The average values and proportions indicated above, together with the transformed variable effects (refer Table E1-1 in Appendix E1 for transformed coefficients and variable means), justify the direction of the endowment effects.

The table further highlights the factors that influence the rural-estate growth differentials, at Q10, Q50 and Q90 of the growth distribution. Looking at the individual variable effects presented in Table 4-17, maternal height, BMI, and proportion of mothers employed in unskilled work are all seen to increase the gap at Q10. In addition to this, low birthweight, and the gender of HH head also result in increasing the gap while the breastfed duration drives the gap down. Looking at the growth gap at Q50, the difference in proportions of children born with normal birthweight, proportion of mothers with secondary education, and average maternal height between the two sectors seems to drive up the rural-estate height-for-age growth. Looking at the detailed decomposition of the growth gap at Q90, maternal education and education of the HH head are again seen to have statistically significant endowment effects. Primary, GCE(O/L) and GCE(A/L) maternal education drives down the growth gap, while secondary education drives up the gap. Education of the HH head is also seen to drive down the growth gap at Q90. It should however be noted that, despite these individual effects, the overall endowment and coefficient effects were not significant.

Broadly these results indicate a number of variables such as low birthweight, maternal health (as captured by height and BMI), maternal education, maternal employment and education of the HH head to be among the variables which show significant differences in average endowments across the rural and estate sectors, in turn driving the growth gap. With regards to the coefficient effects, even though the overall coefficient effect was not significant, the detailed decomposition indicates a few variables which show significant differences in returns across the two sectors. Whilst most of the differences are marginally significant, education of the mother and the HH head show significant differences in returns across the two sectors, and the effects are observed both on the mean differential as well as the quantile differentials. This is suggestive that the returns to education may have been significantly different between the rural and estate sectors in 2006.

Table 4-16: OLS and Unconditional Quantile Regression Decomposition of Rural-Estate Growth Differential (2006) - *HAZ*

2006 (A)	OLS	Q10	Q50	Q90
Raw Differential	0.733**	0.798**	0.727**	0.589**
[Rural-Estate]	(0.074)	(0.100)	(0.088)	(0.127)
Endowment	0.531**	0.310	1.049**	0.143
	(0.172)	(0.22)	(0.216)	(0.339)
Coefficient	0.132	0.220	0.039	0.161
	(0.157)	(0.335)	(0.157)	(0.226)
Interaction	0.069	0.268	-0.362	0.285
	(0.221)	(0.387)	(0.252)	(0.389)
Endowment				
Child	0.115*	0.043	0.095	0.062
	(0.046)	(0.085)	(0.060)	(0.092)
Maternal	0.109	0.334*	0.128	-0.115
	(0.117)	(0.141)	(0.136)	(0.212)
HH	0.184	-0.142	0.596**	-0.017
	(0.169)	(0.227)	(0.214)	(0.354)
Facilities/Care	-0.022	-0.011	-0.016	-0.051
	(0.052)	(0.059)	(0.052)	(0.088)
Province	0.146	0.086	0.247	0.263
	(0.172)	(0.145)	(0.159)	(0.272)
Coefficient				
Child	1.145**	0.457	0.917+	2.298
	(0.433)	(0.703)	(0.515)	(1.297)
Maternal	2.860	2.201	0.726	3.645
	(2.176)	(2.477)	(2.440)	(3.946)
HH	0.503	0.959	1.068*	-0.468
	(0.417)	(0.897)	(0.514)	(0.603)
Facilities/Care	0.063	0.558*	0.207	-0.238
	(0.198)	(0.267)	(0.235)	(0.381)
Province	0.009	-0.029	0.144	0.097
	(0.112)	(0.148)	(0.163)	(0.274)
_cons	-4.448^{+}	-3.926	-3.021	-5.173
	(2.407)	(2.937)	(2.667)	(4.151)

**1% *5% $^{+}$10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, Improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Table 4-17: Detailed Decomposition of Rural-Estate Growth Differential (2006) - *HAZ*

2006 (A)		OLS	Q10	Q50	Q90
Raw Differential		0.733**	0.798**	0.727**	0.589**
[Rural-Estate]		(0.074)	(0.100)	(0.088)	(0.127)
Endowment					
Low BW		0.139**	0.109**		
		(0.043)	(0.039)		
Normal BW				0.059*	
				(0.028)	
Breastfed duration			-0.266*	-0.229+	
			(0.126)	(0.128)	
Mother height (cm)		0.042*	0.039*	0.053*	
		(0.019)	(0.019)	(0.022)	
Mother BMI			0.063*		
			(0.025)		
Mother edu	Primary	-0.087+			-0.253**
		(0.045)			(0.074)
	Secondary	0.037*		0.057*	0.099**
		(0.018)		(0.026)	(0.037)
	GCE(O/L)	-0.030**		-0.030+	-0.073**
		(0.01)		(0.015)	(0.021)
	GCE(A/L)	-0.032**		-0.032+	-0.078**
		(0.011)		(0.016)	(0.021)
Mother emp.	Working_	0.135*	0.191**		
	Unskilled	(0.061)	(0.067)		
Head Gender	Male		0.025**		
			(0.010)		
	Female		0.025**		
			(0.010)		
Head edu	Primary				0.052*
					(0.025)
	Secondary				-0.025+
					(0.013)
	GCE(O/L)				-0.023*
					(0.011)
	GCE(A/L)				0.149*
					(0.072)
Ethnicity	Sinhala			0.278+	
				(0.159)	
	Muslim	-0.087*			
		(0.041)			

Table 4-17 *ctd.*

2006 (A)		OLS	Q10	Q50	Q90
Coefficient					
Low BW		0.141+			
		(0.078)			
Normal BW		0.246+			
		(0.148)			
Age				1.305+	
				(0.754)	
Birth order	2		0.091^{+}		
			(0.050)		
	>2nd				0.117^{+}
					(0.062)
Gender	Male		0.082+		
			(0.049)		
	Female		-0.076+		
			(0.045)		
Antenatal care	Yes		0.627^{+}		
			(0.321)		
Birth sup	Sup_HealthP	0.372+			0.497+
		(0.202)			(0.283)
Mother BMI		0.491+			0.827+
		(0.265)			(0.428)
Mother edu	Primary	-0.270**	0.297**	0.310**	-0.519**
		(0.068)	(0.098)	(0.082)	(0.112)
	Secondary				-0.219^{+}
					(0.119)
	GCE(O/L)	0.039**		0.044**	0.058**
		(0.010)		(0.012)	(0.017)
	GCE(A/L)	0.031**		0.032**	0.054**
		(0.009)		(0.011)	(0.017)
Mother emp	Working_		0.175+		
	Unskilled		(0.094)		
Head Age				0.452+	
				(0.264)	
Head Gender	Male		0.297**		
			(0.092)		
	Female		-0.038**		
			(0.013)		
Head edu	Primary	0.242**	-0.319**	0.268**	0.290**
		(0.045)	(0.069)	(0.049)	(0.078)
	Secondary		0.066*	-0.072*	
			(0.026)	(0.028)	
	GCE(O/L)		0.008*	-0.009*	
			(0.004)	(0.004)	
	GCE(A/L)				-0.055+
					(0.028)

**1% *5% $^{+}$10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, Improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.). Table only contains statistically significant results. Estimates for the 'Not Supervised' category of the Birth supervision and hand hygiene variables are omitted for accuracy due to low counts.

Table 4-18 below, presents the Panel B decomposition results for the rural-estate growth differential in 2016. Looking across Panel A and B, it is clear that the average rural-estate growth differential has nearly halved (by 0.343 standardised units) over the considered period. However, looking at the decline in the gap across the growth distribution, it is evident that the decline is much larger at the upper end of the growth distribution than at the lower end of the growth distribution. Noticeably the decline in the rural-estate growth differential from 2006 to 2016 was 0.329 standardized units (from 0.589 in 2006 to 0.260 in 2016) at Q90, while the decline was only 0.167 standardized units (from 0.798 in 2006 to 0.631 in 2016) at Q10. Further, the raw rural-estate growth differential was not significant at Q90, indicating that at the upper end of the growth distribution, there are no significant differences in average growth between rural and estate sectors, in 2016. The implication of this result is that among children who display good growth (i.e. middle and upper ends of the growth distribution) rural-estate differentials have declined over the ten-year period, while among children who display poorer growth, the rural-estate growth differential is larger, implying that estate sector children displaying poor growth were significantly worse off, compared to similar rural sector children.

Table 4-18: OLS and Unconditional Quantile Regression Decomposition of Rural-Estate Growth Differential (2016) - *HAZ*

2016 (B)	OLS	Q10	Q50	Q90
Raw Differential	0.389**	0.631**	0.502**	0.260
[Rural-Estate]	(0.111)	(0.153)	(0.091)	(0.211)
Endowment	0.547*	0.899*	0.452*	1.286*
	(0.255)	(0.402)	(0.259)	(0.618)
Coefficient	-0.263*	-0.266	-0.133	-0.308
	(0.133)	(0.283)	(0.129)	(0.236)
Interaction	0.106	-0.002	0.182	-0.718
	(0.266)	(0.465)	(0.275)	(0.628)
Endowment				
Child	-0.012	0.173+	-0.036	-0.090
	(0.080)	(0.095)	(0.056)	(0.141)
Maternal	0.199+	0.358*	0.275**	0.225
	(0.121)	(0.147)	(0.106)	(0.251)
HH	0.287	-0.078	0.030	0.436
	(0.203)	(0.299)	(0.212)	(0.494)
Facilities/Care	-0.076	0.061	-0.079+	0.016
	(0.065)	(0.090)	(0.042)	(0.104)
Province	0.148	0.384+	0.262	0.700
	(0.139)	(0.209)	(0.165)	(0.496)
Coefficient				
Child	0.051	0.699	-0.622	0.394
	(0.889)	(1.565)	(0.810)	(1.791)
Maternal	-1.731	-5.589	-6.780**	5.587
	(3.323)	(4.061)	(2.197)	(5.683)
HH	-0.307	-1.161	0.602	-0.634
	(0.931)	(1.246)	(0.697)	(1.523)
Facilities/Care	0.411	-0.549	0.337	1.791+
	(0.385)	(0.866)	(0.371)	(0.942)
Province	0.010	0.150	0.147	0.616
	(0.137)	(0.199)	(0.162)	(0.496)
_cons	1.303	6.184	6.184*	-8.063
	(3.049)	(4.302)	(2.482)	(5.87)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, Improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Based on the results presented above, much of the mean rural-estate growth differential in 2016 can be attributed to observed differences between the explanatory variables (endowment effect) between the two sectors. In fact, rural-estate differences in average endowments is greater than the difference in average growth between the two sectors implying that compared to the rural sector, the estate sector does even worse with regards to endowments than it does with regards to child growth. The coefficient effect is also significant but negative in magnitude, implying that the differences in average returns to controls, causes the average rural-estate growth gap to decline in 2016. The interaction effect is not statistically significant. Looking across the variable groups the maternal variables contribute significantly to the endowment effect, while no singular category is seen to contribute significantly to the coefficient effect. With regards to the rural-estate growth gap at Q10 and Q50, only the endowment effects were seen to significantly contribute to the differential. Looking across the variable groups, maternal variables were significant contributors to the endowment effect at both quintiles. The growth differential was not statistically significant at Q90. Even though the overall coefficient effect was not significant at Q50, maternal variables show marginally significant contributions to the coefficient effect.

Table 4-19 below summarises significant results of the detailed rural-estate decomposition analysis in 2016 shows low birthweight, birth order, breastfed duration, mothers height, BMI and education, education of HH head and wealth to have significant individual effects. With regards to the mean differential, average differences in maternal height, BMI and education of the HH head result in increasing the rural-estate growth differential while differences in the average duration of breastfeeding, proportion of mothers passing GCE(O/L) and proportion of HH belonging to the fourth wealth quintile decrease the growth differential. Differences in the estimated effects of being born with a low birthweight and the estimated effects of birth order result in decreasing the growth gap, while returns to maternal education, the HH head not being educated, HH wealth and belonging to the majority ethnicity group all significantly contribute towards increasing the mean growth differential.

Average differences in the proportion of low birthweight children, maternal height, proportion of mothers passing GCE(A/L) and the proportion of HHs falling within the middle wealth quintile, contributes towards widening the growth gap at the lower end of the growth distribution while differences in average breastfed duration bring down the gap. Differences in the returns to low\normal birthweight result in increasing the growth gap while the difference in the estimated effect of mothers passing GCE(A/L) brings down the growth gap. At the middle of the growth distribution, differences in the proportion of normal birthweight children, the average maternal height, and proportion of HH head having a relatively high education all result in widening the growth gap while, differences in the proportion of GCE(O/L) qualified mothers and proportion of Sri Lankan Tamil HHs result in decreasing the gap. Differences in the estimated effects of low birthweight, normal birthweight, birth order and maternal height, decrease the growth gap while the difference in estimated effects of belonging to 4th wealth quintile, results in increasing the growth gap. There was no significant difference in rural-estate growth differential at the upper end of the distribution. However marginally significant differences were seen with regards to the proportion of Indian Tamil HHs and returns to low birthweight, normal birthweight, age, secondary education of HH head, ethnicity and availability of a flushable toilet.

Table 4-19: Detailed Decomposition of Rural-Estate Growth Differential (2016) - *HAZ*

2016 (B)		OLS	Q10	Q50	Q90
Raw Differential		0.389**	0.631**	0.502**	0.260
[Rural-Estate]		(0.111)	(0.153)	(0.091)	(0.211)
Endowment					
Low BW			0.113*		
			(0.057)		
Normal BW		0.044^{+}		0.052*	
		(0.026)		(0.025)	
Breastfed		-0.220*	-0.214^{+}		
		(0.107)	(0.128)		
Maternal height (cm)		0.119**	0.149**	0.185**	
		(0.043)	(0.052)	(0.040)	
Maternal BMI		0.064^{+}			
		(0.036)			
Maternal edu	GCE(O/L)	-0.044^{+}			
		(0.024)			
	GCE(A/L)		0.137*		
			(0.057)		
HH Wealth	Q3		0.097^{+}		
			(0.053)		
	Q4	-0.076^{+}			
		(0.046)			
Head edu	No education	0.060*			
		(0.024)			
	Primary	0.061^{+}			
		(0.036)			
	GCE(O/L)			-0.038^{+}	
				(0.022)	
	GCE(A/L)	0.039^{+}			
		(0.022)			
	Degree or higher	0.017* (0.008)		0.027* (0.011)	
Ethnicity	SL Tamil			-0.182**	
				(0.064)	
	Indian Tamil				0.353^{+}
					(0.201)
Imp. drinking water	Yes			-0.033^{+}	
				(0.019)	
	No			-0.033^{+}	
				(0.019)	

Table 4-19 *ctd.*

2016 (B)		OLS	Q10	Q50	Q90
Coefficient					
Low BW		-0.195**	0.225^{+}	-0.233**	-0.302^{+}
		(0.078)	(0.126)	(0.069)	(0.1568
Normal BW			0.694+	-0.421*	-0.719^{+}
			(0.359)	(0.181)	(0.435)
Birthorder	2nd	-0.116**		-0.075^{+}	
		(0.043)		(0.043)	
Age					2.924^{+}
					(1.599)
Maternal height (cm)				-6.543**	
				(2.096)	
Maternal edu	GCE(O/L)	0.090^{+}			
		(0.047)			
	GCE(A/L)		-0.077^{+}		
			(0.043)		
HH wealth	Q4	0.016^{+}		0.018^{+}	
		(0.009)		(0.010)	
Head age		-0.659^{+}			
		(0.399)			
Head edu	No education	0.070*			
		(0.032)			
	Secondary				-0.286^{+}
					(0.170)
Ethnicity	Sinhala	0.054^{+}			
		(0.031)			
	SL Tamil				0.567*
					(0.241)
Toilet					1.803*
					(0.864)

**1% *5% $^{+}$10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, Improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.). Table only contains statistically significant results. Estimates for the 'Not Supervised' category of the Birth supervision and hand hygiene variables are omitted for accuracy due to low counts.

The observed effects above, are justified when considering the descriptive and transformed effects estimated through the decomposition analysis in 2016. As evident in Table 4-19, maternal height shows a significant contribution across the mean and quantile differentials, while maternal BMI was significant at the mean. Looking at the descriptive results presented in section 4.1.1., both average maternal height and BMI was higher in the rural sector than the estate sector in both years. Breastfed duration also impacts the growth differential across much of the distribution. Again, considering the differences in the breastfed duration between the sectors in 2016, the average duration was significantly higher within the rural sector than the estate sector. This aligns with the observations in the table above, where differences in average breastfed duration causes the rural-estate growth differential to decline.

4.2.3.1. Sensitivity Analysis: Rural-Estate Growth Differentials in 2006 and 2016

Considering the 2006 rural-estate growth differential results presented in tables 4-16,17 a possible interplay between maternal education, employment, HH wealth and education of HH head was suggested to explain some of the results observed. To further analyse the sensitivity of the decomposition results to these variables, models were run, excluding one or more of the above four variables, and significant changes to endowment and coefficient effects were noted. The following table summarises these results. The first column (Panel I) presents the preferred specification (model including all controls) while Panels II, III, IV and V, exclude maternal education, maternal employment, HH wealth and education of HH head respectively. The models below, only consider the mean differential as the behaviour across the growth distribution can be considered to follow a similar pattern. Endowment effects are significant across all models, whilst coefficient and interaction effects are not significant across any of the models. Similar to the preferred model, the endowment effects of child variables were significant across all panels. Maternal variable endowment effect was significant in panel II and IV while HH variable endowment effects are significant in Panel III. No groups show significant endowment effects in panel V. Coefficient effects for child level variables were significant across all models.

Table 4-20: Sensitivity Analysis Rural-Estate Growth Differential (2006) - *HAZ*

2006 (A)	I (Preferred)	II (ex MEdu)	III (ex MEmp)	IV (ex HHWlth)	V (ex HHEdu)
Raw Differential	0.733**	0.733**	0.733**	0.733**	0.733**
[Rural-Estate]	(0.074)	(0.074)	(0.074)	(0.074)	(0.074)
Endowment	0.531**	0.531**	0.566**	0.524**	0.531**
	(0.172)	(0.172)	(0.169)	(0.169)	(0.172)
Coefficient	0.132	0.132	0.171	0.127	0.132
	(0.158)	(0.157)	(0.156)	(0.157)	(0.157)
Interaction	0.069	0.069	-0.004	0.082	0.069
	(0.221)	(0.221)	(0.218)	(0.219)	(0.221)
Endowment					
Child	0.115*	0.115*	0.117*	0.114*	0.115*
	(0.046)	(0.046)	(0.047)	(0.046)	(0.046)
Maternal	0.109	0.264**	-0.009	0.183+	0.151
	(0.116)	(0.094)	(0.099)	(0.100)	(0.117)
HH	0.184	0.029	0.320*	0.113	0.141
	(0.169)	(0.159)	(0.148)	(0.151)	(0.167)
Facilities/Care	-0.022	-0.022	-0.028	-0.015	-0.022
	(0.052)	(0.052)	(0.051)	(0.048)	(0.052)
Province	0.146	0.146	0.166	0.128	0.146
	(0.109)	(0.109)	(0.102)	(0.109)	(0.109)
Coefficient					
Child	1.145**	1.145**	1.078*	1.169**	1.145**
	(0.433)	(0.433)	(0.452)	(0.425)	(0.433)
Maternal	2.860	3.076	2.777	2.901	3.049
	(2.176)	(2.173)	(2.207)	(2.088)	(2.173)
HH	0.503	0.287	0.542	0.296	0.314
	(0.417)	(0.421)	(0.421)	(0.413)	(0.419)
Facilities/Care	0.063	0.063	0.052	0.043	0.063
	(0.198)	(0.198)	(0.197)	(0.180)	(0.198)
Province	0.009	0.009	0.025	-0.009	0.009
	(0.112)	(0.112)	(0.104)	(0.112)	(0.112)
_cons	-4.448+	-4.448+	-4.304+	-4.273+	-4.448+
	(2.407)	(2.407)	(2.441)	(2.265)	(2.407)

Table 4-20 *ctd.*

2006 (A)	I (Preferred)	II (ex MEdu)	III (ex MEmp)	IV (ex HHWlth)	V (ex HHEdu)
Interaction					
Child	-0.068	-0.068	-0.072	-0.068	-0.068
	(0.046)	(0.046)	(0.046)	(0.045)	(0.046)
Maternal	0.327*	-0.091	0.390**	0.151	0.093
	(0.128)	(0.101)	(0.107)	(0.109)	(0.125)
HH	-0.178	0.240	-0.300	-0.003	0.055
	(0.222)	(0.212)	(0.207)	(0.208)	(0.218)
Facilities/Care	0.007	0.007	0.013	0.001	0.007
	(0.053)	(0.053)	(0.053)	(0.049)	(0.053)
Province	-0.018	-0.018	-0.035	0.001	-0.018
	(0.112)	(0.112)	(0.105)	(0.219)	(0.112)

**1% *5% $^{+}$10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, Improved drinking water and hand hygiene.
NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Even though endowment effects of maternal variables were not significant in the preferred model it is interesting to note that they become significant after excluding maternal education (Panel II). Looking across the detailed analysis in Table 4-21 below, a key difference observed is the significance of the endowment effect of secondary education of HH head, which showed mixed effects at different levels (i.e. secondary education increasing the rural-estate growth gap, whilst primary/GCE (O/L) decreasing it). Endowment and coefficient effects of HH head's education (i.e. primary and GCE(A/L)) has lost statistical significance in the Panel II model. All other significant effects remained unchanged. Results suggest a potential interplay between maternal education and household with secondary educated HH heads.

In Panel III, maternal employment is excluded, and the resulting decomposition again alters the endowment effects, making child and HH-level endowments, statistically significant. Accordingly, differences in average levels of child and HH level variables result in widening the mean rural-estate growth differential in 2006, with the endowment effect of HH variables being particularly strong. The detailed analysis again shows no significant changes in most of the estimated effects. A key difference is in the endowment and coefficient effects pertaining to the education level of the HH head, which is not statistically significant anymore. Instead, maternal education shows more impact, particularly with positive coefficient effects at higher levels of maternal education (GCE(O/L) and GCE(A/L)). Difference in the proportion of Indian Tamil HHs is also seen to significantly contribute towards widening the rural-estate growth differential. With regards to child-level variables, returns to low and normal birthweight which was seen to have a significant coefficient effect in the preferred model did not show statistically significant effects, when maternal employment was excluded.

These results suggest two main aspects. Firstly, the impact of maternal employment on endowments, seems to be linked with ethnicity, particularly from an Indian Tamil background. This observation is justified considering the fact that most of the estate population working within the tea plantation sector come from an Indian Tamil ethnic background and tea estates being heavily dependent on female labour. The results also indicate a possible interplay between maternal employment and HH head's education, given the loss of significance of these variables once maternal employment is unaccounted for in the models. This relationship will be further explored in chapter 5.

Panel IV presents the mean rural-estate growth decomposition excluding HH wealth. Apart from child-level variables, the endowment effect of maternal variables is marginally significant while no other variable groups show significant endowment effects. The most notable change is with regards to the endowment and coefficient effects of the HH head's education. While the endowment effects are no longer statistically significant, the estimated coefficient effects for some of the education levels (GCE(O/L) and GCE(A/L)) have reversed in direction. This indicates that the exclusion of HH wealth changes certain estimated effects of the education of the HH education on the rural and estate height-for-age models. Maternal education also shows some changes particularly with regards to the endowment and coefficient effects of lower levels of education. The model results suggest a potential inter-relationship between HH wealth and education of the HH head, which will be further explored in the next chapter.

Finally, panel V excludes the education of HH head, and the resultant decomposition analysis shows similar results to the preferred specification, with none of the variable groups showing significant endowment effects. Detailed decomposition results are very similar to results for the preferred model. One noted difference was the primary education of mothers, which did not show a significant endowment or coefficient effect. The sensitivity analysis was also done on the RIF regression models which showed similar results to the above panels (results excluded). Overall, the sensitivity analysis highlights maternal education, employment and HH wealth to have significant impacts on the endowment effects while the education of HH head is seen to have some dependence with HH wealth and other control variables. Some of these relationships will be further discussed in the next chapter.

Table 4-21:Sensitivity Analysis Rural-Estate Detailed Growth Differential (2006) - *HAZ*

2006 (A)		I	II	III	IV	V
Raw Differential [Rural-Estate]		0.733** (0.074)	0.733** (0.074)	0.733** (0.074)	0.733** (0.074)	0.733** (0.074)
Endowment						
Low BW		0.139** (0.042)	0.139** (0.042)	0.128** (0.045)	0.144** (0.039)	0.139** (0.042)
Normal BW					-0.054+ (0.032)	
Breastfed duration						
Mother height (cm)		0.042* (0.019)	0.042* (0.019)	0.043* (0.019)	0.044* (0.019)	0.042* (0.019)
Mother BMI						
Mother edu	Primary	-0.087+ (0.045)			-0.068+ (0.039)	
	Secondary	0.037* (0.018)			0.028+ (0.015)	-0.074+ (0.043)
	GCE(O/L)	-0.030** (0.010)			-0.034** (0.012)	0.031+ (0.017)
	GCE(A/L)	-0.032** (0.011)				-0.036** (0.013)
Mother emp.	Not working				0.082+ (0.045)	0.078+ (0.046)
	Working_ Unskilled	0.135* (0.061)	0.135* (0.061)		0.139* (0.06)	0.135* (0.061)
Head Gender	Male					
	Female					

Table 4-21 *ctd.*

2006 (A)		I	II	III	IV	V
Head edu	Primary		-0.074+			
			(0.044)			
	Secondary		0.031+			
			(0.017)			
	GCE(O/L)		-0.036**			
			(0.013)			
	GCE(A/L)					
Ethnicity	Sinhala					
	Indian Tamil			0.129+		
				(0.075)		
	Muslim	-0.086*	-0.086*	-0.073+	-0.083*	-0.086*
		(0.040)	(0.040)	(0.039)	(0.040)	(0.039)
Coefficient						
Low BW		0.141+	0.141+		0.153*	0.141+
		(0.077)	(0.077)		(0.069)	(0.077)
Normal BW		0.246+	0.246+		0.270*	0.246+
		(0.146)	(0.146)		(0.135)	(0.146)
Age						
Gender	Male					
	Female					
Birth sup	Sup_HealthP	0.371+	0.371+	0.379+	0.352+	0.371+
		(0.206)	(0.206)	(0.207)	(0.206)	(0.206)
Mother BMI		0.491+	0.491+	0.464+	0.481*	0.491+
		(0.265)	(0.265)	(0.265)	(0.252)	(0.265)
Mother edu	Primary	-0.270**		-0.188*	-0.196**	
		(0.068)		(0.082)	(0.058)	
	Secondary				0.125*	
					(0.06)	
	GCE(O/L)	0.039**		0.031**	0.048**	0.036**
		(0.010)		(0.011)	(0.013)	(0.01)

Table 4-21 *ctd.*

2006 (A)		I	II	III	IV	V
	GCE(A/L)	0.031**		0.025**		
		(0.010)		(0.009)		
Mother emp	Working_ Unskilled					
Head Age						
Head Gender	Male					
	Female					
Head edu	Primary	0.242**		0.208**	0.169**	
		(0.045)		(0.043)	(0.034)	
	Secondary			-0.067**	-0.106**	
				(0.022)	(0.017)	
	GCE(O/L)		0.036**		-0.013**	
			(0.010)		(0.003)	
	GCE(A/L)			-0.006*	0.029**	
				(0.002)	(0.009)	

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, Improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.). Table only contains statistically significant results. Estimates for the 'Not Supervised' category of the Birth supervision and hand hygiene variables are omitted for accuracy due to low counts.

b) 2016-2006 Height-for-age Differentials

This section presents results of the decomposition analysis of the 2016-2006 growth differentials in each sector. Panel C (Table 4-23) and panel D (Table 4-26), present results for the mean and quantile growth differentials between 2016 and 2006 in the rural and estate sectors respectively. As evident in both panels, the growth of children has improved from 2006 to 2016 in both sectors. The improvement in average growth was 0.234 standardised units in the rural sector while the improvement was much larger, at 0.578 standardised units in the estate sector. Looking across the growth distribution in the rural sector, the growth improvement is clearly largest at the upper end of the distribution (at 0.455 at Q90) while the improvement was less at the lower end of the distribution (0.115 at Q10). This implies that, on average, the improvement in growth from 2006 to 2016 tend to be larger among children displaying relatively better growth in the two years, while the gap is relatively smaller among children displaying poor growth. The same pattern is also evident within the estate sector (Table 4-26) with the improvement being largest at 0.783 units at the upper end of the growth distribution (at Q90) and considerably smaller at the lower end of the growth distribution.

The BO decomposition analysis yields information on the variable groups (child, maternal, HH, facilities and province) that contribute towards the improvement of growth over time. According to the results presented in panel C (Table 4-23), the endowment effect is seen to significantly contribute to the growth improvement from 2006 to 2016 within the rural sector. This suggests that the improvement in growth from 2006 to 2016 was mainly due to changes in the average levels of characteristics as represented by the control variables. The endowment effect is also significant at Q50 and Q90, whilst none of the three effects (endowment, coefficient or interaction) are seen to significantly contribute to the growth improvement at Q10. This could be either due to the improvement in growth being relatively small at Q10 or due to offsetting effects of the control variables, where improvements in certain variables are offset by deterioration in others. Looking across the main variable groups, child and maternal level variables were seen to show significant endowment effects on the mean growth improvement, indicating that a significant improvement in the child and maternal variables have occurred over the considered period. Even though the overall coefficient effect was not statistically significant, returns to child, HH and facilities/care variables as a group, show significant coefficient effects in the mean decomposition. Difference in returns to child level variables were seen to negatively impact the growth improvement while differences in returns to HH variables and facilities were seen to positively impact the growth improvement. This suggests that returns to child level variables, as a group may have been lower in 2016 compared to 2006, within the rural sector. This is further explored through a detailed decomposition analysis.

Across the growth distribution, endowment effects of maternal variables were significant at all three points Q10, Q50 and Q90, while endowment effects of child level variables are significant at Q50 and Q90 of the growth distribution. HH variables show a differential effect across the growth distribution with a significant negative effect at the lower end of the growth distribution (Q10) and positive (non-significant) effects at the median and upper ends of the distribution. The results imply that there may be a relative deterioration of HH characteristics including wealth, over time, experienced by rural children at the lower end of the growth distribution. This may be reflective of the level of income inequality which exists within the rural sector. Whilst rural sector inequality has slightly declined over the considered 10-year period (Gini coefficient reported as 0.46 in 2006 vs 0.44 in 2016), inequality is still noted to be higher within the rural sector than the estate sector.

Child level variables also show a significant coefficient effect at the median and upper ends of the growth distribution while the HH level variables show a significant coefficient effect at the median and low end of the distribution. The estimated direction of the child-level coefficient effects suggests that returns to child level variables as a group may be lower in 2016 than in 2006, which is a pattern warranting further analysis. The negative and positive coefficient effects observed for child variables and HH variables would offset each other making the overall coefficient effect non-significant.

Table 4-22: OLS and Unconditional Quantile Regression Decomposition of 2016-2006 (Rural) - *HAZ*

Rural (C)	OLS	Q10	Q50	Q90
Raw Differential	0.234**	0.115**	0.203**	0.455**
[2016-2006]	(0.029)	(0.044)	(0.031)	(0.056)
Endowment	0.211**	0.032	0.242**	0.232**
	(0.024)	(0.035)	(0.026)	(0.042)
Coefficient	0.018	-0.100	0.029	0.192+
	(0.055)	(0.079)	(0.048)	(0.099)
Interaction	0.005	0.183*	-0.068	0.031
	(0.053)	(0.072)	(0.045)	(0.097)
Endowment				
Child	0.050**	0.036*	0.038**	0.075**
	(0.011)	(0.016)	(0.012)	(0.021)
Maternal	0.100**	0.083**	0.103*	0.119**
	(0.014)	(0.020)	(0.016)	(0.023)
HH	0.063*	-0.093**	0.086**	0.065**
	(0.016)	(0.025)	(0.017)	(0.025)
Facilities/Care	0.0001	-0.003	0.009	-0.008
	(0.007)	(0.012)	(0.008)	(0.013)
Province	-0.002	0.008	0.006	-0.019+
	(0.005)	(0.008)	(0.006)	(0.01)
Coefficient				
Child	-0.844*	0.078	-0.668+	-2.975**
	(0.396)	(0.482)	(0.370)	(0.686)
Maternal	-0.675	0.949	-0.954	1.607
	(0.889)	(1.257)	(0.874)	(1.717)
HH	0.566**	0,046	0.409	0.819+
	(0.214)	(0,385)	(0.250)	(0.451)
Facilities/Care	0.262+	0.128	0.120	0.270
	(0.137)	(0.260)	(0.137)	(0.229)
Province	-0.01	-0.04+	0.016	0.005
	(0.013)	(0.022)	(0.014)	(0.027)
_cons	0.719	-1.262	1.105	0.465
	(1.044)	(1.436)	(0.999)	(1.919)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

The detailed decomposition in Table 4-24 below highlights a number of variables that contribute significantly towards the endowment and coefficient effects that drive the growth improvement within the rural sector. Maternal height, maternal age, maternal education, and education of HH head have significant positive endowment effects on the mean and across the growth distribution. Improvements in maternal height across the 2006-2016 period significantly contributes to the improvement in child growth between the two time periods. Maternal age is strongly positive across the mean and marginally positive across the growth distribution. BMI shows a positive contribution at the mean and median. Overall, these results suggest that part of the improvement in growth of rural children over time may be accounted for, by the improvement in maternal characteristics.

Maternal education is another variable which shows significant endowment and coefficient effects across the mean and quantile distributions. However, unlike the other maternal variables, both positive and negative endowment and coefficient effects are observed across the growth distribution. This implies that changes in both the levels of education and their returns have had a mixed effect across mean and quantile growth differentials. Looking at the endowment effects, higher levels of maternal education (i.e. GCE(O/L) and GCE(A/L)) are seen to positively contribute towards the growth improvement at the mean, median and upper ends of the growth curve, while low levels of maternal education (no edu, primary and secondary) show negative effects. This pattern, however, is reversed at the lower end of the growth distribution, where lower maternal education is seen to positively contribute to the growth improvement as opposed to higher levels of education. In contrast, coefficient effects of maternal education are generally negative implying that the returns to maternal education within the rural sector may have generally declined over the given period. This seems to have a detrimental impact on the growth improvement of children over time. Table 4-25 provides endowment and coefficient effects for the overall maternal education variable. The combined endowment effect of maternal education is positive at the mean and across the growth distribution. However, they are statistically significant only at the mean and the upper end of the growth distribution. The combined coefficient effect of maternal education shows a significant negative contribution at the mean, median and upper ends of the growth distribution. Higher levels of education of the HH head show a positive contribution at the mean, median and upper levels of the growth distribution and a negative contribution at the lower end of the distribution. Coefficient effects are also positive at the mean and median. Considering the combined endowment effects of HH education, this was seen to be positive at the mean, median and upper end of the growth distribution, whilst negative at the lower end of the distribution. Results imply a general decrease in higher education of mothers and HH heads, over time, within the rural sector.

Given that the overall child level variables showed negative endowment and coefficient effects, it is interesting to look at the impact of individual child-level variables on the growth improvement. The proportions of low and high birthweight each showed significant positive endowment effects at the mean. The descriptive analysis shows that the proportion of high birthweight children have increased from 2006 to 2016 while the proportion of low birthweight children decreases within the same time period. This explains the observed result in Table 4-23. Age also shows a significant positive endowment effect and negative coefficient effect across the growth distribution apart from Q10. Given that the returns to age is generally negative, a positive endowment effect implies that children in the 2016 sample may be slightly younger, in general than the 2006 sample while a negative coefficient effect implies that the returns to age is more negative in 2016 than 2006. The descriptive analysis showed a larger proportion of children between 0-6 months in the 2016 rural sector sample. The positive effect of age on the growth improvement, together with the fact that the 2016 sample is on average younger, may be suggesting that smaller age groups show larger improvements in growth between 2006 and 2016. The positive endowment effect is however offset by the negative coefficient effect, making the overall effect of age negative on the growth improvement, and this could be the cause for the overall negative child-level coefficient effects observed in Table 4-23. The non-linear relationship between age and standardized height-for-age was explained in detail in section 4.2.1. The U-shaped distribution between age and standardized height-for-age showed that the inflection point remained unchanged at approximately 34 months in both samples, while the returns to age being more negative in 2016 suggests that the curve is steeper in 2016, compared to 2006. This suggests, that while child growth seems to deviate from the reference growth (as indicated by the growth of similar children in the WHO reference population) with age, this deviation is more rapid in 2016, than in 2006, which negatively impacts the growth improvement from 2006 to 2016, and that this is effect is large enough to offset the positive endowment effects. The same trend is observed at the median and upper ends of the growth distribution as well. Apart from these variables, a few other variables also showed predictable results across one or two points in the growth distribution. However, no consistent patterns were observed with regards to these effects.

Overall, the results suggest that maternal variables are the strongest contributors to the growth improvement of rural children over time. Maternal education in particular is a complex variable showing mixed effects (both in levels and returns) across the growth distribution. Differences in both the levels and returns to maternal education between the two years positively contributes to the improvement in growth observed among children at the lower end of the growth distribution, whilst reducing the growth improvement at the middle and upper ends of the growth distribution. The results also indicate a possible interplay between the education of the HH head and other controls in the model.

Table 4-23: Detailed Decomposition of 2016-2006 Growth Differential (Rural) - *HAZ*

Rural (C)		OLS	Q10	Q50	Q90
Raw Differential		0.234**	0.115**	0.203**	0.455**
[2016-2006]		(0.029)	(0.044)	(0.031)	(0.056)
Endowment					
Low BW		0.006+		0.005+	
		(0.004)		(0.003)	
High BW		0.002+			
		(0.001)			
Birth order	1st		-0.010*		
			(0.005)		
Age		0.084**		0.074**	0.138**
		(0.021)		(0.023)	(0.042)
Maternal age		0.008*	0.011+	0.006+	0.012+
		(0.003)	(0.005)	(0.004)	(0.006)
Maternal height (cm)		0.044**	0.041**	0.046**	0.05**
		(0.008)	(0.008)	(0.008)	(0.01)
Maternal BMI		0.026**		0.029**	
		(0.007)		(0.008)	
Maternal edu	No edu	-0.003**	0.004**	-0.003**	-0.003**
		(0.001)	(0.001)	(0.001)	(0.001)
	Primary	0.028**	-0.046**	0.036**	0.032**
		(0.005)	(0.009)	(0.006)	(0.009)
	Secondary	-0.043**	0.033**	-0.049**	-0.037**
		(0.008)	(0.011)	(0.008)	(0.012)
	GCE(O/L)	0.027**	-0.020*	0.032**	0.024**
		(0.006)	(0.008)	(0.007)	(0.009)
	GCE(A/L)	0.034**	-0.025**	0.037**	0.048**
		(0.007)	(0.010)	(0.007)	(0.012)
	Degree	-0.024**	0.040**	-0.031**	-0.028**
		(0.004)	(0.007)	(0.005)	(0.008)
Maternal emp	Not working			0.004*	
				(0.002)	
Total children		0.011**		0.015**	0.012*
		(0.004)		(0.005)	(0.006)
Head edu	No edu	-0.003**	0.004**	-0.004**	-0.003**
		(0.001)	(0.001)	(0.001)	(0.001)
	Primary	0.050**	-0.071**	0.062**	0.049**
		(0.010)	(0.016)	(0.011)	(0.016)
	Secondary	0.008**	-0.012**	0.01**	0.008**
		(0.002)	(0.003)	(0.002)	(0.003)
	GCE(A/L)	0.004**	-0.006**	0.006**	0.004**
		(0.001)	(0.003)	(0.001)	(0.002)
Ethnicity	SL Tamil		-0.017+		
			(0.01)		
	SL Moor	0.011*	0.023**		
		(0.005)	(0.007)		

Table 4-24 *ctd*.

Rural (C)		OLS	Q10	Q50	Q90
Coefficient					
Low BW				-0.029+	-0.078*
				(0.016)	(0.037)
High BW					0.008+
					(0.004)
Birth order	1st		-0.135*		
			(0.062)		
	> 2nd		0.097*		
			(0.040)		
Age	-1.039**	-1.05**		-0.699*	-3.118**
	(0.288)	(0.289)		(0.333)	(0.617)
Birth sup	Sup_HealthP				-0.727^{+}
					(0.371)
	Sup_NonHP				0.007^{+}
					(0.004)
Mother BMI		0.239^{+}			0.641*
		(0.144)			(0.287)
Maternal edu	Primary	0.029*		0.037**	
		(0.012)		(0.013)	
	Secondary	-0.278**		-0.344**	-0.306**
		(0.059)		(0.057)	(0.113)
	GCE(O/L)	-0.077**	0.083*	-0.106**	-0.091*
		(0.020)	(0.038)	(0.020)	(0.038)
	GCE(A/L)	-0.075**	0.084*	-0.092**	-0.128**
		(0.020)	(0.037)	(0.020)	(0.039)
Wealth	Q3		0.031^{+}		
			(0.018)		
	Q4		0.037^{+}		
			(0.020)		
HH Skilled	Yes		-0.158^{+}		
			(0.091)		
Substance use	Yes		0.092^{+}		
			(0.051)		
Ethnicity	Sinhala	0.329**			0.507*
		(0.085)			(0.241)
	SL Tamil	0.022**		0.016^{+}	0.037*
		(0.007)		(0.009)	(0.015)
	SL Moor	0.068**	0.058^{+}	0.044*	0.103*
		(0.016)	(0.032)	(0.024)	(0.041)
Head edu	Primary	-0.061**	0.086**	-0.074**	-0.066**
		(0.013)	(0.021)	(0.013)	(0.023)
	Secondary	0.086*		0.076*	
		(0.038)		(0.033)	
	GCE(O/L)				
	GCE(A/L)	0.032*		0.034**	
		(0.013)		(0.013)	
Toilet		0.234*			0.368*
		(0.113)			(0.188)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.
NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.). Table only contains statistically significant results. Estimates for the 'Not Supervised' category of the Birth supervision and hand hygiene variables are omitted for accuracy due to low counts.

Table 4-24: Endowment and Coefficient effects on the 2016-2006 Growth Differential (Rural) - HAZ

Rural (C)	OLS	Q10	Q50	Q90
Raw Differential	0.234**	0.115**	0.203**	0.455**
[2016-2006]	(0.029)	(0.044)	(0.031)	(0.056)
Endowment				
Maternal edu	0.019*	0.014	0.016	0.034*
	(0.009)	(0.014)	(0.010)	(0.014)
Head edu	0.058**	-0.083**	0.072**	0.057**
	(0.011)	(0.018)	(0.013)	(0.018)
Coefficient				
Maternal edu	-0.398**	0.335	-0.504**	-0.501**
	(0.089)	(0.186)	(0.084)	(0.170)
Head edu	0.074	0.118	0.058	-0.077
	(0.054)	(0.079)	(0.045)	(0.101)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.

Panel D below, presents results of the decomposition of 2016-2006 growth improvement within the estate sector. What is immediately evident is that while significant growth improvements are observed at the mean, median and upper ends of the growth curve, no significant growth improvement is observed at the lower end of the growth curve. This is particularly problematic considering that this cohort represents the most vulnerable children from a growth perspective. Endowment and coefficient effects are also not significant contributors to the growth differential at the mean, median and Q90 whilst endowment effect is marginally significant at the lower end of the growth distribution. Province effects are the only marginally significant endowment effects seen across the entire growth distribution, suggesting that the improvement in growth over time within the estate sector may be the result of changing areal effects which are largely unobserved. In contrast to endowment effects, coefficient effects show some interesting results. Child and maternal level variables show significant coefficient effects at Q10 while maternal variables showed a significant coefficient effect at the median. Facilities show a marginally significant coefficient effect at the upper end of the growth distribution. Looking at the lower end of the growth distribution, even though the growth improvement at Q10 is not significant, as noted maternal variables show a marginal coefficient effects positively contributing towards the growth improvement whilst child-level coefficient effects are observed to drive down the growth improvement. This mixed effect might be a reason for significant growth improvements not being observed at the lower end of the growth distribution. The results suggest that returns to child and maternal have largely changed over time, some increasing, while others decreased in impact. Though these structural changes have resulted in improving growth on average within the estate sector, they have not manifested into a sustainable improvement in growth among children displaying relatively poor growth within the sector. Maternal variables also show a strong positive coefficient effect at the median, suggesting an overall improvement in returns to maternal variables which positively contribute towards the improvement in median growth.

Table 4-25: OLS and Unconditional Quantile Regression Decomposition of 2016-2006 (Estate) - *HAZ*

Estate (D)	OLS	Q10	Q50	Q90
Raw Differential	0.578**	0.282	0.428**	0.783**
[2016-2006]	(0.130)	(0.177)	(0.123)	(0.240)
Endowment	0.140	0.352+	0.227	-0.180
	(0.178)	(0.197)	(0.170)	(0.259)
Coefficient	0.319	-0.221	-0.030	0.645
	(0.310)	(0.501)	(0.238)	(0.546)
Interaction	0.118	0.151	0.231	0.318
	(0.326)	(0.511)	(0.271)	(0.570)
Endowment				
Child	0.083	-0.041	0.099	0.058
	(0.051)	(0.076)	(0.063)	(0.100)
Maternal	0.011	0.177	0.032	-0.182
	(0.089)	(0.114)	(0.112)	(0.173)
HH	0.009	0.150	0.061	-0.063
	(0.082)	(0.121)	(0.100)	(0.144)
Facilities/Care	-0.007	0.019	-0.015	-0.055
	(0.058)	(0.057)	(0.049)	(0.075)
Province	0.043+	0.047+	0.050+	0.061+
	(0.023)	(0.027)	(0.028)	(0.035)

Table 4-26 ctd.

Estate (D)	OLS	Q10	Q50	Q90
Coefficient				
Child	0.019	-0.219*	0.574	-1.325
	(0.781)	(1.373)	(0.793)	(1.941)
Maternal	4.305	8.304+	6.885*	-0.051
	(3.842)	(4.572)	(3.167)	(6.676)
HH	1.046	2.267	0.605	0.545
	(1.076)	(1.534)	(0.841)	(1.599)
Facilities/Care	-0.011	1.142	0.058	-1.470+
	(0.368)	(0.739)	(0.382)	(0.862)
Province	-0.009	-0.344	-0.051	-0.410
	(0.174)	(0.236)	(0.229)	(0.570)
_cons	-5.032	-11.372*	-8.100*	3.355
	(3.741)	(5.006)	(3.503)	(6.930)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.
NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Table 4-27 below gives a detailed decomposition of the 2016-2006 growth differential within the estate sector. A number of variables show significant endowment and coefficient effects at different levels of the growth distribution. Similar to the pattern observed within the rural sector age shows a positive endowment effect at the mean, Q50 and Q90. Given that the estimated returns to age is negative, a positive endowment effect suggests that children in the 2016 sample may be slightly younger, in general than the 2006 sample, within the estate sector. The descriptive analysis showed a larger proportion of children between 0-6 months to be in the 2016 sample as opposed to the 2006 sample. These observations together could be suggesting that, similar to the rural sector, the growth improvements observed between 2006 and 2016 may be the result of the rapid growth occurring in children belonging to the younger age groups.

Maternal education also shows significant endowment and coefficient effects across most levels. A higher-level decomposition reveals that maternal education as a whole shows a significant effect only at the mean and the upper end of the growth distribution. Both the endowment and coefficient effects are negative (Mean: Endowment (-0.141*), Coefficient (-0.393*); Q90: Endowment (-0.330**), Coefficient (-0.847*)). This is in contrast with the effects observed for the rural sector, where maternal education was seen to have a positive endowment effects at the mean and Q90 (see Table 4-24). Looking across the individual levels of maternal education, endowment effects are again, mostly negative, irrespective of the level of education, as are the coefficient effects. Overall, this suggests a general improvement in both the levels of and the returns to maternal education over time, within the estate sector. This is backed by the descriptive analysis of maternal education within the estate sector which shows that, the proportion of mother with secondary education or GCE(O/L) qualification has increased over time.

Education of the HH head is another variable which shows endowment and coefficient effects across the growth distribution. Difference in the proportion of HH with non-educated HH heads, is seen to negatively contribute towards the growth improvement over time, at Q90. The descriptive analysis revealed that the proportion of HH with non-educated HH heads was 0.11 in 2016, as opposed to 0 in 2006 (number of HH heads with no education was 0 in 2006) which would drive the observed negative endowment effects. The coefficient effects of the HH head's education showed mixed effects at different education levels.

Overall, results point at a number of variables including age, maternal education and education of the HH head to be the main drivers of the growth improvement observed over time, within the estate sector.

Table 4-26: Detailed Decomposition of 2016-2006 Growth Differential (Estate) - *HAZ*

Estate (D)		OLS	Q10	Q50	Q90
Raw Differential		0.578**	0.282	0.428**	0.783**
[2016-2006]		(0.130)	(0.177)	(0.123)	(0.240)
Endowment					
Low BW		0.070*	0.055+		
		(0.034)	(0.029)		
Age		0.222*		0.274*	0.408+
		(0.099)		(0.126)	(0.212)
Maternal BMI			0.050*		
			(0.022)		
Maternal edu	No edu	-0.014*		-0.014^{+}	-0.033**
		(0.005)		(0.007)	(0.012)
	Primary	-0.056+			-0.164**
		(0.031)			(0.056)
	Secondary				0.065+
					(0.037)
	GCE(O/L)	-0.027*		-0.027^{+}	-0.066**
		(0.011)		(0.015)	(0.023)
	GCE(A/L)	-0.014*			-0.034*
		(0.007)			(0.015)
Maternal emp	Working_	0.095*	0.134**		
	Unskilled	(0.043)	(0.048)		
Head gen	Male		0.046**		
			(0.017)		
	Female		0.046**		
			(0.017)		
Head edu	No edu				-0.023*
					(0.011)

Table 4-27 *ctd.*

Estate (D)		OLS	Q10	Q50	Q90
Coefficient					
Low BW		0.370**		0.179⁺	
		(0.125)		(0.108)	
Normal BW		0.544*			1.278+
		(0.226)			(0.770)
Age					-4.819*
					(2.226)
Birth order	2nd	0.099*			
		(0.050)			
Maternal height				7.427*	
				(2.939)	
Maternal BMI		0.828+			
		(0.459)			
Maternal edu	Primary				-0.368⁺
					(0.202)
	Secondary	-0.292*		-0.293*	-0.430⁺
		(0.122)		(0.124)	(0.252)
	GCE(A/L)		0.044*		
			(0.021)		
Wealth	Q3		0.076⁺		
			(0.046)		
Skilled HH Emp	Yes				
Total children					
Head age		0.842*		0.650⁺	
		(0.419)		(0.389)	
Head edu	Primary				0.270⁺
					(0.156)
	Secondary	0.150+			0.339*
		(0.080)			(0.171)
	GCE(O/L)			-0.026⁺	
				(0.015)	
Ethnicity	SL Tamil			0.233**	
				(0.086)	
	Indian Tami			0.327+	-0.746*
				(0.187)	(0.372)

**1% *5% ⁺10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.). Table only contains statistically significant results. Estimates for the 'Not Supervised' category of the Birth supervision and hand hygiene variables are omitted for accuracy due to low counts.

4.3. Analysis of Weight and BMI of Children

This section presents results of the intra-sector analysis (mean and quantile) of the weight-for-age and BMI-for-age of children and analysis of growth differential across the two sectors (rural and estate) and time. Whilst weight-for-age is considered a more composite measure due to the influence of height on weight, the BMI-for-age gives a fair reflection of a child's weight adjusted for both height and age. Together these two measures can be used to get a reliable idea of the growth trajectory of children in the short run. It should again be noted that the BMI-for-age is used in place of weight-for-height in this analysis, owing to certain benefits of the measure as outlined in Chapter 2. Following the methodology applied for the height-for-age analysis above, the intra-sector analysis is first carried out using linear and unconditional quantile regression modelling. This is followed by the Blinder-Oaxaca decomposition analysis on both mean and quantile differentials of BMI-for-age (BMI-for-age differentials are analysed as this would provide a fair representation of changes that occur to children's short-run growth. The section draws from the findings of the descriptive and sensitivity analyses carried out in previous sections, in order to explain the patterns observed.

4.3.1. Intra-Sector Analysis

Tables 4-28 and 4-29 below provides the OLS estimates of regressions of the standardized weight-for-age (*WAZ*) and BMI-for-age (*BMIZ*) of children on the set of controls discussed Chapter 3. The models include the child-level, maternal-level, HH-level, facilities and care variables used in the height-for-age models, with the addition of two extra variables to account for fever and diarrhea. Similar to height-for-age models, age and breastfed duration were included with a quadratic term and province fixed effects are added to the models.

Table 4-27:OLS Estimation by sector and year- *WAZ*

		Rural		Estate	
		2006	2016	2006	2016
Birthweight	Normal	0.605**	0.636**	0.581**	0.39**
		(0.046)	(0.046)	(0.12)	(0.147)
	High	0.956**	1.359**	2.715*	0.048
		(0.181)	(0.157)	(1.318)	(0.538)
Birth order	2nd	-0.123*	-0.06	-0.186	0.033
		(0.047)	(0.058)	(0.167)	(0.287)
	>2nd	-0.180*	0.042	-0.107	0.005
		(0.085)	(0.107)	(0.334)	(0.547)
Gender	Female	-0.001	0.031	0.203+	0.044
		(0.032)	(0.031)	(0.11)	(0.133)
Age		-0.019**	-0.034**	-0.011	-0.035
		(0.006)	(0.006)	(0.016)	(0.021)
Age_sq		0.0002*	0.0004**	0.0002	0.0002
		(0.0001)	(0.0001)	(0.0001)	(0.0003)
Antenatal care	Yes	-0.015	-0.268	-0.107	-0.731
		(0.062)	(0.261)	(0.195)	(0.556)
Birth supervision	Supervised_ NonH person	-0.261	0.233	-0.456	0.685
		(0.224)	(0.292)	(0.277)	(0.443)
Breastfed duration		-0.014*	-0.026**	-0.025+	-0.028
		(0.006)	(0.005)	(0.015)	(0.024)
BF dur_sq		0.0002+	0.0005**	0.001*	0.0004
		(0.0001)	(0.0001)	(0.0001)	(0.0005)
Diarrhea	Yes	-0.232**	0.002	-0.145	-0.349
		(0.085)	(0.109)	(0.254)	(0.33)
Fever	Yes	-0.115**	-0.11**	0.225	-0.105
		(0.041)	(0.042)	(0.138)	(0.193)
Mother age(yr)		0.001	-0.002	0.002	-0.008
		(0.003)	(0.004)	(0.013)	(0.013)
Mother height (cm)		0.035**	0.033**	0.024*	0.032**
		(0.003)	(0.003)	(0.011)	(0.012)
Mother BMI		0.043**	0.038**	0.022+	0.05**
		(0.004)	(0.004)	(0.011)	(0.014)
Mother edu.	Primary	-0.086	-0.447*	-0.035	-0.031
		(0.125)	(0.228)	(0.343)	(0.263)
	Secondary	-0.01	-0.494*	-0.018	-0.083
		(0.123)	(0.217)	(0.317)	(0.244)
	GCE(O/L)	0.053	-0.406+		-0.15
		(0.129)	(0.22)		(0.318)
	GCE(A/L)		-0.424+		-0.064
			(0.221)		(0.317)
	Degree or above		-0.299		0.191
			(0.233)		(0.818)
	D/K			0.043	
				(0.381)	

Table 4-28 *ctd.*

		Rural		Estate	
		2006	2016	2006	2016
Mother emp.	Working_Unskilled	-0.053	-0.057	-0.144	0.116
		(0.06)	(0.074)	(0.141)	(0.174)
	Working_Skilled	-0.008	0.019	0.106	0.041
		(0.045)	(0.051)	(0.311)	(0.21)
WealthQ	Second	0.065	0.001	-0.116	0.077
		(0.05)	(0.049)	(0.136)	(0.173)
	Middle	0.037	0.069	-0.186	-0.095
		(0.057)	(0.051)	(0.19)	(0.261)
	Fourth	0.088	0.177**	0.298	0.175
		(0.059)	(0.056)	(0.261)	(0.417)
	Highest	0.146*	0.224**	0.452	1.253**
		(0.072)	(0.069)	(0.331)	(0.362)
HH emp	Skilled	0.046	-0.002	0.005	-0.057
		(0.043)	(0.037)	(0.128)	(0.152)
Total children		-0.02	-0.079+	-0.167	-0.128
		(0.026)	(0.043)	(0.126)	(0.245)
Substance use	Yes	0.028	-0.012	-0.016	0.15
		(0.034)	(0.035)	(0.118)	(0.169)
Ethnicity	SL Tamil	-0.006	0.057	0.048	0.089
		(0.102)	(0.079)	(0.202)	(0.183)
	Indian Tamil	0.19	-0.835**	0.087	0.004
		(0.169)	(0.2)	(0.184)	(0.209)
	SL Moor	0.003	0.004	0.347	-0.269
		(0.06)	(0.062)	(0.459)	(0.527)
	Malay	0.76**	-1.6**	0.879+	
		(0.246)	(0.091)	(0.456)	
	Burger	-0.142	-0.478*		-0.978
		(0.394)	(0.239)		(0.597)
	Other	-0.713**			
		(0.102)			
Head age(yr)		0.003*	0.001	-0.003	-0.005
		(0.001)	(0.001)	(0.004)	(0.006)
Head gender	Female	0.036	0.008	0.129	0.074
		(0.042)	(0.04)	(0.208)	(0.156)
Head edu	Primary		0.188*		-0.386
			(0.092)		(0.256)
	Secondary		0.163+		0.066
			(0.09)		(0.293)
	GCE(O/L)		0.171+	-0.491	-0.13
			(0.101)	(0.364)	(0.383)
	GCE(A/L)	0.140			
		(0.138)	0.258*		-0.029
			(0.108)		(0.385)
	Degree or above		0.209		0.06
			(0.152)		(0.488)
	D/K	-0.159	0.06		
		(0.154)	(0.226)		

Table 4-28 *ctd.*

		Rural		Estate	
		2006	2016	2006	2016
Toilet	Flush toilet	-0.074	0.17*	-0.158	0.034
		(0.061)	(0.083)	(0.162)	(0.248)
Improved	Yes	0.002	0.107**	-0.064	0.432*
drinking water		(0.035)	(0.034)	(0.146)	(0.21)
Hand washing	Wash after toilet use	-0.135	0.03	-0.237	-0.821*
		(0.097)	(0.096)	(0.225)	(0.362)
	Wash before cooking	0.013	-0.011	0.046	0.115
		(0.034)	(0.036)	(0.121)	(0.168)
_cons		-7.297**	-6.346**	-4.69*	-4.891*
		(0.524)	(0.586)	(1.992)	(2.101)
N		3638	5201	416	392
R-sq		0.211	0.218	0.289	0.309

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.
Base categories (in parenthesis): Birthweight(Low), Gender/Head Gen(Female), ANcare(No), Fever(No), Diarrhea(No), MotherEmp(Skilled work), WealthQ(First), Ethnicity(Sinhalese), Improved drinking water (No)
NOTES: ANcare is on the antenatal care received by mother. Breastfed duration records the total months the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. Estimates for the 'Not Supervised' category of the Birth supervision variable is omitted for accuracy due to low counts. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Table 4-28:OLS Estimation by sector and year- *BMIZ*

		Rural		Estate	
		2006	2016	2006	2016
Birthweight	Normal	0.44**	0.388**	0.362*	0.356+
		(0.05)	(0.056)	(0.181)	(0.189)
	High	0.676**	1.182**	2.353+	1.027
		(0.229)	(0.207)	(1.218)	(0.778)
Birth order	2^{nd}	-0.093+	0.02	-0.074	-0.321
		(0.055)	(0.083)	(0.263)	(0.322)
	>2nd	-0.142	0.083	0.136	-0.06
		(0.098)	(0.161)	(0.495)	(0.637)
Gender	Female	-0.015	0.026	0.252	-0.008
		(0.037)	(0.042)	(0.167)	(0.18)
Age		0.003	0.006	0.043+	0.027
		(0.007)	(0.007)	(0.025)	(0.027)
Age_sq		-0.0002+	-0.0002+	-0.001+	-0.0004
		(0.0001)	(0.0001)	(0.0004)	(0.0004)
Antenatal care	Yes	-0.042	-0.529	-0.071	-1.758**
		(0.068)	(0.392)	(0.291)	(0.454)
Birth	Supervised_	0.103	-0.003	-0.815	0.328
supervision	NonH person	(0.259)	(0.455)	(0.607)	(0.483)
Breastfed		-0.005	-0.015*	-0.007	0.023
duration		(0.007)	(0.007)	(0.025)	(0.029)
BF dur_sq		0.0001	0.0003*	0.0001	-0.001
		(0.0001)	(0.0001)	(0.001)	(0.001)
Diarrhea	Yes	-0.207*	0.084	-0.463	-0.882*
		(0.098)	(0.132)	(0.356)	(0.42)
Fever	Yes	-0.152**	-0.172**	-0.035	0.143
		(0.049)	(0.056)	(0.222)	(0.257)

Table 4-29 *ctd.*

		Rural		Estate	
		2006	2016	2006	2016
Mother age(yr)		-0.009*	-0.006	-0.006	-0.021
		(0.004)	(0.005)	(0.019)	(0.018)
Mother height (cm)		0.003	0.004	0.0005	-0.013
		(0.003)	(0.004)	(0.015)	(0.013)
Mother BMI		0.047**	0.031**	0.036+	0.036+
		(0.005)	(0.005)	(0.019)	(0.019)
Mother edu.	Primary	-0.591**	-0.424+	-0.324	-0.325
		(0.144)	(0.241)	(0.562)	(0.354)
	Secondary	-0.536**	-0.492*	-0.283	0.147
		(0.146)	(0.227)	(0.541)	(0.295)
	GCE(O/L)	-0.471**	-0.42+	-0.407	0.293
		(0.153)	(0.231)	(0.592)	(0.413)
	GCE(A/L)		-0.481*		-0.23
			(0.231)		(0.455)
	Degree or above		-0.291		-0.469
			(0.245)		(1.2)
	D/K			-0.263	
				(0.613)	
Mother emp.	Working_Unskilled	0.029	-0.017	0.223	0.255
		(0.066)	(0.098)	(0.227)	(0.226)
	Working_Skilled	0.013	-0.059	0.243	0.167
		(0.052)	(0.068)	(0.468)	(0.299)
WealthQ	Second	0.063	-0.086	-0.269	-0.172
		(0.06)	(0.064)	(0.208)	(0.239)
	Middle	0.037	-0.03	-0.384	-0.344
		(0.065)	(0.068)	(0.302)	(0.428)
	Fourth	0.085	0.091	0.189	0.52
		(0.068)	(0.074)	(0.445)	(0.494)
	Highest	0.048	0.16+	0.337	1.302*
		(0.082)	(0.09)	(0.563)	(0.521)
HH emp	Skilled	0.008	0.015	-0.077	0.016
		(0.048)	(0.049)	(0.211)	(0.216)
Total children		0.058+	-0.07	-0.081	-0.025
		(0.032)	(0.065)	(0.184)	(0.257)
Substance use	Yes	0.077*	-0.049	-0.086	-0.035
		(0.039)	(0.047)	(0.196)	(0.232)
Ethnicity	SL Tamil	0.171	0.146	0.231	0.116
		(0.113)	(0.106)	(0.343)	(0.258)
	Indian Tamil	0.425+	-0.731**	0.254	-0.048
		(0.245)	(0.262)	(0.322)	(0.276)
	SL Moor	0.205**	0.126	1.35	-0.633
		(0.072)	(0.083)	(0.85)	(0.947)
	Malay	0.539*	-1.05**	0.65	
		(0.257)	(0.159)	(1.238)	
	Burger	-0.244	-0.135		-1.118
		(0.22)	(0.141)		(0.787)
	Other	-1.161**			
		(0.113)			

Table 4-29 *ctd.*

		Rural		Estate	
		2006	2016	2006	2016
Head age(yr)		0.002	-0.001	0.0001	-0.019*
		(0.001)	(0.002)	(0.007)	(0.008)
Head gender	Female	0.065	-0.023	0.06	-0.103
		(0.047)	(0.053)	(0.285)	(0.207)
Head edu	Primary		0.197		-0.771*
			(0.144)		(0.376)
	Secondary		0.089		-0.723+
			(0.144)		(0.405)
	GCE(O/L)		0.161		-0.89
			(0.155)		(0.541)
	GCE(A/L)	-0.391*	0.173		-1.021+
		(0.162)	(0.163)		(0.541)
	Degree or above		0.09		-1.312*
			(0.206)		(0.656)
	D/K	-0.397*	0.131		
		(0.186)	(0.311)		
Toilet	Flush toilet	-0.073	0.064	-0.032	0.164
		(0.077)	(0.105)	(0.228)	(0.327)
Improved	Yes	-0.048	0.112*	-0.175	0.266
drinking water		(0.041)	(0.044)	(0.267)	(0.258)
Hand washing	Wash after toilet use	-0.136	0.001	-0.386	-0.998*
		(0.105)	(0.133)	(0.383)	(0.489)
	Wash before cooking	-0.009	0.025	-0.156	0.384+
		(0.039)	(0.048)	(0.186)	(0.224)
_cons		-1.708**	-1.309	-1.564	3.925
		(0.578)	(0.809)	(2.756)	(2.572)
N		3638	5201	416	392
R-sq		0.093	0.057	0.203	0.221

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.
Base categories (in parenthesis): Birthweight(Low), Gender/Head Gen(Female), ANcare(No), Fever(No), Diarrhea(No), MotherEmp(Skilled work), WealthQ(First), Ethnicity(Sinhalese), Improved drinking water (No)
NOTES: ANcare is on the antenatal care received by mother. Breastfed duration records the total months the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. Estimates for the 'Not Supervised' category of the Birth supervision variable is omitted for accuracy due to low counts. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve water for consumption (i.e. boil, filter etc.).

Birthweight has a significant positive effect on the standardized weight-for-age (*WAZ*) and BMI-for-age (*BMIZ*) across all models except for the effect of high birthweight in the estate sector (possibly driven by the low counts of children reporting high birthweights in the estate sector). Maternal BMI also shows a significant positive effect on *WAZ* and *BMIZ* within both sector in both time periods. In contrast, maternal height shows a significant positive effect on the weight-for-age of children across both sectors in both time periods, whilst no significant effect is detected on the BMI-for-age. This result is plausible given that BMI-for-age is a height-adjusted anthropometric measure. Overall, estimated impacts of maternal height on children's height-for-age, weight-for-age and BMI-for-age (Tables 4-11, 28 and 29), suggest that taller mothers, on average, tend to have taller children with higher weights. However, maternal height not showing a significant impact on the BMI of children suggests that the effect is more 'genetic' than driven by favourable economic conditions.

A few other variables show significant yet differential effects across the two sectors and time periods. Age and breastfeeding variables show significant effects in the weight-for-age model within the rural sector, and effects are similar to those observed in the height-for-age models. The indicator variables representing diarrhea and fever show significant negative effects on both the weight-for-age and BMI-for-age of children, which is in line with expectations. However, these effects are mostly concentrated in the rural sector in 2006 with the exception of fever, which shows a significant negative effect in 2016 as well. The results suggest that diseases such as diarrhea and fever, may be impacting the growth of rural children more which will be further explored using the Hausman test. Antenatal care shows an interesting pattern in the BMI-for-age model. Whilst not being statistically significant in all height-for-age and weight-for-age models, and much of the BMI-for-age model, access to antenatal care shows a strong and large negative effect on the BMI-for-age of children in the estate sector in 2016. However, according to the breakdown of access to antenatal care services presented in Figure 4-7, it is clear that the number of estate mothers not having access to antenatal care services within the estate sector in 2016 was considerable low (only 10 mothers recorded as not having access to antenatal care services). Therefore, the observed effect is considered spurious and does not require further investigation.

The mother's education is another variable which shows a significant effect on the weight-for-age and BMI-for-age in the rural sector. However, as opposed to the mostly positive effects seen on height-for-age, the estimated effects of maternal education on both the weight-for-age and BMI-for-age are largely negative. Significant effects are also limited to the rural sector in both models. Significant effects on BMI-for-age exist in both years and are stronger in 2006, whilst effects on weight-for-age are limited to 2016. Whilst results are at odds with the positive impact of maternal education observed in the height-for-age models, the observed negative effects may be signalling a differential effect of maternal education across the growth spectrum. This is further explored by fitting quantile regression models in section 4.3.2. below.

Education of the HH head also shows significant effects on *WAZ* and *BMIZ*. However, these effects are differential both in impact and across sectors and limited to 2016. Education of the HH head shows significant positive effects on the weight-for-age of children in the rural sector in 2016, whilst significant negative effects on the BMI-for-age are observed within the estate sector in the same year. Education of the HH head also showed positive (statistically non-significant) effects on the height-for-age of children within the rural sector in 2016. This together with the results observed in the weight-for-age models may suggest that children within the rural sector benefit more with regards to growth, from living in a household headed by a person with a relatively good educational background. In contrast the results observed for the estate sector in 2016, in the BMI-for-age model is opposite to what was observed in the height-for-age model where, the education of the HH head is seen to have a positive significant effect on the height-for-age of children within the estate sector in 2016. However, the pattern seems to be reversed in both the BMI-for-age and weight-for-age (statistically non-significant) models within the estate sector in 2016. The significant negative effect of the HH Head's education on the BMI-for-age could again be the result of the compounding of positive and negative effects across the growth distribution of children, which is further explored through the quantile regression models in the next section.

Considering HH wealth, children living in relatively wealthy HHs (fourth and fifth wealth quintiles) are seen to show, higher weight-for-age and BMI-for-age, on average, within both sectors in 2016, implying a significant wealth effect on growth, common to both sectors. Substance use in the HH shows a solitary significant effect on the BMI-for-age within the rural sector in 2006. However, contrary to the hypothesised negative relationship, the estimated effect of substance use was positive on the BMI-for-age. Given the relatively high frequency of HH reporting substance use within the rural sector in 2006 (56.3% of HH report substance use within the rural sector in 2006), the estimated effect cannot be considered spurious. The observed pattern could arise due to a few possible reasons. Given the relatively low-income levels prevalent within the rural sector, substance use in rural households might be selective and limited to relatively high-income households within the sector. This selection effect could result in the observed positive effects of substance use, especially given that the HH wealth variables did not show statistically significant effects within the rural sector in 2006. Another possible reason could be that the observed effect is the result of the compounding of positive and negative effects across the growth distribution of children. This is further explored through the quantile regression models.

Looking at the effects of facilities such as improved drinking water and toilets, both variables are seen to be significant in 2016. Access to improved drinking water is seen to have a significant positive effect on both the weight-for-age and BMI-for-age of children within the rural sector in 2016, while a significant positive effect is also seen on the weight-for-age of children in the estate sector in 2016. Flushable toilet facilities also show a significant positive effect on the weight-for-age of children within the rural sector in 2016. Differences in the estimated effects of the above variables across the two time periods and sectors will be further tested using the Hausman test. Significant effects are observed for handwashing practices after toilet use, within the estate sector. However, given the exceptionally low frequencies observed in the descriptive analysis (Figure 4-10), these estimates are considered spurious and will not be further explored.

Ethnicity also shows a significant impact on both the weight-for-age and BMI-for-age of children within the rural sector in 2016. Similar to the effects observed in height-for-age models, children from Indian Tamil or Malay ethnic backgrounds show relatively poor growth (both in weight and BMI) compared to children from the majority ethnic group within the rural sector in 2016. Whilst possible reasons for this pattern is discussed below, the patterns will also be further analysed through using quantile regressions in the next section.

Prior to the distributional analysis of short-term growth across sector and time, the Generalised Hausman test was carried out to explore some of the key differences in estimated effects, across sector and time. As noted above, the impact of diseases such as diarrhea and fever on the weight-for age of children, was seen to differentiate across the two sectors in 2016. Wealth effects were seen to be different across the two time periods in both sectors, while a few care variables also showed variations in effects across sector and time. Given these observations, the Hausman test was done to compare some of these key effects observed across sector and time. Table 4-30 and 4-31 below compare the estimated effects across the rural and estate sectors in each year, for the weight-for-age and BMI-for-age models. The positive effect of being a girl child is higher in the estate sector in both the weight-for-age and BMI-for-age models, while the positive effect of the mothers BMI on the weight-for-age is marginally higher in the rural sector. Suffering from fever had a larger negative effect in the rural sector than the estate sector, further establishing the notion that diseases like fever have a more negative effect on the weight-for-age of children within the rural sector. Looking across the sectors in 2016, the estimated effects of birthweight, belonging to the highest wealth quantile and belonging to the Indian Tamil minority ethnic group on child growth are observed to be significantly different between the two sectors. Being born with a normal and high birthweight has a higher positive effect within the rural sector.

Indian Tamil children are seen to fare significantly worse within the rural sector compared to the estate sector. This result could be due to a number of different reasons. Firstly, Indian Tamil families living within the rural sector may not have a supportive and inclusive social network that Indian Tamil families living and working within the estate sector enjoy. This is predominantly due to the origins of Indian Tamils within tea estates. The first Indian Tamils arrived in the island as indentured labourers to work in tea fields, during the British colonial period, and current Indian Tamils are descendants of those early settlers. The history and background of the Indian Tamil community in Sri Lanka will be further discussed in Essay 2. Given the historic labour structure of tea estates, majority of Indian Tamils living within the estate sector, live as close-knit communities frequently supporting each other. This support structure would not be in place for solitary families living within the rural sector. Another possible reason may be due to the type of jobs, job security, and income received by Indian Tamil families living within the rural sector. Research has shown that estate workers find it difficult to move on to off-estate work due to a number of reasons, including a certain stigma associated with being from an Indian Tamil ethnic background. This results in most estate residents being unable to find salaried employment in the non-estate sector (CEPA Sri Lanka, 2005). Qualitative data collected through midwife interviews suggest trends in family members or entire families moving away from estate employment, in search of rural employment as semi-skilled workers which pay marginally higher rates. However, living and working within the rural sector would result in significantly higher living costs, especially related rental expenses that families would have to pay, which would not be incurred by families living and working within tea estates. This could result in a drop in disposable income available in such households. The compound effect of these factors could give rise to the above result suggesting that children from an Indian Tamil ethnic background show better growth within the estate sector as opposed to the rural sector.

Some other variables showing key differences in the BMI-for-age models are birth supervision by a non-health person, which is significantly negative within the estate sector in 2006 and higher maternal and HH head education which show negative returns within the rural sector in 2006. This pattern is reversed in 2016, with primary and secondary levels of education of the HH head, showing significant negative effects within the estate sector as opposed to the rural sector.

Table 4-29: Rural-Estate difference in estimated effects within each time-period - *WAZ*

Effect	Level	2006		
		Rural	Estate	Chi2
Gender	Female	-0.001	0.203+	3.54+
Fever	Yes	-0.115**	0.225	6.25*
Mother BMI		0.043**	0.022+	3.37+
N		3638	416	
Effect	Level	2016		
		Rural	Estate	Chi2
Birthweight	Normal	0.636**	0.39**	2.92+
	High	1.359**	0.048	6.21*
Wealth	Highest	0.224**	1.253**	8.91**
Ethnicity	Indian Tamil	-0.835**	0.004	9.05**
Head Edu	Primary	0.188*	-0.386	5.03*
N		5201	392	

**1%, *5%, + 10% significance. NOTE- Generalised Hausman Specification test is run using the *suest* command. Sample weights not compatible with command. Robust standard errors are derived. Estimates derived using *suest* is approximately equal to estimates in Tables 4-27.

Table 4-30: Rural-Estate difference in estimated effects within each time-period - *BMIZ*

Effect	Level	2006		
		Rural	Estate	Chi2
Gender	Female	-0.015	0.252	4.25*
Age		0.003	0.043+	3.54+
Birth supervision	Supervised_ NonH person	0.103	-0.815	3.30+
Wealth	Second	0.063	-0.269	4.60*
	Middle	0.037	-0.384	3.29+
Ethnicity	SL Moor	0.205**	1.35	3.94*
N		3638	416	

Table 4-30 *ctd.*

Effect	Level	2016		
		Rural	Estate	Chi2
Diarrhea	Yes	0.083	-0.882*	5.48*
Mothers Edu	Secondary	-0.492*	0.147	3.22+
Wealth	Highest	0.16+	1.302*	5.33*
Ethnicity	Indian Tamil	-0.731**	-0.048	3.48+
Head Edu	Primary	0.197	-0.771*	6.44*
	Secondary	0.089	-0.723+	4.04*
	GCE(O/L)	0.161	-0.89	3.96*
	GCE(A/L)	0.173	-1.021+	5.08*
	Degree	0.09	-1.312*	4.72*
N		5201	392	

**1%, *5%, + 10% significance. NOTE- Generalised Hausman Specification test is run using the *suest* command. Sample weights not compatible with command. Robust standard errors are derived. Estimates derived using *suest* is approximately equal to estimates in Tables 4-29.

Table 4-32 and 4-33 below compares the estimated effects across 2006 and 2016 within the rural and estate sectors for the weight-for-age and BMI-for-age models. As expected, more significant differences were observed in estimated effects between 2006 and 2016 in both sectors. Estimated effects of having a high birthweight show significant time differences within the two sectors. In the rural sector, the estimated effect is higher in magnitude in 2016, while in the estate sector, surprisingly, the estimated effect is lower in magnitude in 2016. The result may be driven by the significantly low counts of children with high birthweights within the estate sector in both years. Maternal and HH head's education show some interesting patterns within the rural sector, where the estimated effects of mothers having primary, secondary or GCE (O/L) education, are notably negative and significant in 2016 within the rural sector, in both the weight-for-age and BMI-for-age models. The same levels of education for the HH head show significant positive effects in 2016 within the rural sector in the weight-for-age model. HH head's education also shows significant results in BMI-for-age models within the estate sector, where significant negative effects are observed in 2016. It is also noticeable that returns to maternal education does not seem to vary significantly over time, within the estate sector. A consistent story is with regards to the mostly negative returns to maternal and HH head's education observed within both sectors in 2016.

The negative impact of suffering from diarrhea observed in 2006 has disappeared in 2016 within the rural sector. The positive impacts of having clean drinking water has increased in magnitude in 2016 in both sectors, whilst the positive impact of access to flushable toilet facilities has increased in 2016 within the rural sector. The impact of wealth (particularly of belonging to the highest wealth quintile) on growth has also increased over time, within the estate sector. Other significant changes observed, are in line with expectations. However, it is evident that the rural sector showed more differences in estimated effects across the two years than the estate sector.

Table 4-31: 2016-2006 difference in estimated effects within each sector - *WAZ*

Effect	Level	Rural		
		2006	2016	Chi2
Birthweight	High	0.956**	1.359**	2.86+
Age		-0.019**	-0.034**	3.47+
Diarrhea	Yes	-0.232**	0.002	2.87+
Mothers Edu	Primary	-0.086	-0.447*	3.88*
	Secondary	-0.01	-0.494*	3.81+
	GCE (O/L)	0.053	-0.406+	3.28+
Ethnicity	Indian Tamil	0.19	-0.835**	15.47**
	Malay	0.76**	-1.6**	82.36**
Head Edu	Primary		0.188*	3.14+
	Secondary		0.163+	3.31+
	GCE (O/L)		0.171+	2.92+
	GCE (A/L)	0.140	0.258*	5.78*

Table 4-31 *ctd.*

Effect	Level	Rural		
		2006	2006	2006
Flush toilet	Yes	-0.074	0.17*	5.65*
Improved drinking water	Yes	0.002	0.107**	4.62*
N		3638	5201	
Effect	Level	Estate		
		2006	2016	Chi2
Birthweight	High	2.715*	0.048	3.95*
Birth supervision	Supervised_ NonH person	-0.456	0.685	5.43*
Wealth	Highest	0.452	1.253**	3.02+
Improved drinking water	Yes	-0.064	0.432*	4.28*
N		416	392	

**1%, *5%, + 10% significance. NOTE- Generalised Hausman Specification test is run using the *suest* command. Sample weights not compatible with command. Robust standard errors are derived. Estimates derived using *suest* is approximately equal to estimates in Tables 4-29.

Table 4-32: 2016-2006 difference in estimated effects within each sector - *BMIZ*

Effect	Level	Rural		
		2006	2016	Chi2
Birthweight	High	0.676**	1.182**	2.73+
Diarrhea	Yes	-0.206*	0.083	3.19+
Mothers BMI		0.047**	0.031**	5.07*
Mothers Edu	Primary	-0.591**	-0.424+	3.13+
Wealth	Second	0.063	-0.086	2.93+
Substance use	Yes	0.077*	-0.049	4.26*
Total Chi		0.058+	-0.07	3.10+
Ethnicity	Indian Tamil	0.425+	-0.731**	10.53**
	Malay	0.539*	-1.05**	28.03**
Head Edu	Primary		0.197	15.11**
Improved drinking water	Yes	-0.048	0.112*	7.15**
N		3638	5201	

Effect	Level	Estate		
		2006	2016	Chi2
Birth supervision	Supervised_ NonH person	-0.815	0.328	3.33+
Head Edu	Primary		-0.771*	4.82*
	Secondary		-0.723+	3.66+
	GCE (O/L)		-0.89	3.10+
	GCE (A/L)		-1.021+	4.10*
	Degree		-1.312*	4.60*
N		416	392	

**1%, *5%, + 10% significance. NOTE- Generalised Hausman Specification test is run using the *suest* command. Sample weights not compatible with command. Robust standard errors are derived. Estimates derived using *suest* is approximately equal to estimates in Tables 4-30.

The following section presents a distributional analysis of short-term growth of children, across the two sectors and time periods. The analysis is particularly focussed on further exploring some of the estimates reported above, particularly with regards to effects of maternal and HH head education on the weight-for-age and BMI-for-age of children, to better understand the impacts of factors that drive short-term growth within the two sectors at different points of the growth distribution.

4.3.2. Distributional Analysis of Short-Term Growth within Sectors

The following tables present the RIF quantile regression results of weight-for-age of children for 2006 and 2016 across the two sectors. Birthweight is clearly significant across the entire growth distribution in both years in the rural sector. However, the magnitudes of estimated effects are different across the distribution. The magnitude of estimated effects of having a normal birthweight is higher at the lower end of the distribution, in both years, whilst the magnitude of the effects of having a high birthweight is higher at the upper end of the growth distribution. Having a normal birthweight also showed significant positive effects on *WAZ* within the estate sector in 2006 where the magnitude of the estimated effect is larger at the lower end of the growth distribution. Age and breastfed duration show similar effects to those observed in the height-for-age models. Similar to height-for-age models, the estimated effects are considerably small. Diarrhea and fever show an interesting pattern within the rural sector, where the negative effects are seen to be larger at the upper end of the growth distribution (Q50 and Q90) in 2006 whilst fever also shows a significant negative effect at Q50 in 2016. Mothers height and BMI have significant positive effects on the weight-for-age of children in both years, within the rural sector. Magnitude of both effects increase towards the upper end of the growth distribution, in both years suggesting that the positive effects of maternal health on child growth is stronger among children displaying better growth within the rural sector. Mothers height and BMI were also selectively significant within the estate sector across the two years.

The effects of mother's education on the weight-for-age of children was of particular interest given the negative effects of maternal education observed in the rural sector in 2016. The idea was that, similar to the observed differential effects of maternal education on height-for-age in 2006, the patterns observed here could be the compound result of positive and negative effects at either ends of the growth distribution. However, the RIF estimates in Table 4-28 suggest that effects of maternal education on weight-for-age of children is consistently negative across the growth distribution within the rural sector in 2016. The negative effects observed are also statistically significant at Q90. Similar negative effects were also present in the height-for-age models (in Table 4-14) for the rural sector in 2016. In contrast, even though maternal education did not show significant effects on weight-for-age in 2006, the distributional analysis shows significant positive effects at the median (Q50).

Looking across the BMI-for-age models, maternal education again shows some interesting patterns within the rural sector. Estimated effects of maternal education on BMI-for-age is negative and significant at the median and lower ends of the growth curve, whilst the estimated effects are positive at the upper end of the distribution. This pattern is consistently seen within the rural sector in both years (positive effects at Q90 are not statistically significant in 2016). Whilst the BMI-for-age models within the estate sector do not show any consistent patterns, maternal education is seen to have marginally positive effects at the upper end of the growth distribution in 2016.

Overall, the results highlight a couple of important points. Firstly, considering the rural sector in 2006, the effects of maternal education on both the short and long-term growth of children are clearly differential across the growth distribution. Results broadly suggest that, on average, maternal education negatively impacts the growth of children at the lower end of the growth distribution while effects are positive at the upper end of the distribution in 2006. The magnitude of the positive significant effects observed at the median, in the height-for-age and weight-for-age models also tend to increase with increasing education levels whilst the magnitude of the negative effects observed in the BMI-for-age model tends to decrease with increasing education, at the median. This suggests that the impact of maternal education on child growth is relatively complex with differential effects both across the growth distribution as well as across levels of maternal education. However, these effects don't seem to carry forward to 2016 where effects of maternal education on the height-for-age, weight-for-age and BMI-for-age models are mostly negative, statistically insignificant and show no consistent patterns across the growth distribution. However, it is noticeable that the negative effects of maternal education on *WAZ* are significant at Q90, and negative effects on *BMIZ* were significant at Q10 and Q50.

Within the estate sector, similar to height-for-age models, maternal education did not show significant effects on the weight-for-age of children in both years. However, maternal education did show significant negative effects (primary and secondary education) on the BMI-for-age, at the lower end of the growth distribution in 2006. This pattern is somewhat reversed in 2016, with marginally significant positive effects on *BMIZ* of children observed at the upper end of the growth distribution. As suggested in section 4.2.2., the effects of maternal education on growth observed within the rural and estate sectors may be a direct result of mothers with higher levels of education opting to travel to urban areas far from home, for work, and the lack of care faced by children as a result of that. This would particularly be applicable to rural mothers given the higher proportions of mothers with high educational qualifications compared to estate mothers. Lack of care faced by children could lead to the overall negative effects observed especially among children showing poor growth. Developments in public transport and urbanisation of rural areas overtime, may have resulted in lesser time and distances of commute and the general improvement in living standards over time may be a reason for the non-significant effects seen in 2016.

The education of the HH head also showed negative and significant effects on the BMI-for-age of children, in the estate sector in 2016. It was hypothesised that this too, may be the compound effect of positive and negative effects across the growth distribution. However, looking across the quantile regressions, the impact of HH head's education was seen to be negative across much of the growth distribution and significant at the median and lower end of the distribution. The result suggests that having a HH head who is relatively educated tends to work as a deterrent to child growth within the estate sector in 2016. Looking across the weight-for-age models, significant positive impacts of HH head's education were observed at the lower end of the growth distribution, within the rural sector in 2016.

The reason for the negative effects observed on *BMIZ* could again be due to a lack of care received by children as a result of family members working away from the estate. With the head of the HH commuting far to work, coupled together with the female dominant labour structure within tea estates, which will result in mothers also being employed during the day, could result in a significant reduction in adult supervision of children within estates. The observed effects could be reflecting this systematic lack-of-care problem present within the estate sector. Identifying this problem, most tea plantations within the estate sector have established creches which care for the children of plantation workers, during the day. However, with limited government oversight and regulations, the effectiveness of these centres is questionable. The dynamic between maternal education, education of the HH head and maternal employment within the estate sector will be further analysed descriptively in the next chapter. Among the other HH level variables, belonging to the highest wealth quintile shows significant positive effects on the weight-for-age of rural children across the growth distribution in 2016.

Access to improved drinking water shows a positive impact on weight-for-age at Q10 and Q50 in both sectors in 2016, and the magnitude of the effects are larger at the bottom end of the growth distribution. The result is in line with expectations as children at the bottom end of the growth distribution would benefit more from access to clean drinking water. Substance use in the HH shows a negative effect on both the weight-for-ae and the BMI-for-age of children at the lower end of the growth distribution within the estate sector in 2006. The result is in line with expectations as children at the bottom end of the growth distribution would be more impacted with substance abuse of HH members. However no significant impacts are observed within the rural sector, despite the overall significant positive effect observed. The estimated effects are all positive in 2006, indicating that the overall positive effect observed in Table 4-29 is the compound effect of these statistically non-significant yet positive effects across the growth distribution. It should be noted that the direction of effects has changed from positive to negative over time, even though the estimated effects in 2016 are not statistically significant. A descriptive analysis of HH wealth against substance use within the rural sector in 2006, did not support the hypothesised relationship of higher HH wealth leading to substance use, as outlined in section 4.3.1. However, given data limitations it is not possible to further analyse this pattern to identify mechanisms through which this positive effect manifests itself.

Table 4-33: RIF Regression Estimation for the Rural sector 2006-2016 - *WAZ*

WAZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Child-level							
Birthweight	Normal	0.759**	0.606**	0.431**	0.942**	0.637**	0.432**
		(0.094)	(0.051)	(0.068)	(0.106)	(0.051)	(0.065)
	High	0.684**	1.167**	1.508**	0.819**	1.183**	1.685**
		(0.243)	(0.176)	(0.52)	(0.198)	(0.137)	(0.39)
Birth order	2nd	-0.087	-0.099+	-0.254*	0.034	-0.133+	-0.194+
		(0.072)	(0.057)	(0.099)	(0.106)	(0.07)	(0.103)
	>2nd	-0.296*	-0.128	-0.358*	0.214	-0.128	-0.26
		(0.132)	(0.1)	(0.14)	(0.199)	(0.132)	(0.178)
Gender	Female	0.064	-0.009	-0.04	-0.017	0.058	0.001
		(0.05)	(0.04)	(0.07)	(0.054)	(0.038)	(0.064)
Age		-0.009	-0.027**	-0.032*	-0.014+	-0.031**	-0.07**
		(0.009)	(0.007)	(0.013)	(0.008)	(0.007)	(0.011)
Age_sq		0.00002	0.0003**	0.0003+	0.0002	0.0003**	0.001**
		(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0)
Antenatal care	Yes	-0.036	0.039	-0.037	0.274	-0.242	0.032
		(0.098)	(0.073)	(0.116)	(0.37)	(0.218)	(0.47)
Birth supervision	Supervised_	-0.814	-0.185	-0.307*	-0.148	-0.077	1.543+
	NonH person	(0.664)	(0.274)	(0.155)	(0.443)	(0.303)	(0.884)
Breastfed duration		-0.011	-0.015+	-0.01	-0.014+	-0.022**	-0.041**
		(0.01)	(0.008)	(0.013)	(0.008)	(0.007)	(0.011)
BF dur_sq		0.0002	0.0001	0.0001	0.0002	0.0004**	0.001**
		(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0002)
Diarrhea	Yes	0.036	-0.292**	-0.327*	-0.212	0.004	0.151
		(0.13)	(0.112)	(0.157)	(0.195)	(0.122)	(0.216)
Fever	Yes	-0.015	-0.146**	-0.186*	-0.058	-0.155**	-0.114
		(0.068)	(0.051)	(0.085)	(0.078)	(0.054)	(0.084)

Table 4-33 *ctd.*

WAZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Maternal-level							
Mother age(yr)		0.007	-0.001	0.002	0.001	-0.006	-0.002
		(0.006)	(0.004)	(0.007)	(0.006)	(0.004)	(0.007)
Mother height (cm)		0.025**	0.032**	0.041**	0.031**	0.034**	0.042**
		(0.004)	(0.004)	(0.007)	(0.005)	(0.003)	(0.006)
Mother BMI		0.033**	0.049**	0.052**	0.028**	0.037**	0.053**
		(0.006)	(0.005)	(0.01)	(0.006)	(0.004)	(0.007)
Mother edu.	Primary	-0.337+	0.784**	0.253	-0.577	-0.085	-0.978*
		(0.204)	(0.164)	(0.248)	(0.479)	(0.226)	(0.448)
	Secondary	-0.342+	0.923**	0.26	-0.776+	-0.221	-0.767+
		(0.191)	(0.158)	(0.261)	(0.445)	(0.212)	(0.453)
	GCE(O/L)	-0.233	0.98**	0.358	-0.603	-0.141	-0.775+
		(0.201)	(0.168)	(0.274)	(0.447)	(0.217)	(0.462)
	GCE(A/L)				-0.592	-0.145	-0.838+
					(0.445)	(0.219)	(0.466)
	Degree or above				-0.425	-0.058	-0.89+
					(0.449)	(0.236)	(0.496)
	D/K						
Mother emp.	Working_	-0.31**	0.037	0.024	0.017	-0.045	-0.2+
	Unskilled	(0.119)	(0.076)	(0.116)	(0.125)	(0.081)	(0.12)
	Working_	-0.071	0.022	0.051	-0.073	0.103	-0.051
	Skilled	(0.068)	(0.056)	(0.101)	(0.081)	(0.063)	(0.106)
HH-level							
WealthQ	Second	0.127	0.065	0.01	0.021	0.109+	-0.086
		(0.091)	(0.066)	(0.103)	(0.101)	(0.06)	(0.085)
	Middle	-0.038	0.118+	-0.128	0.216*	0.127*	-0.011
		(0.101)	(0.07)	(0.112)	(0.1)	(0.064)	(0.097)
	Fourth	0.034	0.114	0.034	0.347**	0.217**	0.09
		(0.099)	(0.072)	(0.124)	(0.1)	(0.069)	(0.111)
	Highest	0.073	0.103	0.164	0.249*	0.207*	0.385*
		(0.109)	(0.087)	(0.157)	(0.112)	(0.083)	(0.151)

Table 4-33 *ctd.*

WAZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
HH emp	Skilled	0.121	-0.016	-0.018	0.07	-0.039	0.026
		(0.074)	(0.052)	(0.085)	(0.065)	(0.044)	(0.073)
Total children		0.03	-0.014	-0.044	-0.074	0.00001	-0.024
		(0.041)	(0.033)	(0.037)	(0.084)	(0.053)	(0.065)
Substance use	Yes	0.009	0.024	0.018	-0.021	-0.001	0.022
		(0.053)	(0.042)	(0.073)	(0.058)	(0.042)	(0.072)
Ethnicity	SL Tamil	0.071	0.085	-0.073	0.085	0.065	0.075
		(0.161)	(0.116)	(0.207)	(0.128)	(0.095)	(0.158)
	Indian Tamil	0.294	0.326	-0.384**	-1.2*	-0.671**	-0.561**
		(0.308)	(0.259)	(0.148)	(0.548)	(0.176)	(0.205)
	SL Moor	0.117	0.013	-0.13	0.018	-0.008	-0.048
		(0.093)	(0.075)	(0.129)	(0.105)	(0.077)	(0.135)
	Malay	0.771**	0.538	2.037+	0.085	-1.954**	-1.417**
		(0.236)	(0.345)	(1.236)	(0.337)	(0.142)	(0.183)
	Burger	0.181	-0.082	-0.973**	-0.628	-1.254**	-0.789**
		(0.118)	(0.585)	(0.195)	(1.103)	(0.106)	(0.207)
	Other	0.643**	-0.885**	-0.333			
		(0.166)	(0.127)	(0.208)			
Head age(yr)		0.001	0.001	0.005	0.002	0.001	0.00004
		(0.002)	(0.001)	(0.003)	(0.002)	(0.002)	(0.003)
Head gender	Female	0.018	0.099+	0.098	0.005	-0.027	-0.099
		(0.064)	(0.051)	(0.094)	(0.07)	(0.05)	(0.08)
Head edu	Primary				0.372+	0.109	0.041
					(0.204)	(0.114)	(0.176)
	Secondary				0.524**	0.1	-0.073
					(0.2)	(0.112)	(0.174)
	GCE(O/L)				0.436*	0.09	0.098
					(0.209)	(0.124)	(0.199)
	GCE(A/L)	-0.312	1.082**	0.556+	0.539*	0.19	0.295
		(0.208)	(0.174)	(0.296)	(0.215)	(0.132)	(0.221)
	Degree or above				0.305	0.071	0.4
					(0.253)	(0.177)	(0.336)
	D/K	-0.302	0.622**	0.172	0.212	-0.207	0.587
		(0.277)	(0.2)	(0.286)	(0.468)	(0.249)	(0.527)

Table 4-33 *ctd.*

WAZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Care/Facilities							
Toilet	Flush toilet	0.056	-0.082	-0.061	-0.107	0.145	0.142
		(0.114)	(0.075)	(0.118)	(0.156)	(0.097)	(0.143)
Improved drinking water	Yes	0.01	0.074+	-0.042	0.113+	0.111**	0.039
		(0.057)	(0.043)	(0.078)	(0.06)	(0.042)	(0.069)
Hand washing	Wash after toilet use	-0.084	-0.148	-0.092	0.341+	0.034	-0.353+
		(0.154)	(0.111)	(0.186)	(0.195)	(0.106)	(0.185)
	Wash before cooking	0.017	0.022	0.007	-0.054	-0.035	0.069
		(0.054)	(0.043)	(0.074)	(0.065)	(0.046)	(0.076)
_cons		-7.194**	-7.727**	-6.793**	-8.8**	-6.805**	-5.141**
		(0.763)	(0.627)	(1.228)	(0.984)	(0.643)	(1.119)
Sample mean		-2.476	-1.285	0.085	-2.412	-1.106	0.401
R-sq		0.086	0.167	0.080	0.092	0.155	0.118
N		3638			5201		

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.

Base categories (in parenthesis): Birthweight(Low), Gender/Head Gen(Female), ANcare(No), Fever(No), Diarrhea(No), MotherEmp(Skilled work), WealthQ(First), Ethnicity(Sinhalese), Improved drinking water (No)

NOTES: ANcare is on the antenatal care received by mother. Breastfed duration records the total months the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. Estimates for the 'Not Supervised' category of the Birth supervision variable is omitted for accuracy due to low counts. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Table 4-34: RIF Regression Estimation for Estate sector 2006-2016 - *WAZ*

WAZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Child-level							
Birthweight	Normal	0.787**	0.587**	0.394+	0.359	0.491**	0.276
		(0.287)	(0.148)	(0.201)	(0.243)	(0.169)	(0.323)
	High	0.801	1.455*	3.6	0.335	-0.619	-0.635
		(0.617)	(0.593)	(2.773)	(0.801)	(0.667)	(1.086)
Birth order	2^{nd}	0.308	-0.287	-0.114	-0.034	0.015	0.349
		(0.435)	(0.211)	(0.252)	(0.407)	(0.286)	(0.564)
	>2nd	1.205	-0.084	-0.062	0.088	0.105	1.074
		(0.865)	(0.403)	(0.479)	(0.774)	(0.565)	(1.148)
Gender	Female	0.229	0.269+	0.328	0.118	0.136	0.401
		(0.239)	(0.141)	(0.2)	(0.176)	(0.151)	(0.298)
Age		0.036	-0.004	-0.06+	0.013	-0.04*	-0.137**
		(0.032)	(0.021)	(0.031)	(0.037)	(0.019)	(0.048)
Age_sq		-0.001+	-0.0002	0.001+	-0.0005	0.0005	0.002**
		(0.0005)	(0.0003)	(0.0004)	(0.001)	(0.0003)	(0.001)
Antenatal care	Yes	-0.989*	-0.249	0.062	0.903	-0.204	-2.192+
		(0.472)	(0.232)	(0.281)	(0.946)	(0.382)	(1.276)
Birth supervision	Supervised_	0.618	-0.924*	-0.754+	0.471	1.289**	-1.175+
	NonH person	(0.814)	(0.404)	(0.404)	(0.474)	(0.394)	(0.67)
Breastfed duration		-0.113**	-0.014	0.009	-0.018	0.004	-0.032
		(0.03)	(0.021)	(0.026)	(0.039)	(0.023)	(0.052)
BF dur_sq		0.002**	0.0004	0.0001	0.001	-0.0003	0
		(0.001)	(0.0005)	(0.001)	(0.001)	(0.0005)	(0.001)
Diarrhea	Yes	-0.421	-0.235	0.251	-0.155	-0.587+	0.234
		(0.487)	(0.317)	(0.516)	(0.632)	(0.331)	(0.86)
Fever	Yes	0.721**	-0.048	0.05	-0.726*	-0.145	0.346
		(0.248)	(0.175)	(0.293)	(0.352)	(0.217)	(0.471)
Maternal-level							
Mother age(yr)		-0.011	0.017	-0.015	0.021	-0.025	-0.039
		(0.029)	(0.017)	(0.022)	(0.021)	(0.016)	(0.024)
Mother height		0.072**	0.03*	-0.002	0.028	0.056**	0.024
(cm)		(0.021)	(0.013)	(0.019)	(0.018)	(0.013)	(0.024)
Mother BMI		0.042*	0.009	0.021	0.031	0.053**	0.082*
		(0.017)	(0.015)	(0.019)	(0.02)	(0.019)	(0.04)

Table 4-34 *ctd.*

WAZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Mother edu.	Primary	-0.711	0.018	0.13	0.14	-0.003	-0.16
		(0.517)	(0.434)	(0.777)	(0.565)	(0.338)	(0.659)
	Secondary	-0.244	-0.18	-0.235	0.528	-0.052	-0.323
		(0.453)	(0.418)	(0.721)	(0.567)	(0.319)	(0.571)
	GCE(O/L)				0.463	-0.25	-0.578
					(0.631)	(0.378)	(0.683)
	GCE(A/L)				0.179	-0.114	0.191
					(0.639)	(0.423)	(0.895)
	Degree or above				-0.709	3.234**	0.454
					(1.363)	(0.907)	(1.629)
	D/K	-0.181	-0.043	0.395			
		(0.619)	(0.479)	(0.87)			
Mother emp.	Working_	-0.057	-0.155	-0.298	0.175	0.03	0.005
	Unskilled	(0.262)	(0.192)	(0.268)	(0.216)	(0.185)	(0.414)
	Working_	-0.543	0.127	0.885	-0.095	0.069	-0.434
	Skilled	(0.614)	(0.378)	(0.67)	(0.321)	(0.222)	(0.426)
HH-level							
WealthQ	Second	0.131	-0.186	-0.328	0.176	0.028	0.048
		(0.294)	(0.169)	(0.238)	(0.242)	(0.19)	(0.369)
	Middle	0.007	-0.186	-0.149	0.18	-0.115	0.22
		(0.412)	(0.242)	(0.366)	(0.364)	(0.327)	(0.791)
	Fourth	0.436	-0.134	0.18	-0.564	-0.312	2.544*
		(0.394)	(0.366)	(0.599)	(0.574)	(0.426)	(1.278)
	Highest	0.22	0.629+	0.917	0.46	1.057**	-0.513
		(0.471)	(0.359)	(0.941)	(0.471)	(0.397)	(0.927)
HH emp	Skilled	0.139	0.052	-0.292	-0.267	-0.08	0.1
		(0.261)	(0.173)	(0.24)	(0.195)	(0.176)	(0.344)
Total children		-0.554	-0.147	-0.225	-0.134	-0.093	-0.394
		(0.349)	(0.151)	(0.144)	(0.321)	(0.223)	(0.457)
Substance use	Yes	-0.479+	0.141	0.207	0.162	-0.049	0.207
		(0.248)	(0.162)	(0.212)	(0.231)	(0.179)	(0.338)

Table 4-34 *ctd*.

WAZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Ethnicity	SL Tamil	0.297	0.021	0.251	0.477+	0.245	
		(0.392)	(0.297)	(0.423)	(0.276)	(0.241)	0.026 (0.5)
	Indian Tamil	0.14	0.053	0.265	0.202	0.312	-0.363
		(0.39)	(0.263)	(0.397)	(0.35)	(0.248)	(0.481)
	SL Moor	0.394	1.05+	-0.902	0.243	-0.471	-1.255+
		(0.726)	(0.626)	(0.891)	(0.395)	(0.915)	(0.703)
	Malay	3.502**	0.655	-0.894			
		(0.855)	(1.063)	(0.775)			
	Burger				-1.804	-0.916*	-0.851
					(1.227)	(0.424)	(1.058)
	Other						
Head age (yr)		0.001	-0.002	-0.008	-0.016+	-0.002	0.001
		(0.009)	(0.005)	(0.009)	(0.009)	(0.006)	(0.013)
Head gender	Female	0.297	0.003	0.316	0.076	0.01	-0.001
		(0.361)	(0.244)	(0.352)	(0.237)	(0.175)	(0.319)
Head edu	Primary				-0.295	0.06	-0.552
					(0.35)	(0.241)	(0.57)
	Secondary				-0.017	0.238	-0.452
					(0.372)	(0.272)	(0.659)
	GCE(O/L)	-0.413	-0.721	-0.472	-0.204	-0.057	-0.953
		(0.531)	(0.484)	(0.796)	(0.492)	(0.383)	(0.819)
	GCE(A/L)				0.524	0.254	-1.832*
					(0.452)	(0.432)	(0.874)
	Degree or above				-0.032	-0.996+	-0.331
					(0.665)	(0.557)	(1.167)
	D/K						

Table 4-34 *ctd.*

WAZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Care/Facilities							
Toilet	Flush toilet	-0.146	-0.117	0.226	-0.504*	0.347	0.392
		(0.325)	(0.2)	(0.276)	(0.211)	(0.382)	(0.462)
Improved	Yes	-0.324	0.038	-0.002	0.806*	0.416*	-0.033
drinking water		(0.299)	(0.21)	(0.269)	(0.319)	(0.176)	(0.434)
Hand washing	Wash after toilet	0.134	0.1	-0.359	-0.524	-0.414	-1.348*
	use	(0.475)	(0.299)	(0.562)	(0.371)	(0.29)	(0.649)
	Wash before	0.082	-0.059	-0.191	-0.085	0.273	0.496
	cooking	(0.251)	(0.153)	(0.233)	(0.248)	(0.178)	(0.31)
_cons		-12.371**	-6.363*	1.164	-8.86*	-10.344**	1.321
		(3.883)	(2.497)	(3.371)	(3.444)	(2.211)	(4.525)
Sample mean		-2.988	-1.449	-0.082	-2.668	-1.419	0.250
R-sq		0.251	0.190	0.138	0.216	0.270	0.255
N		416			392		

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.

Base categories (in parenthesis): Birthweight(Low), Gender/Head Gen(Female), ANcare(No), Fever(No), Diarrhea(No), MotherEmp(Skilled work), WealthQ(First), Ethnicity(Sinhalese), Improved drinking water (No)

NOTES: ANcare is on the antenatal care received by mother. Breastfed duration records the total months the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. Estimates for the 'Not Supervised' category of the Birth supervision variable is omitted for accuracy due to low counts. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Table 4-35: RIF Regression Estimation for the Rural sector 2006-2016 - *BMIZ*

BMIZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Child-level							
Birthweight	Normal	0.731**	0.406**	0.371**	0.558**	0.302**	0.307**
		(0.105)	(0.057)	(0.07)	(0.108)	(0.057)	(0.09)
	High	0.623*	0.672**	1.094*	0.837**	0.723**	1.51**
		(0.308)	(0.223)	(0.458)	(0.184)	(0.164)	(0.43)
Birth order	2^{nd}	-0.052	-0.032	-0.227*	0.065	0.015	-0.259+
		(0.081)	(0.066)	(0.107)	(0.133)	(0.077)	(0.15)
	>2nd	-0.336*	-0.068	-0.232	0.268	0.08	-0.211
		(0.146)	(0.119)	(0.19)	(0.257)	(0.145)	(0.289)
Gender	Female	0.076	-0.022	-0.023	0.037	-0.036	0.012
		(0.059)	(0.043)	(0.066)	(0.062)	(0.041)	(0.075)
Age		0.008	-0.001	-0.016	0.031**	0.001	-0.019
		(0.012)	(0.008)	(0.012)	(0.01)	(0.007)	(0.013)
Age_sq		-0.0002	-0.0001	0.0001	-0.0004**	-0.0001	0.0001
		(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0002)
Antenatal care	Yes	-0.014	-0.024	-0.072	-0.267	-0.027	-0.317
		(0.113)	(0.082)	(0.126)	(0.359)	(0.28)	(0.507)
Birth supervision	Supervised_	-0.041	0.037	0.128	-1.227	-0.18	1.211
	NonH person	(0.5)	(0.328)	(0.483)	(0.899)	(0.373)	(0.98)
Breastfed duration		-0.005	-0.002	0.0001	-0.017+	0.0005	-0.022+
		(0.012)	(0.008)	(0.012)	(0.01)	(0.007)	(0.013)
BF dur_sq		0.0002	0.00001	-0.00004	0.0004*	0.00001	0.0004
		(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0002)
Diarrhea	Yes	-0.087	-0.195+	-0.107	0.038	-0.038	0.155
		(0.175)	(0.116)	(0.178)	(0.19)	(0.126)	(0.239)
Fever	Yes	-0.179*	-0.162**	-0.182*	-0.09	-0.272**	-0.098
		(0.083)	(0.055)	(0.081)	(0.089)	(0.057)	(0.099)
Maternal-level							
Mother age(yr)		-0.002	-0.014**	-0.002	-0.015*	-0.008+	0.001
		(0.006)	(0.005)	(0.007)	(0.007)	(0.005)	(0.008)
Mother height		-0.002	0.006	0.011	0.004	0.002	-0.0003
(cm)		(0.005)	(0.004)	(0.007)	(0.005)	(0.003)	(0.007)
Mother BMI		0.037**	0.046**	0.048**	0.027**	0.029**	0.049**
		(0.007)	(0.005)	(0.01)	(0.007)	(0.005)	(0.009)

Table 4-35 *ctd.*

BMIZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Mother edu.	Primary	-0.568*	-1.399**	0.915**	-0.663	-0.493+	0.296
		(0.24)	(0.174)	(0.268)	(0.448)	(0.289)	(0.352)
	Secondary	-0.526*	-1.361**	0.98**	-0.737+	-0.623*	0.225
		(0.237)	(0.167)	(0.275)	(0.412)	(0.273)	(0.328)
	GCE(O/L)	-0.361	-1.305**	0.87**	-0.711+	-0.612*	0.38
		(0.253)	(0.177)	(0.287)	(0.417)	(0.278)	(0.343)
	GCE(A/L)				-0.752+	-0.701*	0.181
					(0.418)	(0.279)	(0.351)
	Degree or above				-0.519	-0.531+	0.347
					(0.426)	(0.294)	(0.404)
	D/K						
Mother emp.	Working_	0.194+	-0.004	0.028	0.039	0.218*	-0.132
	Unskilled	(0.1)	(0.081)	(0.116)	(0.134)	(0.088)	(0.149)
	Working_	0.079	-0.042	-0.055	0.038	0.056	-0.077
	Skilled	(0.079)	(0.06)	(0.089)	(0.091)	(0.068)	(0.121)
HH-level							
WealthQ	Second	0.063	-0.001	0.041	-0.09	-0.018	0.105
		(0.099)	(0.072)	(0.101)	(0.106)	(0.066)	(0.107)
	Middle	-0.034	0.054	0.067	-0.003	0.014	0.136
		(0.107)	(0.077)	(0.115)	(0.108)	(0.069)	(0.115)
	Fourth	-0.004	0.055	0.2	0.123	0.119	0.183
		(0.107)	(0.078)	(0.121)	(0.11)	(0.074)	(0.128)
	Highest	-0.008	-0.067	0.17	0.24+	0.213*	0.41*
		(0.122)	(0.095)	(0.142)	(0.128)	(0.09)	(0.174)
HH emp	Skilled	0.112	0.013	-0.006	-0.014	0.016	-0.07
		(0.085)	(0.056)	(0.085)	(0.075)	(0.048)	(0.087)
Total children		0.097*	0.041	0.056	-0.119	-0.057	-0.016
		(0.044)	(0.041)	(0.066)	(0.108)	(0.058)	(0.118)
Substance use	Yes	0.073	0.053	0.014	0.022	-0.006	-0.067
		(0.063)	(0.045)	(0.07)	(0.068)	(0.046)	(0.085)

Table 4-35 *ctd.*

BMIZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Ethnicity	SL Tamil	0.343+	0.181	0.147	0.161	0.147	0.225
		(0.176)	(0.127)	(0.212)	(0.146)	(0.103)	(0.2)
	Indian Tamil	0.278	0.417	0.449	-0.718	-0.317	-0.7**
		(0.291)	(0.267)	(0.45)	(0.606)	(0.296)	(0.149)
	SL Moor	0.451**	0.191*	0.256+	0.157	0.157+	0.143
		(0.104)	(0.079)	(0.133)	(0.109)	(0.084)	(0.171)
	Malay	0.992**	0.27	0.612	0.376*	-1.718**	-1.305**
		(0.223)	(0.404)	(0.969)	(0.148)	(0.111)	(0.196)
	Burger	0.357*	-0.042	-0.834**	0.573**	-0.275	-0.588**
		(0.164)	(0.606)	(0.137)	(0.145)	(0.848)	(0.188)
	Other	0.543**	-1.235**	-0.25			
		(0.185)	(0.137)	(0.202)			
Head age(yr)		-0.002	0.002	0.004	0.001	0.0005	-0.007*
		(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
Head gender	Female	0.012	0.074	0.112	-0.018	0.037	-0.132
		(0.079)	(0.056)	(0.088)	(0.08)	(0.053)	(0.091)
Head edu	Primary				0.125	0.363**	-0.101
					(0.215)	(0.129)	(0.224)
	Secondary				0.238	0.331**	-0.322
					(0.211)	(0.127)	(0.22)
	GCE(O/L)				0.195	0.397**	-0.298
					(0.229)	(0.139)	(0.243)
	GCE(A/L)	-0.37	-1.198**	1.086**	0.315	0.493**	-0.023
		(0.254)	(0.183)	(0.303)	(0.238)	(0.148)	(0.271)
	Degree or above				-0.165	0.231	-0.165
					(0.32)	(0.196)	(0.385)
	D/K		-1.23**				
		-0.179	(0.22)	0.927**	0.371	0.51+	-0.282
		(0.281)		(0.325)	(0.454)	(0.28)	(0.474)

Table 4-35 ctd.

BMIZ		Rural					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Care/Facilities							
Toilet	Flush toilet	-0.128	-0.153+	-0.131	0.074	-0.015	-0.023
		(0.117)	(0.084)	(0.124)	(0.164)	(0.104)	(0.182)
Improved drinking water	Yes	-0.022	-0.02	-0.087	0.085	-0.0003	0.158*
		(0.065)	(0.047)	(0.074)	(0.068)	(0.045)	(0.081)
Hand washing	Wash after toilet use	-0.262+	-0.131	-0.282	0.254	-0.006	-0.244
		(0.14)	(0.127)	(0.212)	(0.211)	(0.12)	(0.223)
	Wash before cooking	-0.07	0.006	-0.01	-0.067	0.026	0.059
		(0.064)	(0.046)	(0.069)	(0.072)	(0.05)	(0.089)
_cons		-2.437**	-0.937	-2.772*	-3.407**	-1.488*	0.873
		(0.859)	(0.661)	(1.129)	(1.018)	(0.682)	(1.243)
Sample mean		-2.184	-0.918	0.441	-2.261	-0.846	0.788
R-sq		0.054	0.075	0.045	0.035	0.055	0.047
N		3638			5201		

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.

Base categories (in parenthesis): Birthweight(Low), Gender/Head Gen(Female), ANcare(No), Fever(No), Diarrhea(No), MotherEmp(Skilled work), WealthQ(First), Ethnicity(Sinhalese), Improved drinking water (No)

NOTES: ANcare is on the antenatal care received by mother. Breastfed duration records the total months the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. Estimates for the 'Not Supervised' category of the Birth supervision variable is omitted for accuracy due to low counts. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Table 4-36: RIF Regression Estimation for Estate sector 2006-2016 - *BMIZ*

BMIZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Child-level							
Birthweight	Normal	0.514+	0.26	0.35	0.657*	0.152	-0.051
		(0.263)	(0.172)	(0.298)	(0.334)	(0.177)	(0.297)
	High	1.49+		4.451	2.155+	2.23**	-0.257
		(0.823)	0.235 (1.3)	(3.605)	(1.147)	(0.801)	(1.072)
Birth order	2nd	0.715	-0.636*	-0.261	-0.772	-0.696*	-0.186
		(0.444)	(0.268)	(0.409)	(0.477)	(0.334)	(0.539)
	>2nd		-0.95+	-0.04	-0.703	-0.897	0.108
		1.4 (0.895)	(0.532)	(0.828)	(0.915)	(0.65)	(1.091)
Gender	Female	0.514*	-0.034	0.658*	-0.584*	0.023	0.071
		(0.243)	(0.165)	(0.257)	(0.284)	(0.172)	(0.292)
Age		0.081*	0.03	0.012	0.099*	0.064*	-0.051
		(0.04)	(0.024)	(0.04)	(0.045)	(0.024)	(0.033)
Age_sq		-0.001*	-0.001	-0.0004	-0.002*	-0.001**	0.001
		(0.001)	(0.0004)	(0.001)	(0.001)	(0)	(0.001)
Antenatal care	Yes	-0.519	0.383	-0.022	-1.13*	-1.257**	-2.9*
		(0.465)	(0.294)	(0.421)	(0.504)	(0.346)	(1.334)
Birth supervision	Supervised_	-0.349	-0.555	-0.64+	1.163+	0.593	-0.939+
	NonH person	(0.922)	(0.598)	(0.353)	(0.621)	(0.824)	(0.499)
Breastfed duration		-0.055	0.015	-0.01	-0.021	-0.012	0.081*
		(0.033)	(0.023)	(0.036)	(0.049)	(0.027)	(0.038)
BF dur_sq		0.001	-0.0004	0.0003	0.001	-0.0001	-0.002*
		(0.001)	(0.0005)	(0.001)	(0.001)	(0.001)	(0.001)
Diarrhea	Yes	-0.759	-0.629+	0.062	-2.168*	-0.308	-0.913*
		(0.628)	(0.339)	(0.511)	(1.046)	(0.368)	(0.402)
Fever	Yes	0.49+	-0.17	-0.394	0.314	0.117	0.083
		(0.25)	(0.211)	(0.307)	(0.401)	(0.294)	(0.476)
Maternal-level							
Mother age(yr)		-0.026	-0.007	0.018	0.002	-0.014	-0.079*
		(0.033)	(0.019)	(0.034)	(0.03)	(0.018)	(0.031)
Mother height (cm)		0.008	0.017	-0.021	0.004	-0.008	-0.033
		(0.018)	(0.014)	(0.023)	(0.02)	(0.015)	(0.022)
Mother BMI		0.062**	0.034	0.014	-0.027	0.045*	0.081*
		(0.02)	(0.021)	(0.023)	(0.034)	(0.019)	(0.031)

Table 4-36 *ctd.*

		Estate					
BMIZ		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Mother edu.	Primary	-2.168**	0.025	1.092	-0.663	-0.36	0.712
		(0.717)	(0.529)	(0.699)	(0.448)	(0.505)	(0.459)
	Secondary	-1.523*	-0.023	1.097	-0.188	-0.056	0.781+
		(0.693)	(0.509)	(0.666)	(0.377)	(0.482)	(0.429)
	GCE(O/L)				0.471	0.153	0.766
					(0.557)	(0.528)	(0.524)
	GCE(A/L)				-0.742	-0.338	1.019
					(0.677)	(0.576)	(0.635)
	Degree or				-1.975	-1.319	2.545+
	above				(2.12)	(1.127)	(1.444)
	D/K	-1.203	-0.022	1.171			
		(0.739)	(0.585)	(0.865)			
Mother emp.	Working_	0.163	0.413+	0.157	-0.154		0.063
	Unskilled	(0.32)	(0.218)	(0.295)	(0.29)	0.35 (0.22)	(0.354)
	Working_	-1.38+	0.29	1.253	-0.206	-0.091	0.358
	Skilled	(0.811)	(0.419)	(0.76)	(0.435)	(0.266)	(0.457)
HH-level							
WealthQ	Second	-0.168	-0.214	-0.53	-0.509	-0.027	-0.275
		(0.269)	(0.194)	(0.325)	(0.442)	(0.21)	(0.331)
	Middle	-0.775+	-0.289	-0.579	-0.146	-0.881*	-0.772+
		(0.445)	(0.273)	(0.429)	(0.918)	(0.363)	(0.436)
	Fourth	-0.044	0.42	-0.283	0.224	0.794	0.301
		(0.444)	(0.371)	(0.828)	(0.826)	(0.515)	(1.007)
	Highest	-0.769	0.321	0.704	1.44*	1.9**	-0.954
		(0.758)	(0.518)	(1.114)	(0.732)	(0.566)	(0.879)
HH emp	Skilled	0.001	-0.078	0.234	0.059	0.287	0.016
		(0.286)	(0.204)	(0.367)	(0.329)	(0.219)	(0.271)
Total children		-0.378	0.202	-0.058	0.066	0.296	0.141
		(0.34)	(0.208)	(0.29)	(0.354)	(0.27)	(0.438)
Substance use	Yes	-0.456+	0.028	0.232	-0.448	-0.212	-0.016
		(0.253)	(0.181)	(0.265)	(0.354)	(0.218)	(0.379)

Table 4-36 *ctd.*

BMIZ		Estate					
		2006			2016		
		Q10	Q50	Q90	Q10	Q50	Q90
Ethnicity	SL Tamil	0.162	0.045	0.627		0.105	0.116
		(0.441)	(0.339)	(0.515)	0.613 (0.5)	(0.274)	(0.332)
	Indian Tamil		0.064	0.612	0.581	0.226	-0.088
		0.1 (0.452)	(0.304)	(0.471)	(0.554)	(0.293)	(0.38)
	SL Moor	0.121	1.385+	3.298	-1.088	-0.439	0.411
		(0.727)	(0.714)	(2.154)	(1.707)	(0.72)	(1.079)
	Malay	0.726	0.765	-0.454			
		(0.688)	(1.24)	(0.929)			
	Burger				-2.932*	0.538	-1.043
					(1.43)	(0.674)	(0.634)
	Other						
Head age (yr)		-0.01	0.005	-0.015	-0.026+	-0.012+	-0.016
		(0.01)	(0.006)	(0.011)	(0.014)	(0.007)	(0.011)
Head gender	Female	-0.319	0.044	0.629	-0.293	-0.046	
		(0.466)	(0.292)	(0.489)	(0.353)	(0.205)	0.5 (0.401)
Head edu	Primary				-1.006+	-0.336	-0.462
					(0.584)	(0.306)	(0.495)
	Secondary					-0.259	-0.661
						(0.342)	(0.595)
	GCE(O/L)	-1.71*	-0.517	0.993	-1.816*	-0.806+	0.177
		(0.864)	(0.581)	(0.705)	(0.897)	(0.446)	(0.889)
	GCE(A/L)				-0.738	-0.962+	-1.248
					(0.909)	(0.552)	(0.766)
	Degree or				-1.107	-1.825**	-0.075
	above				(0.977)	(0.644)	(0.994)
	D/K						

Table 4-36 *ctd.*

BMIZ		Estate 2006 Q10	Q50	Q90	2016 Q10	Q50	Q90
Care/Facilities							
Toilet	Flush toilet	0.349	-0.074	0.416	-0.316	0.677	0.382
		(0.321)	(0.232)	(0.357)	(0.301)	(2.637)	(0.545)
Improved drinking water	Yes	-0.47	-0.145	-0.166	0.442	0.677	-0.125
		(0.327)	(0.257)	(0.315)	(0.429)	(2.637)	(0.401)
Hand washing	Wash after toilet use	-0.447	-0.238	0.165	-0.502	0.677	-0.827
		(0.317)	(0.323)	(0.633)	(0.358)	(2.637)	(0.612)
	Wash before cooking	0.048	-0.148	-0.161	0.183	0.677	0.213
		(0.259)	(0.184)	(0.317)	(0.316)	(2.637)	(0.276)
_cons		-1.087	-5.176*	0.867	-0.706	0.677	10.183*
		(3.536)	(2.621)	(3.702)	(3.766)	(2.637)	(4.321)
Sample mean		-2.173	-0.570	1.057	-2.330	-0.788	0.975
R-sq		0.164	0.155	0.140	0.269	0.199	0.197
N		416			392		

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used.

Base categories (in parenthesis): Birthweight(Low), Gender/Head Gen(Female), ANcare(No), Fever(No), Diarrhea(No), MotherEmp(Skilled work), WealthQ(First), Ethnicity(Sinhalese), Improved drinking water (No)

NOTES: ANcare is on the antenatal care received by mother. Breastfed duration records the total months the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. Estimates for the 'Not Supervised' category of the Birth supervision variable is omitted for accuracy due to low counts. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Overall results presented in this section suggest some heterogeneity in the effects of short-term growth determinants between the two sectors and across time. This justifies the need to carry out a more detailed analysis into what contributes to the rural-estate gap in short-term growth in each time period as well as well as the growth gap over time within each sector. This is again done through a detailed decomposition analysis. Given that the BMI-for-age is a measure of children's weights adjusted for height, this measure is better placed in reflecting a child's short-term growth. Therefore, the decomposition analysis below will specifically focus on the BMI-for-age measure.

4.3.3. Differentials in Short-Term Growth across Sector and Time

This section explores the short-term growth differentials across sector and time, in order to identify factors that drive differentials in short-term growth. As noted earlier, given that the BMI-for-age is a better measure of the variations in child weight, adjusted for their height, this analysis particularly focuses on modelling the differentials in BMI-for-age between the two sectors in each time period, and the two time periods in each sector. The descriptive analysis indicated statistically significant differences in average BMI-for-age across time as well as sectors. Differences were also observed across the quantiles, suggesting that rural-estate differences varied at different points of the BMI-for-age distribution. Apart from this, significant sector and time differences in control variables were also observed in the descriptive analysis. The OLS and RIF regression results highlight key child, maternal, HH and care variables which impact BMI-for-age of children within each sector and time period while the Generalised Hausman tests reveal significant differences in some of the estimated effects. These results together with the differences in the levels of controls observed in the descriptive analysis, support a decomposition analysis which would enable the identification of the key sources that drive short-term growth differential between the two sectors and the two time periods. Following the methods adapted in analysing long-term growth differentials, a detailed decomposition analysis is carried out, on the mean and quantile differentials of BMI-for-age, using the Blinder-Oaxaca decomposition technique.

a) Rural-Estate BMI-for-Age Differentials

Panel A and B in Table 4-38 and Table 4-40 present the mean and quantile rural-estate BMI-for-age differential in 2006 and 2016 respectively. Each table is followed by a table presenting the detailed decomposition of differentials in each year (Table 4-39 and Table-41). Looking across the results, it is immediately evident that unlike the height-for-age differentials presented in Table 4-16, the BMI-for-age differentials are negative both at the mean and across the quantiles, in 2006. This suggests that the mean and quantile BMI-for-age was higher in the estate sector than the rural sector in 2006. The mean differential was -0.35 standardized units in 2006. Looking across the growth distribution, the rural-estate gap was not significant at the lower end of the distribution, but clearly widened across the distribution resulting in a large and significant gap at Q90. This suggests a gradual increase in the gap across the growth distribution, which again is in contrast with what was observed for the height-for-age differential. The pattern suggests that on average estate children show better BMI-for-age than rural children, and the gap is more pronounced among children showing better growth.

Table 4-37: OLS and Unconditional Quantile Regression Decomposition of Rural-Estate Growth Differential (2006) - *BMIZ*

2006 (A)	OLS	Q10	Q50	Q90
Raw Differential	-0.35**	-0.011	-0.347**	-0.617**
[Rural-Estate]	(0.072)	(0.122)	(0.087)	(0.140)
Endowment	-0.319+	-0.073	-0.319	-0.366
	(0.182)	(0.328)	(0.249)	(0.359)
Coefficient	-0.175	0.113	-0.143	-0.513+
	(0.164)	(0.214)	(0.183)	(0.305)
Interaction	0.144	-0.051	0.115	0.263
	(0.234)	(0.372)	(0.297)	(0.450)
Endowment				
Child	0.063	-0.049	0.119+	0.106
	(0.053)	(0.099)	(0.065)	(0.096)
Maternal	0.045	0.286	-0.118	-0.137
	(0.130)	(0.218)	(0.164)	(0.238)
HH	-0.032	-0.329	0.092	0.145
	(0.196)	(0.420)	(0.258)	(0.377)
Facilities/Care	0.011	0.119	0.004	0.085
	(0.043)	(0.075)	(0.059)	(0.081)
Province	-0.406**	-0.101	-0.417*	-0.565**
	(0.133)	(0.239)	(0.185)	(0.214)
Coefficient				
Child	-0.138	-0.403	-0.751	0.799
	(0.709)	(1.001)	(0.689)	(1.452)
Maternal	0.443	-1.132	-2.207	5.089
	(2.011)	(3.156)	(2.387)	(3.904)
HH	1.057*	1.336	0.363	1.336
	(0.537)	(1.002)	(0.668)	(0.970)
Facilities/Care	0.127	-0.146	0.035	-0.587+
	(0.175)	(0.292)	(0.245)	(0.353)
Province	-0.363**	0.013	-0.355+	-0.587**
	(0.136)	(0.243)	(0.193)	(0.213)
_cons	-1.302	0.445	2.772	-6.563+
	(2.174)	(3.412)	(2.570)	(3.982)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.
NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Looking across the endowment, coefficient and interaction effects, the endowment effect at the mean was marginally significant and negative, suggesting that differences in endowments of variables significantly contributed towards reducing the rural-estate growth gap. A negative coefficient effect is also observed at Q90. Apart from this, no other significant endowment, coefficient or interaction effects are observed. Looking across the variable groups, child-level variables show a marginally significant positive endowment effect at the median whilst HH variables show a significant positive coefficient effect at the mean. Other groups do not show significant endowment or coefficient effects apart from Province. Even though variable groups did not show significant effects, results of the detailed decomposition in Table 4-39 highlights a number of variables which show individual endowment and coefficient effects suggesting that the rural-estate BMI-for-age differential may be caused by individual child, maternal, HH and care variables rather than by groups of variables as a whole.

Table 4-38: Detailed Decomposition of Rural-Estate Growth Differential (2006) - *BMIZ*

2006 (A)		OLS	Q10	Q50	Q90
Raw Differential		-0.35**	-0.011	-0.347**	-0.617**
[Rural-Estate]		(0.072)	(0.122)	(0.087)	(0.140)
Endowment					
Low BW		0.148+	0.109*		
		(0.089)	(0.053)		
Maternal BMI		0.071*	0.124**		
		(0.031)	(0.044)		
Maternal edu	Primary		0.365**		
			(0.115)		
	Secondary		-0.097+		
			(0.053)		
	GCE(O/L)		0.078*		
			(0.034)		
	GCE(A/L)		0.083*		
			(0.036)		
Maternal emp	Working_ Unskilled		-0.313+		
			(0.178)		
	Working_ Skilled		-0.134+		
			(0.075)		
Wealth Q	Second	0.036+			
		(0.021)			
	Middle	-0.036+			
		(0.019)			
Ethnicity	Sinhalese	-0.253*			
		(0.120)			
	SL Moor	0.113+		0.121+	
		(0.058)		(0.068)	
Head edu	Primary		-0.061+		
			(0.031)		
	Secondary		0.029+		
			(0.016)		
	GCE(O/L)		-0.163+		
			(0.084)		
	GCE(A/L)		0.029+		
			(0.015)		
	Degree				
Substance use	Yes		0.05+		
			(0.03)		

Table 4-38 *ctd.*

		OLS	Q10	Q50	Q90
Coefficient					
Gender	Male	0.069+ (0.036)	0.114+ (0.065)		0.177* (0.069)
	Female	-0.064+ (0.033)	-0.105+ (0.060)		-0.164* (0.064)
Birth order	2nd		-0.263+ (0.156)	0.207* (0.096)	
	>2nd		-0.447+ (0.237)		
Age		-1.253+ (0.703)	-2.268+ (1.306)		
Fever	Yes		-0.119* (0.048)		
Antenatal care	Yes				
Maternal edu	Primary		0.377* (0.160)	-0.288* (0.117)	
	Secondary			-0.335* (0.141)	
	GCE (O/L)	-0.020+ (0.012)	-0.047* (0.021)	-0.040* (0.016)	0.053* (0.022)
	GCE (A/L)			0.023* (0.011)	
Maternal emp	Working_ Skilled		0.052+ (0.032)		
Wealth Q	Second	0.093+ (0.05)			
	Middle	0.041+ (0.023)		0.045+ (0.026)	
Substance use	Yes		0.358* (0.177)		
Ethnicity	Sinhalese	0.040+ (0.021)			
	Indian Tamil	0.326+ (0.172)		0.430+ (0.221)	
Head age					0.829+ (0.483)
Head edu	Primary			0.093** (0.034)	
	Secondary			0.120** (0.044)	
	GCE(O/L)		0.086+ (0.045)		-0.063+ (0.036)
	GCE(A/L)	-0.014* (0.007)	-0.022* (0.011)	-0.037** (0.012)	0.038** (0.014)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.
NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.). Table only contains statistically significant results. Estimates for the 'Not Supervised' category of the Birth supervision and hand hygiene variables are omitted for accuracy due to low counts.

It is interesting to note that despite not showing a statistically significant rural-estate BMI-for-age differential, most of the significant endowment effects are observed at the lower end of the growth distribution. Birthweight, maternal BMI, HH wealth and ethnicity are among the few variables which show significant endowment effects on the mean differential. Difference in the average values of the proportion of low birthweight children and maternal BMI between the two sectors resulted in narrowing the rural-estate growth differential at the mean. Sector differences in the proportion of HH belonging to the second wealth quantile also result in narrowing the mean growth gap, while the difference in proportions of mid-wealth HHs result in broadening the gap. Looking at ethnicity, difference in the proportion of Sinhalese HHs between the two sectors widen the mean growth gap whilst difference in the proportions of Muslim HHs result in narrowing the growth gap both at the mean and median. This suggests that cultural differences could be a significant factor which drives the gap in BMI-for-age between the two sectors.

The observed effects are justified when considering descriptive results for the mentioned variables. The proportion of children born with low birthweight was higher in the estate sector whilst average maternal BMI was higher in the rural sector, in 2006. Similarly, the proportion of HHs belonging to the second wealth quintile was higher within the estate sector while the opposite is true for the proportions of HHs belonging to the middle wealth quintile. Th proportion of Sinhalese HHs and Muslim HHs were both higher within the rural sector in 2006. Given that average BMI-for-age was higher in the estate sector than the rural sector, the observed endowment effects of the above variables on the rural-estate BMI-for-age differential is in line with expectations.

With regards to the coefficient effects, a number of significant effects are observed across child, maternal and HH level variables. Difference in returns to gender and age of children significantly affect the rural-estate growth differential at the mean, Q10 and Q90 in 2006. Difference in returns to being female results in widening the rural-estate growth gap at the mean and upper end of the distribution. The BMI-for-age models presented in Table 4-29 further justifies this result, given that the estimated returns to female children was negative within the rural sector and positive within the estate sector in 2006. This would therefore act towards widening the growth gap in favour of the estate sector. Given the dichotomous nature of the gender variable, the opposite affect can be expected for male children, as observed.

Difference in returns to birth order results in a narrowing of the growth differential at the median, whilst it widens the gap at Q10. Whilst birth order does not show significant effects in the BMI-for-age models presented in Table 4-36 and 4-37, the differences in the direction of the estimated effects within the rural and estate sectors, provide a reasonable basis for the results seen above.

Differences in the returns to maternal education significantly contribute towards widening of the growth gap at the median (primary, secondary and GCE (O/L)) whilst difference in returns to GCE (A/L) education is seen to narrow the median gap. Differences in returns to the 2^{nd} and mid wealth quantiles also result in narrowing the mean growth differential. These results are justified by the differences in returns to maternal education and HH wealth observed in the BMI-for-age models in section 4.3.1. For example, the returns to low levels of maternal education (primary, secondary and GCE(O/L)) were seen to be more negative within the rural sector than the estate sector in 2006. This would support the observed results with regards to differences in returns of these three education levels widening the growth gap in favour of the estate sector. This ties in with the negative returns to maternal education observed within the rural sector in 2006, and further establishes the need for child-care mechanisms for rural HHs where educated mothers choose to travel further for work within urban areas.

The difference in returns to high levels of education of the HH head (GCE(A/L)) is seen to have differential effects across the growth distribution. Particularly, the difference in returns appears to widen the growth gap in favour of the estate sector, at the mean, median and lower end of the growth curve, whilst narrowing the gap in favour of the rural sector at the upper end of the distribution. This result needs to be interpreted in light of the differential behaviour of the HH head's education, observed in the BMI-for-age models in the distributional analysis. As noted in section 4.3.2., returns to GCE(A/L) education was seen to be negative and significant at Q10 and Q50, whilst the estimated return was positive at Q90. Even though the corresponding estimates were omitted in the BMI-for-age quantile regression models (due to multicollinearity), transformed effects were estimated for this education level within the estate sector in 2006, under the decomposition analysis[3]. Accordingly, the corresponding transformed effects for GCE(A/L) within the estate sector were seen to be positive at Q10 and Q50 while the estimated transformed effect was negative at Q90. These estimated effects justify the above observed effects on the rural-estate growth differential, where higher levels of education of the HH head is seen to widen the growth gap in favour of the estate sector at the median and lower ends of the growth curve. These effects, however, do not carry forward to 2016. Results observed in the distribution analysis in section 4.3.2. suggests that the estimated effects of education of the HH head have reversed, with positive effects observed for the rural sector and negative effects observed for the estate sector in 2016. These results will be further discussed in the Chapter 5.

Overall, the results suggest that differences in returns to key maternal and HH variables drive much of the rural-estate gap in BMI-for-age in 2006, whilst a few variables also contribute with endowment effects at the mean. Whilst much of the effects result in driving down the gap in favour of children living within the rural sector, a few factors also contribute towards increasing the gap in favour of estate children. However, the key highlight lies in the fact that contrary to the patterns observed for the height-for-age, the BMI-for-age of children were on average, higher within the estate sector than the rural sector in 2006. This result, however, is not reflected as strongly in 2016. In fact, as indicated in Panel B below, the rural-estate BMI-for-age differential was not statistically significant

[3] The Blinder-Oaxaca decomposition method uses the mean deviation method to transform all estimated effects of categorical variables, to be independent of the choice of base category. This method therefore allows for the estimation of effects for excluded categories including the base category in group-wise models. See methodology for more details, and Appendix E1 for transformed effects.

at the mean or across the growth differential, suggesting that rural and estate children are on average, similar with regards to their BMI-for-age in 2016. This again contrasts with the decomposition results observed for height-for-age in 2016, which suggested significant rural-estate height-for-age differentials both at the mean and across much of the growth distribution.

Table 4-39: OLS and Unconditional Quantile Regression Decomposition of Rural-Estate Growth Differential (2016) - *BMIZ*

2016 (B)	OLS	Q10	Q50	Q90
Raw Differential	0.024	0.068	-0.058	-0.186
[Rural-Estate]	(0.095)	(0.158)	(0.091)	(0.146)
Endowment	-0.186	-0.68	-0.326	-0.186
	(0.253)	(0.467)	(0.269)	(0.474)
Coefficient	-0.234	-0.267	-0.146	-0.467*
	(0.149)	(0.294)	(0.156)	(0.187)
Interaction	0.444	1.016+	0.414	0.466
	(0.278)	(0.527)	(0.297)	(0.489)
Endowment				
Child	-0.025	0.172+	0.0004	-0.108
	(0.057)	(0.096)	(0.058)	(0.080)
Maternal	-0.034	-0.056	-0.052	0.132
	(0.118)	(0.179)	(0.112)	(0.184)
HH	0.103	-0.255	-0.010	-0.258
	(0.231)	(0.379)	(0.247)	(0.441)
Facilities/Care	-0.092	-0.104	-0.015	-0.016
	(0.061)	(0.082)	(0.046)	(0.090)
Province	-0.138	-0.437	-0.248	0.063
	(0.253)	(0.352)	(0.172)	(0.289)
Coefficient				
Child	0.961	1.913+	2.041*	0.408
	(0.844)	(1.087)	(0.821)	(1.690)
Maternal	2.721	0.275	1.089	6.88+
	(2.331)	(3.784)	(2.520)	(3.753)
HH	0.755	0.240	0.020	-0.038
	(0.824)	(1.236)	(0.732)	(1.095)
Facilities/Care	0.202	0.528	-0.398	-0.089
	(0.389)	(0.381)	(0.476)	(0.612)
Province	-0.059	-0.435	-0.180	0.164
	(0.201)	(0.366)	(0.176)	(0.307)
_cons	-4.814+	-2.788	-2.719	-7.793+
	(2.533)	(3.734)	(2.713)	(4.344)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.
NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

b) 2016-2006 BMI-for-Age Differentials

This section presents results of the decomposition analysis of the 2016-2006 BMI-for-age differential in the rural and estate sectors respectively. Panel C in Table 4-41 presents results for the mean and quantile growth differentials between 2016 and 2006 in the rural sector while panel D in Table 4-43, presents the same for the estate sector. Looking across the two panels, what is immediately evident is the fact that, whilst BMI-for-age on average has improved within the rural sector over time, it shows a deterioration within the estate sector. An improvement of 0.091 standardized units in mean BMI-for-age was observed for the rural sector, over the 2006-2016 period, while the estate sector showed a decline of 0.284 units. Looking across the growth distribution in the rural sector, the growth improvement is clearly largest at the upper end of the distribution (at 0.347 at Q90). It is also noticeable that despite the improvement in growth at the mean, median and upper tails of the growth distribution, the lower end of the distribution showed a marginally significant decline in BMI-for-age. This implies that, on average, the improvement in BMI-for-age from 2006 to 2016 tend to be larger among children displaying relatively better growth, whilst among children displaying poor growth, BMI-for-age has deteriorated over time. In contrast, the estate sector, shows a consistent decline in BMI-for-age both at the mean and across the growth distribution, with statistically significant declines both at the mean and median. As expected, the deterioration is relatively smaller (and statistically non-significant) among children at the upper end of the growth spectrum. However, contrary to what is expected, the deterioration among children at the lower end of the growth distribution was also small and not statistically different. The larger deterioration was detected towards the middle of the growth distribution (i.e. at the median and mean). This suggests that even though the BMI-for-age shows a general deterioration over the considered period within the estate sector, the decline is not observed among children displaying poor growth.

The decomposition analysis also yields information on the variable groups that contribute towards the improvement/deterioration of BMI-for-age over time. According to the results presented in panel C, the endowment effect is seen to significantly contribute to the mean, Q10 and median growth improvement within the rural sector. Maternal variables and province contribute significantly to the endowment effects across the mean, Q10 and the median. Child and HH level variables are also significant at the median. Even though the coefficient effects were not significant at the mean or quantiles, significant interaction effects are observed across the growth spectrum which suggests that there may be individual variables whose coefficient effects contribute towards the overall differential.

Table 4-40: OLS and Unconditional Quantile Regression Decomposition of 2016-2006 (Rural) - *BMIZ*

Rural (C)	OLS	Q10	Q50	Q90
Raw Differential	0.091**	-0.077+	0.071*	0.347**
[2016-2006]	(0.029)	(0.043)	(0.03)	(0.051)
Endowment	0.172**	0.119*	0.318**	-0.076
	(0.035)	(0.054)	(0.041)	(0.065)
Coefficient	0.060	-0.062	0.033	0.209*
	(0.063)	(0.073)	(0.053)	(0.093)
Interaction	-0.141*	-0.134+	-0.280**	0.214*
	(0.066)	(0.081)	(0.060)	(0.104)
Endowment				
Child	0.018+	0.018	0.025*	0.026
	(0.010)	(0.016)	(0.012)	(0.018)
Maternal	0.128**	0.113**	0.216**	-0.030
	(0.021)	(0.032)	(0.026)	(0.038)
HH	0.018	-0.022	0.066**	-0.064+
	(0.017)	(0.027)	(0.022)	(0.033)
Facilities/Care	-0.004	-0.016	-0.006	-0.006
	(0.007)	(0.011)	(0.008)	(0.012)
Province	0.012*	0.025**	0.017**	-0.002
	(0.005)	(0.007)	(0.005)	(0.008)
Coefficient				
Child	-0.548	0.320	0.117	-1.445+
	(0.481)	(0.690)	(0.438)	(0.759)
Maternal	-0.094	0.392	-0.449	-1.863
	(0.860)	(1.182)	(0.844)	(1.516)
HH	-0.263	-0.105	-0.157	-0.302
	(0.216)	(0.335)	(0.261)	(0.398)
Facilities/Care	0.216	0.442*	0.189	0.159
	(0.137)	(0.211)	(0.144)	(0.240)
Province	-0.003	-0.003	-0.004	-0.019
	(0.015)	(0.021)	(0.014)	(0.027)
_cons	0.752	-1.108	0.336	3.678*
	(1.026)	(1.378)	(0.981)	(1.764)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

The detailed decomposition below reveals a number of variables which show significant endowment and coefficient effects. Differences in the proportion of disease (fever), maternal BMI, education, and education of the head of the household contribute to the endowment effects across much of the growth distribution within the rural sector. Based on the descriptive analysis it was clear that the proportion of children recorded as having had fever, declined over the considered period within both sectors. Hence it is clear that this decline would contribute to the improvement in average and median BMI-for-age within the rural sector. Maternal BMI and education are key maternal-level variables that show significant endowment effects across the distribution. The difference in average maternal BMI between 2006 and 2016, positively contributes to the rural sector growth improvement both at the mean and across the distribution. This result is in line with the increase in average maternal BMI observed across time within the rural sector. Maternal education within the rural sector showed heterogenous changes across different levels and time. As indicated in Table 4-5, the proportion of primary and secondary educated mothers within the rural sector significantly declined from 2006 to 2016, while the proportion of mothers with GCE(O/L), GCE(A/L), degree qualifications, increased over the same period. The detailed decomposition below indicates that apart from GCE(O/L), improvements observed in levels of maternal education all contribute positively towards the growth improvement at the mean, Q10 and median. However, the improvements seen in maternal education negatively impact the growth improvement at the upper end of the growth distribution. This result is in line with the transformed effects of maternal education on BMI-for-age estimated under the decomposition analysis (see Table E1-3 Appendix E1). The transformed effects at Q10 and Q50 were negative for primary-GCE(O/L) levels and positive for the GCE(A/L) and degree levels while the opposite was observed at Q90. Given this, the observed endowment effects of maternal education are plausible. The results broadly suggest that improvements in the levels of maternal education within the rural sector over time, has contributed to improving growth levels among children at the median and lower ends of the growth distribution. However, among children showing better growth, higher maternal education acts as an impediment to the improvement of child growth over time. This is in line with the changing impacts of maternal education observed in the distributional analysis which saw much of the negative returns to maternal education at the lower end of the growth distribution dissipate over time. Reasons for these observations were highlighted in section 4.3.2. as possible developments in public transport systems and increasing urbanisation of rural regions of the country overtime, which would result in more educated rural mothers working closer to home or spending less time commuting to-and-from work. Education of the HH head also show significant endowment effects within the rural sector. Similar to maternal education, generally higher levels of education (except secondary) contribute positively towards the growth improvement at the mean and median. However, a negative effect is observed at the upper end of the growth distribution.

Looking across the coefficient effects on the detailed decomposition, it is clear that a considerable number of variables showed statistically significant coefficient effects. The Generalised Hausman test results indicated in table 4-33 reveal a number of variables which show significantly different returns in the two time periods within the rural sector. These variables also show significant coefficient effects in Table 4-42 below, and the estimated effects are in line with expectations. Despite the many significant coefficient effects observed at the individual variable level, it should also be noted that the overall coefficient effects were not statistically significant at the mean and quantiles. This may be the result of positive coefficient effects of certain variables being off-set by the negative effects of other variables. The detailed decomposition indicates maternal education, wealth and the education of the HH head show significant coefficient effects across much of the growth distribution. Overall results indicate differences in the levels of maternal BMI, education and HH head's education to be the main driving factor of the 2016-2006 BMI-for-age differential across the rural sector, whilst differences in the returns to variables tend to offset each other.

Table 4-41: Detailed Decomposition of 2016-2006 Growth Differential (Rural) - *BMIZ*

Rural (C)		OLS	Q10	Q50	Q90
Raw Differential		0.091**	-0.077+	0.072*	0.347**
[2016-2006]		(0.029)	(0.043)	(0.03)	(0.051)
Endowment					
Low BW		0.005+			
		(0.003)			
Birthorder	2nd				-0.009+
					(0.005)
Fever	Yes	0.004*	0.005+	0.004*	0.005+
		(0.002)	(0.003)	(0.002)	(0.003)
Maternal age		-0.007*		-0.012**	
		(0.003)		(0.004)	
Maternal BMI		0.068**	0.054**	0.066**	0.070**
		(0.008)	(0.011)	(0.009)	(0.015)
Maternal edu	No edu	0.001**	0.001+	0.004**	-0.002**
		(0.001)	(0.001)	(0.001)	(0.001)
	Primary	0.023**	0.022*	0.04**	-0.032**
		(0.006)	(0.009)	(0.007)	(0.011)
	Secondary	0.033**	0.034*	0.064**	-0.063**
		(0.010)	(0.015)	(0.011)	(0.019)
	GCE(O/L)	-0.015*		-0.033**	0.029*
		(0.006)		(0.007)	(0.012)
	GCE(A/L)	0.016**	0.015*	0.052**	-0.028**
		(0.005)	(0.007)	(0.009)	(0.009)
	Degree	0.013**	0.011*	0.041**	-0.022**
		(0.003)	(0.006)	(0.006)	(0.006)
Maternal emp	Not working		-0.005+		
			(0.003)		
Total children		-0.007+	-0.011*		
		(0.004)	(0.006)		
Head age					
Head edu	No edu	0.003*		0.005**	-0.008**
		(0.001)		(0.001)	(0.002)
	Primary	0.009*		0.013**	-0.022**
		(0.003)		(0.002)	(0.007)
	Secondary	-0.008*		-0.013**	0.022**
		(0.004)		(0.003)	(0.007)
	GCE(A/L)	0.011*		0.041**	-0.033**
		(0.005)		(0.01)	(0.011)
	Degree	0.003*		0.004**	-0.007**
		(0.001)		(0.001)	(0.002)
Ethnicity	SL Tamil				
	SL Moor	-0.010*		-0.011+	
		(0.004)		(0.006)	
Toilet	Flush toilet			-0.008+	
				(0.004)	

Table 4-41 *ctd.*

Rural (C)		OLS	Q10	Q50	Q90
Coefficient					
Normal BW		-0.166+			
		(0.085)			
High BW		0.003+			
		(0.002)			
Birth order	>2nd		0.144*		
			(0.070)		
Diarrhea	Yes	0.011+			
		(0.006)			
Maternal BMI		-0.366*		-0.375*	
		(0.163)		(0.156)	
Maternal edu	Primary	0.022+		0.052**	-0.039+
		(0.013)		(0.015)	(0.023)
	Secondary			0.224**	-0.316**
				(0.066)	(0.113)
	GCE(O/L)			0.059**	
				(0.022)	
	GCE(A/L)	-0.065**	-0.076**	-0.162**	0.059*
		(0.016)	(0.027)	(0.022)	(0.029)
Maternal emp	Not working			-0.078*	
				(0.039)	
Wealth	Q2	-0.027*	-0.042*		
		(0.011)	(0.018)		
	Q5	0.018+	0.027+	0.031**	
		(0.010)	(0.014)	(0.011)	
HH Substance Use	Yes	-0.071*			
		(0.035)			
Total children		-0.265+	-0.449+		
		(0.151)	(0.242)		
Head age					-0.478**
					(0.183)
Head gen	Male				0.098+
					(0.051)
	Female				-0.024+
					(0.013)
Head edu	Primary			-0.013+	0.033*
				(0.007)	(0.013
	Secondary	-0.080+		-0.094**	
		(0.041)		(0.034)	
	GCE(A/L)	0.053*	0.072*	0.186**	-0.104*
		(0.023)	(0.035)	(0.029)	(0.044)
	Degree				
Ethnicity	Sinhala	0.185*	0.284**		0.306*
		(0.074)	(0.106)		(0.151)
	Indian Tamil	-0.008*			-0.006+
		(0.003)			(0.004)
	Malay	-0.002*		-0.003*	
		(0.001)		(0.001)	
Imp. drinking water	Yes	0.052**			0.08*
		(0.02)			(0.036)
	No	-0.028**			-0.042*
		(0.01)			(0.019)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.). Table only contains statistically significant results. Estimates for the 'Not Supervised' category of the Birth supervision and hand hygiene variables are omitted for accuracy due to low counts.

Panel D in the tables below present the decomposition results for the 2016-2006 BMI-for-age differential within the estate sector. Unlike the growth differentials observed for the rural sector above, the BMI-for-age differentials within the estate sector are observed to be negative with statistically significant differentials at the mean and median. This suggest that in general, the BMI-for-age of children within the estate sector has declined over time, with a significant decline in average and median BMI-for-age. However, neither the endowment nor coefficient effects are seen to significantly contribute towards the differential. This could imply off-setting effects at the individual variable level. Looking across the variable groups, returns to child level variables are seen to significantly contribute towards the coefficient effect at the median. No other variable groups are seen to significantly contribute either to the endowment or coefficient effect. The direction of the estimated effects suggests that returns to child-level variables may have declined over time, increasing the growth gap. The detailed decomposition indicates differences in returns to antenatal care, maternal BMI and HH wealth are significant drivers of the growth differential. Looking across the intra-sector analysis of BMI-for-age within the estate sector (Table 4-29 and 4-37) the estimated effects of the above variables are seen to considerably change over time. Whilst antenatal care shows significant coefficient effects, as noted in the intra-sector analysis, results observed for this variable is considered spurious due to low counts of mothers not receiving antenatal care within the estate sector in 2016. Looking across the HH level variables, difference in returns to the proportion of HHs belonging to the middle and highest wealth quantiles also contributed to the coefficient effects at Q10 and median. Revisiting the intra-sector analysis, the returns to wealth quantile Q3 was seen to be negative in both time periods, within the estate sector, with a larger magnitude in 2016. In contrast, returns to wealth quantile Q5 was seen to be positive in both years, with a significantly larger effect in 2016. As noted in the table below, the observed difference in the returns to higher HH wealth results in narrowing the growth deterioration over time, within the estate sector.

Table 4-42: OLS and Unconditional Quantile Regression Decomposition of 2016-2006 (Estate) - *BMIZ*

Estate (D)	OLS	Q10	Q50	Q90
Raw Differential	-0.284*	-0.157	-0.218+	-0.083
[2016-2006]	(0.116)	(0.195)	(0.122)	(0.196)
Endowment	0.109	0.215	-0.041	0.305
	(0.157)	(0.258)	(0.187)	(0.306)
Coefficient	0.080	0.328	0.275	0.133
	(0.228)	(0.335)	(0.236)	(0.467)
Interaction	-0.473+	-0.700+	-0.452	-0.521
	(0.276)	(0.401)	(0.284)	(0.534)
Endowment				
Child	0.030	-0.087	0.067	0.112
	(0.054)	(0.099)	(0.069)	(0.105)
Maternal	0.062	0.155	-0.07	-0.048
	(0.103)	(0.179)	(0.130)	(0.198)
HH	0.026	0.036	-0.025	0.196
	(0.083)	(0.152)	(0.107)	(0.163)
Facilities/Care	-0.014	0.094	-0.024	0.050
	(0.044)	(0.076)	(0.054)	(0.086)
Province	0.004	0.015	0.012	-0.004
	(0.031)	(0.043)	(0.035)	(0.051)
Coefficient				
Child	-1.206	-1.651	-2.158*	-0.356
	(0.911)	(1.252)	(0.921)	(1.880)
Maternal	-2.307	-1.059	-3.520	-3.752
	(2.956)	(4.781)	(3.360)	(5.232)
HH	-0.431	0.690	-0.163	0.466
	(0.977)	(1.562)	(0.970)	(1.420)
Facilities/Care	0.052	-0.233	0.495	-0.432
	(0.373)	(0.407)	(0.457)	(0.596)
Province	-0.293	0.457	-0.207	-0.701+
	(0.243)	(0.445)	(0.260)	(0.371)
_cons	4.264	2.125	5.827	4.908
	(3.177)	(4.867)	(3.606)	(5.622)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.

NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.).

Table 4-43: Detailed Decomposition of 2016-2006 Growth Differential (Estate) - *BMIZ*

Estate (D)		OLS	Q10	Q50	Q90
Raw Differential [2016-2006]		-0.284* (0.116)	-0.157 (0.195)	-0.218+ (0.122)	-0.083 (0.196)
Endowment					
Low BW			0.059+ (0.036)		
Age		-0.313+ (0.185)	-0.306+ (0.182)		
Maternal BMI		0.098* (0.038)	0.099* (0.039)		
Maternal edu	No edu	0.036* (0.017)			
	Primary	0.234** (0.085)			
	GCE(O/L)		0.068* (0.033)		
	GCE(A/L)		0.036+ (0.021)		
Maternal emp	Working_unskilled		-0.218+ (0.125)		
	Working_skilled		-0.153+ (0.089)		
Wealth	Q3	0.024+ (0.014)			
Coefficient					
Birth order	2nd		-0.510* (0.226)		
Gender	Male		0.285** (0.098)		
	Female		-0.264** (0.091)		
Antenatal care	Yes	-1.237** (0.377)		-1.203** (0.335)	-2.111* (1.028)
Birth sup	Sup_HealthP	-0.373+ (0.218)			
Mothers Age					-2.787* (1.323)
Maternal BMI			-1.830* (0.809)		1.367+ (0.794)
Maternal edu	Primary		0.425* (0.205)		
	Secondary		0.476+ (0.256)		
	GCE(O/L)				
	GCE(A/L)		-0.040+ (0.024)		
Wealth	Q2		-0.319* (0.162)		
	Q3			-0.106* (0.043)	
	Q5		0.058+ (0.033)	0.044+ (0.023)	
Total children					
Head age		-0.811+ (0.433)		-0.726+ (0.407)	
Ethnicity	Sinhala	0.065* (0.031)			

	SL Tamil	0.268*
		(0.133)
	Indian Tamil	0.634+
		(0.334)
Imp. drinking water	Yes	0.377+
		(0.223)
	No	-0.078+
		(0.047)

**1% *5% +10% sig. Robust SE in parenthesis. Sample weights provided by DHS used. Child: Birthweight, Birth order, gender, age, age_sq, antenatal care, birthsupervision, and breastfed duration, bf dur_sq, Maternal: Mothers age, height, BMI, education and employment, HH: wealth, Skilled employment, Total number of children, substance use, ethnicity, Head age, gender, education, Facilities/care: Toilet, improved drinking water and hand hygiene.
NOTES: ANcare is on the antenatal care received by mother. Breastfed records the total duration the child was breastfed. If the child was breastfeeding at time of survey, this variable was replaced by the childs current age. MotherEmp refers to the mother's employment. Improved drinking water captures whether the HH does anything to improve drinking water for consumption (i.e. boil, filter etc.). Table only contains statistically significant results. Estimates for the 'Not Supervised' category of the Birth supervision and hand hygiene variables are omitted for accuracy due to low counts.

In summation, the results observed in this section highlights how the short-term growth (as reflected by BMI-for-age) of children has evolved over the 10 years period considered, within each sector. The results indicate that whilst, growth has improved within the rural sector, the estate sector seems to be showing a significant deterioration in short-term growth over time. This also ties in with the patterns observed in the rural-estate differential in the previous section, where children in the estate sector were seen to initially display better growth (BMI-for-age) than rural sector children (2006), which gradually declined by 2016. The next chapter further summarises the main results observed in this chapter, with a concise discussion on some of the plausible reasons listed for the observed patterns. The chapter also compares results across the long-term and short-term growth analyses presented here.

4.4. Models for Robustness

A number of different model specifications were used to test the robustness and consistency of reported results. With regards to the intra-sector analysis, the Heckman correction was applied to models to account for selection due to mortality both within the rural and estate sectors. Inverse-mills ratios were not statistically significant in any of the fitted models, indicating that selection bias was not a significant factor within the data. The analysis presented above contains data for children between the ages of 0-60 months. Given the possibility of infants between 0-6 months containing maternal antibodies, models were rerun excluding this age category, as a robustness test. Model results closely follow reported results. Controlling for maternal variables in main models will control for the effect of maternal antibodies if any.

With regards to the decomposition analysis, the two-step decomposition with an extension of the Neumark model (Neumark, 1988) was fitted to test whether estimated decomposition results were sensitive to the choice of reference parameters. Results closely follow the three-step decomposition results presented.

Chapter 5: Conclusion and Recommendations

This chapter summarises some of the key results observed in Chapter 4 with regards to short-term and long-term growth of children within the rural and estate sectors of Sri Lanka. As noted in the introductory chapter, the aim of this essay was to explore variations in child growth across the rural and estate sectors with the objective of understanding the nature and drivers of child growth within sectors, and to explore what drives growth gaps between the two sectors. Improvement/deterioration of growth across time was also explored within each sector. The analysis used a number of techniques including linear regression, unconditional quantile regression and Blinder-Oaxaca decompositions to explore these aspects. Given that most of the observed patterns are broadly discussed in Chapter 4, this chapter concentrates on highlighting a few of the more interesting patterns observed.

5.1. Determinants of Long-Term and Short-Term Growth

As explained in the methodology, the long-term growth of children was explored using the height-for-age of children whilst BMI-for-age is considered as a measure of short-term growth, which reflects children's weight adjusted for their height and age. The weight-for-age whilst informative, is a more composite measure, which is also affected by height. OLS and quantile regression analysis was used in each case, to identify the main drivers of the anthropometric outcomes. This section summarises the main results observed through the mean and quantile regressions for the height-for-age and BMI-for-age of children to highlight similar and differential effects observed across sectors and time. The main observations are discussed in light of existing literature and policy insights are drawn from the resultant analysis.

Birthweight and maternal BMI showed similar effects across the height-for-age and BMI-for-age models in both sectors and time periods. Having a normal or high birthweight has a positive effect on both outcomes, as does having a higher maternal BMI, in line with expectations. These effects are almost uniform both at the mean and across the growth distribution in both sector and time periods. Maternal height whilst being a significant factor in height-for-age models, did not show significant effects on the BMI-for-age models. This backs the notion that the relationship between maternal height and child growth is largely a 'genetic effect' rather than the result of favourable economic conditions, as the latter would be expected to impact children's BMI-for-age as well.

Breastfed duration has a clear negative effect on the height-for-age of children across the rural sector (in both time periods) and estate sector in 2016. These effects were also uniform across the growth distribution within the rural sector, and particularly at the lower end of the distribution within the estate sector. Significant negative effects were also observed on the BMI-for-age within the rural sector in 2016 and these effects were largely concentrated at the tail ends of the growth distribution. The results again back the controversial notion that longer durations of breastfeeding show a negative association with children's height-for-age. Whilst the data does not support establishing causality, the observation that extended durations of breastfeeding is also negatively associated with children's BMI-for-age within the rural sector, and particularly at the lower and upper ends of the growth distribution, suggests that longer durations of breastfeeding could result in the deterioration of child growth both in the short and long-run. As noted in the previous chapter, this observation, though controversial, has been previously observed in other countries

(Delgado and Matijasevich, 2013; Martin, 2001). Possible reasons for this deterioration could be the lack of balanced nutrient intake, or delay in the introduction of solid foods including protein rich food. The descriptive analysis also showed some interesting results which link to the above results. According to the analysis, the proportion of children being breastfed over 1 month, and 6 months showed a decline over time, within both sectors, but the proportion of children being breastfed beyond 2 years showed an increase over time. These proportions, together with the results discussed above, may suggest potential gaps in the awareness of the importance of exclusive breastfeeding, as opposed to extended breastfeeding, and gaps in awareness regarding the appropriate timeframes for weaning children off breastmilk. This signals the need for clear interventions in the form of awareness programmes, especially within the rural sector, which shows more negative impacts on growth.

Estimated coefficients of gender suggest that female children tend to have a higher height-for-age than male children, particularly within the rural sector, and predominantly among children showing poor growth. A similar result is also observed within the estate sector in 2006. This result agrees with growth literature which suggests that the rates of growth of girls and boys tend to differ in early life. Some research also suggests that girls generally grow at a faster rate than boys in the first 4 years of life (Tanner, 2019). This could explain the effects observed with regards to gender. Whilst prominent in the height-for-age models, the BMI-for-age shows mixed gender effects across sectors and time, with no clear pattern.

A few variables also show significant yet differential effects across the height-for-age and BMI-for-age models. Maternal education and the educational background of the HH Head are among those which show differential effects on long-term and short-term growth. Maternal education was a complex variable which showed different effects across the growth distribution within both sectors. On height-for-age, maternal education was seen to have a strong positive effect at the median and upper ends of the growth distribution within both sectors, in 2006. However strong negative effects on height-for-age were also observed at the lower end of the growth distribution, particularly within the rural sector. With regards to BMI-for-age maternal education shows significant negative effects across the median and lower ends of the growth distribution, within the rural sector in both 2006 and 2016. Looking at the mean regression models, effect of maternal education on mean height-for-age was positive and significant within the rural sector in 2006, whilst the effect on mean BMI-for-age was significant and negative in both years. A plausible reason for this is presented as the interplay between maternal education and employment. Figure 4-11 suggests that that the percentage of mothers in skilled employment tend to increase with increasing education, within the rural sector in both years. Given limited skilled employment opportunities within the rural sector, this would suggest travel to urban areas for jobs. Whilst, skilled employment would provide more income to households, children may also face a certain level of neglect given the absence of mothers. The resultant effect could be a deterioration in weight and BMI. However, a higher household income sustained over time, would promote child growth in the long-run as reflected by their heights (apart from the cohort of children at the lower end of the growth curve). The effect of maternal education on the height-for-age and BMI-for-age of children was not as pronounced within the estate sector. The only significant (positive) effects on height-for-age are observed at the upper end of the growth distribution in 2006, and similar positive effects on the BMI-for-age are again observed at the upper end of the growth distribution in 2016. These results are not surprising considering the relatively low proportion of mothers showing higher education levels, and the relatively low proportion of mothers in skilled employment, observed within the estate sector in both years. This suggests that contrary to the notion that educating mothers would lead to better growth and health in children, maternal education in the absence of the necessary support systems may result in hindering rather than promoting growth, especially among vulnerable cohorts of children. Policy interventions are required, particularly in the form of better child-care mechanisms, in order to reap the full benefits of maternal education on child growth within the rural sector.

The education level of the HH head shows a similar behaviour to maternal education, particularly within the estate sector in 2016. Whilst higher education levels of the head of the HH, are seen to positively impact height-for-age of children, the impact on BMI-for-age is recorded to be negative. Descriptive statistics across the estate sector, shows more than 70% of HH head’s to be male. Prior research has outlined the lack of skilled employment opportunities within the estate sector (CEPA Sri Lanka, 2005; Rajendran and Abhayaratne, 2008), which would drive estate residents with higher educational qualifications to seek employment opportunities off-estate. The following figure gives a breakdown of the education status of the HH head by the main employment of the HH. Skilled employment clearly increases with education across both sectors in 2006. The estate sector in 2016 deviates slightly from this pattern with a higher percentage of non-skilled employment within the G.C.E.(O/L) category. Research notes the difficulties faced by estate residents in finding off-estate skilled employment despite having higher levels of education, due to stigma associated with their ethnic background (Rajendran and Abhayaratne, 2008). This may be a reason for the unusually high proportion of unskilled workers observed in the GCE(O/L) category. However, a higher percentage of skilled employment is reported above this education level. With regards to the observed negative returns to HH head’s education, the female-intensive labour structure within tea estates could be a potential reason. With fathers working off-estate (potentially in urban areas far from home) and mothers continuing to work as tea-pluckers, children could face considerable lack of care, which could lead to growth deteriorations in the short-run. However, additional HH income would be able to reverse these growth lags in the long-run. Looking across the growth distributions, the negative effects on BMI-for-age are observed to be significant among children showing median and lower growth, whilst the positive effects on height-for-age show an even spread across the growth distribution. This again justifies the stated reasons, given that negative impacts of lack-of-care would be felt more by children showing more vulnerable growth.

From a policy perspective, these results suggest the need for better child-care mechanisms to be put in place within the estate sector, so as to derive the full potential of education of HH heads on improving child growth. Given the female intensive labour structure particularly in tea estates, creches and child care centres have long been part of the estate sector in Sri Lanka. However, their functioning rarely falls under strict monitoring of government authorities. Inequalities that exist within tea-estate management structures in the country add another level of complexity to this problem. Around 25% of the total plantation workforce is managed regional plantation companies (RPC) whilst the remainder work in estates managed by small-holder companies. Residents living and working within estate managed by retail plantation companies usually enjoy better living standards due strong unionisation of workers and the generally higher stature of the companies. This enables better child care facilities as well as other interventions to be initiated within such estates. Essay 2 of this thesis analyses the effectiveness of one such nutrition intervention which targets children living within a select sample of tea estates managed by an RPC. Whilst, regional plantation companies are often able to partner with major charitable institutions and NGOs to implement such programmes, residents living in small-holder estates tend to miss out on similar opportunities. This highlights the need for government led initiatives for improving child-care facilities and implementing focussed interventions which would effectively address these inequalities and provide common safety nets for estate residents to pursue better education and employment opportunities. Existing child-care establishments can easily be used to ramp up these services and to introduce more effective interventions with government oversight.

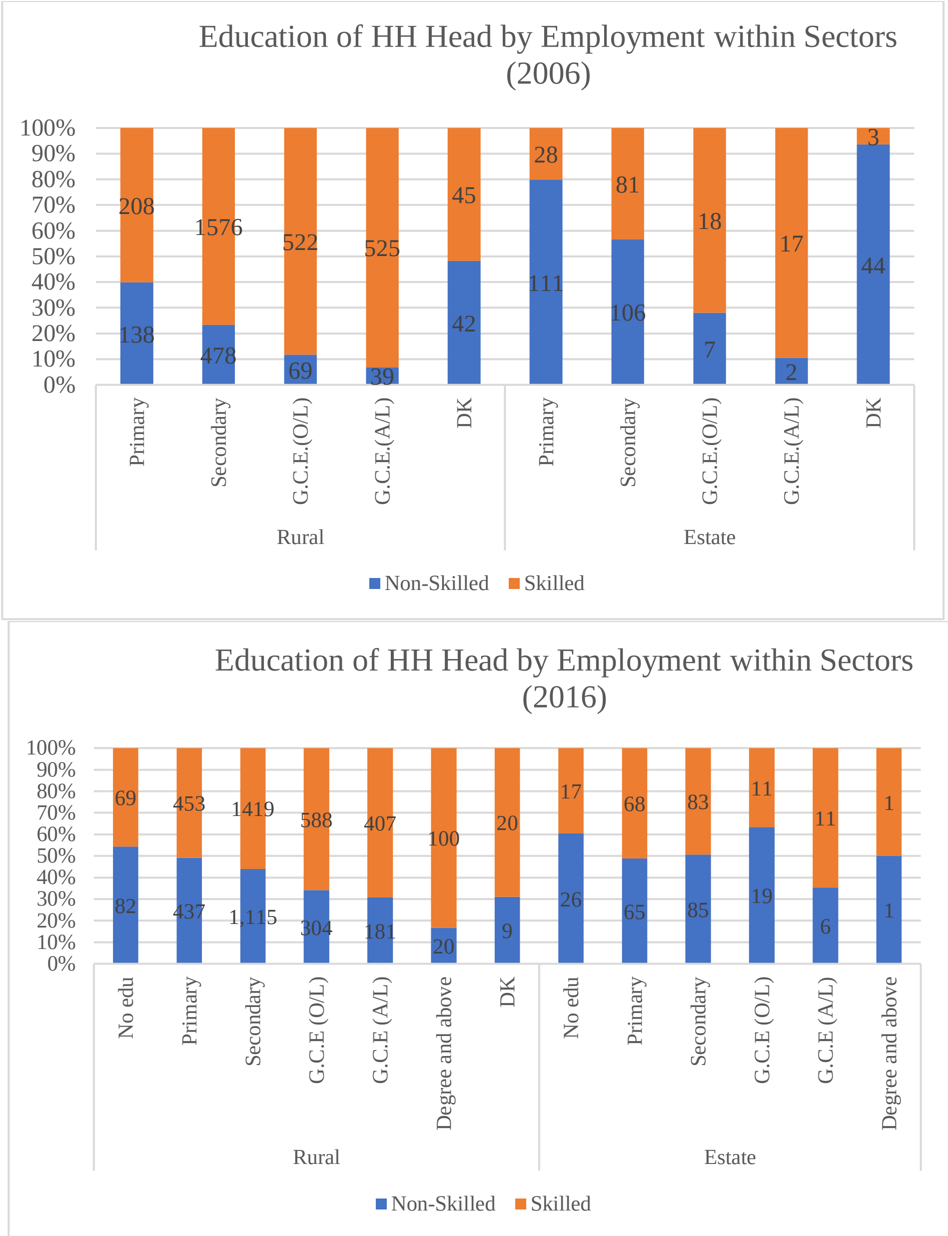


Figure 5-1: Distribution of Education of HH Head by Main Employment
Base: Rural (8847) Estate (810), Rural 2006/2016 (3643/5204), Estate 2006/2016 (417/393)
Note: Rural 2006 excludes 1 observation in the No edu category

Apart from the variables discussed above, a few other significant mean and distributional effects were observed in the height-for-age, BMI-for-age and weight-for-age models. However, these were mostly solitary effects and were discussed in detail, in the previous chapter. Much of these effects were in line with expectations. In summary, a few key variables can be identified as drivers of growth within the two sectors. While some variables such as birthweight and maternal health variables, show consistent effects on child growth, other variables such as maternal education and education levels of the HH head tend to be more complex, impacting child growth differentially, across sectors, times and growth points.

5.2. Rural vs. Estate: Which Sector Performs Better on Child Growth?

As indicated in the introductory chapter, two of the main research questions explored through this essay were with regards to the extent to which the rural-estate growth gap changed over a decadal period and to explore the extent to which growth improved/declined over time within each sector. Given the extensive rural vs estate analysis carried out to explore these aspects, it was interesting to pose the above question regarding the positioning of each sector with regards to child growth. Official statistics on the prevalence of child malnutrition paints a grim picture for the estate sector. Based on most recent statistics, the prevalence of stunting among estate children was at a critically high rate of 31.7%. This was significantly higher than the 17% reported within the rural sector and 14.7% reported for the urban sector (Department of Census and Statistics-Sri Lanka, 2017a). The prevalence of wasting among children was slightly lower within the estate sector (13.4%) than the rural sector (15.6%). The decomposition analyses carried out on the height-for-age and BMI-for-age measures in the previous chapter also reflect these results to a large extent.

As discussed, the decomposition analysis focuses mainly on exploring the height-for-age and BMI-for-age differentials across sector and time. The former measure clearly ties in with the prevalence of stunting while the latter measure can be considered to follow the prevalence of wasting. Overall, the decomposition results of height-for-age across the two years (2006 and 2016) suggests that the rural sector performs better with regards to the long-term growth of children than the estate sector. However, the decomposition of BMI-for-age suggested that the opposite was true with regards to short-term growth, with the estate sector performing better than the rural sector in 2006. Short-term growth of children was not significantly different between the two sectors in 2016. This section aims to draw from the overall finding of the decomposition analysis to compare the effects of some of the main endowment and coefficient contributors to the height-for-age and BMI-for-age differentials. This would allow for the identification of factors which favour the rural sector and those which favour the estate sector with regards to short-term and long-term growth of children providing insights into possible sector-focussed interventions which could improve growth within each sector.

Birthweight is a key factor which drives the rural-estate growth differential in both years. Particularly, differences in the proportion of children with low birthweight contribute toward sector differentials in the height-for-age differential in both years and the differential in BMI-for-age in 2006, and effects were significant among children at the lower end of the growth distribution. The descriptive analysis shows the proportion of low birthweight children to be higher in the estate sector than the rural sector in both years (2006 and 2016), and the decomposition results suggest that this difference widens the growth gaps in favour of the rural sector. Returns to being born with low birthweight, also show differences between the two sectors. However, this difference seems to drive down the height-for-age differential in favour of the estate sector. This could signal that the effect of being born with low birthweight might be more detrimental to future growth, within the rural sector. This might suggest the need for a two-pronged policy, first focussed on decreasing the rate of low-weight births particularly within the estate sector, and secondly to decrease the negative carry-on effects of being born with low birthweight, within both sectors, with a particular focus on the rural sector. The former through careful monitoring and nutritional targeting of pregnant mothers particularly within the estate sector. This could lead to a decrease in the incidence of low weight births within the sector. The latter can be achieved by establishing continuous growth monitoring of low-weight babies, through the first 5 years of life and possibly beyond. Monitoring the growth of children below the age of 5 is routinely carried out by midwives across the country. These programmes can be tweaked to pay special attention to low-birthweight children and enhanced by attaching a growth subsidy (in the form of financial support to the families or direct food and nutrition packages for the child). With clear monitoring and set growth targets which parents need to meet, the negative carry-on effects of being born with a low birthweight could be minimised, particularly within the rural sector. The overall policy target would be to minimise both the rates of low-weight births and negative returns to low birthweights, in both rural and estate sectors.

Maternal education showed some interesting patterns on the height-for-age and BMI-for-age of children within the two sectors in the intra-sector models. Similarly, interesting patterns were also observed in the decomposition analysis particularly in 2006. Differences in the proportions of mothers with relatively high education (i.e. GCE (O/L)) was seen to narrow the rural-estate gap in height-for-age in favour of the estate sector at the mean and upper ends of the growth distribution while differences in proportions of mothers with lower levels of education (primary and secondary) were seen to widen the gap in support of the rural sector. Differences in the levels of secondary education also contributed towards widening the median growth gap. The descriptive analysis showed that the proportion of mothers with primary and secondary education levels was higher within the estate sector while the proportion of mothers showing higher levels of education was higher within the rural sectors. Given this, the results suggest that increasing the levels of education of estate mothers would, in general, help in narrowing the gap in long-term growth between the two sectors. Even though the intra-sector analysis showed maternal education to have significant impacts on the BMI-for-age within the rural sector, differences in the levels of maternal education did not show significant effects on the rural-estate BMI-for-age differential at the mean, median and upper ends of the growth curve. The only significant endowment effects were observed at Q10 which did not show a statistically significant rural-estate BMI-for-age differential in 2006.

The Generalized Hausman tests revealed that the returns to certain levels of maternal education on height-for-age and BMI-for-age of children were significantly different between the two sectors in both years. Given this observation, it was not surprising to note that maternal education also showed significant coefficient effects in the decomposition analysis. Differences in returns to maternal education significantly contributed to both the height-for-age and BMI-for-age differentials in 2006. However, the observed directions of effects were opposite to those observed with the endowment effects. Differences in returns for relatively higher education levels (i.e. G.C.E.(O/L), G.C.E.(A/L)) was seen to widen the rural-estate height-for-age gap in favour of the rural sector in 2006, whilst differences in returns to lower levels of education (i.e. primary and secondary) show mixed effects. Differences in returns to secondary education seem to narrow the height-for-age gap at the upper end of the growth curve while difference in returns to primary education widen the gap at the mean, median and Q90. In contrast differences in returns to primary, secondary and GCE (O/L) education were seen to widen the rural-estate median BMI-for-age gap in favour of the estate sector while differences in returns to higher levels of education (GCE(A/L)) was seen to narrow the gap in favour of the rural sector.

These results must be interpreted in light of the returns to education observed in the two sectors in 2006. As previously discussed, returns to maternal education show positive effects on height-for-age in both sectors, with stronger effects observed within the rural sector. Given this background, it is reasonable to expect that differences in returns to higher levels of maternal education would favour the rural sector, with regards to long-term growth. However, negative returns to maternal education on the BMI-for-age of children observed within the rural sector backs the observed negative effects on the rural-estate BMI-for-age differential in 2006. Potential reasons for the observed negative effects of maternal education on the short-term growth of children within the rural sector were discussed in the previous section. The need for proper child-care support mechanisms within the rural sector was highlighted in order to improve returns of maternal education on short-term growth. It is worth noting here that, while maternal education was identified as a driver of rural-estate growth differentials in 2006, these effects did not persist over time. In fact, the observed positive impacts of maternal education on the height-for-age in 2006, has in fact deteriorated to become negative and mostly non-significant, in 2016. This suggests that the positive impacts of maternal education of child growth has significantly deteriorated over time, especially within the rural sector, and thus does not drive rural-estate growth differentials in 2016. A similar pattern is also seen within the estate sector, though the evidence is not as strong given the relatively weaker relationship between maternal education and child growth, within the estate sector in 2006.

From a policy perspective, a number of different points can be highlighted. Firstly, policy and interventions geared towards improving the levels of education of estate mothers is required to improve long-term growth within the sector and to drive down the rural-estate growth gap. Secondly, interventions for improving positive returns of maternal education on child growth, is a key requirement particularly within the rural sector, which shows a considerable deterioration in positive returns to maternal education over time. This could be achieved by increasing the value of education for women within the rural sector, both through the supply of more skilled employment opportunities within the sector, and also by establishing the necessary support structures which will help care for children whose mothers choose to travel to urban areas or migrate to other parts of the country in search of skilled employment. The latter would particularly help in reversing the negative impacts of maternal education on short-term growth of children observed within the rural sector. In time, these mechanisms could also be rolled out to the estate sector, in order to improve returns to maternal education on child growth within estates.

Another important aspect to be considered is the improvement / deterioration of growth over time, within each sector. Whilst both sectors show a clear improvement in height-for-age a more troubling observation is with regards to the general decline in BMI-for-age observed within the estate sector over time and the decline in BMI-for-age at the lower end of the growth distribution observed within the rural sector. The difference in the proportion of non-working mothers is a significant contributor to the growth deterioration observed at Q10 within the rural sector. Descriptive results suggest that the proportion of HH with non-working mothers significantly increased from 2006 to 2016, within the rural sector. This could lead to a significant decrease in HH income, which would negatively impact the long-run growth particularly among the vulnerable groups of children. In contrast, the growth deteriorations observed within the estate sector are seen to be driven more by differences in returns to controls, rather than changes in the levels of controls. This points to possible structural issues whereby returns to controls seem to deteriorate over time, within the estate sector. Differences in returns to antenatal care, maternal BMI and HH wealth are identified as key variables that drive growth differentials.

Broadly, results suggest that whilst significant sector differences in long-term and short-term growth of children exist, targeted sector specific interventions, as explained above, can be used to achieve growth parity between the two sectors in the long run.

Essay 2: Merrill J Fernando (MJF) Mid-Day Meals Programme-Survey and Evaluation

Chapter 6: Introduction and Review of Literature

"Not often is it that men have the heart when their one great industry is ruined, to rear up in a few years another as rich to take its place; and the tea fields of Ceylon are as true a monument to courage as is the lion of Waterloo" ~ Sir Arthur Conan Doyle

From colonial Ceylon to modern day Sri Lanka, Tea has been the crowning jewel of our island nation. The tea plant or *camellia sinesis* was first introduced to Sri Lanka in 1824 by the British. This tea plant was planted on display at the Royal Botanical Gardens in Kandy. The first tea seedlings, for commercial cultivation was planted by James Taylor, a young Scotsman, in 1867. The first 19 acres of tea was planted by him in what is today known as the Loolecondera Estate in Kandy, the heart of the then thriving coffee industry in the plush interior of the country approximately 500m above sea level. After the collapse of the coffee industry due to the spread of the coffee rust fungus, many British planters left the island while the few remaining decided to give it another chance by diversifying in to the tea industry which has today grown to be one of Sri Lanka's main breadwinner industries grossing exports of approximately $1.5 billion per year (Rosenfeld, 2015). As refreshing as Ceylon tea tastes, the story of the labour force behind this massive industry is one of bitter truth. The rise of the coffee plantations and demand for Ceylon coffee in the early 19th century led to a steady increase in the demand for labour. With the native Ceylonese being reluctant to work under British planters, they were compelled to import labour from the closest neighbouring colony, which was the Indian subcontinent. Similar to India as well as many other British colonies in the tropical and sub-tropical regions, a plantation system established in Ceylon was also dependent on residential labour. Starting with the coffee fields, this system continued after the conversion to tea cultivation and continues to the present day. The resident labour population living in tea estates today, are mostly descendants of the early indentured labourers from India and forms a historically deprived and impoverished part of Sri Lankan society.

The Merrill J Fernando Charitable Foundation (MJF) was established by the founder of Dilmah (the famous Ceylon tea brand), Merrill J. Fernando, in 1999, with the vision of "making business a matter of human service". Since its inception, the MJF foundation has provides aid in a range of areas such as health, nutrition, education, and human development through well placed outreach programmes within vulnerable communities of the country (including tea estates). However not much assessment has been done on the effectiveness of many of these outreach programmes. The Mid-Day Meals programme which is the focus of this essay is one such outreach programme which targets children living in a number of tea plantations within the estate sector of the country. Despite being implemented as far back as 2007, the programme has not been evaluated to measure its effectiveness since its implementation. Therefore, the primary focus of this essay is to carry out a comprehensive evaluation of this programme to assess whether the programme is successful in promoting the growth of children living within these tea estates. In particular, the essay focusses on exploring the following research questions.

Q1: Does the mid-day meals programme benefit the growth of children, living within tea estates that host the programme?
Q2: What impact does regular programme participation have, on the growth of children?
Q3: Does the effectiveness of the programme change based on different characteristics (e.g. gender, birth cohort etc.)?

A structured survey method was utilised to collect necessary data required for the evaluation. Given that baseline data at the time of programme implementation was not available, suitable econometric methods were used to overcome analytical issues arising from this. The survey conducted as part of this study covered children from three different tea estates. Two of these were treatment estate as they hosted the mid-day meals programme whilst the third was used as a control estate as it did not host the programme. The survey was funded through the Overseas Research and Travel Grant provided by Monash University Australia and carried out under the guidance and support of both the MJF

Foundation and the Plantations Human Development Trust (PHDT), which is the main government authority overseeing and regulating for the welfare of plantation workers in Sri Lanka. A research assistant was employed to assist during the field survey, and data entry operators were employed to enter the collected data.

Chapter 7 presents details of the survey design and sampling procedure used for the field survey. The following sections present a brief overview of the history of tea plantations in Sri Lanka and the MJF mid-day meals programme followed by a review of relevant literature on nutrition interventions.

6.1. History of Tea Plantations in Sri Lanka

6.1.1. The British Colonisation (1802-1948): The Dawn of the Tea Industry

Sri Lanka has faced several foreign invasions throughout its history. Whilst many of the earlier invasions (predominantly by Indian emperors) did not last long, recent history marks three main invasions by western empires. The western invasions started with Portugal in the 16th century, followed by the Dutch in the 17th century. However, the longest period of colonisation is marked by the British, who invaded the island in 1796. The Kingdom of Kandy in the heart of the island which had withstood assaults by both the Portuguese and the Dutch finally fell to the British in 1815, making the entire island a crown colony. A colonial economic system was established, and subsequently the land which was once owned by local communities was confiscated using the "Crown Land Encroachment Ordinance" of 1840 (Mapa et.al., 2002). This was accompanied by a conventional plantation system to cultivate coffee and other spices for trade. By the mid-19th century, many British colonies such as India, Malaysia as well as a few colonies in Africa and the Caribbean Islands had different plantations established within them, depending on the various geographical characteristics. Among the major commercial crops were tea, coffee, cocoa, sugar cane and palm. Monoculture and resident labour being two key elements of traditional plantation systems, the system depended on a large number of labourers willing to reside and work within the plantations. The Kandyan Kingdom being the last stronghold of native Ceylonese, anti-British sentiments were high amongst the native Ceylonese, specifically within the hill-country region which was also the key coffee cultivation region of the country. This made it difficult for the British Planters to attract enough labour to man the coffee fields. As a result, labour had to be imported from South India (Shunsuke, 2011).

The resident labour system that was established by the British in Sri Lanka was unique in that it exploited the caste system that was in place in South India at the time. The labourers were hired through Indian labour contractors known as *Kanganys* (labour supervisors). The *Kanagnys* were typical higher caste leaders in villages in South India, and the workers hired through them usually belonged to the lowest social castes and were often in debt to the *Kangany*. The plantation management not only paid a hiring fee to the *Kangany*, but also the wages to the labourer, and this was offset against the debt that each labourer owed the *Kangany*. Therefore it is clear that the initial labour system established in the plantations in Sri Lanka could characteristically be called a bonded labour system, with labourers working day and night to pay off the debt that they owed to the *Kangany* (Dawood, 1980). The resident labour was largely used in coffee plantations until 1886 when the coffee rust fungus saw the end of the many coffee plantation by 1886. This saw the replacement of coffee with tea, a much more labour-intensive crop. Plantations were extended owing to the large profits derived from the tea industry, and more resident labourers migrated to the country from South India. Initially the workers were permitted to leave the estate once they had paid off the debt owing to the *Kangany*, however later workers started migrating with their families and settling within the estates. This established what is today referred to as the Indian Tamil community of Sri Lanka.

Owing to the bonded labour characteristic, the socio-economic status of estate sector residents was significantly low, from its inception. The plantation management paid the wages of all workers to the respective *Kangany*. Social welfare and basic social services were provided at a very low level by the respective plantation management. The culture and habits of the Indian Tamils being different to the native communities coupled together with the hard to reach mountainous terrain where most of the early plantations were located made the estate community a closed enclave system with minimal interactions with local communities. Completely dependent on the *Kangany* and the plantation management for their basic need, and paid the lowest possible wages at the time, poverty was inherent among the first generation of Indian Tamil workers in the estate sector (Gunetilleke et al., 2008).

6.1.2. Post Independence Era (1948-to present): The Growth of the Tea Industry

Sri Lanka gained independence and became a sovereign state in 1948. Post-independence brought about many structural changes to the economy as well as the plantations sector of the country. Much of the tea estates which were owned by the British companies were sold to Ceylonese companies during the early 1950s as part of the Ceylonization process. This process continued till 1975. However, the economic and social conditions of the resident work force remained much the same irrespective of the change in ownership since the main objective continued to be profit generation. In 1975, another major structural change occurred wherein all plantation estates were nationalized and absorbed to the government as part of the nationalization process. Two separate government corporations, the State Plantations Corporation and the Janatha Estate Development Board were established in 1976, in order to take over and manage the estates. With little knowledge of how the estate sector functioned, the two corporations were unable to produce any profit through the tea estates, causing the conditions of the workers to further deteriorate. Finally, in 1992, the government took steps to re-privatize the management of the plantations while retaining their right to land. Accordingly, the management of 449 estates were handed over to 22 regional plantation companies (RPC). In 1995, the then government took steps to carry out the second stage of the re- privatization offering shares to the RPCs.

The establishment of the Plantation Housing and Social Welfare Trust (PHSWT) in 1992 provided a common platform for all parties associated with the plantation sector to come together. Established as a tripartite organization between the Government of Sri Lanka, the RPCs and the Plantation Trade Unions, the aim of this organization as to implement social development programmes to uplift the quality of living for the estate community. The organization was renamed as the Plantations Human Development Trust (PHDT) in 2002.

Even though the nationalization and subsequent privatization processes brought about a lot of structural changes to the management of the estates, not much changed with regards to the resident workers and families living in the estates. Even with the management of the estates handed over to the private sector part of the responsibility of maintaining and developing the workforce remained with the government. In fact, as Shunsuke (2011) points out, through the history of the Sri Lankan plantation sector, all changes and development made have been done so with little or no consideration of those living and working within the estates and was solely made based on the needs of outside parties such as the British pre-independence and the Ceylonese government post-independence. Thus poverty, poor health and malnutrition became persistent characteristics of the estate community and continues to the present day.

Independence brought about another series of problems to the already supressed estate workers. During the British rule, the Indian Tamils and the native Tamils (reciding in the North and East provinces of the country) were considered as one category with both referred to as Ceylon Tamils (Shunsuke, 2011). However upon independence in 1949, the Indian Tamil workers living in the estates became stateless due to the ammendements made to the 1948 Ceylon Citizenship Act. It should however be noted that both the private plantation companies as well as the nationalized estate managements continued to provide certain basic services to the estate workers despite the statelessness. However the level and quality of services provided were significantly lower compared to those provided to citizens. From this point, obtaining citizenship for approximately 950,000 Indian Tamils living in estates in Sri Lanka became a significant struggle marked with diplomatic tensions rising between Sri Lanka and India for the first time post independence (Kanapathipillai, 2009). Finally after many years of failed negotiations and deals, Indian Tamils living in Sri Lanka were granted citizenship in 1988 after giving them the option to leave for India, if they chose so. A significant proportion of workers and their families left for India, while the remaining were granted citizenship.This change in social identity should have considerably improved their living conditions of the estate workers. Eventhough the past three decades have shown some improvement, due to the ongoing efforts by the government as well as various other parties, there is still room for much improvement.

6.2. The MJF Charitable Foundation and the Child Mid-Day Meals Programme

As noted earlier, over the course of its existence, the MJF charitable foundation has launched many development projects and outreach programmes targeting vulnerable and deprived communities across Sri Lanka. One of its milestone projects, MJF-KIDS was launched in 2005 with the sole objective of providing social and educational support to under privileged children. Through a network of MJF Centres around the country, the foundation provides help on a range of school and vocational subjects to both mainstream and special needs children from impoverished backgrounds. Dilmah being a key player in the Ceylon tea industry, the foundation has a rooted interest in the wellbeing of estate communities and has initiated many projects for their improvement and development. The MJF Child Mid-Day Meals programme is one such programme which was initiated in 2007. The motivation of the programme was to add value to children’s daily stay at the Child Development Centres (CDCs) in tea estates by providing a balanced mid-day meal. The programme was first launched in a few CDCs funded by the MJF foundation. The success of the initial stage of the programme prompted the foundation to further expand the programme to other CDCs. As of 2013 the programme had been extended to 32 tea estates belonging to the Kahawatte Plantations PLC and Talawakelle Tea Estates PLC (TTEL). Currently the programme is functioning in 90 MJF-CDCs across a number of plantations within the upcountry region in Sri Lanka. The meals provided under this programme are carefully prepared by the Child Development Officers (CDOs) at each CDC. The meals are prepared following a standard menu set by health professionals with careful consideration for the required daily calorie intake for children below the age of 5 years. The following figure depicts some of the menus prepared at the MJF-CDCs.

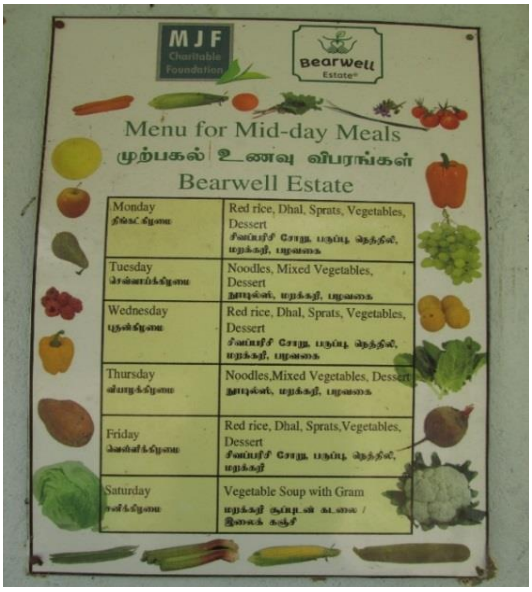


Figure 6-1: MJF Mid-Day Meals Programme Menu
Source: MJF Child Care Centre- Bearwell and Holyrood Estates

In order to understand the implementation of the MJF mid-day meals programme within tea estates, it is important to consider the prevalent labour structure, work patterns and child-care structures within tea estates. The back drop of the estate labour environment was explained in the previous section. As noted, the tea industry is a highly labour-intensive industry with a significantly large proportion of female labourers working as leaf-pluckers. Given this labour structure and the fact that most households within the estate sector tend to have multiple children, meant that a proper mechanism needed to be put in to place to care for the children during the work hours of the mother. This mechanism was in place historically, in the form of basic crèches which were formally known as a *pullèmadù* (i.e. child-huts) where the children were kept under the care of an older retired female plucker. Traditionally these centres comprised of a very basic hut with several baby hammocks made up of lengths of cloth (usually the mothers' sarees) hanging from the roof. The children were thought to be lulled to sleep because they felt their mother's presence when wrapped in her saree. The saree also provided cover from insects such as flies and mosquitoes.

Figure 6-2: Traditional Baby Hammock

With the establishment of the PHDT in 2002 (and previous PHSWT in 1992), closer scrutiny of the plantations sector with a specific focus on the human capital began. This gradually led to many of the traditional *pullèmadùs* being replaced by fully functional Child Development Centres (CDCs) operated by trained Child Development Officers (CDO). Each estate was usually separated into a number of divisions (based on its size) and in each division, a CDC had to be maintained, in order to take care of the children of resident workers within the division, during work hours. Traditionally most estates employed an Estate Midwife and Estate Doctor for provision of medical services to estate residents. Under the PHSWT and later PHDT, it became mandatory for tea plantations to employ an Estate Medical Officer and the Midwife in each estate. Strict regulations were also introduced to gradually replace the baby hammocks with proper child cots and cradles. The process is still under way in many estates with the progress somewhat hampered due to limited resources. CDCs have been established within most tea estates in the country. The CDCs visited as part of this field research, functioned all 5 weekdays from 7.30 a.m. - 5.00 p.m. Most of the CDCs remained open on weekends as well, whenever plucking took place on weekends. Whilst children are generally provided teatime snacks (including the government provided *Thriposha* cereal supplement) by CDCs, lunch is usually provided by parents to be given to children at mid-day. As noted, the MJF mid-day meals programme was implemented through some of these CDCs. Accordingly, in CDCs operated under the patronage of the MJF foundation, a mid-day meal was provided to each child attending the CDC on every day that the centre was open. Therefore, the programme operates as an early childhood nutrition intervention aimed at improving the growth of estate children below the age of 5 years. Nutrition interventions are a popular mechanism used to combat childhood malnutrition in developing countries and has also attracted much research over the last few decades. The following section provides a brief review of available research on some select programmes in Sri Lanka and other parts of the world.

6.3. Effectiveness of Nutrition Interventions – Review of Relevant Literature

Nutrition interventions are a popular method for providing targeted treatments for malnutrition especially within vulnerable groups of society such as children and the elderly. A nutrition intervention can be defined as a “purposefully planned action intended to positively change a nutrition-related behaviour, environmental condition, or aspect of health status for an individual, target group, or the community at large” (Academy of Nutrition and Dietetics, 2014). Nutrition Interventions were considered an important step in the Nutrition Care Process which was introduced by the American Dietetic Association in 2002, with the aim of improving consistency and quality nutrition care.

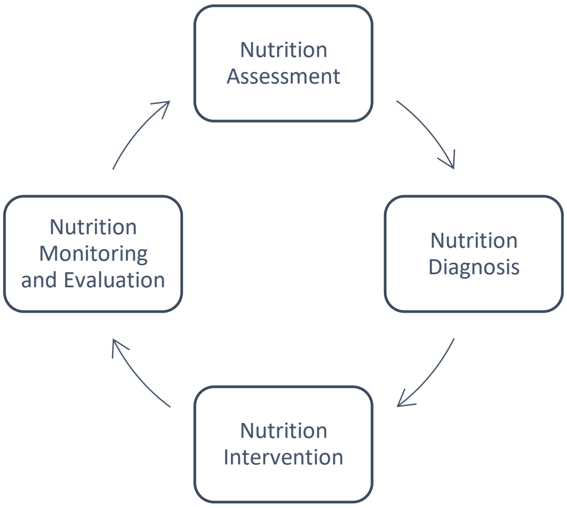


Figure 6-3: Nutrition Care Process

According to the ADA (Lacey and Cross, 2002), nutrition interventions can either be health interventions such as providing nutrition supplements and medical advice to change diet behaviour, or non-health interventions such as nutrition and health education. Both these types of interventions are effective in many parts of the world. There is a considerable pool of literature on various nutritional interventions effective in Sri Lankan and around the world and evaluation of some of these programmes.

When considering Sri Lanka, the Integrated Nutritional Package (INP) programme is one important health intervention programme with wide spread coverage (UNICEF ROSA, 2012). The programme was initiated in 2006 and identified a set of key interventions including infant and young child feeding practices, growth monitoring, supplementary feeding for acute malnutrition and pregnancy weight gain monitoring. The programme uses the life cycle approach in designing well targeted interventions. The key strategy-life cycle approach identifies five key stages at which intervention should be applied in order to address maternal and child malnutrition. The strategies applied under the INP programme targets all five stages of this cycle.

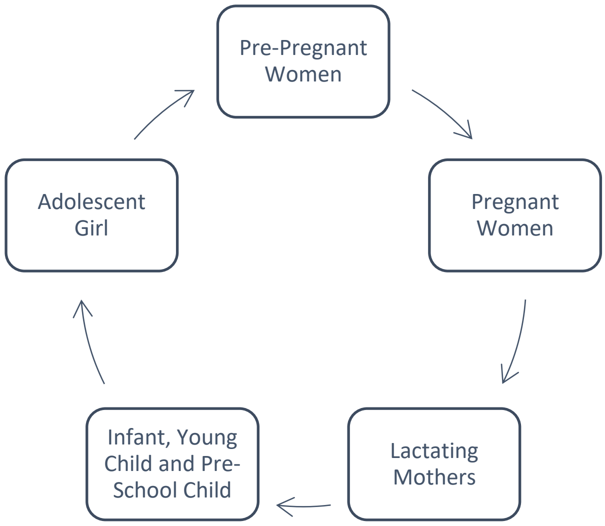


Figure 6-4: Life-Cycle for alleviating maternal and child malnutrition

The INP programme was first implemented in 6 districts which were identified to have a high incidence of child and maternal malnutrition (Moneragala, Badulla, Trincomalee, Batticaloa, Hambantota and Nuwar Eliya). Today the programme is widespread with multiple components. In addition to this, many other projects have been initiated with a link to INP (e.g. the Nutrition Rehabilitation Programme launched in the IDP camps post war). Jayatissa and Bekele (2006) presents a review on the implementation of the INP programme in 2006. The report gives a brief causal analysis of the state of child and maternal malnutrition in Sri Lanka. It also clearly presents the objectives that the programme hoped to achieve by the end of 2008 and explained the target groups and project areas concerned. Rajapaksa et al. (2011) presents a comprehensive desk-review on the nutritional status in Sri Lanka together with a review of various interventions used. The report reviews both published and unpublished work on nutrition, determinants and interventions from 2006-2011 including the INP programme. The report cites two studies, the first done on a cohort of children with moderate acute malnutrition (MAM) and severe acute malnutrition (SAM) selected from the districts where the INP programme was operational, and the second study conducted by the Medical Research Institute of the Department of Nutrition as a mid-term evaluation of the INP programme to examine its effectiveness in reducing child malnutrition and the coverage of certain project components. Under the first study, children were given nutrition supplements for a 1-year duration from January 2010, at the end of which their nutritional status was assessed. The results showed some reductions in MAM and SAM but at varying degrees. The second study was linked to the baseline study carried out in 2006 (Jayatissa and Bekele, 2006) and used 10 clusters (of 30 children each) for each district, from the original 30 clusters used in the baseline study. The study reported that the prevalence of MAM had increased in all districts while the prevalence of SAM had decreased in all districts except Nuwara Eliya and Batticaloa. The study also reported a decrease in the prevalence of low birthweights. However, it was noted that, whilst cited in (Rajapaksa et al., 2011), the above tow studies were not formally published. As of 2015, the programme was still active and was being continuously aided and monitored by the UNICEF.

The Participatory Nutrition Intervention Project (PNIP) is a similar project to INP which was initiated in 1993. The project was a community-based initiative which was launched by the Govt of SL with the help of the UNICEF. The main objective of the project was to support the national nutrition goals which were to reduce, child malnutrition, the incidence of low birthweight and maternal malnutrition. The three main activities carried out under the project were to make necessary institutional arrangements within public institutions to accommodate PNIP, to train and advocate PNIP personnel and mobilizing the target communities to adopt behavioural changes to promote nutrition welfare. Tudawe et al. (1999) presents a mid-term review of the PNIP. The report compares baseline information with the mid-term information collected through a household survey. The report indicated some positive changes in behaviours related to maternal care, breast feeding practices and water and sanitation practices. The improvement in maternal care is reflected by a 13% reduction in low birthweight babies. However, the report reveals that the behavioural changes with regards to growth monitoring, frequency of child feeding, and feeding children during illness was inadequate with no significant difference in their nutritional status over the two periods of study. This indicated that the households did not properly implement the recommended practices with respect to child nutrition. The report also revealed that nutrition and mobilization knowledge was not up to the required standards, and whilst 48% of the villager's surveyed were aware of PNIP activities only 26% actually participated in the programme.

The '*Thriposha'* programme is another popular intervention programme in Sri Lanka, which provides supplementary food to segments of the population identified to be at risk of being deficient in protein and other micronutrients such as iron and vitamin A. The programme started in 1973 as a government initiative backed by CARE and USAID. The name '*Thriposha'* means 'three nutrients'; namely, energy, protein and micronutrients. The programme was aimed at pregnant and lactating mothers and children in the age group of 6-59 months. Hornstein (1986) provides a monograph of the *Thriposha* programme in its early years. The report suggests that the programme was very successful in converting itself from an import-reliant feeding programme to one that was substantially sourced from locally grown produce. The report describes various aspects of the *Thriposha* programme from its conception to its operations as at 1986, and its distribution and impact, by 1986. It also discusses the *Thriposha* programme as a successful use of brand imaging, where the product was branded and packaged attractively with the image of a 'nutritious' processed product, which disassociated it from the stigma of being 'food for the poor'. This positive image, together with the programme's timely integration with other nutrition and health services provided through clinics and rural health centres, was key in its widespread impact. As of 2020, the *Thriposha* programme is still successfully underway in all districts of the country.

Hornstein (1986) also explains how the *Thriposha* programme was implemented as an on-site programme in day-care centres within the Sri Lankan government's tea, rubber and coconut estates. The report shows that, as far back as 1986, the *Thriposha* programme was effective within the *créches* in the tea estates, where the *crèche* attendants underwent a 6-week training programme conducted under a UNICEF project. The *crèche* attendants were supported by the estate midwives and family welfare supervisors. The Ministry of Health appointed Regional Estate Medical Officers were responsible for conducting monthly clinics in each estate, where children were examined, weighed, dewormed and immunized while mothers received health, nutrition and family planning advice. *Thriposha* packets were distributed to the *crèche* through the clinics, according to the number of children within the estate. The monograph also reports findings of a study conducted by Sri Lanka State Plantation Corporation, to assess the impact of on-site feeding of *Thriposha* using 40 estates in the Kalutara region. The study observed infants and pre-schoolers enrolled in the programme in January 1982, and measured their nutritional status before entering and after one year in the programme. The study reported a percentage drop of approximately 55% in second- and third-degree malnutrition in both infants and pre-schoolers. Atukorala, et.al.(1994) is another study which focusses on the estate sector to evaluate the effectiveness of food supplements (*Thriposha*), iron-folate supplements and anthelminthic therapy against anaemia during pregnancy. The study was based on repeated observations (baseline and 30 weeks gestation) of 130 randomly selected pregnant plantation workers. According to the report, no significant benefits of consuming *Thriposha* could be detected, while increased duration of taking iron tablets did show a positive effect. The study also reported a positive effect of receiving anthelminthic therapy. The report indicates inadequate consumption quantities as one probable cause for the *Thriposha* consumption not showing a significant effect.

Jayatissa (2005) provides an evaluation of the *Thriposha* programme for combatting malnutrition in mothers and children based on previous reported studies. The study identified certain issues in the implementation of the *Thirposha* programme as highlighted by past research (e.g. prior research suggesting that 50% of the children receiving *Thriposha* in the non-plantation sector, share it with their families). Using evidence from previous studies, Jayatissa (2005) forwarded the hypothesis that the programme is most effective within the plantation sector where on-site feeding is implemented via the Child Development Centres. The review also highlights the lack of proper regular evaluation of the *Thriposha* programme through health cards. Hettiarachchi and Liyanage (2010) examines the effect of *Thriposha* supplementation on the micronutrient status in young children. The study was carried out as a randomized control trial where two groups of approximately 130 preschool children were used. The intervention group received *Thriposha* (50g/daily) while the control group was fed *Thriposha* without the mineral and vitamin premix (50g/daily). The study duration was nine months and a series of measures including serum calcium, ferritin, folate, vitamin A and vitamin D were taken both before and after the intervention. The study reported that the intervention group showed significant improvements in haemoglobin, ferritin and ceruloplasmin levels over the control group.

Micronutrient supplementation programmes are another popular type of intervention used in Sri Lanka. The iron supplementation programme for pregnant women and the Vitamin A mega dose programme for children are two such popular programmes. Jayatissa, Mahamithawa and Ranbanda (2004) provide a rapid assessment of the coverage of these programmes. The study revealed that the national coverage of the iron supplementation among pregnant women was approximately 93% with approximately 88% of women using the iron tablets, on average. The coverage of Vitamin A supplementation was found to be considerably less, with only 37% of school children receiving the treatment on average. The study suggested that, even three years after the implementation of the Vitamin A supplementation programme, coverage of the programme was significantly low. Jayatissa and Gunathilaka (2006) is another large-scale study that assess the Vitamin A nutrition status among less than 5-year-old children in the country. According to this 66% of children were reported to have received Vitamin A mega dose at least once in their lifetime, with the highest coverage being for the 12-23 month age group. Apart from those reviewed here, several other large and small-scale nutrition and poverty alleviation interventions are in place in Sri Lanka. However, monitoring and evaluation of much of these programmes is sporadic and hence published research is somewhat sparse.

When considering the South East Asian region much of the literature is concentrated on the National Programme for Nutritional Support to Primary Education which is a programme operational in India (Deodhar et al., 2010; Dercon, Park and Singh, 2012; Mishra, 2013; Singh, Park and Dercon, 2014). The programme provides a mid-day meal to primary school students studying in government schools and government assisted schools in India. Deodhar et al. (2010) provides an evaluation of the programme based on observations made by visiting three participating schools and an NGO involved in the preparation and distribution of food. The collected food samples were tested for nutrient content and food safety aspects. The article reveals certain limitations in the implementation of the programme with respect to nutrient delivery, the variety and safety of the food provided as well as loss of study time arising from the method of implementation of the programme within schools.

Singh et al. (2014) is a recent research that focuses on the school mid-day meals programme (Midday Meal Scheme-MDMS) in India. The study uses a longitudinal dataset that collected data over two consecutive periods, on a sample of children within the state of Andhra Pradesh. The study looked at the overall impact of MDMS on the health status of children as well as its effect on ameliorating the negative impacts of weather shocks on the health of children. The study reports that the MDMS entirely compensates for the negative effects of drought on children. However, the study shows that a gap of at least 18 months was required for the catching up process to be completed. The study also reported that both the MDMS and drought showed significant effects on both the height-for-age and weight-for-age of children. Afridi (2011) is another study that analysed the effect of the MDMS using a random sample of children from the Madhya Pradesh region. The study effectively compares the food intake of children on a school and non-school day and reports that the daily nutrient intake of programme participants substantially increased by 49%-100%.

The Integrated Child Development Services (ICDS) programme is another nutrition intervention operational in India (Lokshin, Das Gupta, Gragnolati and Ivaschenko, 2005). In 1975, the government of India with the aid of UNICEF initiated the ICDS programme, in order to provide targeted interventions to malnourished children and women. The programme provided supplementary nutrition, basic health services, nutrition and health education and growth monitoring to children and pregnant/lactating mothers. The interventions were provided through ICDS centres established within villages. Lokshin et.al. (2005) uses the Indian national housing surveys from 1992 and 1998 to assess the programme placement and outcomes. The study revealed that the programme coverage in the Northern states of India, which records higher levels of poverty and malnutrition is considerably low, making programme coverage across states regressive. The study also showed a clear disparity in the budgetary allocations from the central government to those states. Within states, the study showed the programme placement to be progressive with larger and poorer villages having a high probability of having an ICDS centre. The research however does not report any evidence of the programme affecting child's nutrition status in villages.

A similar nutrition intervention effective in Bangladesh is the Food for Education (FFE) programme (Meng and Ryan, 2010). The FFE programme was initiated in 1993 in Bangladesh with the objective of providing food as an incentive to increase school participation. Meng and Ryan (2010) used a propensity score matching technique with the difference-in-difference method to estimate the effects of the programme on school outcomes of children. The study reported the programme to be successful in increasing school participation rates with eligible children having 15%-27% higher school participation rates relative to their counterfactuals. Of those in school, participants in the programmes were also found to stay in school 0.7-1.05 years longer than their counterfactuals.

The Tawana Pakistan Project was an initiative introduced by the Pakistan government to address the issue of poor nutritional status and school enrolment among primary school age girls in Pakistan. The project was focussed on training and empowering village women to collectively plan balanced meal menus, purchase locally available food, and prepare the meals to provide a mid-day meal to schools at a nominal cost. The project was implemented as a pilot project in 4035 rural girls' schools from 2002-2005. Badruddin et al. (2008) presents a review of the programme where heights and weights of participating children were measured prior to treatment as well as every six months during the programme. The study recorded a decrease in wasting, underweight and stunting by 45%, 22% and 6% respectively. School enrolment was also seen to increase by 40%. The programmes reviewed here are a few examples available from an extensive pool of literature on school feeding programmes and other nutrition interventions in South Asia including Sri Lanka. Humanitarian organizations such as the UNICEF and WFP (World Food Programme) often partner with government and private organizations around the world, in implementing such nutrition intervention programmes. However, most programmes are designed to target school children with very few programmes targeting pre-school children. The following section reviews some of the limited research available on early childhood nutrition interventions and their effectiveness, as this directly relates to the target population covered by the MJF mid-day meals programme.

6.3.1. Review of Early Childhood Development and Nutrition Interventions

The consensus on early childhood development (ECD) interventions is that they are beneficial for improving physical, psychosocial wellbeing and cognitive ability of children. Early childhood development broadly combines a variety of interventions involving young children and their parents/carers. These programmes include health and nutrition interventions, childcare support and education. Penn (2004) presents a review of a range of ECD initiatives using case studies from two countries; Swaziland and Kazakhstan. The paper reveals some important limitations in directly applying the conceptualization of ECD derived from developed countries such as the US to developing countries. The paper concludes that ECD needs to have a more ‘pro-poor’ orientation when applied in developing countries. The work largely draws from existing literature and does not utilize any statistical techniques.

Barnett (1995) presents a review of 36 studies on educational ECD programmes which include both model demonstration and large-scale public programmes. The aim of the review is to examine evidence presented in these studies specifically regarding the long-term effects of these programmes on children from low-income backgrounds. The review also pays attention to the research design of each of the 36 studies and concludes that according to most of the studies ECD programmes produce large short-term benefits in children’s intelligence quotient and also significant long-term improvements in school performance.

Boocock (1995) is another review article which presents details of published studies on ECD programmes carried out in 13 developed/developing countries. Much of the discussed research is based on education ECD programmes with results indicating that participation in preschool programmes promote cognitive development and narrows the achievement gap between low-income and advantaged children. Some studies reviewed also show that maternal employment supported by child care services do not hurt children and can also lead to benefits conditional on the quality of child care provided. This result is particularly important in the scenario of this research since the CDC system within tea plantations in Sri Lanka acts as a child care centre for working mothers and where mid-day meals are provided, the CDC acts both as a hub for providing nutrition supplements and child care services during the working hours of the mother. Many of the studies reviewed in Boocock (1995) focus on educational interventions and parental support programmes. The review also includes two studies from India one of which is the India Village Preschool Study comparing 120 children in six villages who attended 49 relatively high-quality child care centres, to a control group of 120 matched children not part of the programme. The study showed certain favourable results on a range of considered measures (measures of health, cognitive ability etc.) for the children who attended the programme compared those not attending the programme. However, many of the differences were not statistically significant. The ICDS programme is the other programme that is reviewed in the article (discussed in the previous section).

Considering early childhood nutrition interventions, a few examples can be drawn from developed countries. The Special Supplemental Nutrition Programme for Women, Infants and Children (WIC) and the Child and Adult Care Food Programme (CACFP) are two early child development and nutrition programmes effective in the US at the federal level. Colman et al. (2012) provides a detailed review of much of the recent studies done on the WIC programme. The review covers research on seven key areas of impact of the WIC programme; pregnancy and birth outcomes, infant feeding practices, infant and child dietary intakes, infant and child growth patterns, child immunization, infant and child utilization of health care services and child health and cognitive and socioemotional development. According to the review, research on the impact of the WIC programme on pregnancy and birth outcomes broadly suggest a positive association between WIC, gestational age and mean birthweight and a negative association between WIC and the incidence of low/very low birthweight (Bitler and Currie, 2005; Joyce, Gibson and Colman, 2005; Joyce, Racine and Yunzal-Butler, 2008).

Research exploring the impacts of the WIC programme on child growth reports mixed results. Black et al. (2004) report that among infants, when comparing WIC participants to non-participants, non-participants tended to be lighter and shorter. Melgar-Quiñonez and Kaiser (2004) suggest that there was a significant reduction in the risk of being overweight among WIC participants relative to non-participants. Rose, Bodor, and Chilton (2006) suggested that the WIC was associated with a greater likelihood of being overweight among white children while this pattern was not seen among Hispanics. Rivera (2008) did not report any significant positive or negative relationship between growth and participation in the WIC programme.

When considering the context of developing countries, there seem to be a marked gap in reported studies on early childhood nutrition programmes. The Indian Village Preschool Study and the ICDS programme both explained above, were two of the few available programmes in the South Asian region. Attanasio et al. (2014) presents a study done in Colombia, where a cluster randomized control trial was used to assess the effectiveness of an integrated early child development intervention. The study used psychosocial stimulation coupled together with micronutrient supplements to form treatments. Four treatment groups were used: psychological stimulation only, micronutrient supplementation only, combined intervention and control. The study showed that while stimulation helped in improving cognitive scores, micronutrient supplementation had no significant effect on any health outcomes (weight, height and haemoglobin levels).

From the above review two main points can be observed. Firstly, that there is very little available literature reviewing or assessing the impact of nutritional and other interventions within the estate sector of Sri Lanka. Secondly, that when considering global literature available on early childhood development programmes, much of it focuses on educational and parental support programmes as opposed to nutritional interventions. The studies that did address nutritional interventions in an early childhood setting were concentrated on developed countries such as the US, with very few focussed in the Asian region. Given this the evaluation of the MJF mid-day meals programme significantly contributes to both these research gaps, by presenting an evaluation of an early childhood nutrition intervention targeting the estate sector of Sri Lanka.

Chapter 7: MJF Mid-Day Meals Programme Survey

Development programmes underway within the tea estates of Sri Lanka, seldom carry out pre-post program evaluations to assess impact. Monitoring and evaluation is key to the improvement and longevity of any programme and this is especially true for nutritional intervention programmes. Particularly in the case of nutritional interventions such as the MJF mid-day meals programme, which focuses on children from critically poor segments of society, the benefits derived from the programme can be marginal or even non-existent owing to deprivations faced by children at the beginning of their lives. Research has shown that severe stunting and wasting within the first two years of their life can significantly impair their ability to achieve catch-up growth even through a targeted intervention programme (Crookston et al., 2010). Hence, this may require the intervention to be coupled with other enforcements to produce the intended impact. This requires regular evaluations to be done to identify and correct such weaknesses at the early stages of the intervention.

The 2015 MJF Mid-Day Meals Programme Survey was designed and implemented in order to collect necessary data required to evaluate the effectiveness of the programme. Planning and implementing a field survey is naturally challenging given limited resources and time constraints. Therefore, certain limitations had to be imposed at the design stage of the process. The following were some of the specific objectives and research questions proposed to be addressed through the field research.

- Are children in treatment estates generally different to children in the control estate, with regards to growth?
- Does the mid-day meals programme benefit the growth of children, living within tea estates that host the programme?
- What impact does regular programme participation have, on the growth of children?
- Does the impact of the programme change, based on different characteristics (e.g. gender, birth cohort etc.)?

With these main research questions in mind, the survey was planned and implemented to collect observational data on a suitable sample of children. The following sections explain the background, planning and implementation of the field survey.

7.1. Survey Background, Plan and Implementation

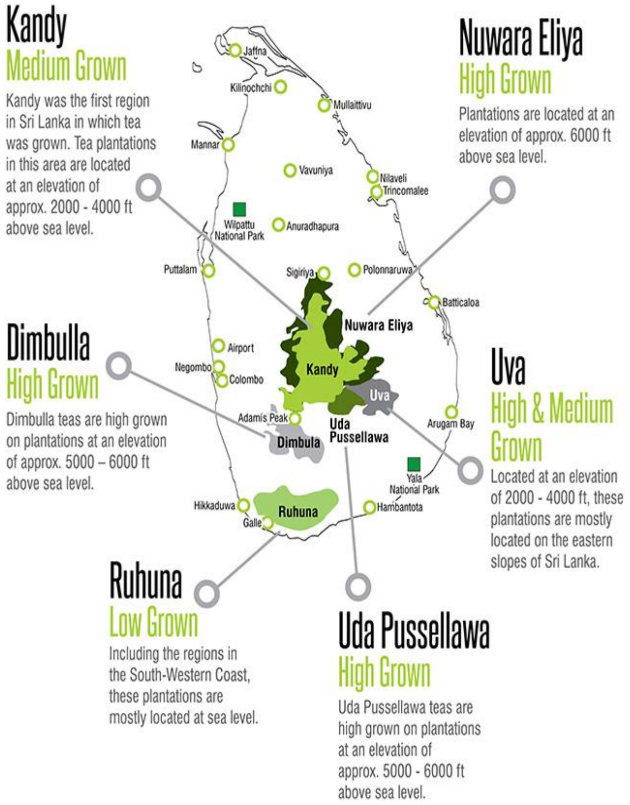


Figure 7-1:Tea Growing Regions in Sri Lanka
Source: (Sri Lank Tea Board, 2011)

The survey was carried out in three separate tea estates within the Thalawakele area in the Nuwara Eliya district of Sri Lanka. Tea estates in Sri Lanka are divided in to three separate categories, as high-grown, medium-grown and low-grown tea and the country is divided in to six main tea growing regions spread across nine districts. Nuwara Eliya, Dimbulla and Uda Pussellawa form the high-growing regions with Kandy and Ruhuna being the medium-growing and low-growing regions respectively. The Uva region is considered to be both a high and medium growing region. Figure 7-1 depicts the six tea growing regions in the country. While, the MJF foundation operated in estates across all six tea growing regions of Sri Lanka, this survey focussed on 3 estates in the Thalawakale area of the Nuwara Eliya district. All three estates (treatment and control) sampled under the survey produce high-grown teas.

Traditionally, an evaluation of a particular programme of this nature will require a baseline-post treatment comparison of the outcomes of interest. This requires baseline data to be collected before the programme is implemented and again at some point after its implementation. Data is collected from the same observational units at both time points. This method was not applicable in the present scenario since no baseline data was collected prior to the implementation of the MJF Mid-Day Meals programme in the estates. Due to the lack of baseline data, it was necessary to consider alternative ways of carrying out the necessary evaluation.

A number of different approaches were used in analysing the data. Descriptive methods were used to visually compare the growth of children in control and treatment estates. This was followed by an 'intention to treat' (ITT) modelling approach using pooled data from the treatment estates, comparing it to the data from the control estate. Following this a marginal structural modelling approach together with inverse probability weighting was used to model panel data within the two treatment estates. Given that baseline data is a strong requirement in causal inference, the lack of a baseline was a significant hindrance in the analysis. Including historical institutional data and manipulating the panel structure of the data, has largely overcome this issue. The methods used are explained in detail, in the following chapter.

7.2. Sample Design

Dilmah teas are derived from a number of different estates managed by different regional plantation companies (RPC). Accordingly, patronage of the MJFCF and its outreach programmes within the plantation community, are usually focussed on these estates. The MJF Mid-Day Meals programme was implemented in the Dilmah estates belonging to two regional plantation companies (Kahawatta Plantations PLC and Thalawakele Tea Estate Limited-TTEL). While the programme was functional in all estates belonging to Kahawatta Plantations PLC, it was only operational in some of the estates belonging to TTEL. The survey was therefore carried out in TTEL estates as this provided the necessary setting to collect data from both treatment and control estates. Choosing treatment and control estates managed by the same RPC also assured a certain degree of homogeneity between the two groups, with regards to services and facilities available within estates, daily wage rates paid to resident labourers and general living standards of estate residents (e.g. housing, quality of CDCs etc.). The treatment and control estates chosen were also situated relatively close to each other (within a 10km distance on average). This geographical proximity allowed for the reasonable assumption of homogeneity of other factors such as environmental conditions and cost-of-living, between treatment and control estates. Several rounds of meetings were held with the MJF foundation management in order to solicit their requirements and expectations for the survey. These meetings were also crucial in understanding the administrative set up within the estates. Figure 7-2 indicates the basic administrative setup within the estates.

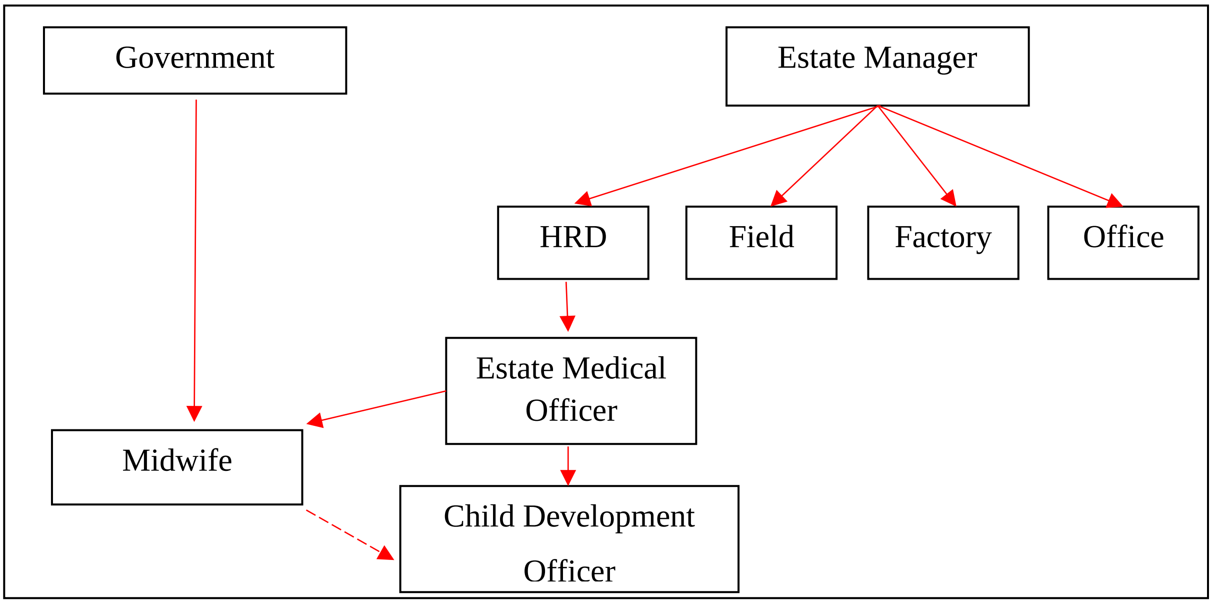


Figure 7-2: Estate Administrative Structure

Generally, the management of the human resource (HRD), field, factory and office fall under the purview of the estate manager. Traditionally each estate employed an estate medical officer and estate midwife, who fell under the estate management. The medical officer was in charge of treating general ailments of the estate population at the estate medical centre while the midwife traditionally monitored the health and wellbeing of pregnant and lactating mothers, children below the age of 5 years and helped with home births. However, with the structural changes that occurred within the plantation sector, with nationalisation and re-privatisation, the roles of estate medical officer and especially midwife became moderated by government bodies such as the Plantations Human Development Trust (PHDT) and the Ministry of Health (MoH). With most child births now being carried out in hospitals, estate midwives currently do less home-births, but are responsible for a range of duties including measuring the weights and heights of estate children below the age of 5 years, maintaining updated records on their growth and making regular home visits to monitor the health of pregnant and lactating mothers within the estates. Given the information maintained by them, the estate midwife became a central focus of the survey. Hence, the approval of the PHDT was obtained to interview estate midwives. Each tea estate was divided into a number of divisions, based on its geographic structure. Each division has a Child Development Centre (CDC) managed by one or two

Child Development Officers (CDO), employed by the estate. Children below the age of 5 years, who live within the division, and who have at least one parent working in the estate were entitled to attend the CDC in their division. A nominal fee of Rs. 50, was charged per month, as a CDC attendance fee, to encourage regular attendance of CDC registered children. CDOs were required to maintain a register of children and mark attendance both in the morning and afternoon of each day. Given this back ground, CDOs formed another important group that required interviewing. It should also be noted that, not all residents in an estate, opted to work in their estate of residence. Due to many generations of the same family having been employed in the same tea estate, families of non-resident workers continued to live in the same household. Employment outside the resident estate was usually considered in cases where such employment offered a higher income. Children belonging to such families were not eligible to attend the CDC. However, given the involvement of government authorities, the estate midwife was required to maintain growth records of all children living in the estate, irrespective of the employment status of the parents. This setup gives rise to an extra level of complexity with regards to gauging treatment effects, which will be further addressed in the methodology.

7.2.1. Sample Size Calculation and Initial Sampling Procedure

Gill, Johnson, and Clark (2010) presents the following equation that can be used to calculate the sample size for survey studies.

$$n = \frac{p(100 - p)z^2}{E^2} \qquad (7.1)$$

Here *n* refers to the sample size, *p* the proportion of occurrence/state being explored, *E* the margin of error % and *z* the confidence level score. Bartlett, Kotrlik, and Higgins (2001) advices the use of 50% as an estimate of *p*, so as to maximize the variance and produce the maximum sample size. This also fits in with the spread of the MJF mid-day meals programme within TTEL plantations. The total population size was set at 2000 children, which is an estimated number of children below the age of 5 living within TTEL estates. Using the standard error of 5% and estimated confidence level of 95%, the required sample size was calculated to be 322. Using this as a guide and given that this field study focussed on sampling from treatment and control estates, the initial sample size was set to be 300 for each group. Considering that the sample size calculation is typically done for a cross-sectional study, accounting for the longitudinal nature of the dataset, and possible data collection issues, the initial sample size was set at 500 for the treatment and control samples.

As mentioned earlier, estates belonging to the Thalawakele Tea Estate Limited were selected as the sampling frame for the survey, given the availability of estates for both the treatment and control samples. The primary sampling unit (PSU) in the study was the estate. Therefore, in order to pick a sample of estates to be surveyed, a list of all estates managed by TTEL was obtained from the company management. The list consisted of 12 tea estates in total with names and statuses (old, upgraded or new CDC) of all CDCs within each estate. The number of children registered at each of the CDCs was also available. Of the 12 listed estates, 5 estates reported the MJF mid-day meal programme to be functional within them while the other estates did not have the programme. Simple Random Sampling using the Order Sampling approach (Saavedra, Harding and Barrington, 2011) was used, to pick the initial sample of estates within the treatment and control groups. Accordingly, within each group, estates were assigned random numbers and arranged in ascending order based on these allotted random numbers. The estates were then drawn in order until the required sample sizes (500 or just below) for the two groups were met. The final sample sizes for the treatment and control groups were 502 and 460 respectively (see Table 7-1), which provided a sizable buffer for the calculated sample size of 322. The reason for selecting estates in this manner was due to the information provided by the plantation company based on which the sample selection was carried out. This data only included the number of registered CDC children as of 2014. Therefore, to account for possible drops in the actual number of children registered at the CDCs, at the start of the survey, in 2015, estates were sampled in such a way so as to provide a reasonable buffer for the calculated sample size of 322.

The sampling procedure resulted in 5 of the 12 estates being selected for the survey (3 treatment estates and 2 control estate). The selected estates had a total of 22 CDCs all of which were planned to be visited throughout the survey period. Table 7-1 below presents the background information on the 5 selected estate. As indicated earlier, a research assistant was recruited for assistance on the field work. The survey period was from 1st July 2015- 25th July 2015.

Table 7-1: Background of Selected Sample

Estate	Total number of CDCs	Number of Children registered at CDC (in 2014)
Treatment		
Bearwell	4	240
Holyrood	5	145
Mattakale	4	117
Estimated Total No. of Children		502
Control		
Dessford	6	322
Logie	3	138
Estimated Total No. of Children		460

At this point, it should also be noted that, due to some practical difficulties that arose during the survey, it was not possible to cover all the above estates. These issues are discussed in the next section.

7.2.2. Organisation of the Survey and Survey Instruments

The survey was conducted in four stages, two of which involved the administration of a questionnaire. Three different parties of interest were covered through the survey; the estate children below the age of five years, estate midwives and CDOs at the CDCs. Prior to explaining the four stages, it is important to indicate the reasons for carrying out the survey in this manner. As noted earlier a baseline study was not carried out prior to the implementation of the mid-day meals programme in 2007. Therefore, it was necessary to collect institutional data maintained by the estate to derive an approximate baseline. Institutional data on child health and growth were maintained by the estate midwife, while institutional data on the programme and implementation was maintained by the CDOs. Whilst the initial sample size was calculated for typical cross-sectional survey, estate midwives of all sampled estates were able to provide panel data on children's weight and height records. This added considerable value to the data used in the study. Apart from anthropometric details of children, the midwives and CDOs were interviewed to collect qualitative information on the general health, growth and wellbeing of estate children, general living standards of residents and the day-to-day functioning of the CDCs. In addition to interviewing the midwives and child development officers, it was also necessary to collect some qualitative data on estate housing in each estate. To this end, an observational study was carried out, on a convenience sample of houses within each estate. The following is a detailed description of the four stages in which the field survey was carried out and the survey instruments used.

Stage 1: The most critical stage of the survey was collecting the weight and height panels and other background information (gender, ethnicity, attendance etc.) of the estate children and those attending CDCs. As discussed earlier, not all families living within the estate were eligible to have their children registered at a CDC, given employment at the estate was a necessary condition for CDC registration. The CDOs maintained information only on those children registered at the CDC. However, the estate midwife collected information on all children living within the estate and both these sources of data was made available to us during the field study. Therefore, required weight/height information was collected from both the log books maintained at the CDC and by the midwife.

Stage 2: This stage was focussed on interviewing the CDO at each surveyed CDC. A structured questionnaire was used for collecting data from the CDOs. The questions included in the questionnaire were largely qualitative in nature. The aim of this stage was to collect information regarding the general functioning and management of the CDC and the running of the mid-day meals programme in CDCs within the treatment estates.

Stage 3: This stage was concentrated on interviewing the estate midwives by administering another structured questionnaire. The questions again were largely qualitative in nature. The aim of these interviews was to collect information and opinions of midwives related to the general health of the estate residents, issues related to health and growth faced by children living in the estate and other lifestyle practices which impact the wellbeing of women and children in the estate.

Stage 4: The final stage of the survey was designed to collect some background information on the quality of housing in each of the visited estates. A check sheet type questionnaire was used for this and a convenience sample of households in the vicinity of the surveyed CDCs was selected. The check-sheet questionnaire was completed for each household in the selected samples. The structure of the questionnaires used are explained below, and the questionnaires are included in the supplementary documents section.

Midwife Questionnaire

The questionnaire administered to the midwife in each surveyed estate comprised of the following main sections:

Midwife Background Section: This section included background information on the general characteristics of the estate population from the point of view of the midwife. The section also included information on the experience and duties of the midwife. A consent form was also included in this section of the questionnaire.

Early Childhood Nutrition in Estates Section: This section was focussed on collecting information on the feeding habits of the estate children by four separate age groups (0-6 months, 6-12 months, 1-2 years and 2-5 years). The midwife was required to indicate the elements of the typical diet that estate parents could afford to provide their children belonging to each of the specified age groups.

General Health Issues Section: This section collected information on the general health issues that the estate population encounter based on the experience and opinion of the midwife. The section required the midwife to identify the main drivers of child malnutrition as well as the main social problems that typical estate families faced within her estate.

CDC and Mid-Day Meals Programme Section: This section solicited the views of the midwife on the functioning of the CDCs within the estate and if present, the functioning of the mid-day meals programme. The section also solicited the midwife's views on possible problems and her ideas for improvement of both CDCs and mid-day meals programmes.

Child Development Officer Questionnaire

The questionnaire administered to the CDO in each surveyed CDC, comprised of the following main sections:

CDC Background Section: This section covered the basic information on the functioning of the CDC including the operating days and hours, number of registered children and their age groups and the services provided by the CDC. Some observational data was also collected which focussed on the general environment (cleanliness, safety, organization etc.) at the CDC as well as on the general attitude of the CDO. A consent form was also provided to the CDOs under this section.

Mid-Day Meals Programme Section: This was the most extensive section of the questionnaire. It collected details on the type of food provided through the programme to children belonging to different age groups. The section also collected information on how the meals were prepared and the average size of the food portions provided.

Housing Quality Questionnaire

This questionnaire was designed as a check sheet detailing the different aspects of a typical household:

Type of House/Quality: Newly built (good quality), refurbished single barrack line houses (medium quality) and double barrack line houses (poor quality)

Main Materials Section: This section notes down the main material used for the floor, walls and roof of the house. The section contains a few common options from which to choose.

Type of Toilet: This section indicates the type of toilet facilities used by household members. Toilet facilities range from newly built flush type toilets to more basic toilet types such as pit-latrines. This section also indicates a question to indicate whether the household shared toilets with other families.

Main Source of Water: The focus of this section was to solicit information on how the surveyed household obtained water for their day-to-day needs.

Fuel Used for Cooking: This section solicits information regarding the main type of fuel used for cooking in the surveyed household.

Windows and Guttering: This section notes down whether the surveyed household has properly constructed windows and guttering on its roof.

Other Facilities and Assets: This section collects information on whether the surveyed household has some basic assets such as a television, vehicle etc., and whether the household has some other facilities such as electricity, satellite TV and home gardens.

7.2.3. Ethics Approval

Given the nature of this survey and the primary sampling units being children below the age of five years, it was necessary to obtain ethics approval from several different institutions. Monash University being the main funding institution, it was required to first obtain ethics approval from the university. The necessary applications and other documentation were forwarded to the Monash University Human Research Ethics Committee (MUHREC) and approval was obtained. Apart from this, since the survey was planned to be carried out within multiple tea estates in Sri Lanka, the necessary approval had to be obtained from the Plantations Human Development Trust. The necessary approval was obtained from the Director of Health- PHDT, and a Memorandum of Understanding was signed between the PHDT and the author prior to conducting the survey. In addition to this, necessary approval was also obtained from the management of both the MJF charitable foundation and the Thalawakele Tea Estates Limited (TTEL) through email. It should also be noted that approval was not obtained from the Ministry of Health (MoH) as the MoH was not considered as a stakeholder of the survey at the planning stage. However, a policy initiative put to action by the MoH in April 2015 resulted in some significant problems in the implementation of this survey in July. This issue is further explained under the methods section. Participant consent forms were provided to all midwives and CDO interviewed for the survey and given that historical data on children’s weight and height measures were being accessed via estate midwives, the consent form provided to midwives outlined that data should be provided in a format that was non-identifiable, hence protecting the identity of children.

7.3. Data Collection Quality Procedures

Designing the two questionnaires for collecting data from the estate midwife and CDO proved to be challenging. The main reason was the non-availability of similar research questionnaires. This again stems from the limitation in documented research on similar programmes conducted in similar settings. The housing quality questionnaire was relatively easier to construct due to the availability of similar survey instruments used in other research settings. The DHS 2006, DHS 2016 and HIES 2012/2013 (Department of Census and Statistics-Sri Lanka, 2015, 2017a) survey questionnaires were used as guides when constructing the housing quality questionnaire. However, constructing the midwife and CDO questionnaires were done concentrating only on the information that needed to be collected through the survey. The requirements of both the MJF foundation and the PHDT were considered when constructing these two questionnaires.

Much of the plantation personnel (plantation workers, midwife and CDOs) are generally Indian/Sri Lankan Tamils. Therefore, it was necessary to create the questionnaire in such a way that the interviewees would be able to understand and answer the questions. For this purpose, both the midwife and CDO questionnaires were first created in English and then translated to Tamil. The translation was done with the help of a colleague at Monash University. After the questionnaires were drafted they were proof read by two colleagues as well as the author's research supervisor. Several corrections were suggested and accordingly accommodated. The draft questionnaires were also presented to both the Monash University Ethics Committee and the PHDT during the ethics approval process.

7.3.1. Pilot Survey and Pre-Testing of Questionnaire

With the above explained issues on the design of the midwife and CDO questionnaires, it was necessary to pre-test the questionnaire in a practically applicable environment. Another important aspect to be considered was the time allocated for the survey. The maximum available time that could be allocated for the survey was a period of one month. However, it was necessary to obtain a rough estimate on how much data could be collected given the time constraints and given that three different questionnaires had to be completed and data recorded from either log books or by individually measuring the weights and heights of children at the CDCs. In order to get a clear idea of the feasibility of covering the decided sample size and of the most efficient method of data collection, it was necessary to carry out a pilot survey.

The pilot survey was carried out in April 2015, at the Craighead Estate, which is a tea estate belonging to Kahawatta Plantations PLC. The estate was situated in Nawalapitiya (belonging to the Kandy region). This estate had 5 CDCs all of which had the MJF mid-day meals programme operating within them. The pilot survey was carried out on one day, and three of the five CDCs were visited. The visited CDCs had approximately 10-20 children on the day of the visit. The log books maintained at the CDC included attendance data and data related to the amount and type of food provided under the MJF programme.

The easiest way to collect data from the log books was to take photographs of the log book pages. However, time had to be allocated for CDC staff to locate old log books from previous years. The CDOs at each CDC visited were interviewed using the drafted questionnaire. Examination of the records maintained by the CDCs showed that the records of monthly and tri-monthly measured weights and heights of children were not available at the CDCs. These logs were maintained by the estate midwife who unfortunately was not available for interview during the pilot survey.

Considering the timing, the CDO questionnaire took between 15-20 minutes to complete. This was because most of the CDOs were able to converse in Sinhala/English apart from Tamil. Upon further discussion it was revealed that the PHDT introduced a policy requiring all CDOs to follow a Diploma programme run by the PHDT and in doing so, many CDOs were able to improve their language skills. The housing quality questionnaire was also tested during the pilot survey. Two separate barrack lines (each with approximately 5-8 line rooms) was visited in the vicinity of the CDCs visited. Except for the questions on household assets and facilities, most of the other questions in the housing quality questionnaire required the interviewer to fill in the data through observation. This required very little interaction with the members of the houses. However, in order to fill the rest of the questionnaire, it was necessary to converse with the members of the households which proved to be difficult due to language limitations. At this stage, it was seen that, having the CDO during these visits was vital for communication purposes since the CDO was able to ask the questions on household assets and facilities from the house members and translate their answers for us to note down.

The one-day pilot survey had one notable drawback, in that the estate midwife could not be interviewed during the pilot. However, the visit revealed that, given the midwife records could be obtained, an estate with approximately 4-5 CDCs may be covered in the space of 7-8 hours. Alternatively, if the midwife records were not available and the weight and height of each child were to be physically measured, covering an estate with 4-5 CDCs would require at least 3-4 days, and this would also limit the sample to children registered at CDCs, excluding non-registered children. These matters were taken in to consideration in the final sample design and survey plan. Another issue highlighted during the pilot survey was the relative difficulty in getting from one CDC to another even within the same estate. Given the mountainous terrain, and considerable distance between divisions, a suitable mode of transportation was required to get from one CDC to another. Thus, the possibility of having to recruit a guide familiar with each of the sampled estates and hire a suitable vehicle for the purpose arose. This was discussed with MJFCF who agreed to provide for this need, throughout the survey.

7.3.2. Training of Research Assistant (RA Training)

Given the strict time limits for the survey, it was necessary for the research assistant to be well familiarized with the data collection process from the first day of the survey. The RA was therefore recruited one month prior to the survey. The recruitment process was competitive, with a number of applicants applying for the position. Selection was done by the author’s research supervisor, based on CVs provided by the applicants. Once the selection was done, a MoU and Recruitment Contract was signed by the RA. A suitable remuneration package was offered to the RA for the duration of the contract. The survey plan, sample design and questionnaires were emailed to the RA, and her inputs were obtained regarding the structure of the questionnaire. This allowed the RA to familiarize herself with the questions a few days prior to the survey start date.

7.3.3. Field Work Background and Problems Encountered

Due to the relatively straightforward attitude of most estate midwives to participate in the survey, and easy access to data, the field work itself utilised 2 weeks with the balance time being spent on data entry and deidentification of collected data from log books. A few unexpected situations arose during the period, which hindered some of the field work. Firstly, the Ministry of Health (MoH) made a key decision to replace the Estate Midwives with MoH Midwives and this process began in April 2015. As part of this new initiative, traditional estate midwives were made to undergo a professional training under the Ministry of Health, after which they were scheduled to be employed as MoH midwives. During this period, MoH midwives were assigned to the tea estates. This impacted the survey because the estate midwives in two of the five survey estates were replaced by MoH midwives by the time the survey was launched in July. However, by the time that this change was brought to our attention, it was too late to obtain the MoH approval for the survey. This resulted in difficulties arising in obtaining information from the midwives of the Logie and Mattakele estates.

In addition to this, a serious wage dispute arose between the main plantation trade union and the representatives of the regional plantation companies during the survey period. Due to the dispute a trade union go-slow was started on the 6th of July 2015. This significantly disrupted work on most of the major tea estates in the country (Paranagamage, 2015). In retaliation, the RPCs instructed the shutdown of all their main offices, factories and CDCs on the 8th of July. As a result, offices and factories were closed down in many of the tea plantations in the country. This too, adversely affected the data collection process as the offices and CDC in some of the sample estates were closed down. Due to these unexpected hindrances, data could only be collected from 3 of the initially planned estates; Bearwell, Holyrood and Dessford. Despite advice from both the PHDT and MJF foundation against visiting the other two estates, a visit was made to Mattakele estate. However, it was only possible to collect data from a single CDC in that estate. No data could be collected from Logie. Given this, the incomplete data collected from the Mattakele estate is not included in the analysis.

Two of the three estates covered had the mid-day meals programme in operation within the CDCs (Bearwell and Holyrood). The other estate (Dessford) was considered as the control since the mid-day meals programme was not operating within it. In the estate without the mid-day meals programme, parents usually sent prepared meals to the CDC to be fed to the child as lunch or picked up the child at the end of the morning session to be fed at home and then returned the child back to the CDC for the afternoon session. Data was collected on the monthly recorded weights and tri-monthly recorded heights of children thus creating two unbalanced panels of weights and heights. Some baseline variables on the children were also collected (date of birth, birthweight, gender, ethnicity and CDC characteristics). Attendance data was collected from the CDCs of the two estates which ran the mid-day meals programme (Bearwell and Holyrood) and used in modelling the impact of treatment days on child growth, while data from all three estates were used in fitting the intention-to-treat models.

The actual field work was both challenging and rewarding. As mentioned before, the main challenge was the mountainous terrain that needed to be navigated throughout the field work. Even within the same estate, CDCs were often miles apart, and certain CDCs were inaccessible on rainy days. This was the case with the Bearwell estate, where one of the four CDCs could not be visited due to rain. A guide (either the midwife or a CDO) and some method of transport (in one case the estate ambulance) was provided at all the estates. The following photos illustrate some snippets of the field work carried out.


HOLYROOD
ESTATE
LOWER
DIVISION
CHILD
DEVELOPMENT CENTER

Figure 7-3: Snippets of the Field Trips

Table 7-2: Characteristics of estates sampled

Estate	# of CDC	Division/CDC name	CDC Category	2014 Onroll
Treatment estates				
Bearwell	4	Belgravia	Upgraded	45
		Fairfield	Old	97
		Walaha	Upgraded	50
		Bearwell	New	48
Total children				240
Holyrood	5	East	New	32
		East-No.18	Upgraded	35
		Rath	New	20
		West/Upper	New	30
		West/Lower	Upgraded	28
Total children				145
Control estates				
Dessford	6	Dessford-A	New	45
		Dessford-B	Old	41
		Lower-A	Upgraded	49
		Lower-B	New	44
		Lorne	Upgraded	83
		Upper	Old	60
Total children				322
Projected Sample Size	*Treatment*	385	*Control*	322

Chapter 8: Conceptual Framework and Methods

This chapter presents the data and methods used in assessing the effectiveness and impact of the MJF mid-day meals programme using the data collected through the above explained survey. As indicated in the literature review, the impacts of early childhood nutritional interventions on the health and growth of children is not a well-researched area in Sri Lanka particularly within the estate sector of the country. Given this, it is important to theorise and conceptualise the possible ways in which a nutrition programme of this nature would impact the health and growth of children.

The impacts of an intervention like the MJF mid-day meals programme could manifest in a number of ways. For example, the programme could have a positive impact on children through an increase in their weights and heights over time. If the nutrition programme does impact their growth, this could again happen in different ways. For example, the programme may be more effective in helping children displaying below average growth to catch-up to average levels of growth in the target population. Or the programme may be helping children who already show better than average growth, to further improve their growth-lead. Another possibility is that both these effects occur together at varying degrees.

When considering the impacts of the programme on children, yet another possibility is that contrary to expectations the growth of children in the programme remains uninfluenced by the programme. This could be the result of offsetting effects, where the mid-day meal provided by the programme acts to substitute for poor nutrition provided to children at home. Hence the programme fails to show a net positive effect. This would signal the need to carry out an outreach programme to provide nutritional education to estate residents, within the estates that have the programme. This could also be due to weaknesses in the programme design, implementation and management as a result of which it is unable to produce the expected change.

Finally, another more serious possibility is that the programme might inadvertently result in a decline in growth of participating children. This could again happen as a result of serious nutritional deprivations that children suffer in their home environment, which may further be exacerbated through the programme. For example, parents may be driven to provide lesser quantities of food (skipping of meals) or lesser nutrient-rich foods, as they feel that the mid-day meals provided by the CDCs would be able to fill the gap. This could happen if parents do not provide a well-balanced breakfast to their children prior to dropping them off at the CDCs in the morning, knowing that the child will be provided a tea-time snack (state provided *Thriposha* supplement) and substantial lunch through the MJF programme. In this case even if the programme provides a well-rounded and nutrient balanced meal, it would not be able to compensate for the adverse effect of skipping breakfast. This could cause the overall impact of the mid-day meal to either be neutral or even negative. Another possible explanation would again be that despite all the measures taken, the meals provided at the CDCs don't reach the required nutritional standards due to quality or quantity issues. This may result in children who are not part of the programme (i.e. those who receive meals prepared at home) to be equal if not better off on average, than children who are part of the programme.

Other factors such as the lack of awareness of parents regarding child nutrition or poor household hygiene could also influence the impact of the programme. This effect however can be considered to be common to both participants and non-participants due to the close-knit structure of estate communities. Regular sickness could however have an asymmetric impact on the growth of children who participate in the programme. CDCs generally discourage parents from sending sick children due to risks of the illness spreading to other children. For children registered at CDC, which provide mid-day meals, this may result in an added disadvantage both due to sickness and losing out on the centre provided balance mid-day meal. Therefore, this factor needs to be reflected in models.

The conceptual scenarios set forth above show that the overall impact of a programme of this nature would be a complex and cumulative result of a range of positive and/or negative effects. From an analytical point of view, it should also be noted that, given the nature of the data collected, it is only possible to detect the overall impact of the programme, and not the individual components which cumulatively form it. However, model effects based on certain characteristics such as age, gender and average growth will be analysed separately to compare programme effects between these groups. Qualitative data collected through CDO and midwifes interviews and house visits will provide further insights to better understand programme effects.

With regards to the outcomes observed, the weight-for-age of a child is often viewed as a compound measure of both the height and weight of a child. Therefore, whilst informative to a certain degree, weight-for-age will not provide enough information on the degree of effectiveness of an intervention of this nature. What would be of more interest would be to also evaluate the effect of the programme on the long-term growth of children as reflected by their height/length-for-age. Another informative anthropometric measure used in evaluating the programme is the BMI-for-age of children. Given that it controls for variations in the heights/lengths of children, this measure can be considered to reflect short-term or acute growth in children. Therefore, models are fitted for the weight-for-age, height-for-age and BMI-for-age of children in order to evaluate the impacts of the mid-day meals programme on both short-term and long-term growth of children.

Essay 1 of this thesis broadly explored the difference in child growth between the rural and estate sectors of Sri Lanka. That analysis revealed that children in estates fared the same if not better than rural children with respect to their BMI-for-age. However, children living in estates were seen to consistently perform worse than rural sector children with respect to their long-term growth (as reflected by height-for-age). Analysing the effects of a nutrition intervention such as the MJF mid-day meals programme, across all three anthropometric measure discussed above would provide some valuable insights to better understand how growth lags in estate children could be remedied both in the short and long-run. Viewed together, Essay 1 and Essay 2 would provide some clear policy insights on possible remedial and preventative measures that can be used to reverse growth lags and promote growth improvements of children living in vulnerable communities within Sri Lanka.

Another point of interest will be to observe the effect of regular attendance to the CDCs which will enable children to receive the mid-day meal regularly. Being registered in the programme does not ensure that the children receive the meal unless they are present at the CDC. Therefore, it is important to study how regular attendance would impact the effectiveness of the treatment. Given this, the programme evaluation is done in two stages. In the first-stage, the 'intention-to-treat' is considered and IV-regression models are fitted to compare child growth between treatment and control estates. The objective here is to assess the impact of access to the mid-day meals programme on children living in estates which host the programme. In the second stage, a marginal structural modelling approach with inverse probability treatment weighting is used to explore the impact of receiving mid-day meals regularly, on the growth of children, who are part of the MJF programme.

As identified above, assessing the impact of the MJF mid-day meals programme on child growth will require exploring different direct and indirect channels through which effects manifest. This coupled together with certain data related issues, such as the lack of baseline information, will require certain assumptions to be made, and different econometric techniques to be used for the analysis. The broader aim of the analysis is to tease out the causal effects of the programme on the growth of children, as measured by their weight-for-age, height-for-age and BMI-for-age measures. Deepening the understanding of these effects of the programme, will enable to make the necessary changes to further improve the programme. In addition to this, given the involvement of state entities such as the PHDT in the project will enable for the results to be effectively used in designing effective policies to tackle child malnutrition within tea estates, at the state level. The following figure depicts the formulated conceptual model, for analysing the effects of the MJF programme on child growth. This conceptual model will form the basis for the analysis presented in the next chapter.

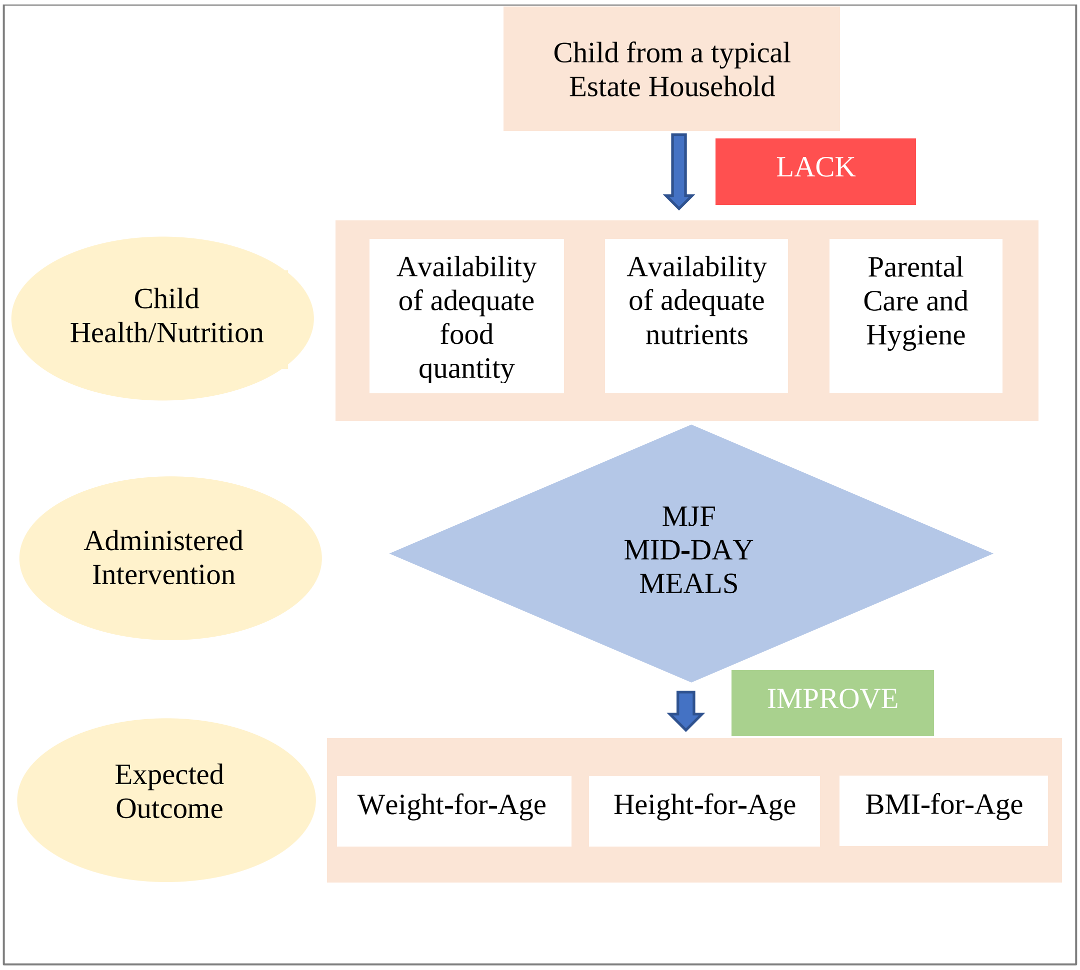


Figure 8-1: MJF Mid-Day Meals Intervention Model for Eradicating Child Malnutrition
Source: Authors Own Model Formulation

8.1. Review of Data

This section focusses on reviewing the nature of the data collected through the survey. Prior to reviewing the variables in the datasets, it is important to discuss the representativeness of the samples obtained. As noted in Chapter 7, the data on the weights and heights of children and other background characteristics were obtained from two main sources; the log books maintained by the estate midwife and the logs maintained by the CDOs at each visited CDC. Based on the availability of past records, data was collected for the period January 2013-June 2015 from some midwives/CDCs and for the period January 2014- June

2015 for some others. As per Ministry of Health guidelines, the growth of children below the age of 5 is monitored by taking regular measures of their weight and height. Each child is issued a ‘growth card’ upon birth and their growth is typically monitored for the first five years of their life. The monitoring is done primarily through midwives or public health officials working at the *Grama Niladhari* level (smallest administrative unit of the country representing a collection of villages) across the country. Within tea, rubber or coconut plantations, this procedure is usually carried out by the estate midwife and medical officer. Therefore, data collected from the estate midwife log books cover the entire population of under-5 children living within the estates during the considered time period of January2013/2014 – June 2015. In contrast the data collected from the CDO’s contain all information on the children registered at the respective CDCs during the considered time period. This allows for the implicit assumption that within the random sample of estates selected for the survey, data on all children aged 0-60 months is collected for the period January 2013/2014 – June 2015, subject to minimal logistic and data availability issues.

Another important factor to consider is whether the sample frame from which estates were randomly selected is representative of overall tea estates in the country. The sample frame consisted of all estates managed by a regional plantation company (Thalawakale Tea Estates PLC). According to a presentation made by the chairman of the Planter’s Association of Ceylon Mr. Roshan Rajadurai in 2014, plantation companies employ 25% of the total plantation workforce. He also notes that RPC workers enjoy greater benefits and better facilities compared to workers of tea small holders. Given the amount of resources available and their corporate obligation towards improving the living standards of its resident workers, RPCs are expected to provide better quality living to its workers as opposed to small holders. To this end RPCs would largely benefit through a research study of this nature since small holders would not have the necessary resources to implement programmes similar to the MJF mid-day meals programme, targeting children in their estates. Therefore, while being representative of only 25% of the estate population of the country, selecting a RPC to carry out the survey can be justified from a practical and policy perspective. However, it should be noted that the results derived would be generalizable only to the segments of the estate community employed by and living in RPC run estates.

The main outcome variables of the study are unbalanced panels of weights and heights of the children. In addition to these measures, some child and CDC level baseline variables were also collected. Among the child-level variables were the child's date-of-birth, birthweight, gender, ethnicity[4] and age at each time point where weights and heights were measured. When considering the CDC, the status of the CDC (either old, upgraded or new) and the average percentage attendance in 2014 and 2015 for each CDC were available. As indicated in Chapter 7, only 3 of the 5 estates included in the initial sample design were covered during the survey. Of these, two estates (Bearwell and Holyrood) had the MJF programme while the third (Dessford estate) did not host the programme. Attendance data on children attending the CDCs were recorded for the two treatment estates. As noted earlier, a lack of baseline is a significant drawback in the study. However, the limited data available was used efficiently in order to derive a number of additional control variables for the models. These will be further discussed later in the chapter.

The data used in the analysis was somewhat complex with weights and heights forming unbalanced panels. The weights were measured monthly whilst the heights were measured tri-monthly. The data set contained missing values owing to two reasons. Firstly weight/height measures could be missing due to non-measurement, where the child failed to turn up at the health centre on the day of the weighing. Another source of missing data is where part of a child's record is missing because it is not captured in the period Jan 2013-June 2015 for which data was collected through the survey (records collected by the midwife were only retained for a maximum of 3-4 years within the estate health centre). The unbalanced panel created due to these two sources of missing data, leads to the complexities in analysing the data.

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[4] The ethnicity of the child was recorded as Sinhalese vs Non-Sinhalese. The Non-Sinhalese cohort includes children who are Sri Lankan Tamil, Indian Tamil and SL Moor/Malay.

Holyrood estate provided the most comprehensive data, with attendance data dating back to January 2013 for some CDCs and January 2014 for others. The Bearwell estate data was incomplete as a result of which a second survey round had to be carried out in June of 2016. In each of the three estates, all weight and height data on children were collected from midwife and CDC log books and deidentified prior to data entry. The midwife and CDOs at each CDC were interviewed and a convenience sample of houses in each division was selected and visited, in order to complete the housing quality questionnaire. The data collected through the housing quality questionnaire was used to create a wealth index for the three estates using the principal components approach (Rutstein and Johnson, 2004).

8.2. Description of Variables

Table E2-1 provided in Appendix E2 presents an overview of the collected and derived variables, that will be used in modelling treatment effects. As mentioned earlier, given the limited information available, a number of control variable were derived to be included as proxies for unobserved variables. The quantitative data collected through the survey included an unbalanced panel of children's weights and heights, their date of birth, birthweight, gender, ethnicity, the status of the CDC. The status of the CDC was specified as *new*, *upgraded* or *old* following the CDC classification method used by the PHDT (*CDC_cat*). Given that height was measured tri-monthly, prior to deriving the outcome variables for the models, missing height measures were imputed, to match the monthly frequency of the weight measurements. Given that heights do not change much month-on-month and taking in to account the possible non-linearity of heights, a cubic spline was used to impute missing heights for each child. Imputed values were tested to detect and correct for anomalies (e.g. instances of decreasing values of imputed heights).

The weight and height measures were used to derive the weight-for-age, height-for-age and BMI-for-age measures standardized following WHO guidelines (WHO Multicentre Growth Reference Study Group, 2006). As mentioned earlier, the data presented two different sources of missingness. Missing due to non-measurement and missing due to the selected survey period. To distinguish between these two sources of missingness, two additional variables were created to store the standardized value of the first weight (*firstzweight*) and first height recorded (*firstzheight*) for each child within the considered data collection time period. These variables were of particular interest since data was only collected from January 2013 onwards in most of the estates, causing earlier weight and height records of most of the older children (3-5 year olds) to be missing. Adding these in models would control for this systematic missingness in the data to a certain extent. These two variables are also useful when deriving other proxies for unobserved variables which may impact the growth of children (history of illness, parental care etc.). It should also be noted that the two variables *firstzweight* and *firstzheight* are calculated as standardized values using in-sample medians (smoothed) and standard deviations, rather than the WHO standardization procedure. This enabled using these variables to control for the relative positioning of the child within the sample under study, at the beginning of the survey period. These two variables would also be able to pick up finer variations in growth between children. Given that children living within estates are known to show significantly poor growth, nearly all the children in the sample would show large negative values when heights and weights are standardized based on the WHO reference population. However, using in-sample smoothed medians and standard deviations the standardized scores created would be more sensitive to growth variations between children. Table E2-1 in Appendix E2 provides a description of the observed and derived variables used in the analysis.

8.2.1. Treatment variables

Two main treatment variables are used in the analysis. The first is a time-invariant binary treatment variable differentiating between children who live in Treatment vs Control estates (*Trt1*). This treatment variable is used in the intention-to-treat models, which form the first stage of modelling. Accordingly, all children living within the Bearwell and Holyrood estates are considered ‘treated’ (irrespective of whether they are registered at a CDC or not) while children living within the Dessford estate would be classified as ‘non-treated’.

The second treatment variable is time-varying and specifies the total number of days that a child attends a CDC in the current month, within the Bearwell and Holyrood estates (*Trt2*). This variable is used in stage 2 models which assess the impact of regular attendance on the growth of children registered under the programme. Therefore, these models exclude children living within the Dessford estate and those living in the Bearwell and Holyrood estates but are not registered under the programme. This variable however required an adjustment prior to use, in order to correct for missing information. This will be explained in coming sections. *Trt2* is also used to derive a number of other variables required at various stages of the analysis. The total number of days a child attends a CDC within the specified survey period is derived by considering the cumulative total of *Trt2* up to and including each month (*Tot_Trt2*). *Tot_Trt2* is also used as an alternative treatment variable, especially when modelling the height-for-age of children. In addition to this, lags 1 to 6 of *Trt2* (*L1_Trt2*- *L6_Trt2*) as well as the cumulative of the treatment up to lag 7 (*Tot_Trt2_L7*) were derived and stored as separate variables, and were used in calculating inverse probability treatment weights.

a) Non-Randomness and Endogeneity of Treatment Variables

One thing that is clearly evident when looking at the two treatment variables is that, while the first treatment variable (*Trt1*) is random, the second variable is neither random nor endogenous. Discussions with MJF management clearly indicated that the implementation of the MJF programme within estates belonging to the Thalawakale Tea Estates PLC was done in stages and in each stage a number of estates were selected randomly for programme implementation. The programme implementation was still ongoing as of 2015. Given this, *Trt1* can be considered random. Given the weak socio-economic status of plantation communities, and issues surrounding land ownership within tea estates, it is highly unlikely that families would move from one estate to another, as a direct result of the MJF programme not being implemented in their resident estate. Given their generational roots as indentured resident labourers of tea estates and their claim to their home being dependent on the fact that many generations of the family lived and worked in the same location, the freedom to relocate between estates is somewhat limited. Due to these reasons, *Trt1* which identifies whether a child lives in an estate which has the MJF programme, is largely exogenous.

With regards to *Trt2* however, it is clear that the treatment is both non-random and endogenous. The non-randomness of *Trt2* stems from the fact that estate residents self-select themselves into the programme rather than being randomly assigned. A couple of factors decide the participation of children in the programme. Firstly, the employment decisions of the parents where at least one parent decides to work in the resident estate. Access to the MJF programme is open to all estate families where at least one member works at the estate. Provision of housing to residents is provided by the estate management. Families tend to live in the same house and work within the same estate for generations. Therefore, most families would have at least one family member working at the estate, while other family members may choose to work off-estate, with time. However, there may be a few families who continue to live in their generational homestead within estates despite all members working off-estate. Such families (though few in number), do not get access to other services provided by the estate management such as access to child-care services through CDCs. Therefore, parental decisions regarding working within the estate, will impact eligibility to the programme. For families who are eligible for CDC support, the decision to enrol a child at a CDC is again a parental decision, whereby parents of eligible children make the choice to register the child at a CDC. This also means that *Trt2* is endogenous, as some of the factors that impact the treatment variable may also impact child growth. The following are some of these reasons which makes *Trt2* endogenous.

- Within the two treatment estates, the decision to send the child to the CDC is clearly a parental decision. Estate workers are free to decide whether they work for the resident estate or another estate ~ **Affects child's CDC registration**

- Workers are paid on a daily basis and can often choose to either work or not work in the resident estate in any particular month, even if registered as workers in the estate ~ **Affects child's CDC attendance**
- Another possible reason for non-attendance could be the presence of grandparents/older siblings of child, willing to take care of the child during working hours of parents (**Unobserved) ~ Affects child's CDC attendance**
- Apart from the mid-day meals programme other factors that impact a child's growth can be present- e.g. household income which affects availability of food and better nutrients (**Unobserved) ~ Affects child's weight/height**
- There may be other factors that are also unobserved

As noted above, some of these factors are not observed given the limited data available. However, it is noticeable that most of these variables do not vary over time, or at least, tend to remain invariant in the short run. For example, factors such as deciding to register as a worker in the resident estate, having a grandparent/older sibling taking care of children, or household income, tend to be stable in the short run. Therefore, though unobserved, their effects can be controlled or removed by exploiting the panel nature of the dataset, particularly by controlling for previous outcome variables. In addition to this, where possible, suitable proxy variables are derived from the data and used to control for some of these effects. Birthweight is one example of a variable which can be used as a proxy to reflect the socio-economic background of children that impact their growth. Apart from the rare occasion of a genetic/medical complication which impacts a child's in utero growth, birthweight is usually a consequence of the nutrients that the mother receives during pregnancy. Given the impoverished background of estate workers and their families, birthweight would therefore act as a proxy for economic background of the child's family, especially around the time of birth.

Subsequent to their birth, a child's health and nutrition during early infancy also has a strong dependence on parental care, and it is important to consider a way to quantify this effect as well. Since children below the age of 5 years are required to be weighed once a month within tea estates, the consistency with which parents bring their child for the monthly clinics to be weighed, could indicate the level of care and attention parents pay to the child. From available data, it was possible to measure this quantity. However, once again, since the sampling procedure caused a portion of the data to be systematically missing, this had to be considered when calculating the above variable. Therefore, all proportions were calculated based on the time-point of the first weight measure on record for each child. Accordingly, for child *i* at month *t* the proportion of weighed instances is given by,

$$propmeasure_{it} = \frac{Number\ of\ measured\ instances\ since\ first\ measure_{it}}{(t - firsttime + 1)} \qquad (8.1)$$

Here *firsttime* is the age at which the first measure of the child's weight occurs within the surveyed period. The proportion is taken as 1 at the point of first measure on record, for every child. *Propmeasure* is used as a time-varying control variable which measures parental care.

Apart from time-invariant unobservables, a more problematic issue arises due to the possible existence of time-varying unobservables, which may impact both the treatment variable and the outcome variable (i.e. child growth). Much of these time-varying unobservables can be controlled for, by controlling for the previous month's weight or height of the child. However, those unobservables that do not act through the previous month's outcome variable, become particularly challenging to control. One example for such a variable would be whether the child fell sick in the current month. This would impact both the weight of the child and the number of days he/she gets to attend the CDC that month, which makes this an unobservable a confounder in the pathway between the treatment (*Trt2*) and the outcome variable. A reasonable assumption can be made that a serious illness of this nature, would result in the child not attending the CDC for at least 5 consecutive days (or a working week). Under this assumption, using the attendance data from the Bearwell and Holyrood estates the longest run of absent days, for each child in each month was recorded and the following variable was defined to reflect illness in child *i* in month *t*.

$$S_{it} = \begin{cases} 1 & if\ atleast\ 1\ run\ of\ 5\ consecutive\ absent\ days \\ 0 & otherwise \end{cases} \tag{8.2}$$

However, given that the proxy suggested here will be highly correlated with *Trt2*, the following adjustment needs to be made to the treatment variable in order to remove the effect of illness from being reflected in the treatment variable as well as the outcome.

$$T_{it-adj} = \begin{cases} Actual\ \#of\ days\ attended & if\ \ S_{it} = 1 \\ Actual\ \#of\ days\ attended - [5 - \max(absent\ run)] & if\ S_{it} = 0 \end{cases} \tag{8.3}$$

Using T_{it-adj} as the new treatment variable should remove effects of a sudden health shock such as an illness or any other external shock which affects both the current months weight and the number of days attending the CDC (i.e. the original treatment variable) but does not act via previous periods weight/height, making children identical in treatment. To adjust for these sudden shocks, the variable S_{it} is added to the model. It should be noted here that an implicit assumption made in the above derivation is that a lengthy period of absent days (i.e. a run of 5 consecutive days) occurs mostly in the case of illness. However, it is possible that there may be other reasons for such an absence. For example, visiting relatives/family friends in other parts of the country, going on recreational trips etc. However, given the historic background of tea estate residents in Sri Lanka, as highlighted in Chapter 6, means that estate communities tend to live within close enclaved communities with limited spread in other parts of the country. This coupled together with their relatively impoverished background makes most of these other reasons for extended absences almost always irrelevant. Therefore, linking consecutive runs of absent days to possible bouts of serious illness is justified. Apart from this, a few other time-varying unobservables which can impact the outcome are as follows,

- Parental characteristics impacting care received at home – While mostly time invariant, any time-variant characteristics can be at least partly controlled by the *propmeasure* variable
- Unexpected health shocks – The HH may face a sudden heath shock due to an unexpected ailment of a HH member other than the child. This may lead to higher expenditure on health services and lowers expenditure on food which can affect a child's food intake and access to food

    - However, it is logical to assume that this will possibly increase the number of days a child attends the CDC as mothers might be tempted to send the child to a CDC more, to make sure they receive at least one balanced meal a day. Also, caring for a sick family member would be easier, when a toddler is placed in child-care than at home. Hence it would be logical to assume that, any decline in weight of the child (due to lower access to food) may be offset by attending the CDC more. Hence, this unobservable, if causing a bias, would under-estimate the effect of the treatment rather than over estimating it.

The above gives a precise explanation of the two main treatment variables used in modelling the outcome, and the intuitive framework and methodological steps taken to control for some of the endogeneity in the treatment variables (*Trt1* and *Trt2*). Please note that all future notations of *Trt2* will refer to the transformed treatment variable according to equation (8.3).

8.2.2. Other derived variables

Apart from the CDC classification variable explained in previous sections, another important variable associated with the CDC were also considered in the models. This is a child-level binary variable which takes the value 1 if the child had been present at a CDC at some point of time, during the considered survey period. The second stage models used data from all children registered at CDCs in the two treatment estates. However, this data included some children, who despite appearing in CDC registers, had not attended the CDC even once during the survey period. These instances had to be identified and a variable (*CDC_adj*) was created to control for this.

The child's birthweight and first weight on record (*firstweight*) were both standardized and the standardized variables (*zbirthweight* and *firstzweight* respectively) were used in the models, both as a control variable, and in order to split the sample to carry out robustness checks on the fitted models.

8.3. Basic Analytical Framework

As explained above *Trt1* which specifies whether a child lives in a treatment state, and *Trt2* which gives the number of days attending the CDC in a treatment estate form the two main treatment variables in the models while the weight-for-age, height-for-age and BMI-for-age standardized according to WHO guidelines form the main outcome variables. The child specific ID and age (in months) form the panel and time variables respectively. Age, gender, standardized birthweight, standardized value of the first weight on record, CDC classification and indicator of CDC attendance during the survey period form the main controls.

Two different modelling approaches are used to analyse the two treatment variables. In the 'intention to treat' model which explores the impact of *Trt1* on child growth, a generalised two-stage least squares (G2SLS) instrumental variable specification is used within a panel data framework. The previous months weight-for-age/height-for-age/BMI-for-age form an important control in the models, as it controls for most of the time-varying and time-invariant unobservables. However, there may be time varying unobservables (not accounted for through proxy variables) which impact both the current and previous months outcome, causing the lagged outcome variable to be an endogenous regressor. Apart from this, part of the cumulative treatment effect of *Trt1* on the current period's outcome, would also act via the lagged outcome variable, and controlling for it would confound part of the treatment effect. Therefore, it is necessary to instrument for the lagged outcome variable in order to control for this confounding effect. Accordingly, the past periods weight-for-age, height-for-age and BMI-for-age are instrumented, using suitable instruments.

8.3.1. Instrumental Variable Estimation and Intention-to-Treat Model

Consider the following linear model specification,

$$y_{i1} = \alpha_1 y_{i2} + \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} + u_i \qquad (8.4)$$

Where y_2 is said to be endogenous when y_2 is correlated with u. This can occur due to a number of reasons such as omitted variables that are correlated with both the outcome variable (y_1) and the endogenous variable (y_2), measurement errors related to (y_2) or the outcome and endogenous variables being simultaneously determined. Given the issue with unobservables, the omitted variable bias becomes particularly important in the current scenario. The instrumental variable approach is a classical solution for this issue, where a reduced form equation for the endogenous variable is specified on the set of exogenous variables in (8.4) and a set of instrumental variables z.

$$y_2 = \delta_z z + \delta_1 + \delta_2 x_2 + \cdots + \delta_{k-1} x_{k-1} + \varepsilon \qquad (8.5)$$

Here the model is considered to be valid, if z is uncorrelated with u and partially or strongly correlated with y_2. The following section outlines the main instruments used to instrument for the lagged weight-for-age, height-for-age and BMI-for-age in the respective models, along with the logic used to ascertain their validity.

8.3.2. Instrumenting for Lagged Outcome Variables

As noted above an instrumental variable approach is used in the ITT analysis, to account for the endogeneity of the previous period's outcome variable in the models. In the weight-for-age model the birthweight and the lagged parental care variable ($propmeasure_{i\ t-1}$) are used to instrument for the previous periods weight-for-age. Given the considered sample of children below the age of 5 years, it is reasonable to assume that the birthweight would be clearly correlated with the weight-for-age in early years. It can also be reliably assumed that the relationship between birthweight and the current period's weight-for-age would largely be via the past period's weight-for-age. Therefore, it can be argued that birthweight would be a valid instrument for the lagged weight-for-age in the model.

Considering the lagged parental care proxy variable, this variable would reflect the general history of care received by children. Therefore, $propmeasure_{i\ t-1}$ would also be strongly correlated with the lagged weight-for-age. In addition to that the relationship between $propmeasure_{i\ t-1}$ and the current periods weight-for-age would also manifest through the previous months weight-for-age. Therefore, $propmeasure_{i\ t-1}$ would also be a valid instrument for the lagged dependent variable in the weight-for-age model.

With regards to the height-for-age models, $propmeasure_{i\ t-1}$ can again be used as a valid instrument following the same logic above. However, birthweight would be a weak instrument for the lagged height-for-age. Given that children's birth height was not recorded the standardized value of the first height on record (*firstzheight*) is used as another instrument for the lagged height-for-age. Since the BMI-for-age uses both the weight and heights for children, all three variables discussed above (i.e. birthweight, standardized value of first height on record and the lagged parental care variable) were used to instrument the previous period's BMI-for-age in the BMI-for-age models.

Given that the treatment variable (*Trt1*) is time-invariant, a random effects model specification is used with robust standard errors for modelling. The validity of the instruments used are assessed using the following tests.

1. Under-identification Test

Under-identification occurs when the defined instrument/s are not correlated with the endogenous regressor they are meant to represent. The Kleibergen-Paap rk test can be used to detect correlation between the instrument and the endogenous variable. The test typically looks at the rank of the coefficient matrix of the reduce form equation (8.5) to determine the correlation. The null is set as no correlation.

2. Weak Instrument Identification Test

Whilst a correlation does exist, a weakly correlated instrument can also significantly bias the causal interpretations of treatment effects and therefore needs to be tested. The Cragg-Donald Wald F Test is a test that can be used for this purpose. Staiger and Stock (1997) recommends an F-statistics of 10 where if the reported F-statistic for the first stage IV model falls below 10, this implies the presence of weak instruments.

3. Over-Identification Test

Overidentification of the model occurs when one or more instruments are correlated with the error term in the main model. This causes the instrument variable regression to be non-consistent. The overidentifying restrictions test (also called the Hansen J test), tests for the exogeneity of the additional instruments when the number of instruments exceeds the number of endogenous variables. The null hypothesis suggests that the overidentification restriction is satisfied and that all instruments are uncorrelated with the error-term in the main model. The Sargan-Hansen test is a similar test to the Hansen test, which also checks for the overidentification restriction in IV regression models.

The Kleibergen-Paap rk test, the Cragg-Donald Wald F-statistic and the Sargan-Hansen score are used for assessing the validity of instruments used in the ITT models in Chapter 9. Test results indicate that the instruments used are valid in the main models. However, they appear to be invalid in some of the models fitted for subsamples due to smaller sample sizes (e.g. subsamples by gender, age and standardized birthweight). Generalized Least Squares Random Effects (GLS RE) models are fitted in these cases, as a robustness test.

8.3.3. Estimating Treatment Effects in the Presence of Time Varying Confounders

The second stage of the analysis deals with modelling the second treatment variable (*Trt2*), which is a time-varying variable indicating monthly attendance of children registered under the programme. As outlined earlier, the intention of modelling using this treatment variable is to identify the effect of an additional day of treatment per month, on the growth of children registered under the mid-day meals programme. Given that children's CDC attendance can vary based on a number of different factors each month, it is clear that the variable *Trt2* is both time-varying and non-random. Therefore, deriving a causal interpretation is somewhat complex and requires complex econometric theory and methods. This stage of the analysis used Marginal Structural Models (MSM) with Inverse Probability Treatment Weights (IPTW) estimated using the Generalized Estimating Equations (GEE) method. The following sections present some of the key concepts related to 'treatment effects' and 'confounding' and the broader theory and methods used in analysing the effect of the time-varying treatment variable.

An observational study where subjects are followed over time, with treatments being administered and certain measurements made periodically are referred to as a panel/longitudinal study. Panel data is often used in order to make both associational and causal inferences in many epidemiological and social sciences. When determining causality, the usual practice is to use randomized controlled experiments where the trials are designed in such a way that external factors impacting the outcome are controlled as much as possible. As the name implies, the treatments are randomly allocated to the experimental units. With controls in place to control external effects and with treatments allocated randomly, this setup can be thought to provide unbiased estimates of the causal relationship between treatments and outcome. However, conducting randomized control trials can, in some cases, be infeasible as well as unethical and observational studies often become the only available method for data collection in such situations. One example would be where an intervention has been implemented without collecting necessary baseline data which will enable the comparison of individual outcomes before and after the intervention. In this case, the only possibility of assessing the effectiveness of the intervention would be to compare individuals receiving and not receiving the said intervention.

Even though observational studies lack the randomized structure of controlled experiments, the amount of data that can be collected through observational studies is often more extensive than in the case of randomized trials. Understanding the abundance of data available through observational studies as well as taking in to account that observational studies are the only data source available in certain scenarios, theories have been developed which enable the use of observational studies in making causal inferences. These methods broadly address some of the main structural issues that arise in using observational studies in making causal inference.

As explained earlier, one main issue in using observational studies for causal inferences is its lack of organized structure unlike a randomized control trial. This causes the typical randomization assumption to be violated (Austin, 2011). For example, in the present scenario, the CDC attendance of children each month is not random and can depend on a number of different factors. This gives rise to a selection bias, particularly with regards to the treatment history of different children. Another scenario could be where typical treatment and control groups exist, but subjects are not randomly assigned to the groups.

When considering a repeated treatment observational study as is the present case, the treatment selection may depend on both time invariant and time-dependent covariates that are also associated with the outcome of interest. These variables are commonly known as confounders. The effect of time invariant confounders can be eliminated to a great extent by identifying and controlling for these variables in the model. However, the same method cannot be applied to time-dependent confounders. A covariate becomes a time-dependent confounder if it is associated with both the occurrence of future outcomes and treatments as well as being influenced by previous treatments (Fewell et al., 2004). Even after controlling for time invariant confounders, if time-dependent confounders are present, the treatments become endogenous and therefore the treatment effect becomes biased for the causality parameter (Robins, Hernan, and Brumback, 2000).

Directed Acyclic Graphs (DAG) are a tool often used in causal literature as it enables researchers to identify causal and associational paths between variables in multi-variable studies (Robins and Hernan, 2009; Robins, Hernan, and Siebert, 2004). The DAGs below present the simple single-point treatment and outcome case to demonstrate how confounding can bias the estimate of the treatment effect. When attempting to use observational studies for causal inference, the general practice is to collect data on as many variables as possible. This is done to satisfy the assumption of no unobserved confounders (discussed in subsequent sections) which is critical to the validity of the inference derived. Accordingly, a typical model would control for as many pre-treatment variables as possible to satisfy the above assumption. In figure 8-2, let T indicate a treatment, Y an outcome, C a common cause of both the treatment and outcome and I, an intermediate variable between treatment and outcome. The objective is to estimate the causal effect of the single-point treatment T on the single-point outcome Y. For illustrative purposes, let us also assume that there are no unobserved confounders and that the chosen model is correctly specified for identification of treatment effects. Then, as indicated in figure 8-2(a), if a common cause of both the treatment and the outcome is present, the basic principles of causal inference indicate that the model should control for the variable C. If not controlled, part of the association observed between T and Y could be due to the association between T and Y induced by the variable C and hence not a causal effect of T on Y. This is generally referred to as the omitted variable bias. Figure 8-2(b) indicates another unique scenario, where a common factor of T and Y (i.e. variable C) and an intermediate variable between T and Y (i.e. variable I) are both present. Once again, according to the basic principles of inference, it is clear that C should be controlled for in the model. However, controlling for I will block a portion of the causal effect of T on Y (i.e. the portion of the causal effect materializing through I) giving rise to what is known as the post-treatment bias. In the presence of time varying T, C and I variables, the treatment variable T becomes endogenous due to its interactions with C and I.

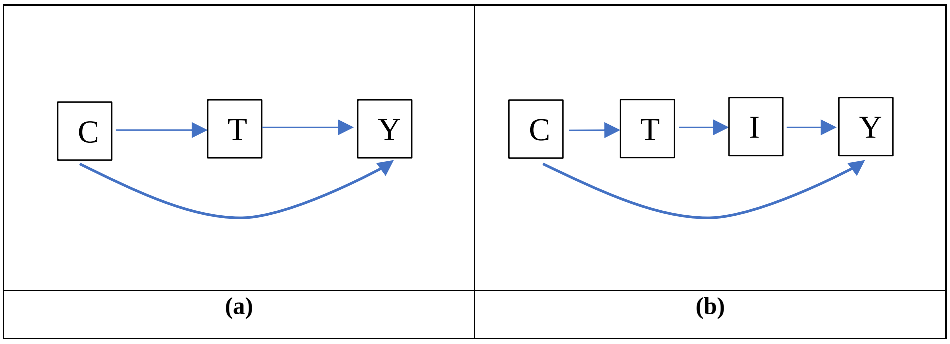


Figure 8-2: Directed Acyclic Graphs with Pre and Post Treatment Variables

In the presence of time varying outcomes, as is the case in panel data, the situation becomes more complicated especially in the presence of lagged outcome variables that are both affected by past treatments and impact future treatments. The following diagram depicts a simple two-period scenario that illustrate this problem.

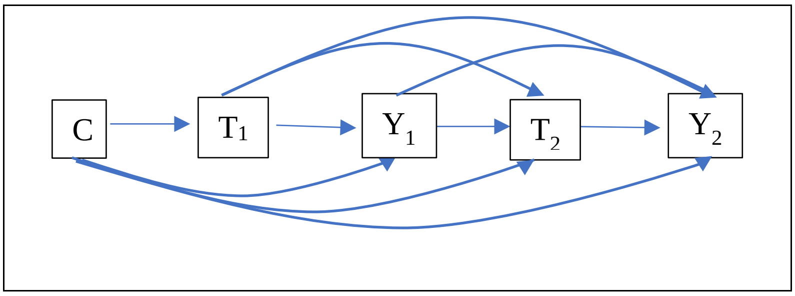


Figure 8-3: Directed Acyclic Graph with Time Varying Treatments and Outcomes

In the above figure, T_1 and T_2 represent the treatments in period 1 and 2, while Y_1 and Y_2 represent the outcomes of period 1 and 2. C represents pre-treatment variables that impact both the treatment and the outcome in both periods. Therefore, following the usual principles of inference, it is clear that the fitted model should control for the variable C. The issue arises when considering the variable Y_1 since it is both a common cause of T_2 and Y_2 as well as an intermediate variable in the causal path between T_1 and Y_2. Therefore, controlling for Y_1 in the model will block part of the causal effect of T_1 on Y_2 while not controlling for Y_1 will lead to an omitted variable bias due to its effect on T_2 and Y_2. Therefore, it is clear that standard statistical models will lead to biased treatment effects in the presence of time varying confounders such as Y_1.

A range of new methods as well as adjustments to existing methods have been introduced to account for the issue of confounding in both fixed and time varying treatments. In the case of fixed or single-point treatments, provided that there is no confounding by unmeasured baseline variables and no model misspecification, methods such as stratification and matching regression have been shown to produce consistent estimates of the causal effect (Robins and Hernan, 2009). However, these conventional remedies fail in producing unbiased estimates of the treatment effect when both the treatment and confounders are time varying. As a solution to this, a collection of three possible analytical techniques, commonly referred to as the *g-methods* was introduced by James Robins and his colleagues (Robins and Hernan, 2009). The *g-methods* consist of the g-computation algorithm formula (the "g-formula") (Robins, 1986), Structural Nested Models (SNMs) based on the g-estimation (Robins, 1994, 2000a) and the Marginal Structural Models based on inverse probability treatment weighting (Robins, 1998; Robins et al., 2000). The differences between the structural nested models and marginal structural models have been extensively discussed in Robins (2000). The most prominent difference between the two approaches is that SNMs model the magnitude of the causal effect of the final 'blip' of a time-dependent treatment at a particular time point *t*, as a function of the past treatment and prognostic factor history. MSMs model the causal effect of a treatment given at time *t* as a function of only the baseline values of the prognostic factors. Whilst both MSMs and SNMs have certain advantages and disadvantages over each other, MSMs are considered to be more computationally flexible than SNMs (Robins, 2000). Both models are defined for *counterfactual/potential* outcomes (Rubin, 1974).

The theory of counterfactual outcomes dates back to as far as the 18th century in the works of the Scottish philosopher David Hume. These basic ideas were subsequently used in various experiments and was developed in to causal language by David Lewis in 1973 (Lewis, 1986) and later developed in to a formal statistical counterfactual framework by Rubin, in 1974 (Rubin, 1974). Subsequent models such as the Marginal Structural Model was introduced based on these counterfactual/potential outcomes. It is also worth noting that these models were often referred to as structural models in Epidemiology.

Let $\overline{a} = \{a_u\,; 0 \leq u \leq T\}$ be a fixed non-random (non-dynamic) treatment history and let $\overline{A}$ be the actual observed treatment history for an individual. In essence, counterfactual/potential outcome theory states that a random variable $Y_{\overline{a}}$ can be defined to represent the individual's outcome, had he/she had been treated with a history $\overline{a}$ rather than his/her observed history $\overline{A}$. For each possible history $\overline{a}$, it is assumed that the individual's response $Y_{\overline{a}}$ is well defined even though it may not be observed (Robins, 2000). In the context of both time-varying treatments and outcomes, the counterfactual variables will also be defined for each time point considering all possible treatment histories up to and including that point. Counterfactual variables in the context of the marginal structural models will be discussed in subsequent sections.

Rosenbaum and Rubin (1983) presented three main identifiability conditions under which it would be possible to obtain consistent estimates of counterfactual quantities using observational data. For simplicity, let us consider the case of a fixed treatment A and a set of baseline covariates L. Rosenbaum and Rubin (1983) presents the following three necessary conditions for deriving estimates of causality.

1. Consistency: If $A = a$ for a given subject, then $Y_a = Y$ for that subject - This assumption requires the counterfactual outcome to be equal to the observed outcome when a subject receives his/her assigned treatment.
2. Conditional exchangeability: The assumption of no unmeasured confounding given the data on baseline covariates L. This implies that,

   $Y_a \coprod A|L = l$, for each possible value a of A and l of L
3. Positivity: If $f_L[l] \neq 0$, then $f_{A|L}[a|l] > 0$ for all a, where $f_L[l]$ is the population marginal probability or the marginal density of L. This requires that the treatment was not deterministically allocated within any stratum defined by a particular value of L.

Even though the above conditions were defined for a single-point treatment, the conditions equally apply to time-varying treatment and outcomes hence MSM for longitudinal treatment and outcomes are based on these conditions (Hernan, Brumback and Robins, 2002; Robins et al., 2000). However, when using observational studies for purposes of causal inference, these conditions should be carefully considered as they would significantly impact the validity of the inferences made. While the first condition is relatively easier to satisfy, the second and third conditions often pose a significant challenge with the breakdown of the positivity assumption giving rise to the issue of confounding which was described above. Therefore, it is clear that a suitable adjustment needs to be made, which will overcome the issue of confounding, prior to using observational data for causal inference.

Given the background of the available methods for dealing with time-varying treatments and the data structure in this study, the Marginal Structural Model with Inverse Probability Treatment Weights introduced by Robins (1998) was thought to be the most suitable analytical method for obtaining unbiased estimates of the causal effect of the mid-day meals programme. The following section presents the relevant theory on this model.

8.3.4. Theory of Inverse Probability of Treatment Weighting and Marginal Structural Models

As explained above, when using observational data to make causal inferences, often times biased estimates arise due to the breakdown of the randomized allocation assumption and the presence of endogenous treatments. When the observed data set is an unbalanced panel this poses a further set of complications in both modelling as well as with regards to historical effects of treatments. As explained earlier, regression and matching approaches can succeed in estimating contemporaneous effects of a treatment (i.e. an effect of a fixed- or single-point treatment) but fail in the presence of a sequence of treatments which is habitual in a panel data setting. Thus, when making causal inferences using panel data, these issues need to be accounted for, in order to obtain unbiased treatment effects. Inverse Probability of Treatment Weighting (IPTW) is a popular method used when using cross-sectional observational studies to assess treatment effects (McCaffrey, Ridgeway and Morral, 2004). However the application of IPTW to panel data was introduced by Robins in a series of publications where he introduced two classes of models; Structural Nested Models and Marginal Structural Models (Robins, 1998; Robins, 1994). The suggested method of applying IPTW calculates weights for each repeated measurement in the dataset and uses them to reweight each observation to create a reweighted dataset. In this new dataset, historical sequences of treatments can be considered to originate from a sequentially randomised experiment. The assumption of sequential ignorability is a key assumption of this methodology. In essence, this assumption means that there are no unobservable variables that impact both the treatment and the outcome variables (i.e. unobservable confounders). By observing a wide range of variables, this assumption may be thought to be satisfied to a considerable extent. The theory and background of Marginal Structural Models and the application of IPTW to panel data is briefly explained below.

- **Inverse Probability Treatment Weights (IPTW)**

The notation used here follow the standard pattern of those introduced by Robins (1998) and Robins (2000). Let A_t be the treatment at time *t*, which in this study would be whether the child was treated under the mid-day meals programme in month *t*. Let Y be the outcome of interest, which is either the standardized weight or height of the child. The goal is to estimate the causal effect of the time dependent treatment on the mean of *Y*. In the case of panel data, a history of treatments exists, which can be denoted by $\bar{A}_t$, where $\bar{A}_t = \{A_u;\ 0 \leq u \leq t\}$. In addition to treatments there may also exist time varying explanatory variables, which can be denoted by the vector L_t with $\bar{L}_t = \{L_u;\ 0 \leq u \leq t\}$ being the history of the explanatory vector through time *t*. If the conditional probability of receiving a treatment in month *t* given past treatment and explanatory variable history depends only on the past treatment history, such a treatment process is defined to be causally exogenous (Robins, 1998). For A_t to be causally exogenous, it is an essential condition for A_t to be statistically exogenous. However, it should be noted that statistical exogeneity implies 'causal' exogeneity only if the assumption of 'no unmeasured confounders' (i.e. sequential ignorability assumption) is satisfied.

Robins (1998) defines statistical exogeneity to be satisfied if the probability of receiving treatment at time *t* does not depend on the history of measured time varying explanatory factors $\bar{L}_t$ up to time *t* when conditioned on the prior treatment history. This can be mathematically represented as,

$$\bar{L}_t \coprod A_t \mid \bar{A}_{t-1}$$

This condition can be tested by constructing the following random product.

$$w_t = \frac{\prod_{k=1}^{t} f(A_k|\overline{A}_{k-1}, V^+)}{\prod_{k=1}^{t} f(A_k|\overline{A}_{k-1}, \overline{L}_k, V^+)} \qquad (8.7)$$

Where $f(A_k|\overline{A}_{k-1}, \overline{L}_k, V^+)$ and $f(A_k|\overline{A}_{k-1}, V^+)$ represent probability functions. Each term in the denominator represents the probability that the subject received his/her own observed treatment at time *t*=*k* (i.e. A_k), given his/her past treatment and time-varying explanatory variable history while each term in the numerator represents the same probability only controlling for the treatment history and not the time-varying explanatory variable history. It should also be noted that any baseline variables V^+present in the data are typically added to both the numerator and denominator models and also includes the baseline values of time-varying covariates L_0 . In an observational study the w_t values will be unknown and would have to be estimated from the data at hand. Logistic regression can be used to fit two separate models to predict the numerator and denominator probability functions required for the estimation of w_t. Whilst the theory presented above was framed for a binary treatment variable, the theory was later extended to accommodate continuous valued treatment variables (Robins et al., 2000). Unlike the case of binary treatment variables, a continuous treatment variable A_k gives rise to an extremely large number of counterfactual outcomes. Under the assumption that the treatment variable is distributed with a Normal distribution, $f(A_k|\overline{A}_{k-1}, \overline{L}_k, V^+)$ gives the conditional density of A_k given the past treatment and time-varying explanatory variable history while $f(A_k|\overline{A}_{k-1}, V^+)$ gives the marginal density of the continuous treatment A_k. The stabilized weights given in equation (8.7), can then be constructed by fitting two ordinary least squares regression models for the numerator and denominator. Given that *Trt2* is a continuous treatment this method was utilised in estimating the IPTW.

Statistical exogeneity entails $w_t = 1$ for all *t*. When A_t is statistically non-exogenous the derived w_t's can be estimated and used to weight each unit-time record in order to create a pseudo-population in which A_t is statistically exogenous and thus could yield estimators with a causal interpretation.

In essence the method weights each unit-time observation by the inverse of the probability of a unit receiving its observed treatment at the considered time point, to remove the effect of confounders. Prior to applying this method to the data, it is important to identify which variables act as time dependent confounders in the various models that will be fitted. The following causality diagrams look at the setup of some of the considered models in order to identify the confounding variables.

Causality Diagram for the Standardized Weight-for-age Model

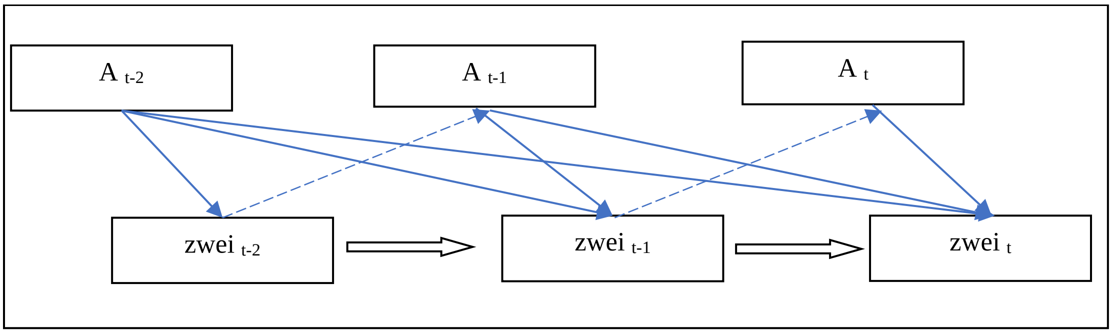


Figure 8-4: Causality Diagram for Weight Model

The above figure presents the DAG for explaining the links between the various elements of the weight-for-age model fitted in Chapter 9. It should also be noted that, the baseline variables which include the gender, birthweight and first weight on record of the child are also part of the model but have been excluded from the figure since their impact does not vary with time. Given that the dataset has a panel/longitudinal structure, the age (in months) of the child is treated as the panel variable. From the figure, it is clear that, at any given time point *t*, the previous period's weight plays a significant role in explaining the current period's weight. The weight of the child in the previous month is not only associated with past treatments but is also directly related to his/her current month's weight. However, whether this variable becomes a time-dependent confounder or not depends on the existence of the links indicated by the dashed arrows. That is, for the weight of the previous month to act as a time-dependent confounder, it should ideally be a determinant of, or at least associated with the treatment of the current period. Therefore, the existence of such a link should be intuitively reasoned before attempting to fit the model. In the context of the present problem, this link suggests that a child's weight in the previous month is associated with the number of days the child attends the CDC in the current month. Since the number of days the child attends the CDC is a parental decision, it is worthwhile to argue the nature of the relationship between the child's weight in the previous month and parental decisions regarding child participation at the CDC.

There are a couple of possible scenarios that could exist with regards to this question. Firstly, if a mother notices that her child's weight has declined in a given month, she may be naturally inclined to send the child to the CDC more frequently in the next month, with the allure being the free daily meal provided by the CDC. Another possibility would be that, since the estate midwife monitors the growth of children living within the estate, she may persuade parents to send their children to the CDC regularly, especially if she notices a marked decline in their growth. Yet another possibility could be where parents decide not to send their child regularly to the CDC because despite the child's regular attendance at the CDC, they feel that the child is not showing any marked improvement in his/her weight over a few months. Apart from those mentioned above, there may be several other scenarios that may explain the link between children's past month weights and their current period's treatment. It is therefore clear that the links illustrated using the dashed arrows could exist. Hence the past period's weight measure can be considered as a time-dependent confounder in the weight model.

Causality Diagram for the Standardized Height-for-age Model

The figure below depicts the links between variables when considering the child's height-for-age as the outcome of interest. In this scenario, the time-dependent confounder in the model is the standardized height of the child in the previous period. Similar to the weight models, both the current and previous period's standardized heights are affected by previous treatments. The previous period's height is also directly related with the current period's height, and these cross-relationships can cause confounding of the treatment effect. However, once again, for the child's height in the previous period to become a time-dependent confounder, it is necessary for the links denoted by the dashed lines to exist. The height is considered as a particularly important indicator of growth in children below the age of 5 as it reflects long term trends in growth. Given this, midwives often monitor this variable closely, and would advise parents to take sustainable remedial actions to support the child's growth, if anomalous height trends are detected. Given this, it is logical to assume that previous heights of the child would have an impact on parental decisions and motivations to improve or withdraw participation of the child from the mid-day meals programme. For example, parents of children with low attendance who also show anomalous height trends may be advised to improve CDC attendance so that the child could benefit more from the programme. Similarly, parents of children who regularly attend the centre and yet continue to show anomalous growth may be advised to reconsider their nutrition and feeding strategies. Therefore, the previous month's height can be considered as a time-dependent confounder in this model. It should also be noted that the baseline variables used in this scenario additionally include the first height on record.

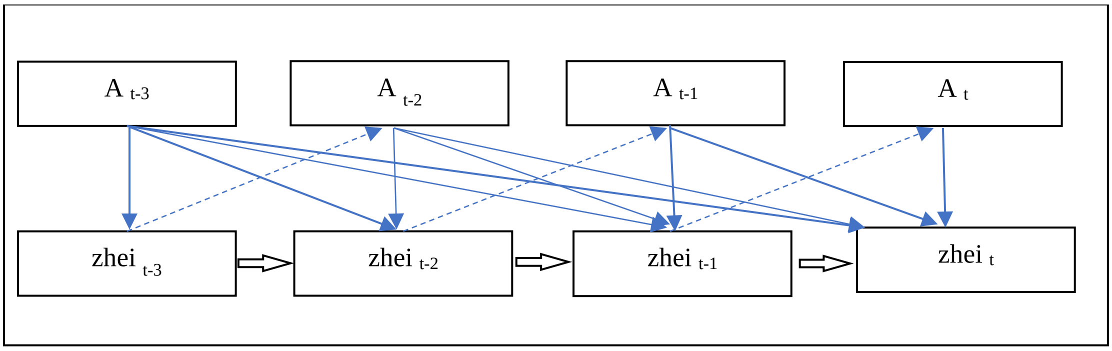


Figure 8-5: Causality Diagram for Height Model

The DAGs depicted in Figure 8-4 and 8-5 indicate the existence of time-varying variables that clearly confound the treatment effect, and therefore it is clear that IPTW is applicable in the current scenario. However, the assumption of sequential ignorability or no unobserved confounders needs to be satisfied. The weight and height of a child can depend on a multitude of variables that vary from parental and household attributes to environmental attributes. For example, the weights and heights of the child's mother can be a significant variable that predicts the child's anthropometrics. Characteristics of the household that the child lives in, can also yield valuable information regarding the living standards of the child. The weight of a child can also be impacted by illness and disease. A possible proxy for illness and disease could be the environment in which the child lives. Logistic limitations of the field survey prevented the collection of many of these variables that could have potentially impacted the weights and heights of children apart from the observed variables. Given this, controlling for the previous periods weight and height becomes a necessity as these variables control for much of these time-invariant unobservables. In addition to this, certain other steps were also taken to minimise any potential biases that may occur in the modelling process.

- **Marginal Structural Models**

Marginal Structural Models (MSM) were introduced by Robins (1998) as an alternative class of models to the Structural Nested Models (SNM) which were a set of causal models introduced previously by the same author (Robins, 1993). Some of the differences between MSMs and SNMs were briefly stated in the previous section. Another major difference between the two classes of models is that MSMs, unlike SNMs are non-nested models. MSMs provide semiparametric estimates of the causal effect of a time-dependent treatment variable on a response. As indicated earlier, they are based on the concept of counterfactual outcomes. The term 'counterfactual outcomes' refers to the fact that, in a time-dependent treatment study, an outcome $Y_{\overline{a}_t}$can be defined for every possible treatment history $\overline{a}_t$ where $\overline{a}_t = \{a_u\,; 0 \leq u \leq t\}$, despite the fact that only one such outcome will be observed for any subject (i.e. for the realized treatment history) (Rothman and Greenland, 1998). Therefore $Y_{\overline{a}_t}$ can be treated as the random variable representing a subject's outcome had he/she been treated with a history $\overline{a}_t$ rather than his/her observed history $\bar{A}_t$. Hence the full data for the subject is the collection of counterfactuals generated by allowing all possible treatment histories from the treatment space A. For example the full data for the subject could be defined as, $O = (\overline{Y}_{\overline{a}}, \overline{L}_{\overline{a}},\ V^+ : \overline{a} \in A)$ where $\overline{Y}_{\overline{a}}$ is the vector of counterfactual outcome variables, $\overline{L}_{\overline{a}}$ is the vector of time varying covariates and $V^+$the vector of baseline covariates. The confounders in $\overline{L}_{\overline{a}}$ are used in deriving the IPTW after which the MSM for each $\overline{a}_t$ and a known function g (.,.,.) is given as follows,

$$E\left[Y_{\bar{a}_t} \middle| V^+\right] = g\ (\bar{a}_t\ , V^+, \beta) \qquad (8.8)$$

The above model is referred to as 'marginal' since it models the marginal distributions of the counterfactual variable $Y_{\overline{a}_t}$ conditional on the baseline variables as opposed to a joint distribution of $Y_{\overline{a}_t}$'s. As mentioned earlier, these types of counterfactual models are also referred to as 'structural' in econometrics literature (Hernan et al., 2002). The parameter vector β is estimated using the Inverse Probability Treatment Weighted estimator (IPTW estimator) by solving the IPTW estimating function which has the following form (Bryan, Yu, and Van Der Laan, 2004),

$$\begin{aligned} IC_{IPTW}(O|f, \beta, h) &= \sum_t w_t \times h\ \left(t,\ \overline{A}_k, \overline{Y}_k, V^+\right) \times \varepsilon_{\overline{A}}(\beta) \\ &= \sum_t \frac{\prod_{k=1}^{t} f(A_k|\overline{A}_{k-1}, V^+)}{\prod_{k=1}^{t} f(A_k|\overline{A}_{k-1}, \overline{L}_{k-1}, V^+)} \times h\ \left(t,\ \overline{A}_k, \overline{Y}_k, V^+\right) \times \varepsilon_{\overline{A}}(\beta) \\ &= 0 \qquad (8.9) \end{aligned}$$

Here $h\ (.)$ is any function of time, the baseline variables, observed history of treatment and the outcomes and $\varepsilon_{\overline{A}}(\beta)$ defines the residuals, both of which are derived from the fitted MSM. For example the score function of the MSM is one possible choice for $h\ (.) \times \varepsilon_{\overline{A}}(\beta)$ (Bryan et al., 2004). The estimated βs are known to have a causal interpretation.

Fitting MSM is done as a two-stage process. The first stage is to estimate each subject's probability of receiving their own treatment history and use these probabilities to derive the inverse-probability-treatment weight (IPTW). The second stage is to estimate the treatment-outcome association using a suitable model (GEE, Pooled OLS etc.) that is weighted using the derived IPTWs.

- **Assumptions for the Application of IPTW and MSM**

The three identifiability assumptions necessary for valid causal inference (Rosenbaum and Rubin, 1983) was briefly outlined in section 8.3.3. It should be noted that the assumption of consistency is relatively straight forward and can be assumed to be satisfied in this case. In addition to this, the causal interpretation of β in MSMs also depend on the following assumptions which are crucial for satisfying the other two identifiability assumptions.

1. No unmeasured confounders or the assumption of sequential ignorability (i.e. all variables that are associated with both the weight/height of the child and the probability that the child receives a mid-day meal for a prescribed number of days at the CDC, each month are measured).
2. The marginal structural model for the effect of the treatment on the weight/height of children is correctly specified
3. The treatment models used for deriving the inverse probability treatment weights have been correctly specified

The sequential ignorability assumption requires that there are no unobservable confounders present. When considering the nature of the unobserved variables some of which were described above, it is unlikely that many of these variables could potentially confound the treatment effect. For example, even though the mother's height/weight clearly has a relationship with the child's height/weight, it is unlikely that the mother's height/weight is affected by/affects the mid-day meal treatment process. Therefore, these unobserved variables are unlikely to be confounders. Similarly, other possible unobserved household and environmental characteristic variables other than those controlled for, are also considered unlikely to act as confounders. Therefore, in this scenario, it is logical to assume that the sequential ignorability assumption is met. Nevertheless, these unobserved variables can cause an omitted variable bias.

As a possible remedy for the omitted variable bias, three additional variables were used in the weight models. In the weight models, the standardized weight of the previous month, the standardized value of the first recorded weight (included in the sample collected) and the standardized value of the birthweight were considered. The reasoning behind adding these variables was to proxy the impact of the unobserved variables. The logic behind including these variables was that the impact of unobserved variables such as the maternal and household characteristics should have an approximately similar effect on the child's weight throughout his/her existence. Therefore at least a portion of the effect of the omitted variables on the child's weight may be captured by these three variables which are measures of the child's past weight at various points of time. These three variables can be considered to capture the impact of maternal anthropometrics as well as other household characteristics on the child's weight. The effect of living standards can also be reasonably captured by these variables since living standards can't be expected to change sharply over a period of five years. Since the three prior weight measures are spread over a considerable portion of the five-year period, even if changes in living standards did occur, having multiple covariates at different time points will ensure that at least part of the effect of the change in living standards on child weight is captured by the covariates in the model. With regards to the impact of illness on weight, the illness indicator variable (S_{it}) as defined in equation (8.2) is used to capture this effect and the adjustment indicated in equation (8.3) is applied to the treatment variable prior to modelling.

For the height models a similar approach is used whereby the standardized value of the first recorded height (included in the model) and the standardized value of the previous month's height are used as covariates in the model. These two height measures are used as a proxy for some of the unobserved variables. Even with these proxy variables in the model, there may still be certain unobservable variables that may cause an omitted variable bias, however it is reasonable to assume that these variables would not be confounders in the model.

Therefore, it is clear that the use of IPTW coupled together with MSMs can be justified in this scenario, in order to adjust for the effect of the observed confounders. The second and third assumptions presented above are somewhat stringent and often difficult to formally test. However, the model specifications can be considered valid as they follow typical models used in malnutrition research.

8.3.5. Generalized Estimating Equations for Panel Data

The method of Generalized Estimating Equations (GEE) is a popular modelling technique used in modelling repeated measures data. Therefore marginal structural models for repeated measures data also uses GEE in order to account for within subject correlations (Hernan et al., 2002). In the absence of confounding, the expected value of the outcome Y_t given the treatment history $\overline{A}$ (i.e. $E[Y_t|\overline{A}]$) is thought to be equal to the expected value of the counterfactual outcome $Y_{\bar{a}_t}$ indicated in equation (8.8). The mean of the observed outcome variable Y_t can be modelled using the following GEE model,

$$E[Y_t|\overline{A}] = g(\overline{A}_t, \gamma) \qquad (8.10)$$

Where g is a known function and γ is a parameter vector to be estimated. For example, g could be a linear function where,

$$g(\overline{A}_t, \gamma) = \gamma_0 + \gamma_1 cum[\overline{A}_t] + \gamma_2 t \qquad (8.11)$$

With $cum[\overline{A}_t] = \sum_{k=0}^{t} A_k$ and $\gamma = (\gamma_0, \gamma_1, \gamma_2)'$.

The above model can be further expanded by adding baseline variables and non-confounding time varying covariates/factors. The treatment variable can also be changed by separating the present period's treatment status and the cumulative function of previous treatments.

The specification of GEE further requires a variance function and a correlation structure to be specified. The variance structure depends on the form of the function g while the correlation structure represents the relationship between repeated outcomes measured for the same unit. A number of possible working correlation structures are available for this purpose (e.g. the independent structure that assumes a homoscedastic variance and independence among repeated measures; the exchangeable structure that assumes heteroscedastic variance and equal correlation between repeated measures; the autoregressive structure that assumes an AR relationship for the correlation between repeated measures). The formulation of GEE allows the model to produce asymptotically unbiased parameter estimates even when the defined working correlation structure does not hold (Liang and Zeger (1986); Zeger and Liang (1986)).

In the presence of counterfactual outcomes $Y_{\bar{a}_t}$s, the above model (8.10 and 8.11) can be re-specified as,

$$E[Y_{\overline{a}_t}|\overline{A} = \overline{a}] \; = g(\overline{a}_t, \gamma) \qquad (8.12)$$

Where,

$$g(\overline{a}_t, \gamma) \; = \; \gamma_0 + \gamma_1 cum[\overline{a}_t] + \gamma_2 t \qquad (8.13)$$

Here $\gamma_1$will have a causal interpretation provided it is the weighted GEE linear regression estimator using IPTW as weights. A baseline covariate vector can also be included in the model as required.

8.3.6. Model Specification

As noted earlier the second stage of the analysis consisted of modelling the effect of regular participation in the programme on child growth by using the treatment variable *Trt2*. Accordingly, models were estimated separately for the standardised weights-for-age (*WAZ*), height-for-age (*HAZ*) and BMI-for-age (*BMIZ*) of the children in the two treatment estates. Only the children who were registered in the programme were used in the analysis, as the objective was to observe the effect of regular participation in the programme rather than registration in the programme (which is captured in the intention-to-treat models). The outcome variables (*WAZ* , *HAZ* and *BMIZ*) were obtained following the standardization method outlined by WHO. All IPTW calculations as well as the GEE models were limited to the sample of children above the age of six months since below that age infants are usually not fed anything apart from breast milk and hence would not have any impact from the mid-day meals programme. It should also be noted that the treatment variable (*Trt2*) has undergone the transformation noted in equation (8.3) and hence all models include the variable S_{it} which reflects illness/sudden shocks, as specified in equation (8.2).

1. Creating Inverse Probability Treatment Weights for Models Fitted

Following the theory of IPTW outlined above, the treatment variable *Trt2* is used in order to derive the weights required for the MSMs. Given that the treatment variable is continuous valued, the numerator and denominator models for the sample weights calculation outlined in equation (8.7) is fitted using ordinary least squares regression (Robins et al., 2000). A few tweaks have been made to the model, where necessary, to accommodate for the nature of the dataset. These changes will be explained below. The coding used for deriving the weights is included in the appendices.

- **IPTW for standardized weights-for-age models**

The IPTW model for the treatment variable (equation 8.7) requires the current period's treatment to be modelled using its entire history. In addition to the treatment variable, the denominator model of IPTW also requires the history of other time varying confounders and baseline covariates to be accounted for. In the present scenario the treatment and covariate history could run up to 20-30 months, and past values of some time-varying covariates would not have an impact on the current month's treatment. Therefore, it was necessary to decide which time-varying covariates would be included as lags and the suitable number of lags to include in the model. Past research has shown this to be done at the discretion of the researcher, based on intuition and background of the research (Hernan et al., 2002). In most cases, only the last period's treatment and up to two past values of these covariates have been considered. In the present scenario, given the treatment is the attendance at the CDC each month, past values of the child's weight/height/BMI-for-age and the $propmeasure_{it}$ variable (i.e. variable reflecting parental care) were decided to be included in the denominator model. Considering the number of lags, it was decided to include up to 6 lags of the treatment and the mentioned covariates, considering that a six-month period would be sufficient for the impacts of a mid-day meals programme of this nature, on growth, to manifest. A range of baseline variables (V^{+}in the models below) including the child's gender, ethnicity, standardized birthweight, standardized values of the first weight measure, whether the child has ever been present at a CDC during the sampled period, the CDC classification, division and the estate the child lives in, were included in the models. The following equations provide the general model used in obtaining the numerator and denominator for the calculation of sample weights for child *i* in month *t*.

Numerator:

$$Trt2_{it} = \alpha_0 + \alpha_1 L1\_Trt2_{it} + \cdots + \alpha_6 L6_{Trt2_{it}} + \ \alpha_7 Tot_{Trt2_{L7}{}_{it}} + \gamma\ V^{+} + \varepsilon_{it} \quad (8.14)$$

Denominator:

$$Trt2_{it} = \alpha_0 + \alpha_1 L1\_Trt2_{it} + \cdots + \alpha_6 L6\_Trt2_{it} + \ \alpha_7 Tot\_Trt2\_L7_{it} + \ \beta_1 L1\_zwei_{it} + \cdots + \beta_6 L6\_zwei_{it} + \beta_1 L1\_propmeasure_{it} + \cdots + \beta_6 L6\_propmeasure_{it} + \ \gamma\ V^{+} + \varepsilon_{it} \quad (8.15)$$

The above models are fitted and used to estimate the conditional and marginal density function for calculating the numerator and denominator of the expression given in equation (8.7).

- **IPTW for standardized heights-for-age models**

Figure 8-5 represents the causality paths between the heights of children and the treatment. The height is generally considered as stock variable that does not vary a lot in the short term. Thus, height is generally considered as a measure of long-term growth. Therefore, the impact of the mid-day meal as a treatment on the height of a child can be difficult to precisely visualize. For example, the effect of the current month's treatment on that month's height would be minimal since changes in height happen as a long-run result of health and nutrition. It is also clear that the past records of a child's height become a confounder in the model for current heights since it is both affected by previous treatments, is a determinant of the current month's height and can also impact future treatments (indicated by the dashed arrows in Figure 8-5). Possible reasons for these relationships were outlined in the previous section.

Once again it is necessary to decide the number of treatment and time varying covariate lags to include in the calculation of sample weights. As before, past measures of the standardized height-for-age (*HAZ*) and the proportion of weighed instances (*propmeasure*) are included in the numerator and denominator models. Similar to the IPTW calculations for the weight-for-age models, past values of the *Trt2*, *HAZ* and *propmeasure* are considered up to six lags. Maintaining up to six lags is particularly applicable in the case of height, as height is considered to be a stock variable which does not vary too much in the short run. Hence it can be assumed that the impact of the treatment on child height would appear with a lag.

Only very few children had their birth heights on record and hence the standardized birth height could not be used in the model as a baseline variable. All baseline variables used in the weight-for-age IPTW calculation were also used here. Apart from these controls, the standardised value of the first height record was also used in the model (*firstzheight*). The model specification is equivalent to that presented in equations (8.14) and (8.15).

- **IPTW for standardized BMI-for-age models**

A similar approach was used when calculating the IPTW for the BMI-for-age models. The baseline covariates (V^{+}) used are similar to the IPTW for the weight-for-age models. Similar to the earlier IPTW specifications, up to six lags of the treatment, standardized BMI-for-age and *propmeasure* were added to the models.

2. The Empirical Model Using IPTW

The final model for the time-varying treatment variables is a weighted GEE model with weights derived as explained in the sections above. The exchangeable working correlation structure was used in all models. Two main model specifications were used in the analysis. The first model fits the current periods treatment (equation 8.16) while the second model fits the cumulative treatment up to and including the current month (equation 8.17).

$$zwei_{it} = \beta_0 + \beta_1 Trt2_{it} + X_{it}{}'\gamma + \varepsilon_{it} \qquad (8.16)$$

$$zwei_{it} = \beta_0 + \beta_1 Tot\_Trt2_{it} + X_{it}{}'\gamma + \varepsilon_{it} \qquad (8.17)$$

Here the vector $X_{it}{}'$ is a $1 \times k$ vector of independent child and CDC level variables which include the *Age, Gender, Ethnicity, firstzweight, zbirthweight, propmeasure*$_{it}$, S_{it}, *CDC_adj*, *CDC_cat* and *Estate*. The past period's standardized weight-for-age plays a vital role in the model specification as it is required to control for much of the unobserved time-invariant factors that impact child growth. However, given that the past weight-for-age acts as a confounder, it cannot directly be added as a covariate to the models above. The IPTW takes care of this issue by incorporating it in the weight calculation instead so that it can be left out of the main model, without biasing the causal estimates. The model specification for standardized height-for-age is very similar to the above models with the exception of controlling for *firstzheight* in addition to the variables included in models 8.16-8.17. The past period's standardized height-for-age is again controlled for through the IPTW. The BMI-for-age models are similar to the weight-for-age models.

8.3.7. Robustness Analysis

The above models were fitted to a number of different subsamples, in order to test for the robustness of the estimated treatment effects. The sample was first split by birthweight, as children with higher than average standardized birthweight (*zbirthweight>0*) and lower than average standardized birthweight (*zbirthweight<0*). Next the sample is split by the standardized value of the first weight-for-age on record (*firstzweight*), again with higher than average *firstzweight* and lower than average *firstzweight* (*firstzweight>0* and *firstzweight<0*). The above subsamples are used to assess treatment effects based on initial/baseline growth status, as both the birthweight and first weight on record can be considered as baseline measures of child growth.

In addition to this, other characteristics such as gender, birth cohort (i.e. born between 2007-2009, 2010-2012 and 2013-2015), and estate of residence are used to split the sample, and MSMs are fitted within each subsample to explore the variations in treatment effects.

In order to assess whether the general living standards across the sampled estates is similar, models are fitted incorporating the housing quality index as a control variable. As noted earlier, a convenience sample of households was selected from each sampled plantation and a housing quality checklist was used to collect data on the quality of housing within each plantation. Models incorporating the housing quality index as a control variable show similar results to the main models fitted, further verifying the similarity in general living standards across the treatment and control samples. These results are excluded due to space considerations.

Chapter 9: Data Analysis

As indicated in the previous chapter, two different treatment variables are explored through the analysis. The first treatment variable is time invariant and identifies whether a child lives in an estate which runs the mid-day meals programme. Instrument variable panel regression models are used to fit the intention-to-treat models. Three outcome variables weight-for-age, height-for-age and BMI-for-age are explored in the models. The second treatment variable which is time-varying models the attendance of children at CDCs each month. Height-for-age models are used to analyse the impact of the programme on long-term growth while the BMI-for-age models which adjusts for height, is used to analyse the impact of the programme on short-term growth. Given that weight is affected by height, weight-for-age is considered as a composite measure of growth, which should be analysed in conjunction with the height-for-age and BMI-for-age models. The following section presents a brief descriptive analysis of the data followed by the Intention-to-Treat and Marginal Structural Models, which model the two classes of treatment variables.

9.1. General Descriptive Analysis

This section presents the basic descriptive analysis carried out on the collected data. Table 9-1 below provides a breakdown of the data collected from the three estates. It should be noted that the sample numbers indicated here are those obtained after data cleaning to remove abnormal observations and after correcting for data entry errors[5].

Table 9-1:Background Characteristics of Sampled Estates

Estate	# of CDCs	Females	Males	# of children in estate	# of MJF prog children	Participation rate
Bearwell	4	178	151	329	203	61.7%
Holyrood	5	239	231	470	185	39.4%
Dessford	6	231	249	480	0	N/A

[5] A physical recheck of the data was carried out. Data entry errors included mistakes in gender and mid-day meals status, particularly in Holyrood estate data. Records giving abnormally high/low standardized weight and height values were removed.

Looking across the programme participation in the two treatment estates, one clear observation is the higher participation rates observed in Bearwell estate compared to the Holyrood estate. Of the sample of children observed within Bearwell, 61.7% of children were enrolled in the mid-day meals programme, while in the Holyrood estate participation was just below 40%. This is indicative of the possible existence of some estate specific heterogeneity in programme participation. Exploration of this heterogeneity was beyond the scope of this study and will be explored through a future study. The table below provides a gender breakdown by participation in the two treatment estates.

Table 9-2: Gender breakdown by programme participation

Estate	Programme participants			Non-participants			Estate Total
	Female	Male	Total	Female	Male	Total	
Bearwell	109	94	203	69	57	126	329
Holyrood	94	91	185	145	140	285	470
Total	203	185	388	214	197	411	799

Looking across genders, both estates reported equally high percentages of male and female children participating in the programme.

9.1.1. Descriptive Analysis

9.1.1.1. Sample Profile

As mentioned above, the final sample contained records from 1279 children in total. This consisted of 329, 470 and 480 children from Bearwell, Holyrood and Dessford estates respectively. The initial dataset contained 47,510 records of which, of which after accounting for missing data values, 17,214 weight-for-age and 10,309 height-for-age records were used in the intention-to-treat models. The following figures provide a breakdown of the sample by key variables.

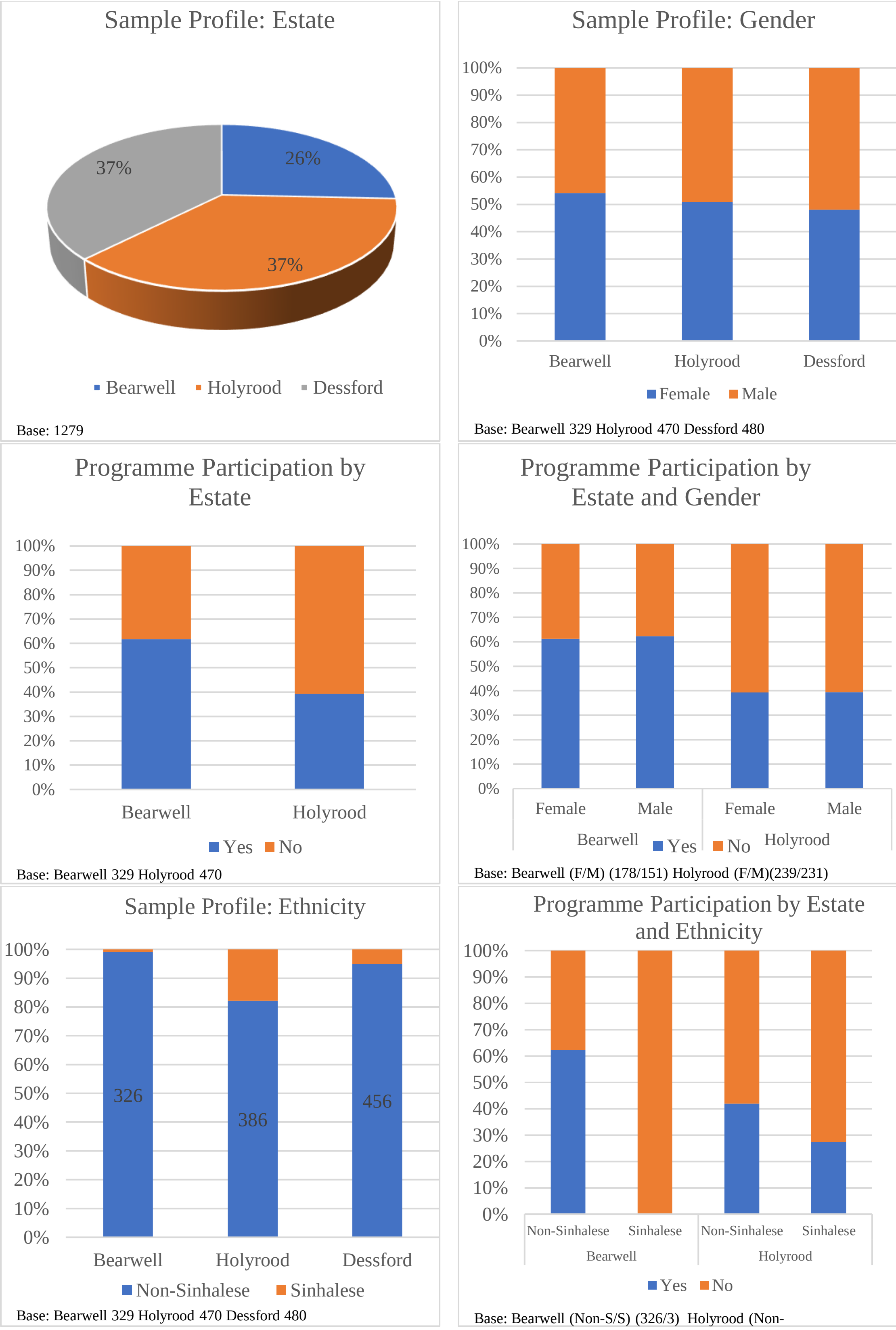


Figure 9-1: Sample profile by Estate, Gender, Ethnicity and Programme Participation

The sample is almost evenly split between the three estates, with a slightly higher percentage of children from Holyrood and Dessford estates. The gender split is also even within each estate. When looking at children's participation in the MJF mid-day meals programme, across the Bearwell and Holyrood estates, participation was clearly higher within Bearwell compared to Holyrood. However, participation rates do not show significant differences by gender. Given the unique history of the resident worker population within the tea plantations of Sri Lanka, it was interesting to explore the ethnic composition of the dataset. As noted earlier, due to data limitations the ethnicity of sampled children was identified either as Sinhalese or non-Sinhalese. The non-Sinhalese category contained all minority ethnicities including Indian Tamil, Sri Lankan Tamil and Muslim children. According to the figure above a clear majority of the sampled children in all three estates consisted of Non-Sinhalese children. The percentage of Sinhalese children was slightly higher (20%) within the Holyrood estate. Looking at programme participation across the ethnic groups within the Bearwell and Holyrood estates, it was also noticeable that a majority of the Sinhalese children in both estates did not participate in the programme.

9.1.1.2. Distribution of Weight-for-age, Height-for-age and BMI-for-age

Prior to modelling it was important to descriptively explore the growth distribution of children within the treatment and control estates. Table 9-3 provides summary statistics for weight-for-age, height-for-age and BMI-for-age. The figure below presents histograms of the distributions of standardized weight-for-age, height-for-age and BMI-for-age across the estates and by treatment.

Table 9-3: Summary of weight-for-age, height-for-age and BMI-for-age by treatment variables

		Weight-for-age (*WAZ*)	Height-for-age (*HAZ*)	BMI-for-age (*BMIZ*)
Overall sample	N	17214	10309	7638
	Mean	-1.689	-2.010	-0.677
	SD	0.932	1.173	1.208
Sample by Estate				
Bearwell	N	4019	1664	1650
	Mean	-1.767	-2.014	-0.751
	SD	0.899	1.161	1.080
Holyrood	N	7815	5917	4185
	Mean	-1.726	-1.923	-0.762
	SD	0.899	1.134	1.133
Dessford	N	5380	2728	1803
	Mean	-1.577	-2.196	-0.409
	SD	0.990	1.240	1.430
Sample by Treatment				
Treatment	N	11834	7581	5835
	Mean	-1.740	-1.943	-0.759
	SD	0.900	1.141	1.118
Control Estate	N	5380	2728	1803
	Mean	-1.577	-2.196	-0.409
	SD	0.990	1.240	1.430
Participation within Treatment Estates*				
Participant	N	6683	3925	3271
	Mean	-1.774	-1.999	-0.732
	SD	0.870	1.122	1.074
Non-Participant	N	5151	3656	2564
	Mean	-1.697	-1.883	-0.794
	SD	0.935	1.158	1.170
Participation by Estate				
Bearwell				
Participant	N	3058	1305	1291
	Mean	-1.798	-2.009	-0.734
	SD	0.865	1.124	1.055
Non-Participant	N	961	359	359
	Mean	-1.671	-2.033	-0.811
	SD	0.995	1.289	1.166
Holyrood				
Participant	N	3625	2620	1980
	Mean	-1.754	-1.993	-0.730
	SD	0.874	1.121	1.087
Non-Participant	N	4190	3297	2205
	Mean	-1.703	-1.866	-0.792
	SD	0.920	1.141	1.171

* A child who attends the programme at least once within the survey period was taken as a participant

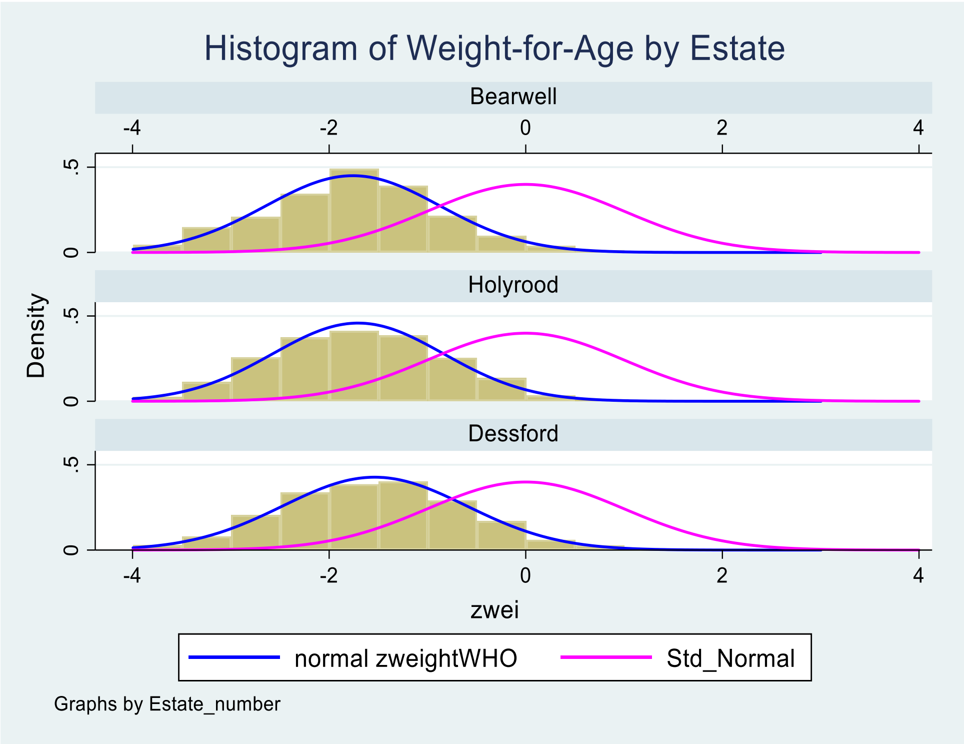
The mean standardized height-for-age is more negative (-2.010) than the mean weight-for-age and BMI-for-age values, in the overall sample, clearly showing that children in the sample lag well behind WHO standards with regards to long-term growth. Looking across the three estates, the mean weight-for-age is similar across all three estates. However, the mean height-for-age is more negative within Dessford estate and least negative within Holyrood estate while the BMI-for-age is seen to be less negative within Dessford estate compared to Bearwell and Holyrood.

Looking at the participants and non-participants of the mid-day meals programme, within the two treatment estates (Bearwell and Holyrood) it is clear that the mean weight-for-age, height-for-age and BMI-for-age is similar between participants and non-participants of the programme. However, it is also noticeable that the mean weight-for-age and height-for-age are slightly less negative for non-participants than participants, while the opposite is true for BMI-for-age. This pattern is also evident within the Bearwell and Holyrood estates. To further explore this, summary statistics for children in the 0-6 month category were obtained. Given that the mid-day meals programme is only applicable to children above 6 months, records of children below the age of 6 months provide an approximate baseline to compare the status of children in the three estates.

Table 9-4: Summary of weight-for-age, height-for-age and BMI-for-age by estate for 0-6 month olds

		Weight-for-age (*WAZ*)	Height-for-age (*HAZ*)	BMI-for-age (*BMIZ*)
Sample by Estate				
Bearwell	N	212	3	3
	Mean	-1.303	-1.414	-0.618
	SD	0.950	0.988	0.621
Holyrood	N	705	6	6
	Mean	-1.471	-1.909	-0.867
	SD	1.051	1.838	1.605
Dessford	N	505	85	71
	Mean	-0.787	-1.975	0.814
	SD	1.054	1.480	1.620
Sample by Treatment				
Treatment	N	917	9	9
	Mean	-1.432	-1.744	-0.784
	SD	1.030	1.554	1.313
Control Estate	N	505	85	71
	Mean	-0.787	-1.975	0.814
	SD	1.054	1.480	1.620

What is immediately evident is the relatively small number of observations available for height-for-age and BMI-for-age in the Bearwell and Holyrood estates. However, looking across weight-for-age it is clear that the mean weight-for-age is slightly higher (less negative) within the Dessford estate as compared to Bearwell and Holyrood estates. It is also noticeable that the mean BMI-for-age is positive (0.814) within the control estate. Looking across the treatment and control estates, the mean weight-for-age among 0-6 month old's is considerably higher (less negative) in the control estate than in the treatment estates. This may be an indication that children in the control estate generally show better growth than children in the treatment estates, on average. The following figure presents histograms of the standardized weight-for-age, height-for-age and BMI-for-age which further illustrates the patterns observed above.



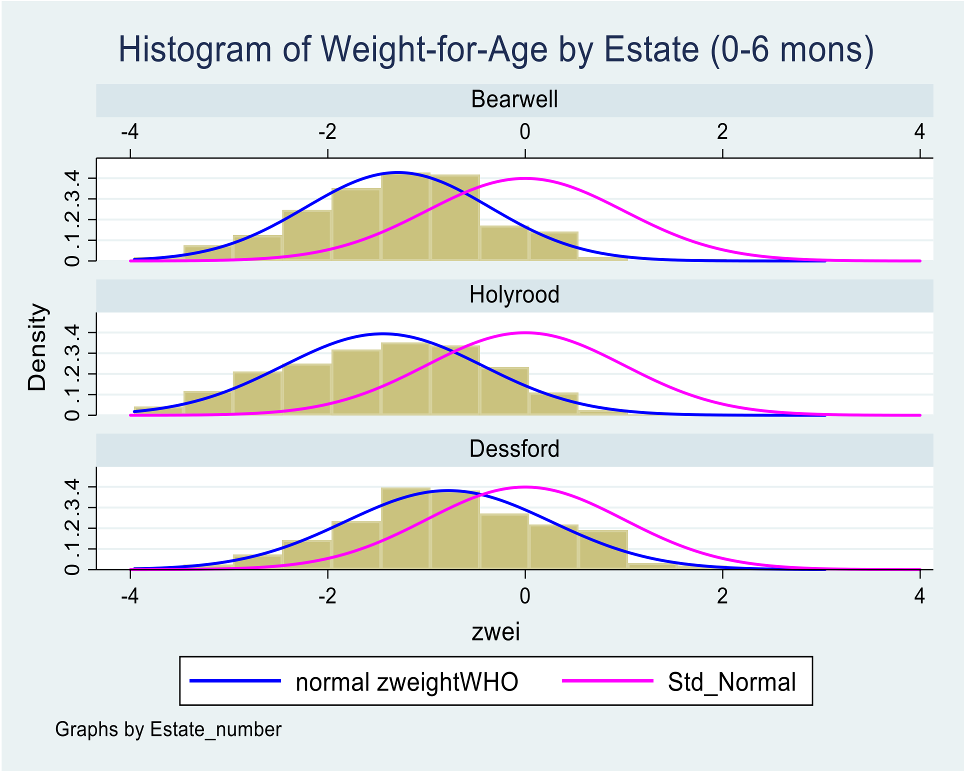


Figure 9-2: Histogram of Standardized Weight-for-Age by Estate

No significant difference can be seen in the weight-for-age distributions between the three estates in the overall sample. However, looking at records of children below the age of 6 months, the distribution of weight-for-age measures within Dessford is closer to the standard normal distribution than in the other two estates.

The figure below shows the distribution of weight-for-age by the treatment status (*Trt1*) which specifies whether records are from children living in estates that had the programme, and by programme participation which specifies if the record is from a child who has been part of the programme at some point. Looking at the histograms in the top panel, again no significant difference in the distributions were observed between the control and treatment estates in the overall sample, in the subsample of 0-6 month old's, the distribution of weight-for-age was clearly closer to the standard normal in the control estate than within the treatment estates. Looking across the bottom panel, a similar pattern is again observed in 0-6 month period, where the distribution among non-participants is slightly closer to the standard normal curve, than for participants.

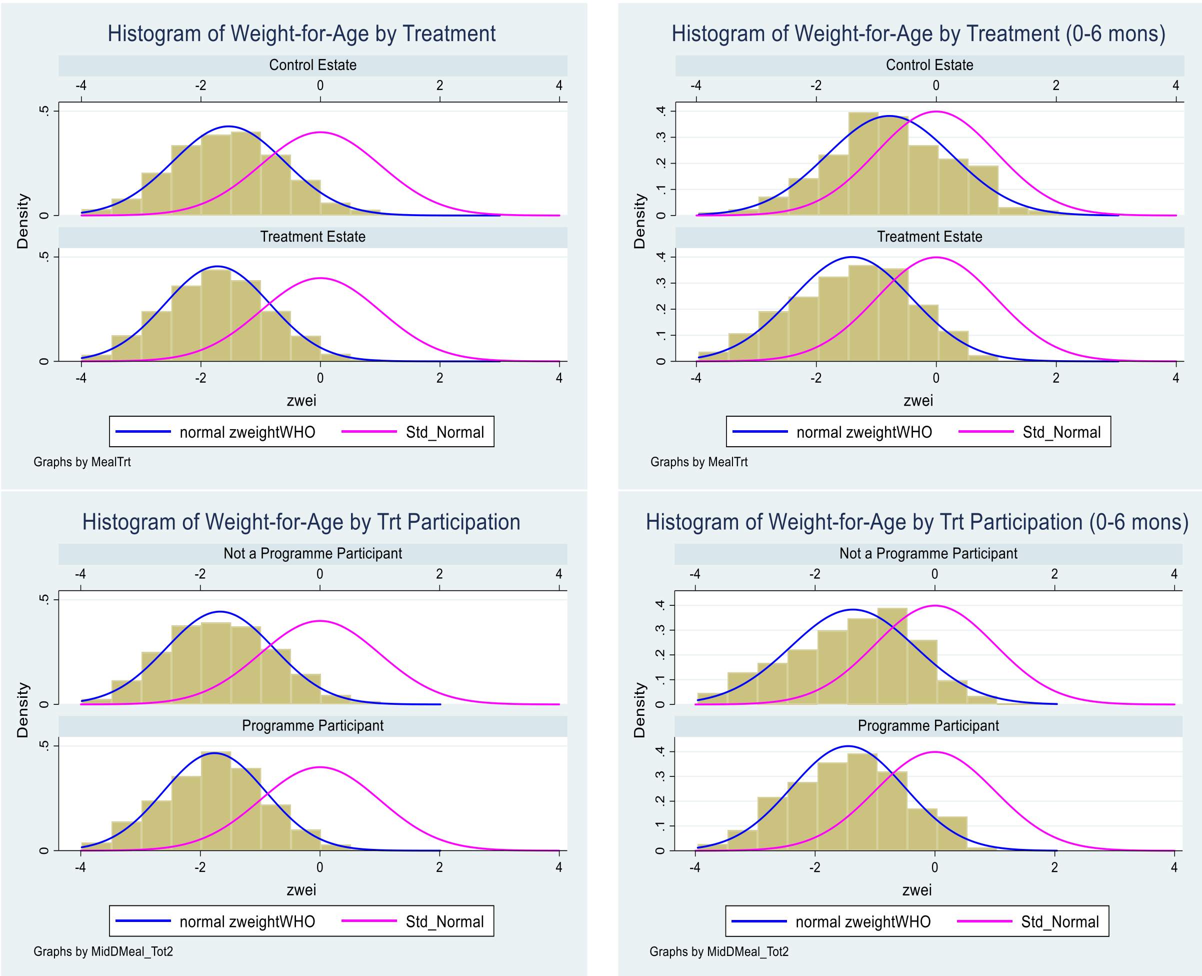


Figure 9-3: Standardized Weight-for-Age by Treatment and Participation

Figure 9-4 below presents the histograms of the standardized height-for-age and BMI-for-age. The histograms for the 0-6 month group are not presented due to small counts. The height-for-age distributions for all three estates are seen to significantly deviate from the standard normal, indicating that children in all three estates show relatively poor height-for-age measures. In comparison the BMI-for-age distributions are somewhat closer to the standard normal. Similar to the weight-for-age distributions, the height-for-age and BMI-for-age distributions in the overall sample do not show significant differences between control and treatment estates or between participants and non-participants. However, it is noticeable that the BMI-for-age distributions somewhat closely follow the standard normal distribution across all subsamples.

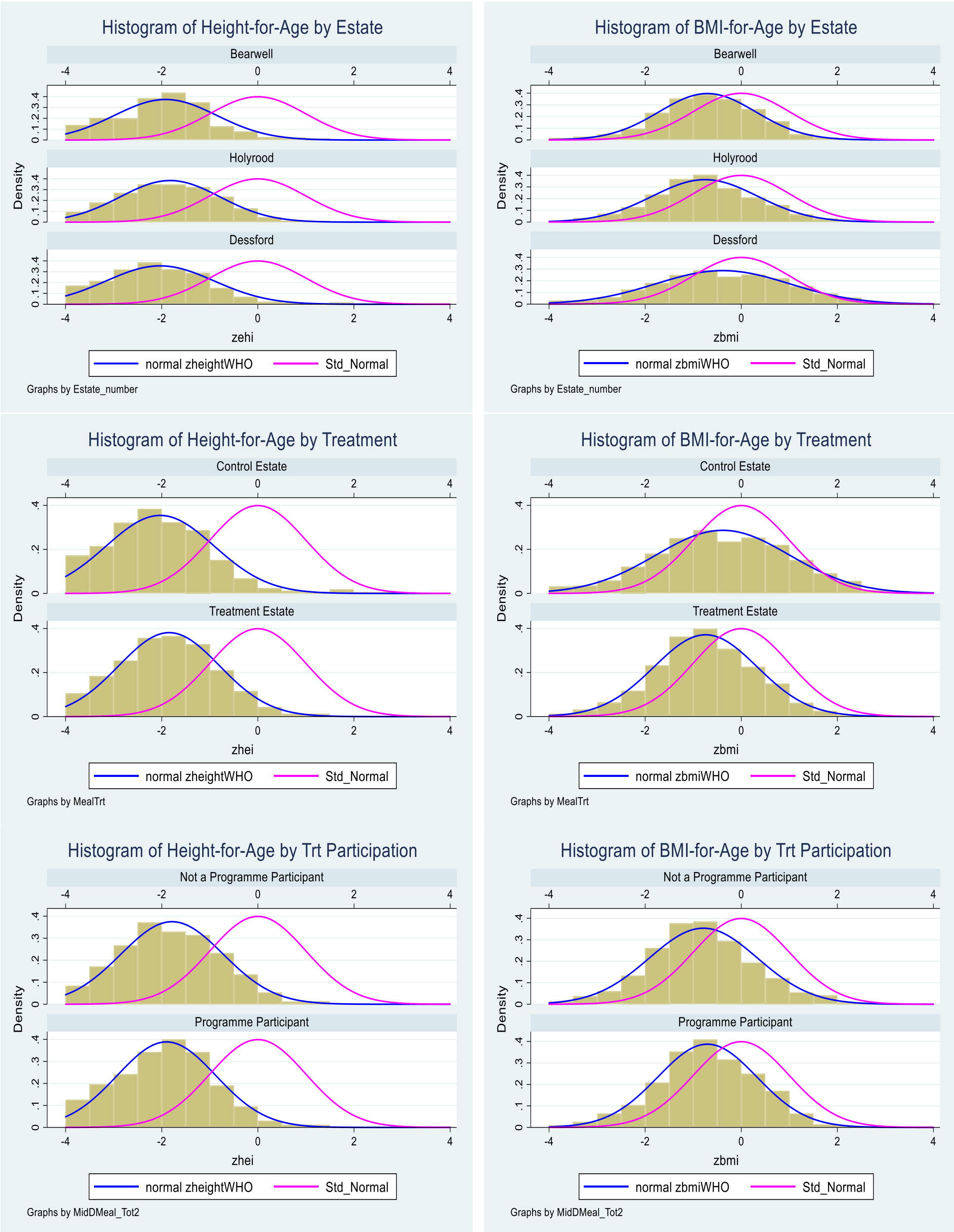


Figure 9-4: Histogram of Standardized Height-for-age and BMI-for-age

Overall, the summary statistics and histograms clearly indicate children in control estates to be generally ahead of children in treatment estates in the 0-6 month age group. Thus, it would be interesting to assess the treatment effect on child growth.

Given that the second stage of the analysis looks at the effect of regular attendance on the growth of children who are part of the mid-day meals programme, it was interesting to descriptively explore this relationship. The treatment variable used in this stage of the analysis (*Trt2*) gives the number of days each child attended a mid-day meals CDC each month, after adjusting for health shocks as given in equation 9.3.

Table 9-5: Summary of *Trt2* by age group

		Overall Sample	6-12 mons	12-24 mons	24-36 mons	36-48 mons	48-60 mons
Trt2	N	16640	2031	4081	3899	3546	2150
	Mean	4.988	4.065	4.724	5.232	5.701	5.789
	SD	7.312	6.947	7.234	7.377	7.396	7.484
By Gender							
Female	N	8309	989	1971	2024	1770	1123
	Mean	5.026	3.941	4.754	5.275	5.733	5.904
	SD	7.331	6.858	7.280	7.465	7.356	7.537
Male	N	8331	1042	2110	1875	1776	1027
	Mean	4.950	4.183	4.695	5.185	5.669	5.664
	SD	7.293	7.032	7.195	7.282	7.437	7.427
By Estate							
Bearwell	N	4019	366	845	1002	1047	547
	Mean	9.832	7.503	9.320	10.527	11.117	12.089
	SD	6.368	6.932	6.445	6.122	5.605	5.061
Holyrood	N	7241	985	1840	1678	1486	1036
	Mean	6.006	5.594	6.196	5.871	5.771	5.632
	SD	8.236	7.974	8.262	8.189	8.098	7.964

Mean attendance is 4.988 in the overall sample and the mean is also seen to gradually increase with age. Mean attendance is also observed to be higher among females than males and the same pattern is seen across all age groups above 12 months. Looking across the two treatment estates, the mean attendance is seen to be considerably higher in Bearwell estate than in Holyrood estate, and this pattern is clearly observed across all age categories. Particularly in age groups above 24 months, mean attendance is almost double in magnitude within the Bearwell estate than in the Holyrood estate.

It is also interesting to explore whether any possible drop in attendance at Holyrood CDCs could be attributed to the lack of facilities and poor maintenance of the CDCs themselves. With most RPCs launching projects to update the old crèches within their plantations, the

PHDT introduced a CDC classification to keep track of the development process occurring within the estates. Under the classification each CDC was classified as 'old', 'upgraded' or 'new' based on the level of facilities available at the CDC. This classification is included in models as a CDC level variable as well. Each estate is divided into a number of divisions based on its geographical spread, and each division has a CDC. Accordingly, Holyrood was divided in to five divisions while Bearwell had four divisions, with each division having a CDC.

Background details such as the number of children on-roll, and daily average attendance are periodically collected by the estate office, and records are maintained for each year. Upon request, the data for 2014 (year prior to the survey year) was made available within the Bearwell and Holyrood estates. The following table and figures depict the status of the CDCs as reported in 2014, and the distribution of children included in models, by CDC status in both estates.

Table 9-6: Reported status of CDCs - 2014

Division	CDC_cat	Reported_2014		
		On-roll	Daily avg. attendance	% Avg, Attendance
Bearwell Estate				
Belgravia	Upgraded	45	36	80
Fairfield	Old	97	62	64
Walaha	Upgraded	50	48	96
Bearwell	New	48	28	58
Holyrood Estate				
East	New	32	28	88
East Num18	Upgraded	35	29	83
Rathneelakalle	New	20	18	90
West/Upper	New	30	22	73
West/Lower	Upgraded	28	22	79
Dessford Estate				
Dessford A	New	45	35	78
Dessford B	Old	41	29	71
Lower A	Upgraded	49	49	100
Lower B	New	44	30	68
Lorne	Upgraded	83	50	60
Upper	Old	60	45	75

According to the above table, Bearwell estate had one ‘old’ CDC which had 97 children enrolled. Holyrood estate had no old CDCs. Most of the CDCs at Holyrood were classified as ‘new’. The overall average daily attendance was 72.5% within the Bearwell estate while it was 82.1% in Holyrood. The percentage daily attendance reported for three of the four Bearwell CDCs were above 60%. It is interesting to note that the CDC reporting the lowest average daily attendance in Bearwell, was the one classified as ‘new’. The CDC also showed the second lowest enrolment of children. It should also be noted that, while the log books and data were obtained from this CDC, the CDC itself was inaccessible during the field survey due to bad weather conditions. The CDC was situated in a very distant part of the estate geographically separated from the other divisions. Even though the CDC was newly constructed, it was somewhat difficult to reach it especially during rain, due to poor roads conditions within the division. This could be one possible reason for the low enrolment and attendance numbers within this CDC. The division may have a lesser resident population due to poor infrastructure and living conditions which could result in a lesser number of parents seeking to register their children at the CDC. Another possibility could be that the CDC being newly built, it may not be as popular among resident workers as the other three CDCs. Another possible reason could be that this division being somewhat separated geographically from the others, much of the tea plucking work may be concentrated within the other divisions. If this is the case resident workers who live within this division, may prefer to register their children at the CDCs in the divisions they work in, so as to be closer to the child. This could be prominent particularly among infants, where the mothers visit the CDC every 2-3 hours during work, in order to breastfeed their children. It is also interesting to note that the CDC classified as ‘old’ had close to 100 children on-roll in 2014 and was the CDC with the highest number on-roll at a Bearwell CDC. However, this CDC also reported the second lowest percentage daily attendance.

Dessford estate, had equal numbers of new, upgraded and old CDCs. With regards to % average attendance, lowest attendance was reported from an upgraded CDC which reported the highest number of enrolled children. The highest % average attendance was also reported from an upgraded CDC.

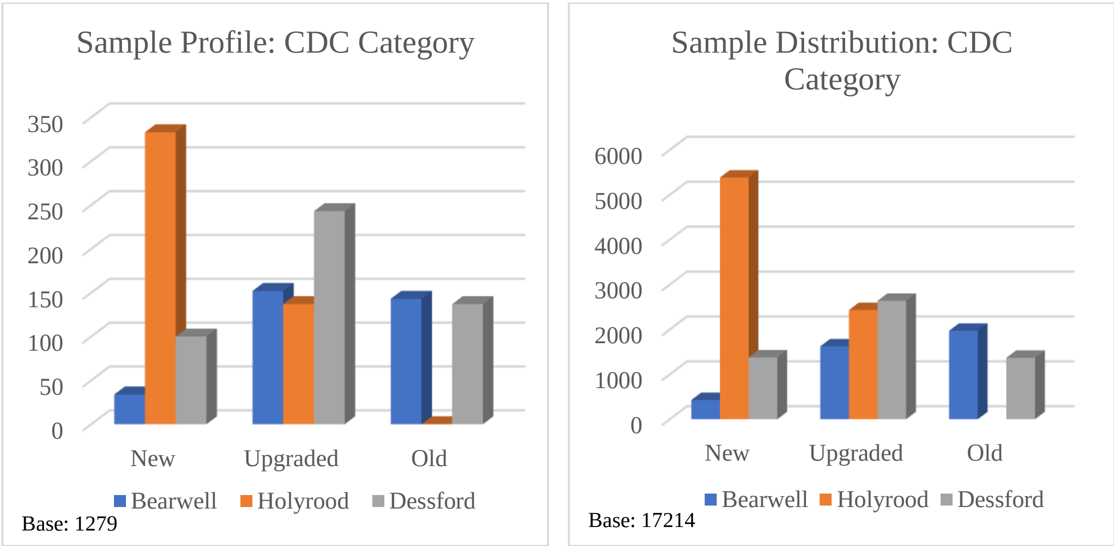


Figure 9-5: Sample Profile and Distribution by CDC Category

Figure 9-5 represents the sample breakdown according to the CDC category. Of the sample of 1279 children included in the ITT models, the highest number of children from a new CDC was reported from Holyrood estate, while the highest number of children from an upgraded CDC was reported from Dessford estate. Bearwell and Dessford estates reported equally high numbers of children from old CDCs. looking across individual records, Holyrood estate contributed the highest number of records from children registered at new CDCs, while Bearwell and Dessford contributed equivalent shares of records from children registered at old CDCs. The three estates showed equivalent numbers of records from children registered at upgraded CDCs.

The following figure gives a breakdown of the sample by age. The distribution of records across age was similar in all three estates. Majority of records were for ages between 13-48 months. Holyrood estate clearly contributes the most records across all age categories. The percentage of records coming from the 0-6, 7-12 and 13-24 month categories were the least in Bearwell estate. Similarly, the records coming from the 25 month and above age categories were comparatively low from Dessford estate.

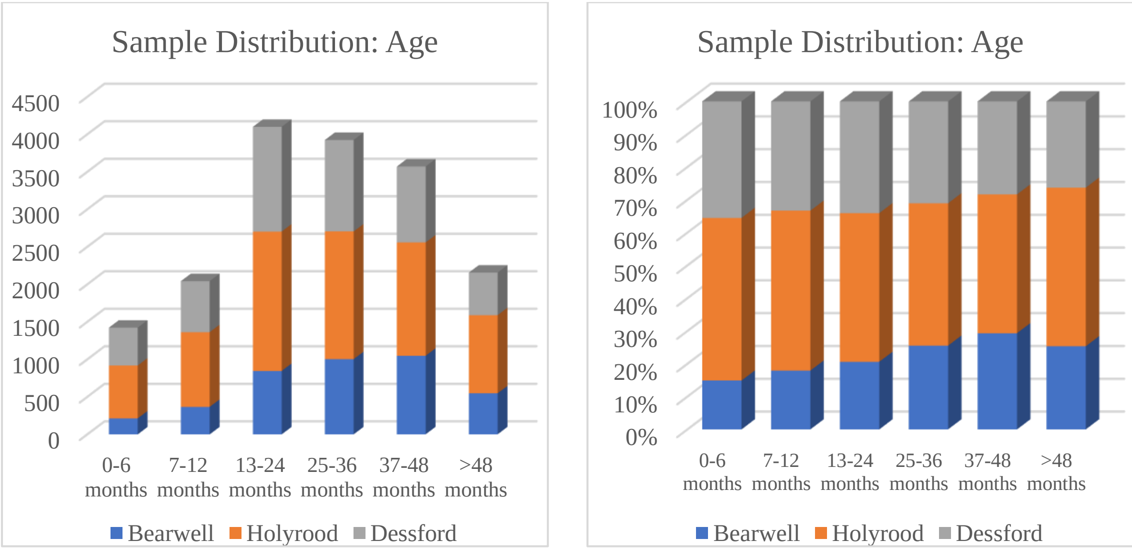


Figure 9-6: Sample distribution by Age

It was also interesting to explore the distribution of programme take-up by CDC and age, given that both these factors can impact programme enrolment. The following graphs depict the sample profile by programme participation and CDC category in the two treatment estates. A point clearly visible is the relatively high count of non-participating children living in divisions with 'new' CDCs within Holyrood estate. Whilst there were no non-participants in the division with a new CDC in Bearwell estate, the number of participating children were also considerably low within this division. This result could imply two separate underpinning causes for the low participation in divisions with new CDCs. In the case of Bearwell which showed low numbers of both participating and non-participating children, the result may be signalling towards a generally sparse population living within the division. In the case of Holyrood, divisions with new CDCs clearly show a higher number of non-participating children. This could signal lower popularity of newly built CDC over older/ updated CDCs, among resident workers. This could be particularly true if new CDCs also hire new staff, which may make residents less inclined to enrol children at the CDC. Divisions with 'updated' CDCs had an even split of participating and non-participating children in both estates while the number of participating children was slightly higher within the division with an old CDC in Bearwell estate (no old CDCs are reported in Holyrood).

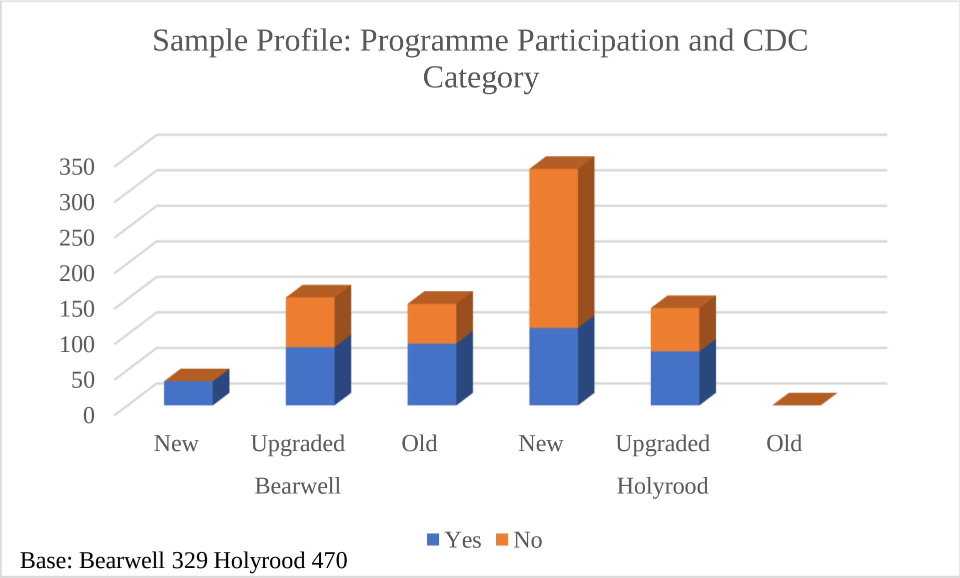


Figure 9-7: Programme Participation by CDC Category

To look at programme participation by age, a breakdown of the sample was considered by the birth year and participation in both estates. It should be noted that the dataset included records from a sample of children born between 2007-2009, which meant that these children were not part of the CDC or the programme at the point of survey (i.e. in 2015). However, their records were retained, as they presented historical data on children who were part of the mid-day meals programme at some point in the recent past. The distribution of participating children takes a bell shape in both estates indicating that most participating children were born between 2010-2012. This meant that most participating children would be aged between 36-60 months at the point of the survey. However, when looking at non-participants, the distributions are very different across the two estates. Bearwell estate shows and increasing pattern with the highest number of children belonging to the 2013-2015 birth year category (hence 0-24 months old at the point of survey). In Holyrood a bell-shaped distribution was detected which again implies that the sample had a relatively higher number of older children, at the point of survey. These results suggest the need for running age-wise models as a robustness measure.

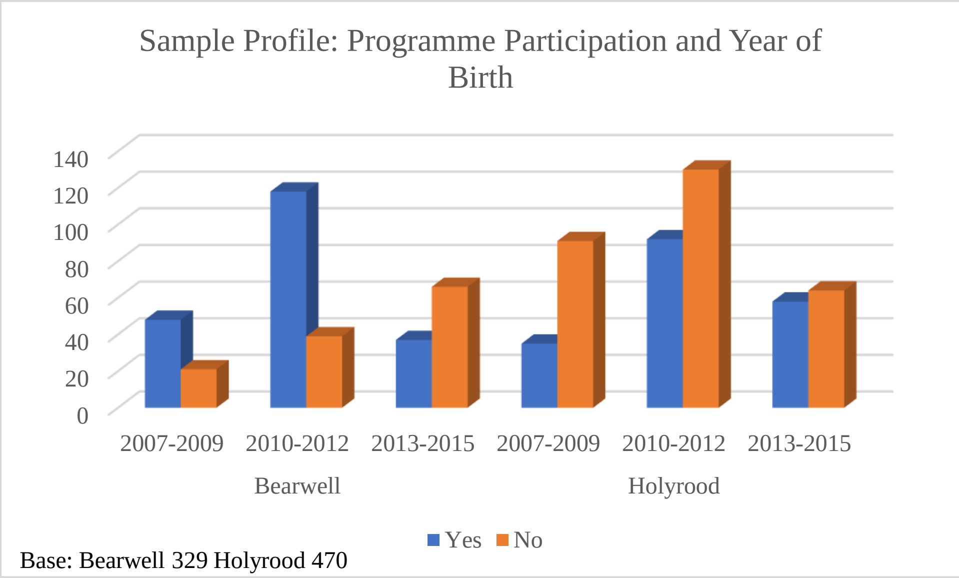


Figure 9-8: Programme participation by Birth Year

Apart from this, the distribution of birthweights was also analysed across the three estates. The distribution of birthweights in Holyrood estate clearly follows a normal distribution, centring around a mean slightly higher than 2.5 kg (indicated by reference line) (2.64±0.41). Compared to Holyrood estate, birthweights within Bearwell estate is more spread with a mean of 2.37 and standard deviation of 0.63. As is evident by both the calculated mean and the plotted distribution below. Birthweight distribution for Dessford estates also takes an approximate bell shape with a relatively high spread (mean 2.44 and standard deviation of 0.59). The distributions suggest that children at the Holyrood estate generally report better birthweights (with respect to both the mean and the minimum birthweight recorded) compared to children in the other two estates.

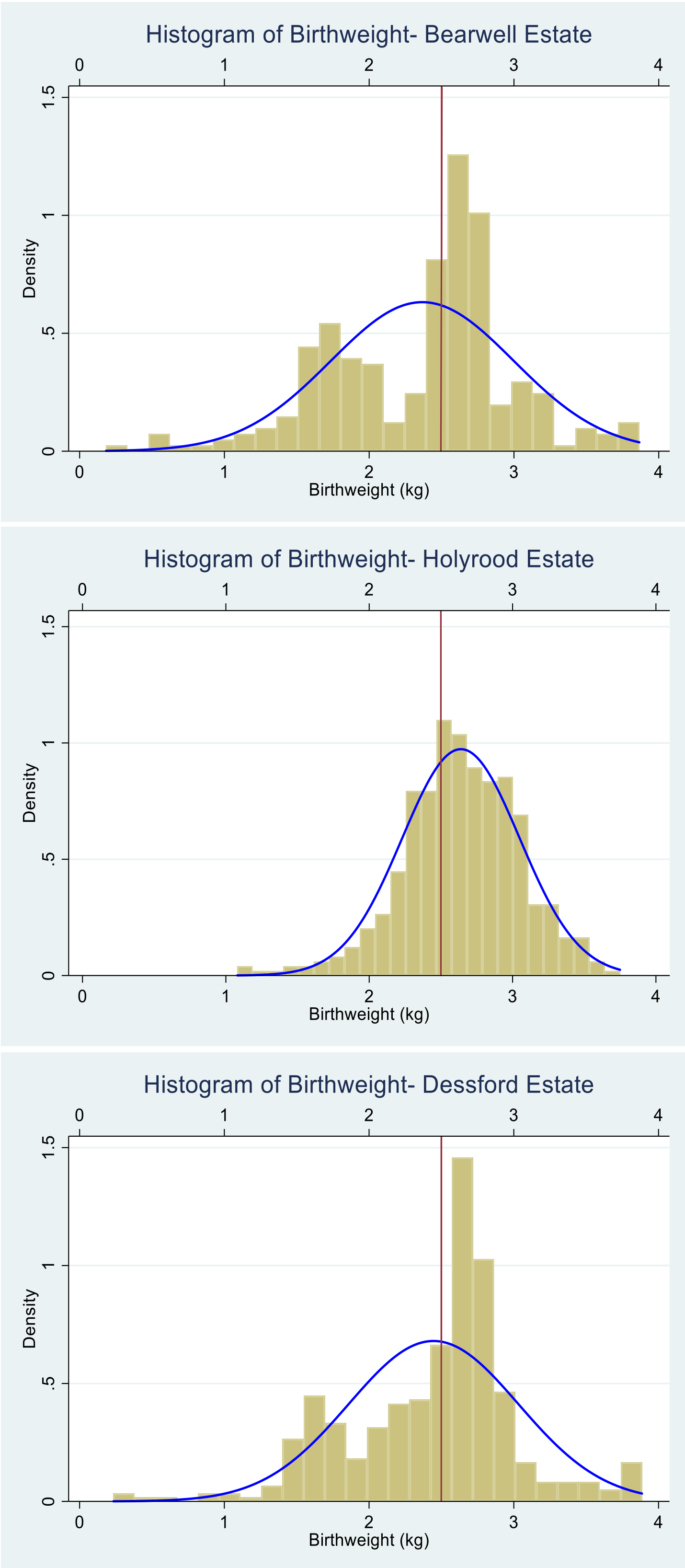


Figure 9-9: Distribution of Birthweight by Estate

9.1.1.3. Summary of Descriptive Results

The sections above presented a basic descriptive analysis of the quantitative data collected through this study. The sample was approximately evenly split between the three estates, with Bearwell having a slightly lesser number of children. The sample shows an even gender split in all three estates. However, with regards to uptake of the programme within the two treatment estates, a clear difference is seen between the two estates. Take-up of the programme was relatively low within Holyrood compared to Bearwell estate. However, participation rates did not show significant differences by gender. Take-up was also seen to be relatively low among children belonging to the Sinhalese ethnic group. However, this was not a significant issue considering that this ethnic group is not considered to be a vulnerable group within the estate region. Average standardized weight-for-age, height-for-age and BMI-for-age show some interesting patterns across estates and treatment groups. Average weight-for-age is similar across all three estates. Average height-for-age is more negative within Dessford estate while BMI-for-age is less negative within Dessford estate compared to Bearwell and Holyrood. Looking at the participants and non-participants of the mid-day meals programme, the mean weight-for-age, height-for-age and BMI-for-age is similar between participants and non-participants of the programme. Among children below the age of 6 months, the mean weight-for-age was considerably higher (less negative) in the control estate than in the treatment estates signalling that children in the control estate may generally be showing better growth than children in the treatment estates. The distribution of birthweights across the estates suggest that children within the Holyrood estate generally report better birthweights (with respect to both the mean and the minimum birthweight recorded) compared to children in the other two estates.

As outlined in Chapter 7, apart from collecting available quantitative data, the estate midwives and child development officers of the estates were also interviewed. In particular, the midwives and CDOs of the two treatment estates (Bearwell and Holyrood) were interviewed in depth, to gain qualitative insights into the general nutritional status of estate children, functioning of CDCs and implementation of the mid-day meals programme within

CDCs. Results of the qualitative analysis is presented in Appendix E2. The following section presents a basic summary of the main qualitative results.

9.1.2. Summary of Qualitative Analysis Results

According to Qualitative analysis presented in Appendix E2, a few interesting points were noted by the estate midwives of Bearwell and Holyrood estates, which shed some light on nutrition-related issues within their respective estates. Limited access to food and intake of imbalanced meals were generally highlighted as drivers of malnutrition in both estates. Issues surrounding pregnancy patterns and antenatal care were also highlighted by both midwives. Particularly both midwives noted issues around having 3-4 close pregnancies and lack of care afforded to the third child in most cases. Alcohol abuse was noted as a clear issue by both midwives.

The functioning of the CDCs was seen to be relatively uniform with regards to structure, general functioning and daily routines. CDCs were generally well maintained and the CDOs were experienced in running CDCs over several years. In all three estates, CDOs were seen to maintain a close relationship with the mothers. However, the participation of fathers in the day to day activities of their children both generally and within the CDCs was noted to be low by both the CDOs and the midwives. Whilst mid-day meals were prepared and provided following a fixed menu around mid-day within the two treatment estates, a difference was noted in the time that *Thriposha* was provided to the children. Bearwell and Dessford noted that they provided *Thriposha* to children in the morning, whilst Holyrood provided it in the afternoon. The reason for the shift to providing *Thriposha* in the afternoon instead of morning was to avoid parents dropping their children at the CDCs without providing breakfast.

With regards to housing quality, Holyrood estate was seen to have generally better-quality housing (based on the convenience sample). However, Holyrood and Dessford estates also reported a slightly higher number of poor-quality houses. Dessford estate showed a higher number of flushable/pour-flush toilets and households using tube wells, as oppose to public taps. Bearwell estate was seen to have a higher number of household assets. As noted in Chapter 7, a PCA approach was used in constructing an estate housing quality index, where Dessford was ranked highest and Bearwell the lowest considering overall housing quality, facilities and assets.

9.2. Empirical Analysis

This section presents the analytical results for the intention-to-treat (ITT) and marginal structural models (MSM) fitted for the standardized weight-for-age (*WAZ*), height-for-age (*HAZ*) and BMI-for-age (*BMIZ*) variables. The ITT models are fitted for the treatment variable *Trt1* which specifies whether the child lives in an estate which runs the mid-day meals programme. The MSMs are fitted for the treatment variable *Trt2* which specifies the number of treatment days each month. These models are fitted for children who are registered under the programme in the two treatment estates.

9.2.1. Intention-to-Treat Models

The table below provides estimated results for the Random-Effects GLS regression and the Generalised Two-Stage Least Squares Random-Effects (G2SLS RE) IV regression models fitted for the standardized weight-for-age (*WAZ*), height-for-age (*HAZ*) and BMI-for-age (*BMIZ*). As explained earlier, the standardized birthweight (*zbirthweight*) and the lagged parental care variable ($propmeasure_{i,\,t-1}$) were used as instruments for the previous period's outcome in the weight-for-age model. Similarly, the standardized value of the first height on record (*firstzheight*) and the lagged parental care variable were used as instruments for the previous period's height-for-age, in the height-for-age models. The standardized birthweight, standardized value of the first height on record and the lagged parental care variables were used as instruments for the past period's BMI-for-age in the BMI-for-age model (refer Table E2-2 for first-stage model results for the main IV models). As expected, a few of the estimated effects show significant differences between the GLS and IV models. However, the direction of the estimated effects of the treatment variable and the lagged outcome variable remain the same between the GLS and IV models. Particularly the magnitude of treatment effects is seen to be somewhat overestimated in the GLS regression models. In addition to this, the instruments used in all three IV models were observed to have strong and highly significant effects in the first-stage models (Table E2-2). These observations together back the use of IV models over GLS models and also support the validity of the instruments used.

The *Kleibergen-Paap LM*, *Cragg-Donald* and the *Sargan-Hansen* tests were carried out to further check the validity of the instruments (for underidentification, weak-identification and overidentification respectively) used in the IV models. All three tests confirm the validity of the instruments used in the weight-for-age and height-for-age models. These two models also show significant treatment effects. According to the S-H score, the BMI-for-age model is marginally overidentified. However, the observed treatment effect is not significant in both the GLS and IV specifications of the BMI-for-age model.

Results show a significant positive effect of living in an estate with the mid-day meals programme, on the standardized weight-for-age and height-for-age of children. A child living in a treatment estate, on average has a standardized weight-for-age 0.03 standard deviation (SD) units and standardized height-for-age 0.05 SD units higher than a similar child living in a control estate. The estimated effects noted above show the impact of access to the programme on growth at a particular point in time. However, long-term impacts of access to the programme can be assumed to be larger due to the multiplier effect of the treatment occurring via the lagged outcome variable in models. Whilst assessing this multiplier effect of treatment is beyond the scope of this analysis, this will be explored in future research.

Table 9-7: IV regression main-effects model results

		G2SLS RE (IV) REG					
		WAZ		*HAZ*		*BMIZ*	
		GLS	IV	GLS	IV	GLS	IV
Treatment var							
Trt1		0.088**	0.03**	0.058**	0.05**	-0.013	-0.001
		(0.012)	(0.007)	(0.015)	(0.012)	(0.019)	(0.018)
Instrumented var							
$WAZ_{i,t-1}$/ $HAZ_{i,t-1}$/ $BMIZ_{i,t-1}$		0.732**	1.012**	0.903**	0.908**	0.824**	0.839**
		(0.009)	(0.029)	(0.01)	(0.008)	(0.009)	(0.017)
Child-level							
Age		-0.006**	0.006**	0.007**	0.008**	-0.012**	-0.011**
		(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
Age_sq		0.0001**	-0.0001**	-0.0001**	-0.0001**	0.0001**	0.0001**
		(0.00001)	(0.00002)	(0.00003)	(0.00003)	(0.00004)	(0.00004)
Gender	Male	-0.008	0.015**	-0.008	-0.005	0.012	0.009
		(0.011)	(0.004)	(0.012)	(0.010)	(0.015)	(0.014)
firstzweight		0.144**	-0.042*	0.044**	0.041**	0.064**	0.06**
		(0.009)	(0.020)	(0.007)	(0.006)	(0.008)	(0.011)
propmeasure		0.074*	0.066**	0.107*	0.086*	-0.125*	-0.133*
		(0.032)	(0.017)	(0.044)	(0.036)	(0.062)	(0.057)
Ethnicity	Sinhalese	0.014	0.003	0.021	0.022	-0.076**	-0.077**
		(0.023)	(0.007)	(0.019)	(0.018)	(0.028)	(0.026)
zbirthweight				-0.007	-0.006		
				(0.005)	(0.004)		
CDC-level							
CDC_cat	New	-0.005	0.003	0.017	0.016	-0.063**	-0.053*
		(0.016)	(0.005)	(0.017)	(0.015)	(0.022)	(0.02)
	Upgraded	-0.002	0.003	0.028	0.023	-0.038+	-0.032+
		(0.015)	(0.005)	(0.017)	(0.015)	(0.022)	(0.02)
_cons		-0.487**	-0.193**	-0.476**	-0.451**	0.274**	0.242**
		(0.043)	(0.034)	(0.056)	(0.044)	(0.077)	(0.073)
N		17214	17214	10309	10309	7780	7780
σ_u		0.095	0	0.167	0.107	0.123	0
σ_e		0.306	0.309	0.224	0.237	0.490	0.700
ρ		0.088	0	0.357	0.169	0.059	0
Underidentification							
Kleibergen-Paap LM Stat			17.741***		120.59**		81.64**
Weak-instrument							
Cragg-Donald Wald F statistic			66.9		1275.44		433.30
Overidentification							
Sargan-Hansen test			0.497		0.61		5.742+

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1
K-P LM test [Null: matrix of reduced form coefficients has rank=K1-1], C-D Wald F Test [Null: Equation is weakly identified], S-H Test [Null: Overidentification restriction is satisfied]

Among other variables in the model, the effect of the previous month's outcome (the instrumented variable) is clearly significant with a considerably large effect across all three models. Age shows small yet significant effects across all three models. However, it is noticeable that the relationship between age and growth is opposite of what is usually observed in developing countries. As evidenced by other research (including the study presented in Essay 1 of this thesis), the growth of children in developing countries tend to be closer to the growth of children in the US reference population, closer to birth and deviates away with age (Wagstaff et al., 2003). However, the results above suggest an opposite pattern, where children tend to move closer to the reference population with age. The inflection points for the *WAZ* and *HAZ* models are approximately 30 and 40 months respectively. Given the age range in the data is from 0-60 months, this suggests that the relationship remains approximately linear and increasing through at least half of the age-range in the dataset. This is further backed by the estimated effects of age in the models across different subsamples, presented in the tables below, where the inflection points for the *HAZ* models in particular tend to be above 30 months in all of the subsample models. This suggests that children in the sample may be somewhat different to a general cross section of estate sector children in Sri Lanka. This ties in with the notion that residents of estates managed by RPCs enjoy a relatively better standard of living than residents of small-holder tea estates. Another possibility may be that the sample estates show a higher incidence of children born with low birthweight who thereafter tend to improve and catch up with age, due to the better facilities and living standards enjoyed by residents living in RPC estates. The improvement however tapers off after a particular age.

Gender showed a significant impact in the weight-for-age model where a boy child shows a standardized weight-for-age 0.015 SD higher than a similar girl child (*ceteris paribus)*. The parental care variable (*propmeasure*) was also significant and showed a positive effect on both the weight-for-age and height-for-age. A 1% increase in the proportion of weighed instances (*propmeasure*) would result in a 0.0007 increase in the standardised weight-for-age and 0.0009 increase in the standardized height-for-age of the child. Whilst these increases are statistically significant, the magnitude of the effects are noticeably small. This may imply that while higher levels of parental attention, improve growth, the magnitude of the improvement may not be significantly large. The standardized value of the first weight on record showed significant yet differential effects on weight-for-age and height-for-age. A 1SD increase in the first weight on record results in a 0.04 SD decline in the standardized weight-for-age whilst it results in an increase by the same magnitude in the standardized height-for-age. This result suggests that the relative point at which children start within the survey panel (their weight/height relative to the sample) has a significant impact on the current period's outcome. Given this variation in effects, models were fitted across subsamples based on this variable, as a robustness check.

With regards to the RE specification, the estimated error components suggest that the time-invariant child specific unobservables form a significantly small component across all models (low values of ρ), and this further justifies the fact that much of the time-invariant unobservables can be controlled for, by the addition of the lagged outcome variables to the models. The BMI-for-age model needs to be interpreted with caution as the Sargan score implies overidentification. A few noticeable results, as noted earlier the treatment effect is not significant. Age shows the opposite pattern, decreasing with age (inflection point sits beyond the studied age range). Unlike its effects on the weight-for-age and height-for-age models, *propmeasure* shows a negative effect on BMI-for-age where a 1% increase in the parental care variable results in a 0.001 SD decrease in the standardized BMI-for-age. Even though unusual it should be noted that the GLS model also shows a similar estimated effect for *propmeasure*. A possible explanation for the opposite signs on the estimated effects of *propmeasure* across the three models can be as follows. A higher number of visits to the midwife (as is reflected by a higher *propmeasure* value) may have a positive effect on long-term growth (as reflected by the increase in height-for-age) of children which also leads to a higher weight-for-age (through its effect on height). However, given that BMI-for-age adjusts for the impact of height on weight, the negative effect on BMI-for-age may be a selection effect, where parents who notice a reducing BMI of their child, may be tempted to present the child to the midwife more often. This could also be in the reverse where midwives who notice low BMI children informs parents to bring those children for regular visits to better monitor their growth. Either of these could explain the negative impacts seen on the BMI-for-age models as opposed to the positive effects seen in the height-for-age and weight-for-age models. Ethnicity is another important variable which shows a significant effect on BMI-for-age. The estimated effect suggests that Sinhalese children may be showing a general lag in BMI compared to non-Sinhalese children in the sample. However, these effects don't extend to long-run growth as is evident by the non-significant Ethnicity effect in the other two models. CDC-level variables also show a significant effect in BMI-for-age models generally implying that the BMI of children attending older CDC tend to be better compared to those attending newer CDCs. This could be due to a number of reasons. On reason could be that older CDCs, having operated for a longer time, may have more experienced child-development officers in charge of them, which could have a positive impact on the health and growth of children, while newer CDCs may have operated for a shorter period of time, and may require more time to be able to produce tangible impacts on children.

Given that the birthweight and first weight on record (*firstzweight*) are significant variables in the main models, it is interesting to explore treatment effects across subsamples by birthweight and *firstzweight*. Table 9-8 presents models for subsamples of children with below and above average standardized first weight records (i.e. *firstzweight<0* and *firstzweight>0*) and Table 9-9 presents similar results for subsamples by birthweight (i.e. *zbirthweight<0* and *zbirthweight>0*). According to Table 9-8, a significant treatment effect is only observed in the height-for-age model among children with above average *firstzweight*. Accordingly, among children with an above average standardized first weight record, living in a treatment estate produces a standardized height-for-age 0.085 SD units higher on average than a similar child in a control estate.

With regards to subsamples by birthweight positive treatment effects were observed in both the *WAZ* and *HAZ* models, but this is again limited to the subsample of children with above average standardized birthweight. Accordingly, among children in this cohort, a child living in an estate with the mid-day meals programme on average, shows a weight-for-age 0.036 SD units and height-for-age 0.086 SD units higher than a similar child living in an estate that does not run the programme. Similar to the main effect models, no significant treatment effect is detected on the BMI-for-age of children. Other variables show similar effects to those observed above, apart for age in the *WAZ* model for the subsample of children with below average *firstzweight* (i.e. *firstzweight<0*). Here age shows a typical U-shaped pattern indicating that the growth of children within the subsample tend to deviate more from the US reference population, with age.

Table 9-8: IV regression model results- by *firstzweight*

		G2SLS RE (IV) REG					
		firstzweight<0			*firstzweight>0*		
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
Treatment var							
Trt1		0.005	0.017	-0.013	-0.032	0.085**	0.002
		(0.007)	(0.016)	(0.023)	(0.065)	(0.019)	(0.027)
Instrumented var							
$WAZ_{i,t-1}$ / $HAZ_{i,t-1}$ / $BMIZ_{i,t-1}$		0.988**	0.914**	0.873**	1.215**	0.897**	0.815**
		(0.026)	(0.010)	(0.02)	(0.262)	(0.014)	(0.027)
Child-level							
Age		-0.006**	0.009**	-0.015**	0.028*	0.007*	-0.007*
		(0.001)	(0.003)	(0.004)	(0.014)	(0.003)	(0.003)
Age_sq		0.0001**	-0.0001**	0.0001**	-0.0004*	-0.0001	0.00004
		(0.00002)	(0.00004)	(0.00005)	(0.0002)	(0.00004)	(0.00005)
Gender	*Male*	0.011*	-0.009	0.007	0.033	-0.003	0.022
		(0.005)	(0.014)	(0.018)	(0.030)	(0.016)	(0.022)
firstzweight		-0.029	0.043**	0.024	-0.172	0.042**	0.081**
		(0.019)	(0.012)	(0.017)	(0.171)	(0.012)	(0.02)
propmeasure		0.009	0.086*	-0.207**	0.087+	0.105+	-0.033
		(0.023)	(0.043)	(0.074)	(0.051)	(0.059)	(0.085)
Ethnicity	*Sinhalese*	-0.001	-0.010	-0.044	-0.019	0.059+	-0.105**
		(0.011)	(0.019)	(0.029)	(0.033)	(0.034)	(0.039)
zbirthweight			-0.006			-0.006	
			(0.007)			(0.006)	

Table 9-8 *ctd*.

		G2SLS RE (IV) REG					
			firstzweight<0			*firstzweight>0*	
		zwei	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
CDC-level							
CDC_cat	*New*	0.002	0.028	-0.07**	0.008	0.002	-0.041
		(0.007)	(0.020)	(0.026)	(0.016)	(0.021)	(0.031)
	Upgraded	0.0003	0.023	-0.044+	0.003	0.019	-0.019
		(0.007)	(0.021)	(0.026)	(0.012)	(0.022)	(0.027)
_cons		0.001	-0.413**	0.38**	-0.176	-0.497**	0.075
		(0.034)	(0.062)	(0.103)	(0.282)	(0.063)	(0.099)
N		8981	5203	4094	8233	5106	3686
σ_u		0	0.1	0.1	0	0.118	0
σ_e		0.327	0.263	0.490	5.724	0.211	3.103
ρ		0	0.126	0.04	0	0.238	0
Underidentification test							
Kleibergen-Paap LM Stat		28.66**	61.10**	52.61**	5.58+	62.68**	36.18**
Weak instrument test							
Cragg-Donald Wald F Stat		103.95	876.04	194.65	3.17	405.67	222.10
Overidentification test							
Sargan-Hansen score		0.153	0.22	9.869**	6.665**	0.390	3.750

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1.

K-P LM test [Null: matrix of reduced form coefficients has rank=K1-1], C-D Wald F Test [Null: Equation is weakly identified], S-H Test [Null: Overidentification restriction is satisfied]

Table 9-9: IV regression model results- by *zbirthweight*

		G2SLS RE (IV) REG					
			zbirthweight<0			*zbirthweight>0*	
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
Treatment var							
Trt1		-0.112	0.023	0.009	0.036**	0.086**	-0.039
		(0.195)	(0.014)	(0.022)	(0.008)	(0.023)	(0.037)
Instrumented var							
$WAZ_{i,t-1}$/ $HAZ_{i,t-1}$/ $BMIZ_{i,t-1}$		1.631+	0.914**	0.859**	0.998**	0.901**	0.813**
		(0.92)	(0.012)	(0.022)	(0.023)	(0.011)	(0.026)
Child-level							
Age		0.017	0.007*	-0.008*	0.009**	0.008**	-0.01*
		(0.025)	(0.003)	(0.004)	(0.001)	(0.002)	(0.004)
Age_sq		-0.0001	-0.0001	0.0001	-0.0001**	-0.0001**	0.0001
		(0.0002)	(0.00004)	(0.0001)	(0.00002)	(0.00003)	(0.00005)
Gender	*Male*	0.067	-0.012	0.016	0.011+	-0.002	-0.006
		(0.083)	(0.014)	(0.019)	(0.006)	(0.016)	(0.023)
firstzweight		-0.475	0.046**	0.057**	-0.045**	0.034**	0.05**
		(0.661)	(0.01)	(0.015)	(0.014)	(0.008)	(0.016)
propmeasure		0.023	0.119*	-0.218**	0.088**	0.056	-0.022
		(0.086)	(0.047)	(0.075)	(0.026)	(0.056)	(0.087)
Ethnicity	*Sinhalese*	0.075	0.023	-0.089*	0.006	0.027	-0.074*
		(0.12)	(0.03)	(0.039)	(0.01)	(0.023)	(0.034)
zbirthweight			-0.003			0.003	
			(0.01)			(0.013)	

Table 9-9 *ctd*.

		G2SLS RE (IV) REG					
			zbirthweight<0			*zbirthweight>0*	
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
CDC-level							
CDC_cat	*New*	-0.065	0.034	-0.057*	-0.018+	-0.015	-0.052
		(0.112)	(0.021)	(0.026)	(0.009)	(0.025)	(0.033)
	Upgraded	-0.079	0.016	-0.032	-0.011	0.018	-0.02
		(0.129)	(0.02)	(0.024)	(0.009)	(0.026)	(0.033)
_cons		0.819	-0.416**	0.27*	-0.249**	-0.460**	0.177
		(1.344)	(0.074)	(0.107)	(0.037)	(0.058)	(0.108)
N		7687	5135	3966	9527	5174	3814
σ_u		0	0.104	0	0	0.115	0
σ_e		7.226	0.228	0.647	0.435	0.241	0.732
ρ		0	0.172	0	0	0.187	0
Underidentification test							
Kleibergen-Paap LM Stat		1.58	68.65**	42.51**	26.97**	51.49**	38.35**
Weak instrument test							
Cragg-Donald Wald F statistic		0.63	667.15	244.08	103.79	535.03	185.31
Overidentification test							
Sargan-Hansen score		0.055	0.427	0.581	3.72+	0.16	1.412

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1.
K-P LM test [Null: matrix of reduced form coefficients has rank=K1-1], C-D Wald F Test [Null: Equation is weakly identified], S-H Test [Null: Overidentification restriction is satisfied]

The results outlined above suggest a few points. Firstly, access to the mid-day meals programme under review clearly shows a positive impact on improving the weight-for-age and more importantly height-for-age of children at the estate level. Secondly, whilst the main effects models suggest an overall positive impact of the mid-day meals programme on growth, these effects are mostly concentrated on children who show generally good growth in comparison to their peers (as identified by above average birthweight and first weight on record).

As indicated in Chapter 7, the programme implementation at the estate level was based on managerial decisions and were not impacted by inputs from the resident population. The implementation of the programme in estates was done randomly and was still an on-going process at the time of the survey and there was no evidence to suggest that the programme was first implemented in estates whose children showed weaker growth. Therefore, the treatment variable *Trt1* was considered to be random. Given this, and the fact that children in the control estate showed a generally higher weight-for-age, at the baseline level (0-6 month children), as indicated in Figure 9-3, would further accentuate the observed positive treatment effects of the programme.

9.2.1.1. Programme Effects by Gender and Age

Age and gender effects of child malnutrition is well researched within malnutrition literature. In the context of developing countries, general patterns of age and gender have been observed across different research. One example is the pattern that children from developing countries tend to show growth similar to those of developed countries closer to birth but tends to deviate with age soon after (Prendergast and Humphrey, 2014; Victora, de Onis, Hallal, Blössner and Shrimpton, 2010; Wagstaff et al., 2003). Specific patterns have also been observed between girls and boys, where boys have a higher likelihood of stunting than girls in countries in certain sub-Saharan Africa (Wamani, Åstrøm, Peterson, Tumwine and Tylleskär, 2007). Given these patterns and the fact that, even after accounting for the impact of the treatment, gender and age both show significant effects in the main effects models in Table 9-7 it was interesting to examine the impact of the mid-day meals programme across age and gender to identify potential differences in programme effects across these two parameters. Accordingly, the ITT model was fitted to boys and girls separately, and 3 age cohorts (0-6 month old, 6-24 month old and >24 month old) was considered for the age analysis. It should however be noted that the instrument variable approach tends to produced biased estimates in small samples (Angrist and Krueger, 2001; Boef, Dekkers, Vandenbroucke and Le Cessie, 2014; Moffitt, 2005) which should be considered when interpreting some of the age specific models which have relatively small sample sizes. Such estimates will be interpreted in conjunction with GLS results as these tend to be less biased under small sample sizes.

The treatment effects were significant and positive on the weight-for-age and height-for-age of children across both genders. However, the magnitude of the effect was large among girls than boys. A girl child living within a treatment estate was seen to have a standardized weight-for-age 0.035 SD higher on average than a similar girl child living in a non-treatment effect. The same effect is seen to be slightly lower at 0.03 SD among boys. Similarly, a girl child living within a treatment estate was observed to have a standardized height-for-age 0.054 units higher, on average, than a similar girl child living within a non-treatment estate. The positive effect of living within a treatment estate was somewhat lower at 0.039SD among boys. The main models in Table 9-7 showed boys to have a higher weight-for-age, on average, compared to girls, after controlling for treatment effects. This together with the above results would suggest that, whilst the programme benefits children across both gender categories, the results are particularly stronger in favour of girl children. The treatment effect was not significant in the BMI-for-age models of either gender. The other estimated coefficient effects were similar to the effects observed in the main effect models (Table 9-7).

With regards to the three age groups explored, the 0-6 month age group was used as a measure of the baseline status of children in the treatment and control estates. The mid-day meals programme is open for children over the age of 6 months as exclusive breastfeeding is recommended for children below the age of 6 months. Therefore, adhering to health ministry guidelines, the mid-day meals programme was offered to children above the age of 6 months. Given this, modelling for children between 0-6 months gives a sense of the relative positioning of children in the treatment estates compared to the control estate, prior to the programme taking effect. There could however, be spill-over effects of the mid-day meals programme, even within this age-group, as estate households usually tend to have multiple children, and benefits of older siblings being participants of the mid-day meals programme, could have spill over effects towards the growth of younger siblings who are still not part of the programme. Nevertheless, this effect can be considered as an approximate baseline analysis. Looking at treatment effects *Trt1* is statistically significant across all three models, in the 0-6 month age group. The estimated effects are positive in the *WAZ* and *BMIZ* models, while the estimated effects are negative in the *HAZ* model. The results broadly suggest that in the 0-6 month age group a child living within a treatment estate had a standardized weight-for-age 0.13 SD and a standardized BMI-for-age 0.31 SD higher, on average, than a similar child living within a control estate. However, with regards to the height-for-age, a child living within a treatment estate showed a standardized height-for-age 0.47 SD lower on average, than a similar child living within a control estate. This signals that children living within treatment estates show a comparative advantage over children living within the control estate, with regards to their weight-for-age and BMI-for-age. However, they are at a relative disadvantage compared to the control group with regards to their height-for-age. This somewhat contrasts with the descriptive analysis results for the 0-6 age group, presented in Figure 9-3 which showed the distribution of standardized weight-for-age of children in treatment estates deviated more from the standard normal, than the distributions within the control estate. Given that the histograms in Figure 9-3 present the overall weight-for-age measures, this may also reflect part of the differences in heights of children. The above results are comparatively more accurate as they control for external factors.

The second age category compared was the 6-36 month category. This encompassed all available records of children from 6 months up to 3 years. This age category is particularly important given the focus on the first 1000 days of life as a critical window for applying corrective interventions (Prendergast and Humphrey, 2014). The 6-36 month age group captures this crucial period with an additional year in order to capture any lagged effects especially on height-for-age. Looking across treatment effects within this age-group, a marginally significant negative effect on the weight-for-age models and a significant positive effect on the height-for-age model was observed. Accordingly, a child living in a treatment estate, was observed to have a weight-for-age 0.016 SD lower on average, than a similar child living within a control estate. However, a child living within a treatment estate was seen to have a standardized weight-for-age 0.04 SD higher on average, than a similar control estate child. The BMI-for-age model did not show any significant effects. Given the results observed in the 0-6 month age-group showed children living in treatment estates to be at an advantage with respect to their weight-for-age, the negative treatment effect on weight-for-age observed here is rather problematic. However, it should be noted that this effect was only marginally significant (at 10%) and relatively small in magnitude. This is easily overshadowed by the comparatively large positive effect observed on their height-for-age.

When considering the final age group (above 36 months), the positive treatment effect on height-for-age is seen to persist with a child living in a treatment estate showing a standardized height-for-age 0.024 SD higher, on average, than a similar child from a control estate. No significant treatment effects were observed on weight-for-age, indicating that the marginally significant negative effect observed above, seems to dissipate over age. The BMI-for-age model again did not show significant treatment effects.

Looking across the other controls, the effects of age on growth was clearly different within different age groups, which is expected, given the quadratic behaviour observed across the entire age-range in the main models. For example, age showed an inverted-U shaped relationship with both weight-for-age and height-for-age with estimated inflection points at 30 and 40 months respectively. This supports the change in direction of the *Age* and *Age_sq* coefficients observed in the *WAZ* model in the 6-36 month age group and the *WAZ* and *HAZ* models in the >36 month age group. Age showed similar effects on BMI-for-age across all three age groups. Apart from the above, the only other change observed was on the effect of the first weight record (*firstzweight*) on BMI-for-age among children below the age of 6 months. As opposed to the positive effects observed in the main models and most subsamples, the estimated effect was negative. However, as noted earlier, results obtained for the height-for-age and BMI-for-age IV models should be interpreted cautiously given the small sample sizes. Comparison with GLS regression results did not reveal any major differences between estimated effects (Refer Table E2-3 in Appendix E2 for GLS results of age-models). The estimated negative effect of *firstzweight* on BMI-for-age may reflect declines in growth observed soon after birth, in developing regions of the world.

Overall a couple of important effects can be highlighted. First, with regards to gender, whilst the programme is seen to benefit both girls and boys, the effects on girls seem to be higher in magnitude. This is particularly evident with regards to positive impacts of the programme on the long-term growth of children, as reflected by their height-for-age. With regards to age, the programme shows a consistent positive impact on the height-for-age of children, effectively reversing their status of showing poorer long-term growth compared to control group children at the baseline (0-6 months).

Table 9-10: IV regression model results- by *Gender*

		G2SLS RE (IV) REG					
		Female			*Male*		
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
Treatment var							
Trt1		0.035+	0.054**	0.018	0.03**	0.039*	-0.011
		(0.018)	(0.017)	(0.025)	(0.008)	(0.018)	(0.026)
Instrumented var							
$WAZ_{i,t-1}$/ $HAZ_{i,t-1}$/ $BMIZ_{i,t-1}$		0.999**	0.905**	0.815**	1.01**	0.911**	0.861**
		(0.066)	(0.016)	(0.032)	(0.037)	(0.009)	(0.018)
Child-level							
Age		0.004	0.007*	-0.01**	0.008**	0.01**	-0.011**
		(0.004)	(0.003)	(0.003)	(0.002)	(0.003)	(0.004)
Age_sq		-0.00004	-0.0001+	0.0001+	-0.0001**	-0.0001**	0.0001*
		(0.00004)	(0.00004)	(0.00004)	(0.00003)	(0.00004)	(0.0001)
firstzweight		-0.032	0.041**	0.063**	-0.043+	0.042**	0.055**
		(0.045)	(0.012)	(0.017)	(0.024)	(0.007)	(0.014)
propmeasure		0.094**	0.072+	-0.08	0.044+	0.095+	-0.154+
		(0.024)	(0.043)	(0.075)	(0.026)	(0.051)	(0.084)
Ethnicity	Sinhalese	-0.005	0.041	-0.133**	0.015	-0.005	-0.005
		(0.011)	(0.025)	(0.036)	(0.01)	(0.022)	(0.039)
zbirthweight			-0.005			-0.006	
			(0.007)			(0.006)	

Table 9-10 *ctd*.

		G2SLS RE (IV) REG					
		Female			*Male*		
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
CDC-level							
CDC_cat	*New*	0.008	0.015	-0.037	0.0005	0.023	-0.061*
		(0.01)	(0.019)	(0.029)	(0.007)	(0.021)	(0.028)
	Upgraded	0.006	0.021	-0.029	0.001	0.023	-0.034
		(0.012)	(0.02)	(0.026)	(0.007)	(0.022)	(0.027)
_cons		-0.213**	-0.429**	0.175+	-0.176**	-0.476**	0.279**
		(0.071)	(0.057)	(0.096)	(0.045)	(0.065)	(0.105)
N		8567	5285	3948	8647	5024	3832
σ_u		0.021	0.087	0	0	0.107	0
σ_e		0.299	0.335	1.186	0.350	0.243	1.028
ρ		0.005	0.063	0	0	0.162	0
Underidentification test							
Kleibergen-Paap LM Stat		5.57+	64.25**	42.83**	13.52**	67.28**	46.27**
Weak instrument test							
Cragg-Donald Wald F statistic		17.58	700.45	164.87	41.16	804.25	280.85
Overidentification test							
Sargan-Hansen score		0.466	0.975	4.966+	0.062	0.049	4.378

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1.
K-P LM test [Null: matrix of reduced form coefficients has rank=K1-1], C-D Wald F Test [Null: Equation is weakly identified], S-H Test [Null: Overidentification restriction is satisfied]

Table 9-11: IV regression model results- by *Age*

		G2SLS RE (IV) REG								
		0-6 mon			*6-36 mon*			*>36 mon*		
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
Treatment var										
Trt1		0.13**	-0.467+	0.308+	-0.016+	0.04*	0.002	0.012	0.024*	0.001
		(0.045)	(0.256)	(0.171)	(0.009)	(0.017)	(0.026)	(0.012)	(0.009)	(0.023)
Instrumented var										
$WAZ_{i,t-1}$/ $HAZ_{i,t-1}$/		1.184**	0.937**	1.011**	1.062**	0.89**	0.803**	0.934**	0.956**	0.899**
$BMIZ_{i,t-1}$		(0.097)	(0.044)	(0.038)	(0.029)	(0.011)	(0.026)	(0.075)	(0.009)	(0.02)
Child-level										
Age		0.297**	0.316	-0.501	-0.00001	0.004	-0.009	-0.006	-0.009	-0.003
		(0.108)	(0.264)	(0.42)	(0.002)	(0.005)	(0.007)	(0.008)	(0.009)	(0.022)
Age_sq		-0.025*	-0.012	0.049	0.0001	-0.00002	0.0001	0.0001	0.0001	0.00001
		(0.012)	(0.03)	(0.05)	(0.00005)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0002)
Gender		0.041	-0.006	0.092	0.028**	-0.002	-0.002	0.014*	0.003	0.016
		(0.029)	(0.14)	(0.11)	(0.006)	(0.015)	(0.021)	(0.006)	(0.008)	(0.015)
firstzweight		-0.403**	0.04	-0.324**	-0.06**	0.045**	0.069**	0.033	0.022**	0.042**
		(0.106)	(0.085)	(0.059)	(0.018)	(0.009)	(0.015)	(0.053)	(0.005)	(0.013)
propmeasure		0.835**	0.805+	-5.569**	0.077**	0.141**	-0.19*	0.008	0.01	-0.027
		(0.222)	(0.429)	(0.609)	(0.022)	(0.047)	(0.085)	(0.025)	(0.025)	(0.069)
Ethnicity	Sinhalese	0.038	-0.251	0.246	-0.01	0.035	-0.085*	-0.003	-0.007	-0.038
		(0.03)	(0.207)	(0.212)	(0.007)	(0.025)	(0.039)	(0.01)	(0.012)	(0.028)
zbirthweight			-0.162			-0.002			-0.007*	
			(0.149)			(0.009)			(0.003)	

Table 9-11 *ctd.*

		G2SLS RE (IV) REG								
		0-6 mon			*6-36 mon*			*>36 mon*		
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
CDC-level										
CDC_cat	*New*	0.007	-0.21	0.265+	-0.002	0.014	-0.078**	-0.005	0.011	-0.031
		(0.032)	(0.178)	(0.141)	(0.007)	(0.021)	(0.03)	(0.009)	(0.01)	(0.023)
	Upgraded	-0.054+	0.23	-0.505**	0.008	0.034	-0.06*	0.002	-0.014	0.016
		(0.03)	(0.155)	(0.132)	(0.007)	(0.022)	(0.03)	(0.01)	(0.01)	(0.02)
_cons		-1.59**	-2.337**	7.027**	-0.025	-0.479**	0.291*	-0.015	0.094	-0.006
		(0.307)	(0.666)	(0.792)	(0.044)	(0.066)	(0.114)	(0.263)	(0.221)	(0.497)
N		1422	94	86	10065	6306	4828	5727	3909	2866
σ_u		0	0	0	0.004	0.133	0	0	0	0
σ_e		0.599	0.785	0.865	0.316	0.272	1.349	0.411	2.769	0.971
ρ		0	0	0	0.0001	0.192	0	0	0	0
Underidentification test *Kleibergen-Paap LM Stat*		34.69**	13.85**	12.60**	15.55**	86.20**	56.89**	5.22+	57.49**	40.40**
Weak instrument test *Cragg-Donald Wald F stat*		30.24	83.74	42.05	63.34	840.29	243.82	18.66	763.41	188.17
Overidentification test *Sargan-Hansen score*		3.175+	N/R	N/R	0.001	0.210	4.217	1.348	5.525*	1.895

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1.
K-P LM test [Null: matrix of reduced form coefficients has rank=K1-1], C-D Wald F Test [Null: Equation is weakly identified], S-H Test [Null: Overidentification restriction is satisfied].
N/R-Not Reported

9.2.1.2. Programme Effects by Birth Cohort

As noted in the models above, age showed some interesting patterns particularly with regards to the effectiveness of the programme. The impact of age on programme effects, could manifest due to a number of reasons. One clear reason could be the differential impact of the programme on children belonging to different age groups. Another possible reason would be the relative maturing of the programme, over time. Most interventions of this nature show teething problems in early stages, which eventually settle down improving the effectiveness of the programme over time. The MJF mid-day meals programme was implemented in 2007, in both treatment estates and the data contained records of children born between 2007 and 2015. This meant that children born between 2007 and 2009, within treatment estates, would be the first batch of children to have access to the programme from early infancy. Children born between 2010 and 2012, would have been beneficiaries of a relatively more mature programme, while children born between 2013 and 2015 would have had access to a well-seasoned programme. Therefore, it was interesting to explore how well the programme was received by children within these three age cohorts. The following tables present results of the weight-for-age, height-for-age and BMI-for-age IV models on these three birth cohorts. Prior to discussing the results, it is important to consider the validity of the instruments used in the different models. As is evident by the K-P, C-D and S-H tests, the instruments are valid in most of the fitted models, with the exception of a few (underidentification in *WAZ* model (2007-2009) and overidentified in *BMIZ* model (2010-2012) and *HAZ* model (2013-2015)). However, the treatment effects are not significant in the above instances, both in IV and GLS models (refer Table E2-4 in Appendix E2 for GLS results).

Looking at the treatment effects across birth cohorts, very clear patterns emerge with regards to the impact of the programme on the growth of children both in the short and long-term. Particularly, among the older cohort of children (i.e. 2007-2009 birth cohort) a strong positive treatment effect is seen on the standardised height-for-age of children where a child from a treatment estate is seen to be generally taller (by an average of 0.052 SD units) than similar children living in a control estate. A similar pattern is also observed among children belonging to the next oldest cohort (2010-2012 birth cohort), where a child living in a treatment estate is seen to be generally taller (by an average of 0.046 SD units) than a similar child living in a control estate. However, among children in the youngest cohort (i.e. 2012-2015 birth cohort) a particularly strong positive treatment effect is observed on the weight-for-age and BMI-for-age of children, where a child living in a treatment estate is seen to have a standardized weight-for-age and BMI-for-age 0.068 SD units and 0.188 SD units higher, on average than a similar child from a control estate. The treatment effects outlines were also seen to be statistically significant (with larger magnitudes) in the GLS models (Table E2-4 in Appendix E2). Effects of other controls, where significant, are similar to those observed in the main IV-models in Table 9-7.

The results robustly suggest a clear positive effect of the mid-day meals programme on the growth of both older and younger children. As is intended the programme seems to have a positive influence on improving the height-for-age among older children, suggesting that the programme is effective in improving growth in the long-run. Even in the younger cohort of children (i.e. children born between 2013-2015, who would be less than 2 years old during the time of the survey) the programme is seen to have a positive influence on improving weight and BMI, which would in time manifest in to improvements in height.
Overall, the Intention-to-Treat models suggest that children living in estates which run the MJF mid-day meals programme, show a consistently better growth, compared to children living in an estate without the programme. Positive effects of the programme are consistent across gender, age and birth cohort, and both short-term and long-term growth improvements are observed. The next stage of the analysis looks within estates that run the mid-day meals programme and focuses on analysing the impact of regular programme attendance on growth.

Table 9-12: IV regression model results- by *Birth Cohort*

		G2SLS RE (IV) REG								
		2007-2009			*2010-2012*			*2013-2015*		
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
Treatment var										
Trt1		-0.029	0.052*	-0.031	0.008	0.046**	-0.01	0.068**	-0.015	0.188**
		(0.076)	(0.021)	(0.031)	(0.007)	(0.014)	(0.021)	(0.017)	(0.051)	(0.053)
Instrumented var										
$WAZ_{i,t-1}$/ $HAZ_{i,t-1}$/		1.556	0.936**	0.883**	1.028**	0.917**	0.85**	1.031**	0.871**	0.781**
$BMIZ_{i,t-1}$		(1.057)	(0.018)	(0.023)	(0.036)	(0.01)	(0.022)	(0.022)	(0.024)	(0.055)
Child-level										
Age		-0.004	0.005	0.0002	0.006**	0.005*	-0.01**	0.031**	0.042+	-0.022
		(0.018)	(0.009)	(0.016)	(0.002)	(0.002)	(0.003)	(0.007)	(0.021)	(0.027)
Age_sq		0.00005	-0.00004	-0.00003	-0.0001*	-0.0001+	0.0001*	-0.001**	-0.001	-0.0001
		(0.0002)	(0.0001)	(0.0002)	(0.00003)	(0.00003)	(0.00005)	(0)	(0.001)	(0.001)
Gender		-0.027	0.005	0.004	0.022**	0.002	0.007	0.005	-0.031	-0.03
		(0.058)	(0.014)	(0.021)	(0.004)	(0.011)	(0.017)	(0.011)	(0.047)	(0.053)
firstzweight		-0.447	0.049**	0.031*	-0.044+	0.033**	0.063**	-0.093**	0.014	0.051
		(0.818)	(0.014)	(0.014)	(0.024)	(0.008)	(0.014)	(0.017)	(0.024)	(0.033)
propmeasure		-0.093	0.094*	-0.061	0.058**	0.1*	-0.148*	0.181**	-0.004	-0.291
		(0.204)	(0.037)	(0.093)	(0.018)	(0.039)	(0.069)	(0.069)	(0.242)	(0.26)
Ethnicity	Sinhalese	0.101	-0.018	-0.049	-0.001	0.037	-0.077*	0.045+	-0.036	0.226*
		(0.214)	(0.018)	(0.032)	(0.005)	(0.024)	(0.031)	(0.025)	(0.069)	(0.11)
zbirthweight			-0.013+			-0.009			0.039	
			(0.007)			(0.005)			(0.043)	

Table 9-12 *ctd.*

		G2SLS RE (IV) REG								
		2007-2009			*2010-2012*			*2013-2015*		
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
CDC-level										
CDC_cat	*New*	-0.001	-0.004	-0.021	0.01+	0.017	-0.043+	-0.022+	-0.059	-0.061
		(0.061)	(0.033)	(0.051)	(0.006)	(0.016)	(0.025)	(0.013)	(0.046)	(0.068)
	Upgraded	-0.006	-0.027	0.019	0.007	0.019	-0.03	-0.024*	0.025	-0.029
		(0.068)	(0.035)	(0.051)	(0.006)	(0.015)	(0.022)	(0.011)	(0.053)	(0.061)
_cons		1.25	-0.32	-0.036	-0.146**	-0.392**	0.236*	-0.412**	-0.702**	0.473
		(2.614)	(0.226)	(0.379)	(0.044)	(0.056)	(0.097)	(0.087)	(0.237)	(0.313)
N		2468	1878	1282	11192	7562	5835	3554	869	663
σ_u		0	0	0	0	0.097	0	0	0.143	0
σ_e		1.437	2.179	2.506	0.401	0.274	0.820	0.756	0.389	0.829
ρ		0	0	0	0	0.112	0	0	0.119	0
Underidentification test *Kleibergen-Paap LM Stat*		0.68	31.69**	25.55**	6.16*	91.85**	50.48**	20.72**	17.89**	19.31**
Weak instrument test *Cragg-Donald Wald F stat*		0.74	457.61	230.06	29.87	857.52	248.95	113.54	358.97	47.43
Overidentification test *Sargan-Hansen score*		0.690	0.534	0.260	0.037	1.508	8.993*	1.197	4.167*	3.465

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1.
K-P LM test [Null: matrix of reduced form coefficients has rank=K1-1], C-D Wald F Test [Null: Equation is weakly identified], S-H Test [Null: Overidentification restriction is satisfied].
N/R-Not Reported

9.2.2. Marginal Structural Models for Programme Attendance

As an alternative to the ITT models above, this stage of the analysis used Marginal Structural Modelling with IPTW to model the continuous valued time-varying treatment variable (*Trt2*) which indicates the number of participation days of children registered for the mid-day meals programme. The sample was restricted to the children above 6 months of age registered in the mid-day meals programme, within the two treatment estates (Bearwell and Holyrood). As explained in section 8.2.1., the participation days are adjusted according to equation 8.3, to account for possible time-varying shocks (such as illness) which were unobserved yet could impact the treatment and outcome variables. It should be noted that *Trt2* in models below refer to this adjusted treatment variable.

Table 9-13 presents the results for the MSMs fitted using GEE estimation, for the weight-for-age, height-for-age and BMI-for-age records of children. Two different models are fitted in each case. *Model 1* fits the current periods treatment (i.e. the number of participation days in the current month), while *Model 2* fits the cumulative treatment variable which represents the total number of participation days up to and including the current month (within the survey period). The thought behind fitting a cumulative treatment variable is to account for possible snowballing effects of the treatment on child growth, over a considerable period of time. The results presented below show significant treatment effects for both the cumulative and current month's treatment. However, as expected, the magnitude of treatment effects are small (much smaller than the treatment effects detected in the ITT models in Table 9-7).

With regards to children's weight-for-age, the cumulative treatment effect (*Trt2_tot*) is significant and positive, implying that a unit increase in the total number of participation days in the mid-day meals programme, would result in increasing the weight-for-age of a child by 0.001 SD units, on average. With regards to their height-for-age, contrary to expectations, the current periods treatment (*Trt2*), shows a significant positive effect indicating that an additional day's participation in the current month, results in an increase in the height-for-age of a child by 0.007 SD units, on average. The cumulative treatment effect is also marginally significant in the BMI-for-age model where a unit increase in the total number of participation days across the survey period, would result in an increase of the standardized BMI-for-age by 0.001 SD units, on average.

Looking across the other controls in the models, age and its quadratic show the expected U-shaped pattern which suggests that children in the study sample follow the growth of the reference population closer to birth and begins to deviate with age. Though this is in contrast with the what was observed in the ITT models, this may suggest that children who participate in the mid-day meals programme do follow a standardized growth pattern generally displayed by children in developing countries. The weight-for-age and BMI-for-age of girls is seen to be generally better than boys. This observation could be a direct implication of the gender effects of treatment observed in Table 9-10, where living in an estate which ran the mid-day meals programme was seen to have a larger positive impact on the growth of girls. Standardized values of the first weight and height measures on record (*firstzweight*, *firstzheight*) were also significant across the models and the direction of results were as expected (i.e. higher values of these variables generally reflect better future growth). It was also noticeable that unlike in ITT models, the birthweight, parental care proxy variable (*propmeasure*) and health shock proxy variable (S_{it}) were not statistically significant. Children were seen to show a generally better growth within Holyrood estate compared to Bearwell estate.

Overall, the results clearly indicate a positive impact of regular programme attendance on both short-term and long-term growth of children. Much of the other effects observed in the models were in line with general expectations (e.g. age effects) indicating that the growth of children within the sample follow normal patterns observed in other developing countries. However, given some of the other significant effects observed in the models (e.g. *Gender*, *firstzweight* etc.) MSMs were fitted within different cross-sections of the dataset, to observe whether programme effects significantly vary across different sample characteristics.

Table 9-13: GEE Models with IPTW- Overall sample

		GEE MODELS					
		WAZ		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var							
Trt2		0.003		0.007*		-0.002	
		(0.002)		(0.003)		(0.004)	
Trt2_tot			0.001*		-0.0003		0.001+
			(0.0002)		(0.001)		(0.0005)
Child-level							
Age		-0.025**	-0.031**	0.01	0.013	-0.054**	-0.061**
		(0.007)	(0.007)	(0.014)	(0.016)	(0.013)	(0.013)
Age_sq		0.0003**	0.0003**	0.00003	0.00004	0.001**	0.0004**
		(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Gender	Male	-0.524*	-0.524*	0.06	0.075	-0.309*	-0.309*
		(0.257)	(0.253)	(0.096)	(0.1)	(0.122)	(0.127)
zbirthweight		0.075	0.069	0.005	0.005	0.096	0.089
		(0.049)	(0.048)	(0.04)	(0.04)	(0.071)	(0.073)
firstzweight		0.436**	0.457**	0.15**	0.135**	0.477**	0.511**
		(0.081)	(0.076)	(0.041)	(0.044)	(0.1)	(0.106)
firstzheight				0.841**	0.838**	-0.347**	-0.34**
				(0.065)	(0.066)	(0.104)	(0.105)
propmeasure		0.192	0.13	-0.298	-0.288	0.115	0.174
		(0.165)	(0.143)	(0.259)	(0.261)	(0.268)	(0.277)
S_{it}		-0.023	-0.022	-0.01	-0.037	-0.006	0.014
		(0.03)	(0.025)	(0.057)	(0.056)	(0.045)	(0.046)
Ethnicity	Sinhalese	-0.498	-0.486	0.336+	0.302	-0.471+	-0.424+
		(0.312)	(0.308)	(0.189)	(0.188)	(0.268)	(0.245)
CDC-level							
CDC_cat	New	0.256	0.312	0.165	0.142	-0.312+	-0.253
		(0.221)	(0.225)	(0.182)	(0.199)	(0.168)	(0.169)
	Upgraded	-0.185	-0.128	0.039	0.007	-0.198	-0.122
		(0.144)	(0.139)	(0.1)	(0.111)	(0.12)	(0.121)
Estate	Holyrood	0.516*	0.425*	-0.257+	-0.236	0.345*	0.287+
		(0.216)	(0.206)	(0.134)	(0.156)	(0.146)	(0.151)
_cons		-1.156**	-0.963**	-2.179**	-2.174**	0.664*	0.697*
		(0.233)	(0.208)	(0.395)	(0.414)	(0.338)	(0.334)
N		6189	6189	4064	4064	3483	3483

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *CDC_adj* omitted due to multicollinearity. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

9.2.2.1. Treatment Effects based on Initial Growth

The birthweight (*zbirthweight*) and the first weight on record (*firstzweight)* are two measures that reflect a child's initial or baseline growth status within the sample. The first weight on record was also seen to be significant in the models above. Therefore, it was interesting to observe treatment effects within subsamples of children by these two variables. The subsamples of children with *firstzweight<0* or *zbirthweight<0* can be considered as a group showing weaker initial/baseline growth, whilst the subsample of children with *firstzweight>0* or *zbirthweight>0* would represent those showing better initial/baseline growth. Table 9-14 present results for the MSMs fitted for the two subsamples by *firstzweight* while Table 9-15 presents results for the MSMs fitted for the two subsamples by *zbirthweight.*

Cumulative treatment effects were not significant in any of the models in Table 9-14, while a few marginally significant treatment effects for the current month's treatment were observed. Accordingly, in the subsample of children showing a weaker baseline growth (i.e. *firstzweight<0*), one additional day of attendance in the current month, was seen to increase the standardized height-for-age by 0.008 SD units, on average. In the subsample of children showing better baseline growth, an additional day of attendance would result in an increase in weight-for-age by 0.003 SD units, on average.

The subsamples by birthweight show an interesting pattern where, treatment effects are only seen to be significant among children showing above average birthweights (*zbirthweight>0*). The observed treatment effects in this subsample follow the same patterns as those observed in the main effect models in Table 9-13. The cumulative treatment effect was significant in the weight-for-age and BMI-for-age models, while the current period's treatment was significant in the height-for-age model. A unit increase in the total number of participation days across the survey period, would result in an increase in standardized weight-for-age by 0.001 SD units, and an increase in standardized BMI-for-age by 0.002 SD units, on average. With regards to height-for-age, an additional day of participation in the current month, results in an increase of 0.006 SD units in height-for-age, on average. Given that the results observed in Table 9-15 reflect the treatment patterns observed in Table 9-13, this could signal that the treatment may be more effective on children born with above average birthweight. Effects of other variables were similar to those observed in the main models.

Table 9-14: GEE Models with IPTW- by *firstzweight*

		GEE MODELS											
		firstzweight<0						*firstzweight>0*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var													
Trt2		0.002		0.008+		-0.007		0.003+		0.003		0.002	
		(0.003)		(0.004)		(0.006)		(0.001)		(0.004)		(0.004)	
Trt2_tot			0.0004		-0.0004		0.001		0.0003		-0.001		0.001
			(0.0003)		(0.001)		(0.001)		(0.0002)		(0.001)		(0.001)
Child-level													
Age		-0.021+	-0.025*	0.003	0.005	-0.056**	-0.064**	-0.031**	-0.033**	0.017	0.024	-0.044*	-0.049*
		(0.011)	(0.01)	(0.018)	(0.02)	(0.016)	(0.017)	(0.008)	(0.008)	(0.021)	(0.026)	(0.02)	(0.021)
Age_sq		0.0003+	0.0003+	0.0002	0.0002	0.001*	0.0004+	0.0003**	0.0003**	-0.0001	-0.0001	0.001	0.0004
		(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Gender	Male	-0.69*	-0.688*	-0.032	-0.012	-0.391*	-0.407*	-0.149*	-0.156*	0.161	0.162	-0.279*	-0.265*
		(0.279)	(0.278)	(0.123)	(0.121)	(0.181)	(0.192)	(0.072)	(0.071)	(0.109)	(0.116)	(0.111)	(0.115)
zbirthweight		0.231**	0.227**	0.087	0.074	0.224+	0.241+	-0.003	-0.007	-0.037	-0.029	-0.01	-0.019
		(0.083)	(0.081)	(0.066)	(0.065)	(0.123)	(0.127)	(0.022)	(0.022)	(0.049)	(0.051)	(0.057)	(0.058)
firstzweight		0.568**	0.562**	0.206+	0.222+	0.245	0.211	0.729**	0.743**	0.256**	0.259**	0.727**	0.732**
		(0.194)	(0.191)	(0.117)	(0.115)	(0.177)	(0.182)	(0.047)	(0.051)	(0.074)	(0.073)	(0.083)	(0.08)
firstzheight				0.76**	0.762**	-0.289**	-0.301**			0.91**	0.857**	-0.69**	-0.646**
				(0.079)	(0.079)	(0.111)	(0.114)			(0.073)	(0.135)	(0.086)	(0.099)
propmeasure		0.031	-0.002	-0.792*	-0.795*	0.281	0.343	0.214	0.188	0.069	0.08	0.165	0.186
		(0.177)	(0.172)	(0.357)	(0.358)	(0.401)	(0.411)	(0.213)	(0.19)	(0.282)	(0.288)	(0.365)	(0.373)
S_{it}		-0.032	-0.028	-0.049	-0.083	0.028	0.075	-0.011	-0.019	0.049	0.033	-0.05	-0.053
		(0.042)	(0.035)	(0.084)	(0.078)	(0.07)	(0.068)	(0.025)	(0.024)	(0.039)	(0.043)	(0.049)	(0.053)
Ethnicity	Sinhalese	-0.478	-0.477	0.363	0.329	-0.088	-0.038	0.098	0.097	0.334+	0.341+	-0.385+	-0.398*
		(0.352)	(0.348)	(0.368)	(0.355)	(0.431)	(0.433)	(0.087)	(0.093)	(0.176)	(0.185)	(0.206)	(0.201)

Table 9-14 *ctd*.

		GEE MODELS											
		firstzweight<0						*firstzweight>0*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
CDC-level													
CDC_cat	New	0.093	0.15	-0.001	-0.087	-0.347	-0.153	0.107	0.136	0.333	0.342	-0.16	-0.157
		(0.233)	(0.236)	(0.2)	(0.217)	(0.269)	(0.275)	(0.111)	(0.116)	(0.21)	(0.219)	(0.188)	(0.185)
	Upgraded	-0.205	-0.16	0.103	0.053	-0.221	-0.078	-0.028	-0.001	0.129	0.08	-0.135	-0.089
		(0.172)	(0.17)	(0.158)	(0.169)	(0.192)	(0.201)	(0.085)	(0.09)	(0.119)	(0.164)	(0.132)	(0.127)
Estate	Holyrood	0.827**	0.739**	-0.282+	-0.188	0.39	0.157	-0.121	-0.147	-0.212	-0.247+	0.156	0.178
		(0.278)	(0.263)	(0.171)	(0.193)	(0.24)	(0.241)	(0.086)	(0.092)	(0.143)	(0.134)	(0.155)	(0.165)
_cons		-0.996**	-0.869**	-1.509**	-1.445**	0.42	0.388	-1.297**	-1.203**	-2.87**	-2.945**	0.381	0.458
		(0.329)	(0.325)	(0.479)	(0.488)	(0.387)	(0.393)	(0.307)	(0.284)	(0.5)	(0.567)	(0.605)	(0.627)
N		3649	3649	2291	2291	1982	1982	2540	2540	1773	1773	1501	1501

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *CDC_adj* omitted due to multicollinearity. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

Table 9-15: GEE Models with IPTW- by *zbirthweight*

		GEE MODELS											
		zbirthweight<0						*zbirthweight >0*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var													
Trt2		0.002		0.001		0.002		0.003		0.006+		-0.003	
		(0.003)		(0.005)		(0.006)		(0.003)		(0.003)		(0.004)	
Trt2_tot			0.0004		-0.0002		-0.00003		0.001*		-0.0002		0.002**
			(0.0003)		(0.001)		(0.0006)		(0.0003)		(0.001)		(0.001)
Child-level													
Age		-0.027*	-0.033**	0.029	0.031	-0.065**	-0.065**	-0.022*	-0.027**	0.002	0.005	-0.043**	-0.055**
		(0.01)	(0.01)	(0.019)	(0.019)	(0.019)	(0.021)	(0.01)	(0.01)	(0.017)	(0.019)	(0.016)	(0.016)
Age_sq		0.0004**	0.0004**	-0.00002	-0.00001	0.001+	0.001+	0.0002+	0.0002	0.00001	0.00001	0.001*	0.0003+
		(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Gender	Male	0.109	0.115	0.054	0.046	-0.227	-0.225+	-0.782**	-0.796**	0.127	0.147	-0.415*	-0.409*
		(0.154)	(0.151)	(0.13)	(0.135)	(0.139)	(0.133)	(0.262)	(0.261)	(0.133)	(0.14)	(0.1758)	(0.181)
zbirthweight		-0.044	-0.06	0.024	0.03	-0.104	-0.103	-0.186	-0.136	0.279*	0.26+	0.186	0.278
		(0.056)	(0.056)	(0.104)	(0.106)	(0.099)	(0.104)	(0.17)	(0.165)	(0.129)	(0.146)	(0.188)	(0.197)
firstzweight		0.553**	0.568**	0.147*	0.14*	0.654**	0.652**	0.382**	0.391**	0.141*	0.136*	0.283+	0.325*
		(0.082)	(0.077)	(0.06)	(0.064)	(0.067)	(0.069)	(0.081)	(0.08)	(0.058)	(0.058)	(0.157)	(0.163)
firstzheight				0.866**	0.867**	-0.458**	-0.456**			0.822**	0.818**	-0.327*	-0.305*
				(0.069)	(0.072)	(0.076)	(0.077)			(0.089)	(0.093)	(0.13)	(0.133)
propmeasure		0.014	-0.032	-0.038	-0.033	0.028	0.031	0.231	0.173	-0.436	-0.419	0.263	0.392
		(0.16)	(0.15)	(0.36)	(0.373)	(0.469)	(0.462)	(0.232)	(0.203)	(0.306)	(0.308)	(0.304)	(0.311)
S_{it}		-0.045	-0.039	0.049	0.042	0.054	0.049	-0.007	-0.012	-0.035	-0.064	-0.053	-0.022
		(0.052)	(0.046)	(0.056)	(0.059)	(0.092)	(0.09)	(0.023)	(0.022)	(0.066)	(0.063)	(0.049)	(0.049)
Ethnicity	Sinhalese	-0.266	-0.285	0.102	0.116	-0.373	-0.37	-0.445	-0.414	0.676**	0.631**	-0.619	-0.448
		(0.248)	(0.246)	(0.319)	(0.33)	(0.38)	(0.397)	(0.345)	(0.351)	(0.216)	(0.231)	(0.377)	(0.32)

Table 9-15 *ctd*.

		GEE MODELS											
		zbirthweight<0						*zbirthweight >0*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
CDC-level													
CDC_cat	New	-0.017	0.03	-0.213	-0.255	-0.034	-0.047	0.175	0.22	0.366	0.369	-0.667**	-0.632**
		(0.151)	(0.147)	(0.26)	(0.289)	(0.256)	(0.251)	(0.268)	(0.274)	(0.246)	(0.259)	(0.24)	(0.23)
	Upgraded	0.226+	0.248+	-0.122	-0.142	-0.071	-0.079	-0.451**	-0.389+	0.258+	0.238	-0.37+	-0.229
		(0.13)	(0.132)	(0.146)	(0.16)	(0.148)	(0.15)	(0.17)	(0.163)	(0.155)	(0.183)	(0.209)	(0.195)
Estate	Holyrood	0.375+	0.317	0.132	0.164	0.213	0.22	0.342+	0.277	-0.381*	-0.387*	0.585**	0.566*
		(0.216)	(0.201)	(0.237)	(0.267)	(0.208)	(0.202)	(0.191)	(0.191)	(0.168)	(0.18)	(0.212)	(0.223)
_cons		-1.558**	-1.399**	-2.845**	-2.863**	0.774	0.798+	-0.671*	-0.542+	-2.176**	-2.15**	0.372	0.303
		(0.314)	(0.298)	(0.487)	(0.53)	(0.476)	(0.484)	(0.315)	(0.295)	(0.434)	(0.436)	(0.435)	(0.422)
N		2848	2848	1830	1830	1645	1645	3341	3341	2234	2234	1838	1838

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *CDC_adj* omitted due to multicollinearity. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

9.2.2.2. Treatment Effects by Gender and Birth Cohort

Given the significant treatment effects by gender and birth cohort observed in ITT models as well as the significance of gender and age in the main MSM models, the models were fitted by gender and birth cohort, to observe whether the impact of the treatment varied by these variables. Table 9-16 and 9-17 present results by gender and birth cohort (2007-2009 and 2010-2012). The models by gender clearly suggest that the treatment is more beneficial to girls, given the statistically significant treatment effects observed on girls. Similar to the main effect models (Table 9-13), the cumulative treatment effect shows a significant positive effect on the weight-for-age of girls with an additional day of treatment increasing the weight-for-age by 0.001 SD units, on average. A particularly strong treatment effect is observed on the height-for-age, where an additional treatment day in the current month of treatment (*Trt2*) increases the height-for-age of girls by 0.012 SD units, on average. However, the BMI-for-age model for girls suggest a negative treatment effect where an additional day of treatment in the current period, causes a decline in BMI-for-age by 0.009 SD units, on average. Whilst difficult to explain, this effect may be the result of the disproportionate improvements in the heights of girls, compared to their weight. A few other interesting patterns were also evident in the models, especially for girls. Birthweight shows a significant positive impact on weight-for-age whilst being from a Sinhalese ethnic background showed strong positive effects and negative effects on the height-for-age and BMI-for-age respectively. Attending a *new* CDC also shows significant positive impacts on the weights and heights of girls. Apart from age and first weight records, no other variables show significant impacts on the growth of boys.

Looking at Table 9-17, treatment effects are clearly different across the two birth cohorts. The current period's treatment is seen to have a negative effect on the height-for-age of children born between 2007 and 2009, while the effect on height-for-age is positive among children born between 2010 and 2012. An additional participation day in the current month results in an average reduction in height-for-age by 0.005 SD units, among the older cohort of children, whilst it results in an average increase in height-for-age by 0.01 SD units among children born between 2010 and 2012. The cumulative treatment also has a marginally significant positive effect on the weight-for-age of children in the younger age cohort, where an additional day of treatment increases the weight-for-age by 0.0004 SD units, on average. Overall results do suggest that regular participation in the programme particularly benefitted children born between 2010 and 2012, compared to the older cohort of children who were part of the programme at the time of implementation[6]. However, magnitudes of these estimated effects are considerably small compared to other models, suggesting the birth cohort may not be a significant confounder of the treatment effect. Models were also fitted for the 2013-2015 birth cohort. However, neither treatment effects were significant in this age cohort. The effects of other control variables were similar to those observed in the main effect models.

[6] The mid-day meals programme was implemented in the two treatment estate in 2008. Therefore children born between 2007-2009, would be the first batch of children exposed to the programme.

Table 9-16: GEE Models with IPTW- by *Gender*

		GEE MODELS											
		Female						*Male*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var													
Trt2		0.003		0.012**		-0.009*		0.001		0.001		0.006	
		(0.003)		(0.004)		(0.004)		(0.002)		(0.004)		(0.006)	
Trt2_tot			0.001*		-0.001		0.001		0.0003		-0.0004		0.001
			(0.0002)		(0.001)		(0.001)		(0.0003)		(0.001)		(0.001)
Child-level													
Age		-0.033**	-0.038**	-0.022	-0.017	-0.05**	-0.056**	-0.015*	-0.018**	0.052**	0.056**	-0.052**	-0.062**
		(0.013)	(0.012)	(0.016)	(0.018)	(0.018)	(0.019)	(0.007)	(0.007)	(0.017)	(0.018)	(0.02)	(0.022)
Age_sq		0.0004*	0.0004*	0.0005*	0.0005*	0.0004	0.0003	0.0002*	0.0002*	-0.0005*	-0.0005*	0.001*	0.001*
		(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
zbirthweight		0.138+	0.132+	0.024	0.015	0.156	0.157	0.056	0.053	0.028	0.034	-0.027	-0.041
		(0.077)	(0.075)	(0.058)	(0.06)	(0.104)	(0.112)	(0.053)	(0.052)	(0.052)	(0.05)	(0.079)	(0.075)
firstzweight		0.454**	0.482**	0.107*	0.063	0.296**	0.349**	0.449**	0.457**	0.148*	0.135*	0.427**	0.463**
		(0.09)	(0.088)	(0.054)	(0.076)	(0.095)	(0.106)	(0.094)	(0.089)	(0.057)	(0.057)	(0.079)	(0.081)
firstzheight				0.85**	0.849**					0.805**	0.802**		
				(0.092)	(0.094)					(0.072)	(0.073)		
propmeasure		0.205	0.09	-0.247	-0.217	0.105	0.105	0.139	0.141	-0.254	-0.27	0.366	0.476
		(0.217)	(0.19)	(0.332)	(0.347)	(0.334)	(0.345)	(0.158)	(0.158)	(0.32)	(0.336)	(0.431)	(0.465)
S_{it}		0.008	0.006	0.01	-0.037	-0.014	0.027	-0.053	-0.052	-0.005	-0.014	0.008	0.006
		(0.024)	(0.021)	(0.069)	(0.072)	(0.048)	(0.05)	(0.047)	(0.04)	(0.05)	(0.049)	(0.091)	(0.096)
Ethnicity	Sinhalese	-0.525	-0.542	0.623**	0.671**	-0.53*	-0.574*	-0.092	-0.075	0.06	-0.005	-0.323	-0.205
		(0.357)	(0.358)	(0.186)	(0.185)	(0.244)	(0.261)	(0.265)	(0.249)	(0.279)	(0.291)	(0.731)	(0.638)

Table 9-16 *ctd*.

		GEE MODELS											
		Female						*Male*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
CDC-level													
CDC_cat	New	0.694*	0.764**	0.413+	0.322	-0.398	-0.301	-0.319+	-0.294	-0.247	-0.244	-0.58+	-0.603+
		(0.274)	(0.283)	(0.23)	(0.272)	(0.262)	(0.267)	(0.193)	(0.187)	(0.207)	(0.206)	(0.334)	(0.324)
	Upgraded	-0.184	-0.121	0.094	0.013	-0.212	-0.115	0.041	0.063	-0.036	-0.062	-0.408	-0.341
		(0.167)	(0.16)	(0.147)	(0.166)	(0.146)	(0.144)	(0.122)	(0.125)	(0.142)	(0.145)	(0.252)	(0.254)
Estate	Holyrood	0.511*	0.412+	-0.455*	-0.398+	0.271	0.207	0.25	0.21	0.008	0.014	0.548*	0.549*
		(0.248)	(0.235)	(0.177)	(0.239)	(0.189)	(0.201)	(0.184)	(0.166)	(0.138)	(0.143)	(0.27)	(0.278)
_cons		-1.355**	-1.112**	-1.841**	-1.817**	0.715+	0.702	-1.553**	-1.481**	-2.695**	-2.754**	-0.022	0.139
		(0.368)	(0.32)	(0.452)	(0.5)	(0.426)	(0.461)	(0.228)	(0.212)	(0.48)	(0.449)	(0.6)	(0.592)
N		3149	3149	1989	1989	1726	1726	3040	3040	2075	2075	1757	1757

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *CDC_adj* omitted due to multicollinearity. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

Table 9-17: GEE Models with IPTW- by *Birth Cohort 2007-2009, 2010-2012*

		GEE MODELS											
		2007-2009						*2010-2012*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var													
Trt2		-0.001		-0.005*		0.008		0.002		0.01**		-0.007	
		(0.003)		(0.002)		(0.005)		(0.001)		(0.003)		(0.004)	
Trt2_tot			-0.00004		0.0002		0.001		0.0004+		-0.0003		0.001
			(0.0003)		(0.001)		(0.001)		(0.0002)		(0.001)		(0.001)
Child-level													
Age		0.022	0.024	0.051	0.044	-0.009	-0.01	-0.03**	-0.035**	0.016	0.018	-0.059**	-0.066**
		(0.019)	(0.022)	(0.048)	(0.056)	(0.032)	(0.037)	(0.006)	(0.006)	(0.017)	(0.021)	(0.015)	(0.018)
Age_sq		-0.0002	-0.0002	-0.001	-0.001	-0.001	-0.001	0.0004**	0.0004**	-0.001	-0.001	0.001**	0.001**
		(0.0002)	(0.0002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.0001)	(0.0001)	(0.001)	(0.001)	(0)	(0)
Gender	Male	0.03	0.025	-0.038	-0.042	-0.097	-0.047	-0.042	-0.045	0.152	0.18	-0.373**	-0.393**
		(0.059)	(0.064)	(0.146)	(0.166)	(0.348)	(0.355)	(0.072)	(0.07)	(0.114)	(0.115)	(0.142)	(0.149)
zbirthweight		-0.064*	-0.064+	0.005	0.002	0.265	0.232	0.018	0.016	0.012	0.011	0.06	0.055
		(0.032)	(0.033)	(0.087)	(0.1)	(0.206)	(0.213)	(0.026)	(0.026)	(0.05)	(0.05)	(0.071)	(0.073)
firstzweight		0.815**	0.815**	0.112	0.106	0.515**	0.538**	0.659**	0.665**	0.089	0.088	0.431**	0.438**
		(0.034)	(0.039)	(0.093)	(0.098)	(0.138)	(0.151)	(0.032)	(0.032)	(0.058)	(0.056)	(0.067)	(0.071)
firstzheight				0.831**	0.858**					0.77**	0.775**		
				(0.099)	(0.111)					(0.077)	(0.077)		
propmeasure		-0.313	-0.306	-0.29	-0.3	-0.443	-0.411	0.113	0.059	-0.266	-0.253	0.393	0.379
		(0.203)	(0.197)	(0.31)	(0.327)	(0.478)	(0.539)	(0.176)	(0.156)	(0.325)	(0.331)	(0.307)	(0.318)
S_{it}		0.079	0.082	0.219*	0.235*	-0.201	-0.239*	-0.001	-0.001	-0.035	-0.07	0.023	0.057
		(0.055)	(0.053)	(0.099)	(0.095)	(0.125)	(0.118)	(0.019)	(0.018)	(0.062)	(0.06)	(0.052)	(0.052)
Ethnicity	Sinhalese	0.018	0.025	-0.054	-0.02	-1.237**	-1.207**	0.236	0.239+	0.334	0.353	-0.259	-0.276
		(0.086)	(0.103)	(0.182)	(0.213)	(0.432)	(0.424)	(0.143)	(0.139)	(0.271)	(0.272)	(0.359)	(0.378)

Table 9-17 *ctd*.

		GEE MODELS											
		2007-2009						*2007-2009*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
CDC-level													
CDC_cat	New	0.085	0.082	-0.101	-0.112	-0.729	-0.715	0.083	0.112	0.217	0.192	-0.258	-0.188
		(0.087)	(0.094)	(0.208)	(0.218)	(0.722)	(0.712)	(0.105)	(0.106)	(0.221)	(0.255)	(0.234)	(0.25)
	Upgraded	-0.093	-0.096	-0.22	-0.221	0.101	0.135	0.081	0.111	0.053	0.022	-0.296*	-0.232
		(0.098)	(0.103)	(0.164)	(0.184)	(0.536)	(0.534)	(0.081)	(0.082)	(0.11)	(0.121)	(0.144)	(0.145)
Estate	Holyrood	-0.219*	-0.212+	-0.046	-0.073	0.563	0.421	-0.105	-0.183*	-0.303	-0.281	0.429*	0.317
		(0.084)	(0.109)	(0.206)	(0.312)	(0.473)	(0.489)	(0.086)	(0.091)	(0.185)	(0.262)	(0.187)	(0.211)
_cons		-1.875**	-1.939**	-2.469*	-2.334+	-0.635	-0.281	-1.339**	-1.173**	-2.395**	-2.339**	0.563	0.644
		(0.54)	(0.618)	(1.049)	(1.358)	(1.079)	(1.193)	(0.246)	(0.233)	(0.54)	(0.606)	(0.432)	(0.477)
N		765	765	607	607	482	482	4449	4449	3148	3148	2709	2709

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *CDC_adj* omitted due to multicollinearity. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

9.2.2.3. Treatment Effects by Estate

A clearly evident observation in the main effects models as well as models fitted on subsamples were the significant estate effects. In the main effect models, a child living within the Holyrood estate was seen to have a generally higher weight-for-age and BMI-for-age than similar child, living within Bearwell estate, whilst the opposite pattern was observed with respect to their height-for-age. The estate effect was also significant in the subsample models fitted by baseline growth, gender and birth cohort, all suggesting that the growth of children registered under the MJF mid-day meals programme, tend to vary between the two estates. Therefore, it was logical to expect that the treatment effects may also vary within the two estates. Table 9-18 presents results of the MSM models fitted within the two estates separately. The results however, do not show any significant differences in treatment effects by estate. The current period's treatment shows a significant positive impact on the weight-for-age of children, whilst the cumulative treatment effects shows a marginally significant positive effect on the height-for-age of children within the Bearwell estate. Accordingly, an additional day of programme participation in the current month increases the weight-for-age by 0.006 SD units on average, whilst an additional day of overall treatment increases the height-for-age by 0.001 SD units, within the Bearwell estate. The treatment effects observed within Holyrood estate are somewhat different where the current period's treatment is seen to have a positive significant effect on the height-for-age of children whilst the cumulative treatment effect tends to increase their weight-for-age and BMI-for-age. Overall, the results suggest that regular participation in the programme benefits both the short run and long run growth of children, within both estates. However, given that the cumulative treatment effect is seen to translate to an increase in the long-term growth of children (as measured by their heights), within the Bearwell estate, it could be hypothesised that regular participation in the programme has a marginally higher benefit on the growth of children within the Bearwell estate. This estate effect of treatments could arise due to a couple of factors such as, differences in the baseline growth of children and differences in the implementation and efficiency of the programme within the two estates. Table 9-3 shows some interesting descriptive results where, the average growth as well as growth among programme participants is seen to be relatively better within the Holyrood estate than the Bearwell estate. This result further establishes the fact that the mid-day meals programme significantly contributes towards improving the growth of children, particularly within the Bearwell estate. The analysis of qualitative data collected through midwife and CDO interviews (results presented in Appendix E2) does suggest certain differences in the lifestyles and living standards of residents within the two estates, as well as some differences in the implementation of the programme, which would further contribute to the observed difference in treatment effects between the two estates.

Table 9-18: GEE Models with IPTW- by *Estate*

		GEE MODELS											
		Bearwell						*Holyrood*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var													
Trt2		0.006*		0.001		0.009		0.002		0.006+		-0.003	
		(0.002)		(0.005)		(0.007)		(0.003)		(0.003)		(0.004)	
Trt2_tot			-0.0002		0.001+		-0.001		0.001+		-0.0004		0.001+
			(0.0003)		(0.001)		(0.001)		(0.0002)		(0.001)		(0.001)
Child-level													
Age		-0.041**	-0.039**	0.068**	0.061**	-0.071**	-0.065**	-0.019+	-0.024*	0.005	0.009	-0.05**	-0.058**
		(0.007)	(0.006)	(0.022)	(0.02)	(0.024)	(0.023)	(0.01)	(0.01)	(0.015)	(0.017)	(0.015)	(0.016)
Age_sq		0.0005**	0.0005**	-0.001*	-0.001*	0.0005	0.001	0.0002+	0.0002+	0.0001	0.0001	0.001**	0.001**
		(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Gender	Male	-0.02	-0.019	0.117	0.115	-0.334*	-0.333*	-0.835*	-0.832*	0.06	0.077	-0.312+	-0.307+
		(0.066)	(0.066)	(0.109)	(0.108)	(0.131)	(0.13)	(0.346)	(0.342)	(0.146)	(0.155)	(0.178)	(0.184)
zbirthweight		0.009	0.01	0.058	0.051	-0.02	-0.013	0.327*	0.308*	0.032	0.028	0.181	0.17
		(0.022)	(0.021)	(0.037)	(0.035)	(0.051)	(0.05)	(0.142)	(0.139)	(0.101)	(0.099)	(0.161)	(0.17)
firstzweight		0.681**	0.681**	0.061	0.062	0.5**	0.499**	0.143	0.181	0.19**	0.162*	0.206+	0.278+
		(0.03)	(0.03)	(0.049)	(0.049)	(0.052)	(0.052)	(0.143)	(0.135)	(0.062)	(0.074)	(0.122)	(0.136)
firstzheight				0.932**	0.94**					0.826**	0.821**		
				(0.054)	(0.052)					(0.086)	(0.089)		
propmeasure		-0.286+	-0.259+	-0.982	-1.047	0.85	0.93	0.334+	0.275	-0.333	-0.324	0.385	0.416
		(0.156)	(0.153)	(0.836)	(0.84)	(0.637)	(0.645)	(0.2)	(0.174)	(0.272)	(0.276)	(0.295)	(0.301)
S_{it}		0.07**	0.059*	0.059	0.053	0.108+	0.109+	-0.055	-0.05	-0.025	-0.057	-0.034	-0.001
		(0.024)	(0.025)	(0.054)	(0.054)	(0.058)	(0.061)	(0.037)	(0.032)	(0.063)	(0.062)	(0.058)	(0.058)
Ethnicity	Sinhalese							-0.352	-0.347	0.368+	0.329+	-0.484	-0.43
								(0.27)	(0.27)	(0.195)	(0.192)	(0.363)	(0.325)

Table 9-18 *ctd*

		GEE MODELS											
		Bearwell						*Holyrood*					
		WAZ		*HAZ*		*BMIZ*		*WAZ*		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
CDC-level													
CDC_cat	New	0.083	0.051					0.374	0.369	0.141	0.144	-0.305+	-0.306+
		(0.089)	(0.084)					(0.324)	(0.321)	(0.159)	(0.165)	(0.163)	(0.162)
	Upgraded	-0.024	-0.041	-0.131	-0.062	-0.185	-0.254+						
		(0.08)	(0.076)	(0.097)	(0.094)	(0.146)	(0.154)						
_cons		-0.717**	-0.704**	-2.565**	-2.399**	0.331	0.298	-1.088**	-0.939**	-2.275**	-2.287**	0.467	0.55
		(0.18)	(0.173)	(0.868)	(0.862)	(0.645)	(0.64)	(0.329)	(0.283)	(0.423)	(0.446)	(0.355)	(0.369)
N		2938	2938	1390	1390	1377	1377	3251	3251	2674	2674	2106	2106

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *CDC_adj* omitted due to multicollinearity. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

9.2.2.4. Random Effects and Fixed Effects Models for Robustness

As outlined in Chapter 8, the Inverse Probability Treatment Weighting (IPTW) method together with the GEE estimation was necessary for fitting the Marginal Structural Models (MSM), in order to correct for the presence of time-varying confounders in the dataset. Given the complexity of the estimation method, it is important to establish whether the observed treatment effects (particularly the direction of the observed effects) were robust to different model specifications. Accordingly, Random and Fixed Effects models (RE and FE models) were also estimated using Generalised Least Squares (GLS) estimation. These models were fitted excluding the previous periods outcome as a control (i.e. the time varying confounder), as the addition of this endogenous variable would significantly bias results.

The direction of the treatment effects observed in the RE and FE models was the same as the direction of effects observed in the GEE models above. However, only a limited number of treatment effects were seen to be statistically significant. In the random effects weight-for-age models, the current period's treatment was seen to have a marginally significant positive effect, where an additional day of participation in the current month resulted in an increase of 0.003 SD units in the weight-for-age of a child, on average. Looking across the subsamples, it was observed that this treatment effect was particularly applicable to children with a below average birthweight. Among this cohort of children, and additional day of treatment in the current month resulted in an average increase of weight-for-age by 0.004 SD units. The cumulative treatment did not show any statistically significant effects in either RE or FE models. The treatment also did not show any statistically significant effects on the height-for-age of children. However, the observed directions of the effects were mostly positive, similar to those observed in the GEE models. The cumulative treatment showed a statistically significant positive effect in the RE models fitted for the BMI-for-age. A unit increase in the total number of treatment days over the survey period, resulted in an increase in BMI-for-age by 0.001 SD units, on average and this effect was particularly strong among children with below average birthweights, where the increase in

BMI-for-age was noted to be 0.002 SD units on average. The FE models did not show any statistically significant treatment effects across any of the models.

Whilst FE models control for all observed and unobserved child-level confounders, both FE and RE specifications tend to be biased in the presence of observed and unobserved time-varying confounders. This would cause much of the estimated treatment effects to be statistically non-significant. However, the direction of the estimated treatment effects and other controls were in line with what was observed in the IPTW-GEE models, indicating that the estimated treatment effects are largely robust to different model specifications. The results of the RE and FE main-effects models are provided in Appendix E2.

Chapter 10: Conclusion and Recommendations

The broad intention of this essay was to assess the effectiveness of the MJF mid-day meals programme which provided a balanced mid-day meal to all children attending child development centres within certain tea estates in Sri Lanka. A number of research questions were posed at the outset of the study and modelling was done in two stages (ITT and MSM-IPTW) in order to facilitate the exploration of the outlined research questions.

The ITT models were used to assess whether living in an estate which hosted the mid-day meals programme was beneficial to the growth of children living within the estate. Results presented in section 9.2.1 suggest that living within an estate which hosted the programme has a clear positive effect on both the short-run and long-run growth of children living within the estate, irrespective of whether they participated in the programme. The main effects models show a positive impact on both the weight-for-age and height-for-age of children. However, models fitted to subsamples indicate that the treatment effects are mostly concentrated on children showing above average birthweights. This could signal that, whilst access to the programme shows an overall benefit on improving child growth, the benefits may disproportionately favour those children showing relatively better growth than their peers. This might result in more vulnerable children specifically requiring attention (i.e. those born with lower than average birthweight) benefiting less from access to the programme. From a programme evaluation perspective, this result is critical and warrants further exploration to identify why programme benefits fail to trickle down to the children who need it the most. As indicated earlier, research shows that growth deprivation faced by children in the first two years of life can impair their ability to catch up, even with interventions (Crookston et al., 2010). This may be a potential reason for the observed results. Essay 1 highlighted the need for carefully monitoring children showing low birthweight, through the critical 1000 day period and beyond, in order to reverse ongoing adverse effects of being born with a low birthweight. This could also be applicable in the current scenario, where estate children born with low birthweights, could be provided with additional support through regular monitoring, and supplementary nutrition, alongside the mid-day meals programme, in order to aid in their catch-up growth.

Another potentially important observation was with regards to the gender effects of treatment efficacy. Whilst both boys and girls were seen to benefit from living in an estate which hosts a programme, girls were seen to benefit more. From a programme equity perspective an intervention of this nature should ideally distribute benefits equitably across the target population. However, the observed result does not particularly signal inequity given that the treatment also shows statistically significant positive impacts (though smaller in magnitude) on the growth of boys. Nevertheless, it may be interesting to further explore this result, given that similar gender effects are also observed with regards to the impact of regular programme attendance on growth. The birth-cohort analysis also shows some interesting and promising results, where positive impacts on long-term growth of children (indicated by their height-for-age) are observed among older children living in treatment estates. This suggests that the programme is effective in improving long-run growth.

The second-stage analysis focussed on evaluating the effects of continuous programme attendance on the growth of children by analysing the daily attendance patterns of children registered under the programme. The results again show a clear positive impact of regular attendance on both short-run and long-run growth of children. Subsample models again show similar patterns to those observed in the ITT models. For example, once more, the impact of regular participation in the programme was seen to be significant only among children showing above average birthweight. This again suggests that children who show relatively better growth compared to their peers (as reflected by higher birthweights) tend to benefit more from the programme. This result further emphasises the need for supplementary programmes which would particularly focus on children born with low birthweights.

The impact of regular programme participation on child growth also showed similar gender effects, where girls are clearly seen to benefit more by regularly participating in the programme. Continuous attendance showed clear improvements in the weight-for-age and height-for-age of girls whilst, treatment effects were not statistically significant on boys. This together with the gender effects observed in the ITT models signal some form of inequity in the distribution of programme benefits, which disproportionately favours girls. Given that the labour structure in tea estates is predominantly female driven, the results might reflect certain systemic and structural biases which favour girls more than boys, as girls are seen in the light of a future labour force. If true, this could be particularly problematic and appropriate measure should be taken within the mid-day meals programme, in order to reverse any such systemic biases.

The birth-cohort analysis also showed some interesting patterns where regular participation in the programme was seen to benefit children born between 2010-2012, compared to the older cohort of children who were part of the programme at the time of its implementation (i.e. children born between 2007-2009). This could signal that the MJF mid-day meals programme has been successful in overcoming its teething problems and improving over time. Results also suggested some differential treatment effects across the two estates, which could reflect differences in the way the programme is implemented within individual estates. Whilst tailoring programmes according to the needs of individual estates could improve the effectiveness of the programme, necessary monitoring and streamlining of processes is also required to ensure that the overall efficacy of the programme.

Essay 3: Impacts of Individual and Community Exposure to the Tsunami on Child Growth

Chapter 11: Introduction and Background to Study

"I must stop remembering. I must keep them in a faraway place. The more I remember, the greater my agony. These thoughts stuttered in my mind. So I stopped talking about them, I wouldn't mouth my boys' names, I shoved away stories of them. Let them, let our life, become as unreal as that wave"
~ Sonali Deraniyagala (*Wave*)

The Indian Ocean Tsunami or the Boxing Day Tsunami of 2004 is considered as one of the deadliest natural disasters in recorded history. Affecting approximately 14 countries, killing over 230,000 people and displacing millions, the tsunami was caused by an undersea mega thrust earthquake that occurred at 00:58:53 UTC on the 26th of December 2004. The earthquake had its epicentre off the west coast of Sumatra, Indonesia, and recorded an approximate magnitude between 9.1-9.3, making it the third largest earthquake ever recorded on a seismograph. The undersea earthquake triggered a series of devastating tidal waves along the coasts of many of the landmasses bordering the Indian Ocean, engulfing coastal communities with waves up to 30 meters high.

Indonesia, the country closest to the epicentre was the hardest hit, closely followed by Sri Lanka, India and Thailand. Sri Lanka was the 2nd worst hit country in the 2004 tsunami. The first wave hit the Eastern coast of Sri Lanka roughly at about 8.35 a.m. local time, closely followed by a series of waves several meters in height. Waves battered all along the eastern, southern, and western coasts of the country with some reaching the northern coast as well. Sri Lanka was thoroughly unprepared to face a disaster of this magnitude, which it was facing for the first time in recorded history (Jayasuriya et.al., 2006). Twelve of the twenty-five districts of Sri Lanka were affected by the tsunami with close to 800,000 displaced. Over 30,000 people lost their lives in the devastation (Jayatissa and Bekele, 2005). Those displaced lost not only their home but also their livelihood, and in many cases access to natural sources of food, water and healthcare, since the disaster affected entire communities, destroying infrastructure such as roads, hospitals and schools as well. Official records indicate that approximately 96,541 houses were fully destroyed while 26,528 houses were partially damaged. Over 700 camps were established across the island to house the displaced population and massive national level efforts were deployed to help the displaced communities to re-establish their livelihood.

Even before the 2004 tsunami disaster, Sri Lanka has been battling on many fronts to gain economic stability. As noted in Essay 1, after signing the Millennium Declaration, the focus was specifically on making necessary policy changes to battle poverty, child and female mortality and child malnutrition in order to achieve the Millennium Development Goals by 2015. Since 2017, these efforts have been redirected towards achieving sustainable development goals set out by the United Nations. Even with Sri Lanka performing extremely well in the area of reducing infant and maternal mortality, child and maternal malnutrition rates have been uncharacteristically high in comparison (Aturupane and Deolalikar, 2005). Therefore, combating child malnutrition was an issue faced by Sri Lanka even prior to the 2004 tsunami devastation; a situation which was further aggravated after the 2004 tsunami disaster.

Disaster of any magnitude can cause displacement, and a disaster of this magnitude often causes displacement of entire communities. According to Toole and Waldman (1993) 'displacement' is a situation where needs are great, human and material resources are scarce and action must be immediate. Displaced persons often suffer from a combination of exhaustion, seperation and bereavement. To this is added the effects of ill health and injury, inadequate nutrition and shelter as well as poor access to clean water and sanitation and impoverishment (Toole and Waldman, 1993). The 2004 tsunami in Sri Lanka caused displacement in unprecedented numbers and brought siginificant strain on an already flailing economy. Eventhough all efforts were made to respond as quickly as possible to bring relief to these victims, the displacement would have had its biggest impact on the more vulnarable groups such as children below the age of five, and women, specifically pregnant and lactating mothers.The 26th of December 2019 marked 15 years since the tsunami devastation. Over the last decade and a half, many steps have been taken both by the public sector as well as the private sector and NGO's to restore the infrastructure damaged by the tsunami as well as to re-establish the livelihoods and homes of those affected. However, impacts of the disaster are still felt across communities in Sri Lanka.

Whilst being aligned with the core theme of the thesis which is to explore facets of child growth in Sri Lanka, this Essay slightly differs from the themes explored in the previous two essays. The previous essays focussed on exploring child growth within particular geographical and social settings, in Sri Lanka. The geographical and socio-economic systems explored were endemic to Sri Lankas geopolitical structure. In contrast, this essay transcends the usual socio-economic parameters traditionally used in exploring child growth and presents a study which explores child growth within communities distrupted or displaced by a natural disaster, focussing on the 2004 Indian Ocean Tsunami. The study focuses on a time period 2 years post the tsunami, and uses the 2006 Demographic and Health Survey data, to explore child growth within three coastal provinces signficantly impacted by the 2004 tsunami. Given that the impact of the tsunami was near randomly distributed across the Northern, Eastern, Southern and Western coastal communities, based on the wave pattern and land variations, the setup closely reflects a natural experiment. The study exploits this setup using a range of different controls to establish the impact of exposure to the tsunami (at varying degrees) on the growth of children, two years post the disaster. The analysis focuses on children born between 2001-2007, and uses different spatial controls to detect growth impacts of being directly or indirectly exposed to the tsunami.

The significance of this research is that it aims to distinguish between individual (direct) and community (indirect) effects of exposure to the tsunami, on the growth of children two years post the event. Therefore it is safe to assume that any detected effects would be carry-on impacts of deprivations faced at the time of the disaster. However, there is also a remote possibility that lingering effects of the disaster may exist as structural deficiencies within communities that were exposed to the tsunami. In order to differentiate between these two possibilities, the study looks at the impacts of exposure to the tsunami on both the long-term and short-term growth of children. For purposes of defining tsunami exposure variables, individual exposure effects are considered to arise by a child's own household being fully/partially damaged by the tsunami, while community exposure effects arise as a result of living in a village impacted by the tsunami. That a natural disaster would adversely impact the growth of children whose homes are directly impacted is intuitive. However the impact of the tsunami on child growth may manifest through indirect channels such as via damage caused to community infastructure such as health centers and hospitals as well as through the disruption of food supply channels. Children living in communities that faced significant damage may display poorer health conditions even though their homes were not directly affected by the tsunami. Therein lies the importance of also observing the community effects of exposure to the tsunami along side its individual effect. The explored time period (2006-2007) two years after the tsunami, allows for observing carry-on effects of the disaster on child growth, and would be beneficial in devising rapid interventions and long-term strategies to mitigate continuing impacts of disasters on their youngest and most vulnerable victims. The following chapters present results of the analysis as a working paper. This is followed by Appendix E3 which provides detailed estimations and notes on the analysis, omited from chapters due to space considerations.

Chapter 12: Introduction

The disaster literature broadly focusses on four important aspects of natural disasters; Response, Recovery, Prediction and Policy. Research on the household and welfare implications of natural disasters usually falls under the first two categories. When considering welfare implications of natural shocks, the focus is often at the individual or household level with only a few looking at broader communities of affected individuals (Baez and Santos, 2007). The aim of this work is to exploit the 2004 Indian Ocean tsunami as a natural experiment, to explore on-going impacts of a large natural shock on the growth of children. Our study uses cross sectional survey data to develop descriptive models and uses matching of the study locations and adequate controls to correct for potential selection and endogeneity biases. This work contributes to existing disaster literature in a number of ways, as explained later in this section.

The 2004 Indian Ocean tsunami affected twelve of the 25 districts of Sri Lanka, with over 30,527 recorded deaths and more than 773,636 people displaced (Jayatissa et al., 2006). As a nation, Sri Lanka was unprepared to face a disaster of this magnitude (Jayasuriya et al., 2006; Jayatissa and Bekele, 2005; Jayatissa et al., 2006). Those displaced lost their homes, livelihoods, and in many cases access to sources of food, water, and healthcare. The waves destroyed infrastructure such as roads, hospitals, and schools in affected areas. Reports indicate that more than 96,000 houses were fully destroyed while close to 30,000 houses were partially damaged (Jayatissa and Bekele, 2005).

The main objective of this chapter is to explore if any persisting effects of exposure to the tsunami on child growth exists, two years after the event. The focus is on children below the age of 5 years and two specific issues are explored: first, whether the impacts of exposure to a natural disaster in-utero/infancy/toddlerhood influences their subsequent growth, and secondly to differentiate the impacts on growth due to living in a tsunami affected household as opposed to living in a tsunami affected community. This age group is chosen following prior research that shows children below the age of three are generally more vulnerable to shocks (Behrman, Alderman and Hoddinott, 2004; Martorell, 1999).

This study uses the 2006 Sri Lankan Demographic and Health Survey (DHS), the first major island-wide survey carried out post-tsunami. The study aims to capture any effects of exposure to the tsunami on child growth parameters that may persist even 2 years after the tsunami. Much of the research done on the impacts of the tsunami on child health in Sri Lanka has focussed on the immediate aftermath of the tsunami. Therefore, this study contributes to a key gap in this literature.

Another significant and novel contribution of this research is the segregation of the overall effects of tsunami exposure at the individual and community levels. The individual exposure effect refers to the growth impact on a child whose home was directly damaged by the tsunami. However, the impact of a natural disaster may also manifest more broadly, such as through damage caused to community infrastructure or disruption of food channels (shops and grocery stores shutting down due to damage). This could result in children living in tsunami exposed communities displaying poorer health outcomes, despite their own homes not being directly affected by the tsunami. Therein lies the importance of differentiating between the two effects, since it could form the foundation of identifying the channels through which these effects persist in the medium/long run. The findings of this research, apart from their direct implications, could also create the platform for future explorations of the long-term effects of natural disasters and inform policy for better disaster management.

Study results are both intriguing and somewhat revealing in terms of understanding the impacts of natural disasters, and how disaster management activities could be better structured to minimize long term impacts of disasters on those affected. The results clearly indicate an on-going negative effect of exposure to tsunami on the height-for-age of children even two years post the event. However, the mechanism through which these effects persist are found to be more community focussed than household. The remaining sections of this chapter present a brief review of applicable disaster literature. This is followed by chapters presenting a description of the data, methodology and finally the results and discussion of these findings.

12.1. Background: natural disasters, child growth and the 2004 tsunami

Most contributions to micro level disaster impact research are based either on countries which are frequently prone to natural disasters or on single disaster events of large magnitude (e.g. Hurricanes Mitch and Katrina, and the Indian Ocean tsunami). This section reviews some of the recent work which looks at the interrelationship between natural disasters and child growth, focussing both on disaster prone countries and single disaster events. Hoddinott and Kinsey (2001) study the effects of drought on the growth of children in Zimbabwe and report that children aged 12-24 months lose 1.5-2 centimetres of growth immediately after a drought period. Jensen (2000) studies the effects of the extreme rainfall received by Ivory Coast in 1986 and shows that this increased the proportion of malnourished children below the age of ten years by 1%. del Ninno and Lundberg (2005) report on short-term impacts of the 1998 Bangladesh floods and reveal that children above the age of 2 who were exposed to the floods showed lower height-for-age on average, than those not exposed. Hurricanes Mitch and Katrina go on record as two of the deadliest hurricanes in recent history, triggering much research on its impacts on various segments of society. Xiong et al. (2008) looks at the impact of natural disasters on mental health and birth outcomes of women using the backdrop of hurricane Katrina. The study reports that women whose exposure to Katrina was severe or more intense were three times more likely to give birth to babies with low birthweight. Omitsu and Yamano (2006) presents a study on the effects of Hurricane Mitch on the health of affected children below the age of 4 years and show that children exposed to the hurricane were 4 times more likely to be malnourished.

A key observation that can be made on most of these studies is their focus on individually affected children and women as opposed to a broader community focus. A somewhat different study is Baez and Santos (2007), which looks at the impacts of Hurricane Mitch on affected children. The study was more community focussed and showed that sick children in affected areas were 30% less likely to be taken for medical consultation. Further, Kousky (2016) provides an overall review of recent research into the impacts of natural disasters on children. He notes that much of the research focuses on the immediate or short-term effects, usually due to data limitations. However, he does note a few exceptions that look at the long-term impacts of disasters on child growth. One example is Datar et al. (2013) which looks into the impact of 228 small-scale natural disasters on child health and investments in rural India. They report that exposure to a natural disaster in the past year reduces both the height-for-age and weight-for-age zscores and increases the likelihood of stunting and underweight by approximately 7% in children below the age of 5 year.

A steadily growing pool of research has also surfaced with regards to the impacts of the 2004 tsunami on affected individuals. Whilst much of the research focuses on Indonesia, which was the epicentre of the tragedy (Cas et al., 2014; Centers for Disease Control and Prevention, 2006; Rofi et al., 2006), few research also focus on other affected countries (Carballo, Daita and Hernandez, 2005; De Silva and Yamao, 2007; Jayasuriya et al., 2006; Math et al., 2008; Mulligan and Nadarajah, 2012; Oxfam, 2005; Ratnasooriya, Samarawickrama and Imamura, 2007; United Nations Environment Programme, 2005). These studies can broadly be slotted in to one of two groups; research focused on the impacts of the tsunami on affected individuals and research focused on recovery work carried out on affected communities. Cas et al. (2014) studies the impact of parental death on child well-being using data collected from the Aceh region in Indonesia. They analyse the impact of parental death on human-capital related outcomes of children and report that in the long-run, older male children who lost both parents exhibited a lower likelihood of being enrolled in school, lower number of completed schooling years and a higher likelihood of working compared to children who did not lose a parent. Rofi et al. (2006)

explore the impacts of the 2004 tsunami on displaced families in Indonesia. The study reports that 61.8% of households reported one or more family members as dead or missing due to the tsunami, with an overall mortality rate of 13.9%.

Among research focused in countries other than Indonesia, Math et al. (2008) looks at the psychological impacts of the tsunami on children and adolescents in the Andaman and Nicobar Islands and reports adjustment disorder, depression, panic disorder and posttraumatic stress to be among the main psychiatric conditions observed among survivors. Hines (2007) looks at gender inequality and natural disasters, using post-tsunami India as a case study. Carballo, Daita and Hernandez (2005) reviews the impact of the tsunami on the healthcare systems of affected countries and report that the estimated losses and cost of reconstruction to Sri Lanka's healthcare system to be US $60 million and US$ 84 million respectively.

When considering Sri Lanka, much of the published quantitative research was in the form of rapid-assessment studies conducted in IDP camps, immediately after the 2004 tsunami. Jayatissa et al. (2006) report the findings of a rapid assessment study done in 2005, focussing on children, pregnant women and lactating mothers at the camps. According to this, of the 878 children assessed in the survey, 16.1%, 20.2% and 34.7% were wasted, stunted and underweight respectively with more than two-thirds suffering from respiratory tract infections and another significant proportion suffering from diarrhoeal infections. De Silva and Yamao (2007) focus on affected communities in Sri Lanka that depend on fisheries and other coastal livelihoods and looks at the livelihood asset building capacities of the fishing communities in three villages.

Much of the research done at the community level has looked at the post-tsunami recovery work that took place in Sri Lanka. Jayasuriya et al. (2006) reports issues and challenges faced by Sri Lanka in its post-tsunami recovery. The report identified several issues in the relief and reconstruction activities, particularly noting that reconstruction of individual houses has been hampered by the ‘no-build’ coastal buffer zone and cuts to relief payments. Progress was also shown to be uneven mainly concentrating in the south and southeast coastal areas as opposed to north and east coastal areas. The authors note that the weaknesses and inefficiencies in the rehabilitation and relief mechanism have led to an increase in the funds required to meet reconstruction targets, over and beyond what was initially estimated and pledged. Other reports also elaborate on the issue of corruption and inefficiencies in the aid distribution process by various stakeholders (Sarvananthan, 2005). Ratnasooriya, Samarawickrama and Imamura (2007) look at different areas such as housing, fisheries, tourism, transportation, livelihoods, healthcare and education and report some interesting results on the recovery process. For example, their research cites a report by the Ministry of Finance and Planning (MoFP, 2006) which indicates that 95% of women and 84% of men who lost their income due to the tsunami had re-established a significantly higher source of income one year later. With respect to recovery of healthcare services, 50% of the major construction project work was yet to begin as of the end of 2006. Further research by Sarvananthan and Sanjeewanie (2008) compares the recovery process of Sri Lanka to other affected countries such as India and Indonesia. They identified discrepancies in resource allocation according to needs of local communities, lack of consultation on recovery projects with the affected communities and the non-transparent and non-consultative nature of the decision making and implementation mechanisms. Overall, the tone of much of the research indicates that with regards to recovery efforts, comparatively less attention was given to the recovery of communities as a whole, as opposed to the recovery of individuals affected by the tsunami.

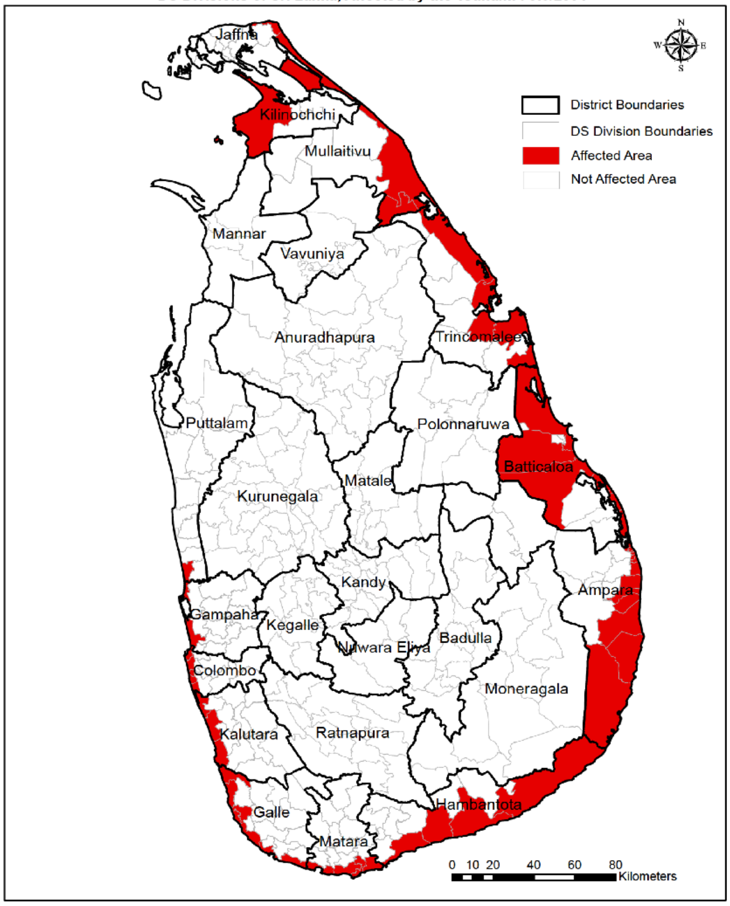


Figure 12-1: Tsunami affected coastal DS divisions of Sri Lanka
Source: Cartography Division-Department of Census and Statistics, Sri Lanka
Date of release: 31st Jan 2005

12.2. Conceptual Framework

This section aims to conceptualize how a natural disaster such as a tsunami could impact the health and growth of children in the target age group. While there is no doubt as to the adverse effects of a natural disaster on child growth, literature suggests that these effects could arise in a number of ways (Datar et al., 2013; Hoddinott and Kinsey, 2001; Omitsu and Yamano, 2006). When considering the general scenario, the first key effect would be the direct effect of the natural disaster on the child's life (mortality) or the child's health (morbidity) in cases where the child survives. For example, in the case of the tsunami, several children lost their lives during the disaster (by drowning etc.) as well as later, due to complications arising from the disaster.

A second effect could be the absence of care for the child, immediately post tsunami, due to death of the child's parents / caregivers. As a result, a child may receive inadequate food and delayed medical attention in the presence of disease. A third impact could arise due to the child's family/social network being disrupted by the disaster. For example, even though the child's own household and caregivers were unharmed, the disaster may have caused loss of extended family members and placed additional financial burdens on the child's nuclear family. Additional strain on income and other such diversions may cause a reduction to the child's care.

Another effect of the tsunami could arise from damage caused to the general infrastructure of the community the child lives in. For example, water sources may have been contaminated, severe damage may have been caused to village facilities such as medical centres, grocery shops etc. and damage to crops in farming areas can disrupt food supply. In other words, it is clear that a natural disaster such as the tsunami could have a complicated network of intertwined effects on child health. In the disaster literature, these effects are often categorised as direct and indirect, based on the research focus at hand. For purposes of this study, individual exposure effects are defined as effects arising from the child's own household being directly exposed to the tsunami and the community exposure effects as effects arising from the child living/born into a community exposed to the tsunami. Therefore, community exposure effects could arise from children living in tsunami-affected areas, even if their own household was not directly affected. A key objective of the study to differentiate between these two broad categories of causal channels and to establish the impact of each on both the short and long-term growth of children below the age of 5 years. The timeframe used in the study is two years post the tsunami, and hence any effects detected can be considered as persistent effects of exposure to the tsunami. Even though identifying the exact channels through which these effects arise is beyond the scope of this study, the findings will still highlight important issues that can guide better disaster management strategies in future.

Chapter 13: Data and Methods

The research questions explored in this study seek first, to establish the nature of any continuing impacts of the 2004 tsunami on the growth of affected children, and second, to differentiate between the individual and community components of such effects, if they exist. To this end, this work aims to test the following hypotheses:

H_1: Children living in/born in households affected by the 2004 tsunami show stunted growth compared to children living in non-tsunami affected households

H_2: Children living in/born into tsunami affected GN divisions (i.e. communities) show stunted growth compared to children living in non-tsunami affected GN divisions

H_3: Children living in tsunami affected households, within a tsunami affected GN division show stunted growth compared to children living in non-affected households in tsunami affected GN divisions

H_4: Children living in non-affected households, within a tsunami affected GN division show stunted growth compared to children living in non-tsunami affected GN divisions

The main outcome variables considered are height/length-for-age, weight-for-age and BMI-for-age of children, standardized following WHO guidelines (WHO Multicentre Growth Reference Study Group, 2006). Height-for-age is generally considered as a measure of long-term growth and therefore is considered less susceptible to sudden health or income shocks such as acute food shortage or disease. It captures more chronic conditions such as continuous bouts of disease, and chronic food shortage. From a disaster perspective, height-for-age can be considered as a growth parameter that would reflect any long-term deprivations faced by victims and survivors of a natural disaster. In contrast, the BMI-for-age and weight-for-age tend to be more sensitive to acute unfavourable conditions such as the immediate aftermath of a natural disaster, sudden economic shocks, food shortage and disease. However, weight-for-age is also considered to be sensitive to chronic conditions, through the relationship between weight and height. Due to its complex nature, weight-for-age should generally be interpreted together with the height-for -age and BMI-for-age measures. For example, in the absence of significant wasting, weight-for-age generally reflects long-term growth conditions whilst in the presence of significant wasting it would reveal a compound effect between short and long-term growth (de Onis and Blössner, 1997). Therefore, together these three measures can be expected to reveal some important patterns with respect to child growth.

The data used for the study was obtained from the 2006/07 Demographic and Health Survey (DHS) of Sri Lanka. This was the first national survey done following the 2004 tsunami disaster. The sampling procedure used was standard and conformed to World Bank recommendations. The design included 20 of the 25 districts, excluding five districts in the Northern Province due to security threats. The survey used the standard stratified two-stage cluster sample design with districts sampled proportionally to population. However, as the aim was also to provide accurate estimates for tsunami affected areas, tsunami-affected districts were oversampled with identifiers for tsunami affected households (The World Bank Group, 2013). Given the age group of interest and factoring in the interview period (June 2006- Oct 2007), the birth year of children in the considered age group ranges from 2001-2007, with the older children being approximately 2-3 years old at the time of the tsunami. This provides a well spread sample for analysing the impacts of interest.

The two geographical markers used for defining the individual and community effects in this study are the household (HH) and village clusters (GN division). A GN division (*Grama Niladari)* is the smallest administrative unit in the country and usually consists of a collection of villages. Several GN divisions cluster together to form a DS division (*Divisional Secretariat division*) which is the second level administrative unit in the country. These two administrative levels are particularly important for this study. Firstly, at times of crisis, local governments are the first state responders and are responsible for organizing search and rescue, disaster relief work etc. Accordingly, GN division and DS division officials were the first points of contact during the tsunami in 2004. Secondly, post tsunami, relief and compensations for affected families as well as rebuilding of damaged public utilities at community levels were mostly carried out under local government supervision. Thirdly, given the size and layout of villages within GN divisions, people living within a division tend to form a close-knit community. In rural areas, neighbours living in the same/adjacent villages are often related to each other and form social support systems. Given this background it is natural to assume that a loss of life/property suffered by one household, can both socially and emotionally impact other families living in their community. Given these reasons and the fact that the DHS 2006/07 oversampled in tsunami affected areas, the use of GN divisions to construct the community tsunami effect variable in this study is justified.

13.1. Variables, Assumptions and other Data Considerations

Prior to presenting the econometric model, it is necessary to discuss the potential analytical challenges and steps taken to overcome them. The height-for-age variables (*HAZ*), weight-for-age variables (*WAZ*) and BMI-for-age variables (*BMIZ*) of children, standardized following WHO guidelines (WHO Multicentre Growth Reference Study Group, 2006) are used as the main dependent variables in models. However, the height-for-age is of particular interest in the analysis. The reason for this is due to the timing of the considered effects. The primary aim of this work is to verify presence or absence of any carry forward effects of the individual/community exposure to the tsunami on the growth of children around two years after the event. A two-year period post-tsunami would be adequate to translate any adverse health impacts of the tsunami in to sustained growth deficiencies which would be reflected in the height-for-age. Therefore, height-for-age forms a core outcome of interest in the analysis. Nevertheless, models are also fitted for the weight-for-age and BMI-for-age in order to detect for lingering effects of the disaster arising as structural deficiencies within communities that were exposed to the tsunami.

Two main analytical challenges could affect the reliability of the estimated effects. First is the sample selection bias due to mortality, which is an inherent issue in using survey data to assess health outcomes of individuals (Pitt, 1997). The secondary sampling unit of the

DHS is the housing unit, and all eligible children (i.e. between 0-5 years) within selected housing units are interviewed. Therefore, children who have died will not be included in the sample by design, and there may be factors, including tsunami-related ones, affecting both mortality and the growth of living children. Heckman corrections (Heckman, 1979; Winship and Mare, 1992) with a carefully constructed selection model was used to overcome this problem. Given that the event of interest here is a natural disaster, which could have a direct impact on the survival status of children living in impacted areas, the Heckman correction is particularly important in this case.

The second and more critical issue is the possible endogeneity of the estimated tsunami exposure effects. In this context, endogeneity would largely arise due to the presence of unobservable variables which correlate with both the tsunami exposure variables and child growth. Prior to considering possible unobservables, it is useful to specify the control variables included in the model.

Based on past research (Black et al., 2008; Dancer et al., 2008) a range of variables at the child and maternal level (child's age, gender, birthweight, antenatal, delivery conditions, mother's height and BMI, mother's education etc.) were added to the model, in order to control for generic factors that influence child health. Age is also added as quadratic term to account for possible non-linearities in the relationship between age and growth. Apart from these variables, given the multi-level nature of the data structure, there can be variables at the HH and GN division level which may impact a child's growth. To account for these, a set of variables at the HH or GN division levels were derived and added to the model. These variables cover a range of factors such as wealth, occupation, ethnicity etc. (at both the HH and GN division level). If not accounted for, these variables could be thought to create systematic difference between households and GN divisions which might confound the individual and community tsunami exposure variables. HH and GN division level wealth variables were created following standard methods (Filmer and Pritchett, 1999; Rutstein and Johnson, 2004; Vyas and Kumaranayake, 2006). Concerns that using the principal components method for deriving GN-division level wealth variables could overlook heterogeneity within divisions is addressed by adding both the GN-division and HH level wealth variables simultaneously to the model (refer Appendix E3 for PCA estimation details of HH and GN-division level wealth). Apart from wealth, characteristics of the Head of the HH were considered at the HH level while the most common type of occupation within each GN division, the proportion of HHs with skilled employment and proportion of HHs with working females were considered at the division level. Identifying and controlling for these child, maternal, HH and GN division factors was crucial in isolating the individual and community tsunami effects.

Concerns about endogeneity now focus on further factors that might affect child growth but are not captured adequately by this set of variables. Despite the fact that a number of controls at varying levels is included in the model, there may still be some important unobservables that are correlated with the tsunami exposure variables. The first area of concern is with geographical location. While the impact of the tsunami was near randomly distributed across the coastal communities within impacted provinces, based on wave patterns and local variations in land structure, the impact was not random at the province level. The impacts were felt more in the North, East and South coastal regions of Sri Lanka. There is a wide variety of economic activities and levels of wealth, access to services, etc. across different areas of the country, and it is likely that not all of these differences are captured by the variables included in the model. To mitigate this concern, a matching approach is taken whereby the sample is restricted to just the three coastal provinces (Eastern, Southern and Western). This ensures that the comparison of children from exposed and non-exposed households (or communities) is limited to the same provincial areas (mostly impacted), on or near the coast. Robustness tests are run further restricting the sample to comparing children from exposed and non-exposed households (or communities) within tsunami exposed divisional-secretariat divisions (DS divisions) which forms the next highest administrative level. This stepwise matching approach would minimise potential endogeneity arising due to geography-based non-randomness of exposure to the tsunami.

The confounding of the individual/community tsunami effects by included controls is another potential source of endogeneity. Antenatal and postnatal care variables are two such variables which might be endogenous within the models. Disruptions to health care centres and other facilities within tsunami affected areas in the immediate period after the tsunami could lead to poorer antenatal and postnatal care services being received by children living within these areas, meaning access to these services is correlated with the tsunami effect variables. This possible endogeneity ought to be constant within each cohort, so it can be investigated by re-estimating models with controls for birth cohort. The results of this robustness check were very similar to those without the cohort controls suggesting this possible endogeneity is not a problem for the estimation of the tsunami exposure effects.

Even with all of the precautions outlined above, there still maybe further unobservables that could cause estimated tsunami exposure effects to be biased. However, with the inclusion of the rich set of control variables in the model coupled together with the sample matching approach, any remaining bias is likely to be small and not obvious in a particular direction that would cause a systematic bias in the estimated tsunami effects; a claim which will be validated using the robustness checks reported in later sections.

13.2. Econometric Models and Model Specifications

Prior to specifying the models, it is important to note the main counterfactuals that define the desired effects. Our method focusses on choosing comparable tsunami affected and non-affected areas, within the coastal belt of the country, to tease out the individual and community tsunami effects. Based on the setup of the two comparison groups, 3 main states can be identified and observed as: ‘unaffected HHs in non-affected areas’ (A), ‘unaffected HHs in affected areas’ (B) and ‘affected HHs in affected areas’ (C). Given that A can be considered as the counterfactual of B and B as the counterfactual of C, the individual tsunami effect and the community tsunami effect can be defined as (C-B) and (B-A) respectively. The following equation represents the general econometric model used to estimate the desired effects.

$$Y_i = \alpha + \underline{\beta}\ T_i + \underline{\gamma}\ X_i + \varepsilon_i \qquad (13.1)$$

Here Y_i stands for the standardized height/length-for-age (*HAZ*), weight-for-age (*WAZ*) or BMI-for-age (*BMIZ*) of the i^{th} child. The vector T_i specifies the individual and community tsunami exposure variables:

$$T_{i,ind} = \{ \begin{matrix} 1 & if\ child\ i\ lives\ in\ a\ HH\ exposed\ to\ tsunami \\ 0 & otherwise \end{matrix} \qquad (13.2)$$

$$T_{i,com} = \{ \begin{matrix} 1 & if\ child\ i\ lives\ in\ GN\ division\ exposed\ to\ tsunami \\ 0 & otherwise \end{matrix} \qquad (13.3)$$

The coefficient vector $\underline{\beta}$ captures individual and/or community effects of being exposed to the tsunami on the child's health. The vector X_i includes the other child, maternal, household and GN division level control variables. These controls included the child's age (if dead, age at death), gender and antenatal/postnatal care received; mother's current height, BMI and education; district of residence and ethnicity; HH wealth quintile; age, gender and education of HH head; as well as the previously mentioned GN division level variables. The individual and community level tsunami variables were included separately to explore hypotheses H1 and H2 respectively, and simultaneously to explore hypotheses H3 and H4.

The stage-1 model in the Heckman's specification[7] is used to model the survival status of the observed sample units (Heckman, 1979; Winship and Mare, 1992). While many of the factors thought to impact a child growth could also easily be associated with their survival

[7] Refer Appendix E3 for stage-1 Heckman results.

status, a few identifying variables were included, which according to past research (Dancer et al., 2008) could be expected to specifically impact mortality (e.g. mother's age at birth of the child, the child's birth order and total number of children in the HH). Apart from this to account for mortality due to the tsunami, the community tsunami exposure variable was also used in the stage-1 model (Table E3-2 in appendix E3).

13.3. Descriptive Analysis

The following tables present some descriptive statistics on the sample used in the analysis. The sample included all living children between the age of 0-5 years and children who lived in the HHs but were dead at the time of the survey (each having a complete record of all control variables used in the models). The final regression models were fitted for a sample of 2822 children (Heckman model fitted for 2898 children including 76 censored observations).

Table 13-1:Summary of child and maternal level variables

Variable Descriptions	Proportion/Mean	No. of Obs.
Total number of children		**2,898**
A. ***Child survival status***		
Dead	2.62%	76
B. ***Exposure to the tsunami (child level)***		
Living/lived in HH affected by the tsunami	8.28%	240
Living/lived in GN division affected by the tsunami	24.40%	707
Living/lived in DS division affected by the tsunami	67.77%	1,964
Dead and lived in tsunami affected HH	5.00%	12
C. ***Child outcomes***		
Stan Height-for-age if living in affected HH	-1.051	228
Stan Height-for-age if living in unaffected HH	-0.760	2,594
Stan Height-for-age if living in affected GN division	-0.891	680
Stan Height-for-age if living in unaffected GN division	-0.749	2,142
D. ***Child variables***		
Gender-Female	49.10%	1,423
Birthweight	2956 g	2,834
Age: 0-6 months	11.32%	328
6-12 months	10.77%	312
12-24 months	20.39%	591
24-48 months	39.51%	1,145
48-60 months	18.01%	522

Table 13-1 *ctd.*

Variable Descriptions		Proportion/Mean	No. of Obs.
E. ***Maternal variables***			
Age		30.47	2,898
Height		152.8 cm	2,898
BMI		23.29	2,898
Education:	Preschool or lower	0.17%	5
	Not completed primary edu	5.97%	173
	Completed primary edu	4.00%	116
	Not completed secondary edu	70.47%	2,042
	Completed secondary edu	19.39%	562

The sample includes 2,898 children born between 2001-2007. Of them, approximately 3% of children (76) were reported to be dead at the time of the survey (censored observations). This low number is in line with the number of censored observations in the overall DHS 2006 dataset (167 of 4682 children) and is also characteristic of the low child mortality rates in Sri Lanka. However, it was noticeable that mortality within tsunami affected HHs was nearly double of that observed in the overall sample (5%). Considering the two effect variables of interest, 8.28% and 24.40% of the 2,898 children, were from HHs and GN divisions affected by the tsunami respectively. Given the close relationship between the variable of interest (i.e. exposure to the tsunami) and mortality, and the relatively higher mortality reported in tsunami affected HHs, the Heckman correction was applied, and the Inverse Mill's ratio considered to check whether the selection bias is statistically significant in models.

A few other interesting points to note from both the summary statistics in Table 13-1 and the histograms below, is that children from affected households and GN divisions show poorer growth, compared to children living in unaffected households and GN divisions, with respect to their standardised height-for-age. This is particularly evident in the height-for-age distributions of children from affected and non-affected HHs and GND divisions, as indicated in the graph below. With respect to the maternal variables, the average maternal age (at the time of the survey) is approximately 30 years and over 70% of mothers were reported to have not completed secondary level education. This result is particularly important given that the lack of maternal education is commonly thought to impact child nutrition, due to the traditional role of mothers as the primary care-givers in Sri Lankan households.

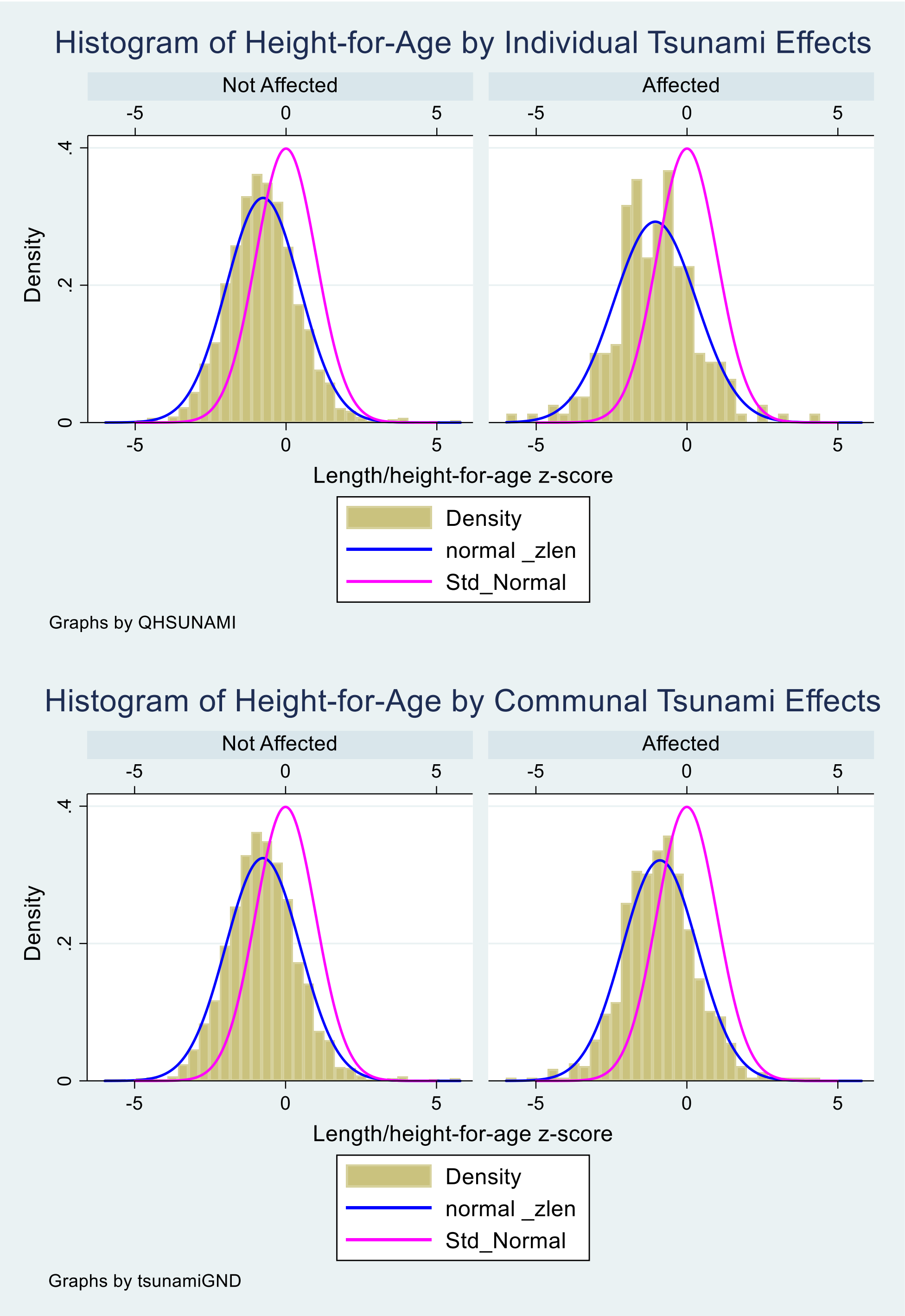


Figure 13-1:Histogram of standardized height-for-age by individual and community tsunami exposure variables (Source: created by author)

Table 13-2: Summary of household and GND level variables

Variable Descriptions		Proportion/Mean	No. of Obs.
Total number of HHs			**2,260**
F. ***HH level variables***			
HH-level Exposure to tsunami			
	HH in affected GN divisions	23.45%	530
	HH in affected DS divisions	66.37%	1,500
HH Wealth Quintile:	Q1	11.90%	269
	Q2	16.24%	367
	Q3	21.19%	479
	Q4	25.22%	570
	Q5	25.46%	575
HH head age		43 yrs	2,260
HH head gender- Female		17.74%	401
Head education:	Preschool or lower	0.13%	3
	Not completed primary edu	13.81%	312
	Completed primary edu	8.10%	183
	Not completed secondary edu	66.59%	1,505
	Completed secondary edu	11.37%	257
HH size		5.10	2,260
Room Ratio (#bedrooms/ HH size)		0.40	2,260
HH with skilled occupation		79.82%	1,804
HH with woman employed		26.24%	593
Ethnicity:	Sinhalese	71.33%	1,612
	Sri Lankan/Indian Tamil	11.02%	249
	SL Moor/ Malay	17.35%	392
	Other	0.3%	7
Total number of GNDs			**619**
G. ***GND level variables***			
Exposure to tsunami (GND level)			
	GNDs affected by the tsunami	20.68%	128
GNDWealthQ:	Q1	11.96%	72
	Q2	13.79%	83
	Q3	19.93%	120
	Q4	26.08%	157
	Q5	28.24%	170

Table 13-2 summarises the household and GN division level variables in the sample. Approximately 80% of households had a main occupation categorized as skilled work. However, only around 26% of households had employed females. The wealth distributions indicate that around 55% of the households and GN divisions in the sample belong to the two highest wealth quintiles (Q4 and Q5). It is also noticeable that the education level of the HH head is generally low, with over 65% of HH heads reported to have not completed secondary level education. This reflects the low levels of maternal education in the sample.

Chapter 14: Empirical Analysis and Results

Three variations on the model given in (13.1) were estimated to test the hypotheses presented in the previous section. The first model includes only the individual tsunami effect variable, together with the set of control variables. This model tests hypothesis H_1, which compares children of affected households with children from non-affected households. The second model fits the same set of explanatory variables with only the community tsunami effect variable in place of the individual tsunami effect variable, in order to test hypothesis H_2. Even though these two models compare children in tsunami affected HHs and GN divisions with a comparison group, the comparison groups used in both models are somewhat heterogeneous, as it does not differentiate between children living in non-affected HHs in affected GN divisions and non-affected GN divisions. Therefore, a third model was fitted with both the individual and community tsunami effect variables. This model is used to test hypotheses H_3 and H_4, which uses the correct comparison group to estimate the true individual and community tsunami effects. Two additional controls reflecting illness in the preceding two weeks (fever and diarrhea) are used in the *WAZ* and *BMIZ* models, as illness tends to directly impact the weight of children. These controls are not included in the *HAZ* models. Two different estimation techniques; Ordinary Least Squares (OLS) estimation and Heckman's two-stage method are used for fitting each model.

14.1. Effects of Exposure to Tsunami on Height-for-age

Table 14-1 presents results for the above three models fitted for the standardized height/length-for-age of children. As noted earlier, models are fitted using two estimation techniques: Heckman's two-stage method (M1, M3 and M5) and OLS (M2, M4 and M6). Inverse Mills ratio was not statistically significant in any of the fitted Heckman models, indicating that the selection bias is not a major concern in the data. Therefore, the OLS specification is used for interpretation purposes. The individual and community tsunami effects show a clear negative relationship with the standardize height-for-age of children, across all models. However, the individual exposure effect is not statistically significant in any OLS models (marginal significance is observed in the Heckman model fitting only the individual exposure effects-M1). In contrast, the community exposure effect is significant in both the community exposure and combined exposure models (i.e. M3, M4, M5 and M6). According to the OLS model estimation, a child living in a tsunami exposed GN division shows a standardized height-for-age 0.16 SD units lower, on average, than a similar child living in a non-exposed GN division. Considering the combined exposure model estimation, a child living in a non-exposed HH in a tsunami affected GN division, shows a standardized height-for-age 0.149 SD units lower, on average than a similar child living in a non-exposed GN division.

With regards to the other control variables, girls show a better growth compared to similar boys across all models. For example, in model M6, a girl child is seen to have a height-for-age 0.091 SD units higher, on average, than a similar boy child. The impact of age on height-for-age takes the predicted U shape (Wagstaff et al., 2003). Given that the standardized height-for-age is generally negative in the sample, the pattern suggests that children tend to further deviate from the WHO reference population as they grow older up to around 26 months, after which the decline tapers off. Birthweight shows the predicted positive impact on height-for-age. Birth supervision also shows a marginally significant effect in the individual exposure OLS model. According to model M2, a child whose birth is supervised by a non-Health professional tends to have a height-for-age 0.822 SD units lower, on average, than a similar child whose birth was supervised by a health professional.

Among maternal-level variables, maternal height and education shows a clear positive effect on the height-for-age of children. Maternal education in particular, shows significantly large positive effects on the height-for-age of children, with the magnitude of the estimated effects generally increasing with increasing education. Ethnicity shows a significant effect across all models. Particularly, belonging to a SL Moor/Malay ethnic group shows a significant negative effect on the height-for-age of children compared to belonging to the majority Sinhalese ethnic group. At the GN division level, the GND wealth variables show significant positive effects across all models. Children from GN divisions belonging to higher wealth quintiles show a considerably better height-for-age than similar children from GN divisions belonging to the lowest wealth quintile.

Overall, results suggest that whilst the individual tsunami exposure effect is not significant, two years post the event, the community exposure effect remains significant, even when controlled for the individual effect (model M6). As noted earlier, fitted alone in model M4, the community effect implies that a child living in a tsunami exposed GN division in a coastal district, has a standardized height-for-age 0.16 SD units lower, on average, than a similar child living in a non-exposed GN division. Similarly, model M6 indicates that a child living in a non-tsunami affected HH in a tsunami exposed GN division has, on average, a standardized height-for-age 0.149 units lower than a similar child living in a non-tsunami exposed GN division. Given that the observed effects exist two years post the tsunami suggests persistent adverse impacts of community exposure to the tsunami.

Table 14-1: Heckman and OLS regression model results- *HAZ*

		Individual Tsunami Exposure		*Community Tsunami Exposure*		*Combined Exposure*	
		Heckman (M1)	OLS (M2)	Heckman (M3)	OLS (M4)	Heckman (M5)	OLS (M6)
Tsunami Effect							
Individual	Affected	-0.151+	-0.148			-0.044	-0.036
		(0.08)	(0.102)			(0.093)	(0.108)
Community	Affected			-0.165**	-0.16**	-0.15*	-0.149*
				(0.053)	(0.058)	(0.061)	(0.06)
Child-level							
Birthweight		0.001**	0.001**	0.001**	0.001**	0.001**	0.001**
		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Gender	Female	0.097*	0.088*	0.102*	0.091*	0.102*	0.091*
		(0.043)	(0.044)	(0.043)	(0.044)	(0.043)	(0.043)
Age		-0.05**	-0.052**	-0.05**	-0.052**	-0.05**	-0.052**
		(0.006)	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)
Age_sq		0.001**	0.001**	0.001**	0.001**	0.001**	0.001**
		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Antenatal care	Yes	0.024	0.01	0.027	0.011	0.027	0.01
		(0.062)	(0.054)	(0.062)	(0.054)	(0.062)	(0.054)
Birth supervision	Sup_NonH	-0.813+	-0.822+	-0.793+	-0.805	-0.786+	-0.799
		(0.421)	(0.486)	(0.42)	(0.502)	(0.421)	(0.501)
Maternal-level							
Mother age(yr)		0.001	0.001	0.001	0.001	0.001	0.001
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Mother height (cm)		0.044**	0.044**	0.045**	0.044**	0.045**	0.044**
		(0.004)	(0.006)	(0.0038)	(0.006)	(0.004)	(0.006)
Mother BMI		0.008	0.009	0.009+	0.009	0.008+	0.009
		(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)

Table 14-1 *ctd*.

		Individual Tsunami Exposure		*Community Tsunami Exposure*		*Combined Exposure*	
		Heckman (M1)	OLS (M2)	Heckman (M3)	OLS (M4)	Heckman (M5)	OLS (M6)
Mother edu.	N/C Pri_edu	0.848	0.864**	0.888	0.907**	0.874	0.895**
		(0.586)	(0.212)	(0.585)	(0.209)	(0.586)	(0.212)
	Comp Pri_edu	0.814	0.811**	0.865	0.859**	0.851	0.848**
		(0.589)	(0.235)	(0.589)	(0.232)	(0.59)	(0.237)
	N/C Sec_edu	1.015+	1.02**	1.062+	1.067**	1.045+	1.054**
		(0.582)	(0.203)	(0.581)	(0.199)	(0.582)	(0.204)
	Comp Sec_ edu	1.126+	1.128**	1.172*	1.174**	1.156*	1.16**
		(0.588)	(0.22)	(0.586)	(0.216)	(0.588)	(0.221)
HH-level							
WealthQ	Second	-0.048	-0.049	-0.043	-0.044	-0.043	-0.045
		(0.083)	(0.098)	(0.083)	(0.097)	(0.083)	(0.097)
	Middle	0.025	0.023	0.028	0.025	0.028	0.025
		(0.085)	(0.097)	(0.085)	(0.096)	(0.085)	(0.097)
	Fourth	0.019	0.017	0.024	0.021	0.024	0.021
		(0.087)	(0.101)	(0.087)	(0.101)	(0.087)	(0.101)
	Highest	0.161	0.154	0.171+	0.162	0.171+	0.162
		(0.099)	(0.109)	(0.099)	(0.109)	(0.099)	(0.109)
Ethnicity	SL/Indian Tamil	-0.031	-0.0203	-0.011	0.001	-0.011	0.001
		(0.083)	(0.09)	(0.083)	(0.09)	(0.083)	(0.09)
	SL Moor/Malay	-0.248**	-0.243**	-0.234**	-0.229**	-0.234**	-0.229**
		(0.068)	(0.073)	(0.069)	(0.073)	(0.069)	(0.073)
	Other	0.389	0.44	0.437	0.498	0.429	0.493
		(0.427)	(0.335)	(0.426)	(0.323)	(0.426)	(0.325)
Head age(yr)		0.001	0.001	0.001	0.001	0.001	0.001
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Head gender	Female	0.038	0.038	0.045	0.044	0.044	0.043
		(0.055)	(0.064)	(0.055)	(0.064)	(0.056)	(0.064)

Table 14-1 *ctd*.

		Individual Tsunami Exposure		*Community Tsunami Exposure*		*Combined Exposure*	
		Heckman (M1)	OLS (M2)	Heckman (M3)	OLS (M4)	Heckman (M5)	OLS (M6)
Head edu	N/C Pri_edu	0.01	0.011	-0.009	-0.007	-0.004	-0.002
		(0.513)	(0.223)	(0.513)	(0.219)	(0.513)	(0.22)
	Comp Pri_edu	-0.062	-0.05	-0.079	-0.065	-0.075	-0.061
		(0.517)	(0.234)	(0.517)	(0.23)	(0.517)	(0.229)
	N/C Sec_edu	0.051	0.05	0.029	0.029	0.035	0.033
		(0.512)	(0.223)	(0.512)	(0.219)	(0.512)	(0.219)
	Comp Sec_ edu	0.113	0.118	0.085	0.091	0.09	0.096
		(0.518)	(0.235)	(0.518)	(0.232)	(0.518)	(0.231)
GND-level							
GND WealthQ	Second	0.194*	0.194+	0.198*	0.198+	0.199*	0.199+
		(0.087)	(0.108)	(0.087)	(0.107)	(0.087)	(0.107)
	Middle	0.263**	0.265*	0.27**	0.274**	0.27**	0.274**
		(0.087)	(0.105)	(0.087)	(0.104)	(0.087)	(0.104)
	Fourth	0.199*	0.201+	0.209*	0.211*	0.209*	0.211*
		(0.091)	(0.108)	(0.091)	(0.107)	(0.091)	(0.107)
	Highest	0.23*	0.235*	0.247*	0.253*	0.245*	0.251*
		(0.105)	(0.119)	(0.105)	(0.118)	(0.105)	(0.118)

Table 14-1 *ctd*.

		Individual Tsunami Exposure		*Community Tsunami Exposure*		*Combined Exposure*	
		Heckman (M1)	OLS (M2)	Heckman (M3)	OLS (M4)	Heckman (M5)	OLS (M6)
GND mode occu	Professionals	-0.033	-0.037	-0.026	-0.031	-0.026	-0.032
		(0.122)	(0.119)	(0.122)	(0.118)	(0.122)	(0.118)
	A/Professionals	-0.066	-0.074	-0.069	-0.079	-0.069	-0.079
		(0.096)	(0.085)	(0.096)	(0.085)	(0.096)	(0.085)
	Clerical/Sup staff	0.215	0.196	0.213	0.19	0.219	0.195
		(0.173)	(0.182)	(0.172)	(0.185)	(0.173)	(0.184)
	Services/Sales	-0.045	-0.05	-0.046	-0.053	-0.046	-0.053
		(0.101)	(0.093)	(0.101)	(0.092)	(0.101)	(0.092)
	Agri/Forestry	0.087	0.077	0.1	0.087	0.103	0.089
		(0.104)	(0.099)	(0.104)	(0.096)	(0.104)	(0.097)
	Carftsman	-0.016	-0.026	-0.008	-0.021	-0.007	-0.019
		(0.094)	(0.084)	(0.094)	(0.083)	(0.094)	(0.083)
	Plant/Machinery	0.149	0.13	0.156	0.132	0.156	0.132
		(0.104)	(0.086)	(0.104)	(0.086)	(0.104)	(0.086)
	Elementary Occu	0.112	0.101	0.117	0.103	0.119	0.104
		(0.092)	(0.084)	(0.092)	(0.084)	(0.092)	(0.084)
Prop_SkilledEmp		0.23	0.225	0.228	0.222	0.232	0.225
		(0.148)	(0.153)	(0.148)	(0.152)	(0.148)	(0.152)
Prop_WomenEmp		0.07	0.067	0.042	0.039	0.041	0.038
		(0.15)	(0.152)	(0.151)	(0.153)	(0.151)	(0.153)
_cons		-10.228**	-10.093**	-10.34**	-10.171**	-10.318**	-10.151**
		(0.914)	(0.85)	(0.913)	(0.853)	(0.913)	(0.842)
Mill’s Ratio		0.318		0.392		0.401	
		(0.402)		(0.402)		(0.398)	
Rho		0.288		0.356		0.364	
N		2898	2822	2898	2822	2898	2822

Cluster robust standard errors (GND level) for OLS in parenthesis. **p<0.01, *p<0.05, + p<0.1.
Base categories (in parenthesis): Gender/Head Gender(Male), MotherEdu\Head Edu(Pre school\Lower), ANcare(No), BirthSup(Supervised by HealthP), WealthQ/GND WealthQ(First), Ethnicity(Sinhalese), GND Mode occu(Managers and administrators)
NOTES: 76 censored observations in Heckman. ANcare is on the antenatal care received by mother. Estimates for the ‘Not Supervised’ category of the Birth supervision variable is omitted for accuracy due to low counts. Prop_SkilledEmp refers proportion of HHreporting skilled employment in GND and Prop_WomenEmp refers to proportion of HH with working women in GND. MotherEdu\HeadEdu - N/C refers to not completed.

14.2. Effects of Exposure to Tsunami on Weight-for-age and BMI-for-age

This section explores the impacts of exposure to the tsunami on the short-term growth of children. It should be noted that, given the tsunami occurred two years prior to the data collection period, it is unlikely that the impacts of individual and community exposure to the tsunami on short-term growth parameters such as the BMI-for-age or weight-for-age exists. If significant effects do exist, this would imply that at least some channels through which the individual and community exposure impacted child growth at the time of the tsunami, continues to exist, even two years post the event. The following table presents results of the individual, community and combined exposure effects OLS models fitted for the standardized weight-for-age and BMI-for-age of children. The OLS specification is used for consistency, given the selection effect was not significant in the height-for-age models.

As hypothesised, the individual tsunami exposure effect is not statistically significant in the weight-for-age or BMI-for-age models. Though the community exposure effect was marginally significant in the weight-for-age model, when fitted alone, it loses statistical significance in the combined effects model. Tsunami exposure variables are not statistically significant in any of the BMI-for-age models. This implies that individual or community exposure to the tsunami does not show adverse impacts on the short-term growth of children, two years post the tsunami. This suggests that, the adverse impacts of exposure to tsunami on the height-for-age of children (Table 14-1) are possibly carry-forward impacts of deprivations faced by exposed families and communities, at the time of the tsunami and not so much the result of any structural deficiencies existing in affected communities, two years post the tsunami. This will be further explored through the birth-cohort analysis presented under robustness tests.

Among the child-level variables birthweight shows a significant positive effect on the short-term growth of children while birth supervision and disease show significant negative effects. Maternal height and BMI both show positive impacts on the weight-for-age and BMI-for-age, while maternal age shows a negative effect. HH and GND level variables do not show consistently significant effects.

Table 14-2: OLS regression model results- *WAZ* and *BMIZ*

		WAZ			*BMIZ*		
		Individual Tsunami	*Community Tsunami*	*Combined Exposure*	*Individual Tsunami*	*Community Tsunami*	*Combined Exposure*
Tsunami Effect							
Individual	Affected	-0.104		-0.052	-0.02		-0.045
		(0.065)		(0.073)	(0.086)		(0.094)
Community	Affected		-0.086+	-0.069		0.018	0.032
			(0.048)	(0.054)		(0.056)	(0.061)
Child-level							
Birthweight		0.001**	0.001**	0.001**	0.0004**	0.0004**	0.0004**
		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Gender	Female	0.054	0.055	0.055	0.014	0.014	0.014
		(0.036)	(0.037)	(0.036)	(0.044)	(0.044)	(0.044)
Age		-0.022**	-0.022**	-0.022**	0.012*	0.011*	0.012*
		(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
Age_sq		0.001**	0.0002**	0.001**	-0.001**	-0.0003**	-0.001**
		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Antenatal care	Yes	-0.074	-0.074	-0.074	-0.119*	-0.118*	-0.118*
		(0.051)	(0.051)	(0.051)	(0.06)	(0.06)	(0.06)
Birth supervision	Sup_NonH	-0.711**	-0.71**	-0.701**	-0.168	-0.18	-0.173
		(0.241)	(0.246)	(0.245)	(0.452)	(0.448)	(0.454)
Diarrhea	Yes	-0.143	-0.137	-0.14	-0.264*	-0.263*	-0.265*
		(0.087)	(0.088)	(0.088)	(0.112)	(0.112)	(0.112)
Fever	Yes	-0.08+	-0.076+	-0.077+	-0.107*	-0.108*	-0.109*
		(0.045)	(0.045)	(0.045)	(0.053)	(0.053)	(0.053)
Maternal-level							
Mother age(yr)		-0.009**	-0.009**	-0.009**	-0.015**	-0.015**	-0.015**
		(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
Mother height (cm)		0.032**	0.032**	0.032**	0.005	0.005	0.005
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Mother BMI		0.035**	0.035**	0.035**	0.045**	0.045**	0.044**
		(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)

Table 14-2 *ctd*.

		WAZ			*BMIZ*		
		Individual Tsunami	*Community Tsunami*	*Combined Exposure*	*Individual Tsunami*	*Community Tsunami*	*Combined Exposure*
Mother edu.	N/C Pri_edu	0.365	0.395	0.378	-0.349	-0.34	-0.355
		(0.527)	(0.52)	(0.527)	(0.686)	(0.676)	(0.685)
	Comp Pri_edu	0.333	0.366	0.349	-0.33	-0.323	-0.338
		(0.535)	(0.528)	(0.535)	(0.69)	(0.681)	(0.688)
	N/C Sec_edu	0.458	0.492	0.472	-0.348	-0.338	-0.355
		(0.529)	(0.521)	(0.529)	(0.685)	(0.675)	(0.683)
	Comp Sec_ edu	0.552	0.586	0.566	-0.303	-0.292	-0.309
		(0.533)	(0.526)	(0.533)	(0.691)	(0.682)	(0.69)
HH-level							
WealthQ	Second	0.015	0.017	0.017	0.046	0.045	0.045
		(0.075)	(0.075)	(0.074)	(0.081)	(0.081)	(0.081)
	Middle	-0.003	-0.001	-0.001	-0.057	-0.058	-0.058
		(0.074)	(0.074)	(0.074)	(0.084)	(0.084)	(0.084)
	Fourth	-0.007	-0.004	-0.004	-0.045	-0.046	-0.046
		(0.075)	(0.076)	(0.076)	(0.088)	(0.089)	(0.089)
	Highest	0.091	0.095	0.095	-0.027	-0.029	-0.029
		(0.087)	(0.087)	(0.087)	(0.102)	(0.103)	(0.103)
Ethnicity	SL/Indian Tamil	-0.004	0.005	0.006	0.029	0.024	0.024
		(0.07)	(0.07)	(0.07)	(0.087)	(0.086)	(0.086)
	SL Moor/Malay	-0.007	-0.0004	-0.001	0.222**	0.219**	0.219**
		(0.06)	(0.06)	(0.06)	(0.079)	(0.078)	(0.078)
	Other	1.077**	1.109**	1.101**	1.181**	1.177**	1.17**
		(0.367)	(0.369)	(0.37)	(0.436)	(0.438)	(0.438)
Head age(yr)		0.001	0.001	0.001	0.001	0.001	0.001
		(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Head gender	Female	0.056	0.06	0.059	0.04	0.04	0.039
		(0.052)	(0.052)	(0.052)	(0.06)	(0.06)	(0.06)

Table 14-2 *ctd*.

		WAZ			*BMIZ*		
		Individual Tsunami	*Community Tsunami*	*Combined Exposure*	*Individual Tsunami*	*Community Tsunami*	*Combined Exposure*
Head edu	N/C Pri_edu	0.218	0.206	0.211	0.373	0.371	0.376
		(0.294)	(0.288)	(0.288)	(0.287)	(0.289)	(0.29)
	Comp Pri_edu	0.16	0.151	0.155	0.334	0.333	0.337
		(0.298)	(0.293)	(0.292)	(0.285)	(0.287)	(0.288)
	N/C Sec_edu	0.259	0.246	0.252	0.394	0.393	0.398
		(0.296)	(0.29)	(0.29)	(0.284)	(0.287)	(0.288)
	Comp Sec_ edu	0.368	0.352	0.358	0.494+	0.493	0.499+
		(0.304)	(0.298)	(0.298)	(0.299)	(0.302)	(0.302)
GND-level							
GND WealthQ	Second	0.138+	0.138+	0.14+	0.011	0.009	0.01
		(0.076)	(0.076)	(0.076)	(0.096)	(0.096)	(0.096)
	Middle	0.095	0.098	0.098	-0.114	-0.115	-0.115
		(0.078)	(0.078)	(0.078)	(0.094)	(0.094)	(0.094)
	Fourth	0.112	0.116	0.116	-0.023	-0.025	-0.025
		(0.08)	(0.079)	(0.079)	(0.099)	(0.099)	(0.099)
	Highest	0.075	0.084	0.082	-0.104	-0.105	-0.107
		(0.096)	(0.096)	(0.095)	(0.114)	(0.113)	(0.113)

Table 14-2 *ctd*.

		WAZ			*BMIZ*		
		Individual Tsunami	*Community Tsunami*	*Combined Exposure*	*Individual Tsunami*	*Community Tsunami*	*Combined Exposure*
GND mode occu	Professionals	-0.055	-0.052	-0.053	-0.053	-0.054	-0.054
		(0.109)	(0.109)	(0.109)	(0.126)	(0.126)	(0.126)
	A/Professionals	-0.077	-0.078	-0.079	-0.057	-0.056	-0.056
		(0.087)	(0.087)	(0.087)	(0.107)	(0.107)	(0.107)
	Clerical/Sup staff	0.002	-0.005	0.002	-0.164	-0.17	-0.164
		(0.165)	(0.167)	(0.167)	(0.196)	(0.196)	(0.196)
	Services/Sales	-0.166*	-0.168*	-0.167*	-0.199+	-0.199+	-0.198+
		(0.081)	(0.081)	(0.081)	(0.109)	(0.109)	(0.109)
	Agri/Forestry	-0.055	-0.053	-0.05	-0.146	-0.151	-0.149
		(0.094)	(0.094)	(0.094)	(0.114)	(0.113)	(0.113)
	Carftsman	-0.131	-0.13	-0.128	-0.174	-0.177	-0.175
		(0.087)	(0.087)	(0.087)	(0.109)	(0.109)	(0.109)
	Plant/Machinery	0.062	0.063	0.062	-0.041	-0.04	-0.041
		(0.085)	(0.085)	(0.085)	(0.103)	(0.103)	(0.103)
	Elementary Occu	-0.07	-0.071	-0.069	-0.183+	-0.185+	-0.183+
		(0.087)	(0.088)	(0.088)	(0.107)	(0.107)	(0.107)
Prop_SkilledEmp		0.064	0.059	0.064	-0.099	-0.103	-0.099
		(0.134)	(0.134)	(0.134)	(0.165)	(0.165)	(0.165)
Prop_WomenEmp		0.105	0.092	0.091	0.084	0.091	0.09
		(0.134)	(0.135)	(0.135)	(0.161)	(0.162)	(0.162)
_cons		-8.767**	-8.823**	-8.794**	-3.377**	-3.39**	-3.365**
		(0.797)	(0.793)	(0.792)	(0.946)	(0.939)	(0.943)
N		2818	2818	2818	2816	2816	2816

Cluster robust standard errors (GND level) in parenthesis. **p<0.01, *p<0.05, + p<0.1.
Base categories (in parenthesis): Gender/Head Gender(Male), MotherEdu\Head Edu(Pre school\Lower), ANcare(No), BirthSup(Supervised by HealthP), WealthQ/GND WealthQ(First), Ethnicity(Sinhalese), GND Mode occu(Managers and administrators)
NOTES: ANcare is on the antenatal care received by mother. Estimates for the ‘Not Supervised’ category of the Birth supervision variable is omitted for accuracy due to low counts. Prop_SkilledEmp refers proportion of HHreporting skilled employment in GND and Prop_WomenEmp refers to proportion of HH with working women in GND. MotherEdu\HeadEdu - N/C refers to not completed.

14.3. Robustness Tests

To further establish the above results a number of robustness tests were carried out, to test the sensitivity of the estimated community tsunami exposure effect on the height-for-age of children. Issues of validation are mostly concentrated around possible endogeneity biases that can impact the estimates. As explained earlier, restricting the sample and including a rich set of child, maternal, HH and GN division-level variables will overcome much of the potential endogeneity bias. However, the following robustness checks were done in order to address any remaining concern.

A complex relationship that may cause endogeneity is the relationship between HH wealth, child growth and the exposure to the tsunami. Given limitations in the data, pre and post tsunami wealth changes cannot be captured by the model. However, this can potentially impact the estimated tsunami effects. A second cause of bias would be if the effects of exposure to the tsunami vary within different age cohorts (for example, due to interventions specifically designed to target different age groups of affected children). Given that the main models control for age and its quadratic term, differential effects by age cohorts will not be captured in the main models. The following checks were done to identify if any such effects exist. In addition to this, models were also estimated using a more geographically restrictive sample to back the matching approach used by considering only the three coastal provinces.

14.3.1. Household and GN division Wealth Effects

It can be argued that the tsunami itself would adversely impact HH and GND wealth, which in turn translates to adverse growth impacts of children. Specifying a model that accounts for only post-tsunami wealth and does not include pre-tsunami wealth could result in an under-estimation of the tsunami effect in the model. Unfortunately, the cross-sectional nature of the dataset means deriving a pre-tsunami measure of wealth is not possible. However, by using different model specifications, it is possible to examine whether such a bias is likely to impact the estimates.

Tables 14-3, -4 and -5 present results for models M2, M4 and M6 refitted using different combinations of the wealth variables. The Generalised Hausman specification test (using *suest* Stata command) is used to compare the estimated coefficients of the individual and community tsunami exposure effects across the models. This allows to identify whether these effects vary significantly depending on the inclusion/exclusion of HH and GND level wealth.

Table 14-3: OLS Models for *HAZ* Inclusive/Exclusive of Wealth Variables- Individual Tsunami Effect only

Individual Tsunami Exposure OLS Model (M2)	*HAZ*			
	Exc wealth	Inc HH WQ	Inc GND WQ	Inc HH /GND WQ
Individual Tsunami Exposure				
Affected	-0.137+	-0.141+	-0.143+	-0.148+
	(0.081)	(0.081)	(0.081)	(0.081)
HH WealthQ (base Q1)				
Q2		0.001		-0.049
		(0.081)		(0.083)
Q3		0.096		0.022
		(0.081)		(0.085)
Q4		0.096		0.017
		(0.082)		(0.088)
Q5		0.233*		0.154
		(0.092)		(0.099)
GN Division WealthQ (base Q1)				
Q2			0.190*	0.194*
			(0.085)	(0.088)
Q3			0.282**	0.265**
			(0.083)	(0.087)
Q4			0.226**	0.201*
			(0.085)	(0.092)
Q5			0.288**	0.235*
			(0.098)	(0.106)

Standard errors (in parentheses). + p<10% * p<5% ** p<1%

Table 14-4: OLS Models for *HAZ* Inclusive/Exclusive of Wealth Variables- Community Tsunami Effect only

Community Tsunami Exposure OLS Model (M4)	*HAZ*			
	Exc wealth	Inc HH WQ	Inc GND WQ	Inc HH /GND WQ
Community Tsunami Exposure				
Affected	-0.143**	-0.152**	-0.156**	-0.160**
	(0.053)	(0.053)	(0.053)	(0.053)
HH WealthQ (base Q1)				
Q2		0.007		-0.044
		(0.081)		(0.083)
Q3		0.101		0.025
		(0.081)		(0.085)
Q4		0.104		0.021
		(0.082)		(0.088)
Q5		0.246**		0.162
		(0.092)		(0.099)
GN Division WealthQ (base Q1)				
Q2			0.194*	0.198*
			(0.085)	(0.087)
Q3			0.292**	0.274**
			(0.083)	(0.087)
Q4			0.238**	0.211*
			(0.085)	(0.091)
Q5			0.307**	0.252*
			(0.098)	(0.106)

Standard errors (in parentheses). + p<10% * p<5% ** p<1%

Table 14-5: OLS Models for *HAZ* Inclusive/Exclusive of Wealth Variables- Combined Tsunami Effects

Combined Tsunami Exposure OLS Model (M6)	*HAZ*			
	Exc wealth	Inc HH WQ	Inc GND WQ	Inc HH /GND WQ
Individual Tsunami Exposure				
Affected	-0.038	-0.355	-0.033	-0.036
	(0.093)	(0.093)	(0.093)	(0.093)
Community Tsunami Exposure				
Affected	-0.131*	-0.141*	-0.145*	-0.149*
	(0.061)	(0.061)	(0.061)	(0.061)
HH WealthQ (base Q1)				
Q2		0.007		-0.045
		(0.081)		(0.083)
Q3		0.101		0.025
		(0.081)		(0.085)
Q4		0.104		0.021
		(0.082)		(0.088)
Q5		0.246**		0.162
		(0.092)		(0.099)
GN Division WealthQ (base Q1)				
Q2			0.195*	0.199*
			(0.085)	(0.088)
Q3			0.292**	0.274**
			(0.083)	(0.087)
Q4			0.238**	0.211*
			(0.085)	(0.091)
Q5			0.306**	0.251*
			(0.098)	(0.106)

Standard errors (in parentheses). + p<10% * p<5% ** p<1%

As was earlier hypothesised, if part of the individual and community tsunami effects do manifest through HH and GN division level wealth variables, the estimated coefficients of the tsunami exposure variables should be considerably different in models that include/exclude the wealth variables. The Hausman specification test results suggest that the estimated effects are not significantly different to each other between any of the models. This is also observationally evident when looking at the very similar estimated tsunami exposure effects in the above tables. Therefore, it can be concluded that not accounting for the pre-tsunami wealth, though problematic, would not significantly bias the estimated tsunami exposure effects.

Even though the above tables show that the estimated tsunami exposure effects are not strictly correlated with wealth effects, there is a possibility that the intensity of the tsunami exposure effects would be felt differently by HHs and communities at different points of the wealth spectrum. In order to further explore this aspect, model M6 was fitted within each quantile of HH and GND wealth. Table 14-6 below provides the estimated results for these models.

Some interesting patterns with regards to the tsunami exposure variables are observed in the wealth models. Looking across models by HH wealth quantile, the individual tsunami exposure effects is not significant across all models. However, the community tsunami exposure variable shows a significant negative effect on the height-for-age of children at the media wealth quantile. This suggests that a child from a non-tsunami exposed median wealth HH living in a tsunami exposed GN division, has a height-for-age 0.394 SD units lower, on average than a similar child from a median wealth HH in a non-exposed GN division.

The GN division wealth quantiles reflect the relative wealth status of GN divisions, and models across the GND wealth quantiles also show some interesting exposure effects especially within the median wealth GN divisions. The results suggest that a child from a tsunami exposed HH, within a median wealth GN division shows relatively better growth (0.497 SSD units higher in height-for-age), on average than a similar child from a non-exposed HH, living within a median wealth GN division. However, among median wealth GN divisions, a child living in a non-exposed HH in a tsunami exposed GN division shows relatively poor growth, on average, compared to a similar child from a non-exposed GN division (0.552 SD units lower height-for-age). Unlike the positive individual exposer effect observed at the median, a marginally significant negative effect is observed at Q4.

Together these results strongly suggest that the observed tsunami exposure effects may be associated with the manner in which post-tsunami recovery aid and interventions were distributed within affected communities. Research on the post-tsunami recovery efforts in Sri Lanka, generally suggests certain weaknesses in the mechanisms used in aid distribution. Most research highlight how immediate post-tsunami aid was targeted specifically towards individuals who were injured and displaced due to damage caused to their households and also indicate inequities in the distribution of subsequent aid and interventions across communities (Gunatillake, 2007; Jayasuriya et al., 2006; Mulligan and Nadarajah, 2012). It is also logical that whilst the first rounds of aid, would have been focussed mainly on identifying affected individuals and HHs, subsequent round would have considered other parameters such as HH income levels and community wealth. This would explain the negative effects of the community tsunami exposure observed among median wealth HHs. Median wealth HH's in tsunami affected areas, might miss out on material and monetary aid due to their homes not being directly damaged by the tsunami, and their income levels falling just above income thresholds used for aid distribution. This may cause a severe strain on the growth potential of children living within such HHs.

A similar scenario could also play out at the community level (based on the GND wealth quantiles). Median wealth GN divisions would attract lesser funding and aid, compared to GN divisions in lower wealth quantiles, and this aid would naturally be directed towards HH directly impacted by the tsunami. In addition to this, median wealth communities would also be in a position to offer monetary and non-monetary help and support to affected HH's within their communities. This could be a possible reason for the observed positive effect of the individual tsunami exposure variable. However, limited aid directed towards median and higher wealth communities (Q3 and Q4) would mean that non-tsunami exposed HHs within these communities would not receive much help through the recovery process, and this could result in the negative impacts on growth observed through community exposure to the tsunami, within these communities. Whilst it is not possible to formally test whether disproportionalities in the aid distribution mechanisms as explained above could have led to the observed tsunami exposure effects, existing information on post-tsunami recovery in Sri Lanka strongly suggests that this may be the case. With regards to other controls, the observed effects are similar to those observed in Table 14-1 and are in-line with expectations.

It should however be noted that a key assumption made with regards to possible channels above, is that the HH and GN division level wealth quantiles used here would reflect the pre-tsunami wealth distribution at the HH and GN division levels. This assumption could easily be violated at the lower wealth quantiles, as economic shocks of natural disasters such as the tsunami would disproportionately hurt the poor. However, it is safe to assume that median and higher wealth HHs and GN divisions would be relatively better at absorbing such shocks, and hence these HH and communities would show relatively stable wealth distributions pre and post the tsunami.

Table 14-6: M6 model results by wealth

		HH Wealth Q					GND Wealth Q				
		Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
Tsunami Effect											
Individual	Affected	-0.105	-0.15	0.277	-0.085	-0.084	-0.203	0.098	0.497*	-0.38+	0.286
		(0.298)	(0.205)	(0.198)	(0.296)	(0.19)	(0.28)	(0.229)	(0.249)	(0.204)	(0.266)
Community	Affected	-0.183	-0.157	-0.394**	-0.061	-0.038	-0.272	-0.217	-0.552**	0.009	0.026
		(0.243)	(0.189)	(0.128)	(0.121)	(0.105)	(0.297)	(0.16)	(0.14)	(0.122)	(0.093)
Child-level											
Birthweight		0.0002	0.001**	0.001**	0.001**	0.001**	0.0004*	0.0004**	0.001**	0.0003**	0.001**
		(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Gender	Female	0.317*	0.015	0.177*	-0.047	0.094	0.223	-0.027	0.239**	-0.149+	0.189*
		(0.142)	(0.107)	(0.084)	(0.1)	(0.074)	(0.16)	(0.121)	(0.088)	(0.084)	(0.079)
Age		-0.092**	-0.039**	-0.049**	-0.051**	-0.046**	-0.094**	-0.053**	-0.042**	-0.045**	-0.047**
		(0.019)	(0.013)	(0.012)	(0.012)	(0.009)	(0.024)	(0.012)	(0.0113)	(0.01)	(0.009)
Age_sq		0.001**	0.001*	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**
		(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0004)	(0.0002)	(0.0002)	(0.0001)	(0.0001)
Antenatal care	Yes	0.333+	0.036	-0.136	-0.053	0.018	0.261	0.173	-0.063	-0.105	-0.009
		(0.186)	(0.15)	(0.128)	(0.11)	(0.098)	(0.201)	(0.16)	(0.107)	(0.094)	(0.099)
Birth supervision	Sup_NonH	-2.754*	-0.77*	0.264			-3.873**	0.098	-0.51		
		(1.081)	(0.3211)	(0.4367)			(0.648)	(0.487)	(0.4)		
Maternal-level											
Mother age(yr)		0.004	-0.014	-0.003	0.002	0.002	0.006	-0.007	-0.017*	0.001	0.013*
		(0.013)	(0.011)	(0.008)	(0.008)	(0.008)	(0.013)	(0.016)	(0.008)	(0.008)	(0.007)
Mother height		0.058**	0.031**	0.053**	0.04**	0.052**	0.026*	0.057**	0.035*	0.044**	0.062**
(cm)		(0.015)	(0.011)	(0.009)	(0.013)	(0.007)	(0.013)	(0.012)	(0.016)	(0.009)	(0.007)
Mother BMI		0.026	0.019	-0.012	0.001	0.007	0.051*	0.02	0.002	0.001	-0.001
		(0.024)	(0.015)	(0.01)	(0.011)	(0.008)	(0.024)	(0.015)	(0.012)	(0.011)	(0.008)
Mother edu.	N/C Pri_edu	0.527	1.809**				0.534		1.03**		
		(0.471)	(0.285)				(0.678)		(0.331)		
	Comp Pri_edu	0.313	2.024**	-0.067	0.29	-0.379	0.477	-0.096	1.314**	-0.33	-0.126
		(0.535)	(0.311)	(0.252)	(0.558)	(0.489)	(0.913)	(0.338)	(0.398)	(0.307)	(0.398)
	N/C Sec_edu	0.683	1.813**	0.132	0.597	-0.021	0.728	0.336	1.346**	0.024	0.039
		(0.531)	(0.242)	(0.235)	(0.498)	(0.317)	(0.698)	(0.209)	(0.346)	(0.264)	(0.287)
	Comp Sec_ edu	0.23	3.006**	0.504+	0.526	0.073	1.203	0.478	1.237**	0.184	0.143
		(0.654)	(0.911)	(0.279)	(0.511)	(0.322)	(0.842)	(0.308)	(0.381)	(0.295)	(0.306)

Table 14-6 *ctd*.

		HH Wealth Q					GND Wealth Q				
		Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
HH-level											
WealthQ	Second						-0.235	0.144	0.132	-0.189	0.569+
							(0.193)	(0.191)	(0.175)	(0.219)	(0.313)
	Middle						-0.033	-0.038	0.33*	-0.201	0.566**
							(0.26)	(0.191)	(0.16)	(0.222)	(0.199)
	Fourth						-0.293	0.122	0.157	-0.154	0.736**
							(0.521)	(0.213)	(0.184)	(0.221)	(0.187)
	Highest						-1.547*	0.608+	0.525*	-0.153	0.89**
							(0.6562)	(0.3407)	(0.2017)	(0.2278)	(0.178)
Ethnicity	SL/Indian Tamil	-0.027	-0.291	0.101	-0.134	0.221	0.195	0.143	0.297	-0.062	-0.014
		(0.273)	(0.251)	(0.212)	(0.221)	(0.158)	(0.315)	(0.353)	(0.282)	(0.165)	(0.133)
	SL Moor/Malay	-0.151	-0.377*	-0.437*	-0.209	-0.106	-0.196	-0.314	-0.079	-0.293*	-0.052
		(0.282)	(0.185)	(0.174)	(0.156)	(0.143)	(0.412)	(0.212)	(0.136)	(0.147)	(0.123)
	Other					0.462				0.81	0.225
						(0.343)				(0.785)	(0.444)
Head age(yr)		0.008	0.005	-0.001	-0.002	0.001	0.006	0.003	-0.001	-0.001	-0.001
		(0.01)	(0.005)	(0.003)	(0.003)	(0.003)	(0.008)	(0.005)	(0.004)	(0.003)	(0.003)
Head gender	Female	0.536+	-0.114	0.015	-0.081	0.078	0.023	0.14	0.243+	-0.075	-0.005
		(0.284)	(0.15)	(0.128)	(0.114)	(0.107)	(0.316)	(0.188)	(0.125)	(0.098)	(0.115)
Head edu	N/C Pri_edu	-0.069	-1.289**	-0.41		0.61*	-0.176			0.75*	0.278
		(0.47)	(0.406)	(0.362)		(0.306)	(0.472)			(0.309)	(0.264)
	Comp Pri_edu	0.047	-1.438**	-0.2	-0.272	0.433+	-0.367	-0.381+	0.166	0.797*	-0.181
		(0.522)	(0.402)	(0.377)	(0.248)	(0.26)	(0.523)	(0.22)	(0.208)	(0.338)	(0.228)
	N/C Sec_edu	0.106	-1.283**	-0.437	0.085	0.434**	0.057	-0.016	-0.107	0.807**	0.268
		(0.531)	(0.371)	(0.355)	(0.17)	(0.15)	(0.552)	(0.181)	(0.151)	(0.305)	(0.167)
	Comp Sec_ edu	0.202	-1.398	-0.375	0.209	0.461**	-0.789	0.077	0.492+	0.716*	0.174
		(0.902)	(1.39)	(0.499)	(0.231)	(0.175)	(1.676)	(0.288)	(0.26)	(0.36)	(0.193)

Table 14-6 *ctd*.

		HH Wealth Q					GND Wealth Q				
		Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
GND-level											
GND WealthQ	Second	-0.088	0.117	-0.074	0.038	2.497**					
		(0.194)	(0.178)	(0.214)	(0.343)	(0.674)					
	Middle	0.115	0.204	0.30	-0.039	2.072**					
		(0.196)	(0.195)	(0.21)	(0.345)	(0.559)					
	Fourth	0.295	0.156	0.245	0.018	1.89**					
		(0.256)	(0.196)	(0.215)	(0.345)	(0.563)					
	Highest	-1.654**	-0.079	0.153	0.021	2.128**					
		(0.402)	(0.332)	(0.248)	(0.369)	(0.558)					
GND mode occu	Professionals	-0.624	-0.474+	-0.479	0.56*	0.027	-1.982**	-0.437	0.483	0.251	-0.087
		(0.599)	(0.287)	(0.311)	(0.249)	(0.152)	(0.566)	(0.295)	(0.547)	(0.254)	(0.127)
	A/Professionals	-0.105	-0.863*	-0.174	0.128	-0.047	-1.146	0.397	-0.143	-0.085	-0.126
		(0.529)	(0.369)	(0.213)	(0.166)	(0.12)	(0.742)	(0.306)	(0.194)	(0.14)	(0.126)
	Clerical/Sup	-1.73*	0.134	-0.727**	0.341	0.523*	-1.7**	0.741*	1.148**	-0.136	0.146
	staff	(0.861)	(0.343)	(0.248)	(0.37)	(0.243)	(0.596)	(0.363)	(0.395)	(0.263)	(0.258)
	Services/Sales	-0.258	-0.227	-0.31	0.12	-0.058	-1.536**	0.093	-0.095	-0.174	0.089
		(0.463)	(0.289)	(0.211)	(0.206)	(0.136)	(0.525)	(0.33)	(0.193)	(0.201)	(0.133)
	Agri/Forestry	0.014	0.01	-0.112	-0.004	0.096	-1.629**	0.491	-0.016	-0.051	0.316+
		(0.502)	(0.3)	(0.224)	(0.185)	(0.21)	(0.564)	(0.308)	(0.203)	(0.202)	(0.173)
	Carftsman	-0.192	-0.418	-0.249	0.263	0.073	-2.386**	0.114	-0.046	-0.01	-0.089
		(0.488)	(0.281)	(0.202)	(0.161)	(0.161)	(0.567)	(0.301)	(0.197)	(0.138)	(0.146)
	Plant/Machinery	-0.328	-0.096	0.225	0.358*	-0.062	-1.577**	1.174**	0.252	0.261	-0.017
		(0.45)	(0.328)	(0.212)	(0.145)	(0.168)	(0.517)	(0.409)	(0.189)	(0.169)	(0.138)
	Elementary	0.32	0.075	-0.133	0.126	0.061	-1.982**	0.324	0.068	0.178	0.113
	Occu	(0.507)	(0.29)	(0.201)	(0.16)	(0.158)	(0.566)	(0.295)	(0.221)	(0.149)	(0.13)

Table 14-6 *ctd*.

	HH Wealth Q					GND Wealth Q				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
Prop_SkilledEmp	1.341**	0.824*	0.291	-0.339	-0.373	0.978	0.396	0.057	0.447	-0.194
	(0.491)	(0.357)	(0.292)	(0.34)	(0.251)	(0.653)	(0.382)	(0.308)	(0.356)	(0.254)
Prop_WomenEmp	-0.11	-0.234	0.147	0.061	0.075	-0.507	0.372	0.279	-0.263	0.368
	(0.493)	(0.445)	(0.322)	(0.326)	(0.306)	(0.486)	(0.462)	(0.332)	(0.319)	(0.309)
_cons	-12.184**	-7.486**	-9.79**	-8.141**	-12.343**	-5.86*	-11.334**	-8.762**	-8.573**	-13.066**
	(2.75)	(1.666)	(1.443)	(2.158)	(1.142)	(2.333)	(2.193)	(2.335)	(1.363)	(1.031)
N	342	457	582	724	717	365	396	616	714	731

Cluster robust standard errors (GND level) in parenthesis. **p<0.01, *p<0.05, + p<0.1.
Base categories (in parenthesis): Gender/Head Gender(Male), MotherEdu\Head Edu(Pre school\Lower), ANcare(No), BirthSup(Supervised by HealthP), WealthQ/GND WealthQ(First), Ethnicity(Sinhalese), GND Mode occu(Managers and administrators)
NOTES: ANcare is on the antenatal care received by mother. Estimates for the ‘Not Supervised’ category of the Birth supervision variable is omitted for accuracy due to low counts. Prop_SkilledEmp refers proportion of HHreporting skilled employment in GND and Prop_WomenEmp refers to proportion of HH with working women in GND. MotherEdu\HeadEdu - N/C refers to not completed.

14.3.2. Birth Cohort Analysis of Tsunami Exposure Effects

The interplay between age, child growth and tsunami effects is another interesting and complex relationship which needs exploration. The primary question of interest is whether the impact of individual and community tsunami exposure effects vary within different age cohorts of children. The sample includes children born between 2001 and 2007. Therefore, this would mean that the sample contained children born up to 2-3 years before the tsunami (between 2001 and 2002), immediately before/after the tsunami (between 2003 and 2005) and those born approximately 2-3 years after the tsunami (between 2006 and 2007). This provides the necessary age spread to explore whether the individual and community exposure (either by being alive during the tsunami, or by subsequently being born in to communities affected by it) differs between these birth cohorts. Research suggests that vulnerable groups such as pregnant women and children, directly impacted by the tsunami were specifically targeted through immediate post-tsunami recovery efforts. However, little information exists as to whether continuous support was provided to monitor the health and growth of children born in affected communities, subsequently. The birth-cohort analysis below would shed some light on this aspect. The analysis fits the combined exposure model (M6) to the height-for-age of children within the three separate birth cohorts, 2001-2002, 2003-2005 and 2006-2007. The following table provides the estimated results.

Statistically significant tsunami exposure effects are only observed in birth cohorts 2001-2002 and 2006-2007. In the 2001-2002 birth cohort, individual exposure effect is marginally significant and positive, suggesting that among children born in 2001-2002, a child living in a tsunami exposed HH shows a height-for-age 0.383 SD units higher, on average, than a similar child belonging to a non-exposed HH. This observation again backs the aid distribution mechanism that was briefly discussed in the above section which suggested that in the immediate aftermath of the tsunami, particular attention was given to people and HH directly impacted by the tsunami, and HH not directly impacted in tsunami affected areas would have likely received less attention and support. Given that children in this birth cohort would have been between 2 and 3 years of age, at the time of the disaster, the attention and support received by children in affected HH, would have been beneficial in reversing any adverse impacts of exposure to the tsunami. In fact, the positive impacts on height-for-age, nearly two years post the even suggests that any nutritional/monetary support received by these HHs were effective beyond mitigating the negative impacts of the natural disaster and actually resulted in boosting the long-term growth of children. The non-significance of the individual and community exposure variable within the 2003-2005 birth cohort (i.e. among children born just before or after the tsunami) also supports the above theory.

In contrast, the tsunami exposure effects on the 2006-2007 birth cohort suggests a different narrative. The results indicate a statistically significant negative impact of community exposure on the long-term growth of children belonging to this birth cohort. Accordingly, among children born between 2006 and 2007, a child living in non-exposed HH within a tsunami-exposed GN division has a height-for-age 0.414 SD units. Lower, on average, than a similar child living in a non-exposed GN division. Given that children in this birth cohort would have been conceived between 2005 and 2006, suggests that the negative impacts observed on the height-for-age of these children, could be results of significant nutritional deprivations faced in-utero. Again, these results may suggest certain short comings in both immediate and on-going community recovery interventions implemented in tsunami exposed communities, which could have overlooked the nutritional needs of pregnant mothers living in non-affected HHs in tsunami exposed areas in the 2005-2006 period. Existing literature on the post-tsunami recovery process in Sri Lanka will be briefly discussed in the Discussion chapter, in order to further highlight some of these issues.

Table 14-7: M6 model results by birth cohort

		HAZ		
		2001-2002	2003-2005	2006-2007
Tsunami Effect				
Individual	Affected	0.383+	-0.071	0.024
		(0.209)	(0.108)	(0.239)
Community	Affected	-0.204	-0.024	-0.414**
		(0.126)	(0.072)	(0.159)
Child-level				
Birthweight		0.0004**	0.001**	0.001**
		(0.0001)	(0.0001)	(0.0001)
Gender	Female	-0.073	0.046	0.446**
		(0.086)	(0.05)	(0.113)
Age		-0.342	0.001	0.018
		(0.2814)	(0.0117)	(0.0373)
Age_sq		0.003	0	-0.007**
		(0.0027)	(0.0002)	(0.002)
Antenatal care	Yes	0.044	-0.043	-0.152
		(0.093)	(0.069)	(0.314)
Birth supervision	Sup_NonH		-1.221*	-0.42
			(0.513)	(0.817)
Maternal-level				
Mother age(yr)		0.017*	-0.001	-0.009
		(0.0079)	(0.005)	(0.01)
Mother height		0.065**	0.049**	0.027**
(cm)		(0.0078)	(0.005)	(0.009)
Mother BMI		-0.002	0.009	0.006
		(0.01)	(0.006)	(0.015)
Mother edu.	N/C Pri_edu	0.152	0.919	0.696
		(1.351)	(0.729)	(1.437)
	Comp Pri_edu	0.278	0.857	0.538
		(1.357)	(0.733)	(1.443)
	N/C Sec_edu	0.198	1.044	0.925
		(1.341)	(0.725)	(1.422)
	Comp Sec_ edu	0.224	1.169	0.976
		(1.356)	(0.731)	(1.429)
HH-level				
WealthQ	Second	0.156	0.092	-0.388+
		(0.189)	(0.099)	(0.205)
	Middle	0.164	0.122	-0.452*
		(0.181)	(0.1)	(0.22)
	Fourth	0.262	0.112	-0.404+
		(0.178)	(0.105)	(0.225)
	Highest	0.441*	0.193+	-0.14
		(0.2005)	(0.1166)	(0.266)
Ethnicity	SL/Indian Tamil	0.063	-0.186+	0.289
		(0.185)	(0.1)	(0.205)
	SL Moor/Malay	0.008	-0.396**	-0.02
		(0.148)	(0.083)	(0.175)
	Other	1.053*	-0.347	1.483
		(0.5282)	(0.592)	(1.474)

Table 14-17 *ctd*.

		HAZ		
		2001-2002	2003-2005	2006-2007
Head age(yr)		0.001	0.0003	0.005
		(0.004)	(0.002)	(0.005)
Head gender	Female	0.112	0.058	-0.035
		(0.109)	(0.067)	(0.142)
Head edu	N/C Pri_edu	0.301	-0.248	0.039
		(0.663)	(0.724)	(0.295)
	Comp Pri_edu	-0.007	-0.225	-0.13
		(0.672)	(0.727)	(0.305)
	N/C Sec_edu	0.339	-0.184	-0.108
		(0.654)	(0.723)	(0.222)
	Comp Sec_ edu	0.446	-0.116	
		(0.671)	(0.729)	
GND-level				
GND WealthQ	Second	0.47+	0.201*	0.184
		(0.241)	(0.102)	(0.21)
	Middle	0.328	0.254*	0.308
		(0.232)	(0.101)	(0.226)
	Fourth	0.2	0.207+	0.371
		(0.248)	(0.106)	(0.231)
	Highest	0.288	0.28*	0.253
		(0.264)	(0.124)	(0.273)
GND mode occu	Professionals	0.4+	-0.093	0.037
		(0.229)	(0.144)	(0.351)
	A/Professionals	0.114	-0.012	-0.433
		(0.166)	(0.116)	(0.269)
	Clerical/Sup	0.196	0.124	0.417
	staff	(0.352)	(0.2)	(0.504)
	Services/Sales	-0.016	0.112	-0.313
		(0.187)	(0.122)	(0.268)
	Agri/Forestry	-0.075	0.14	0.203
		(0.206)	(0.124)	(0.278)
	Carftsman	0.135	0.106	-0.417
		(0.169)	(0.113)	(0.253)
	Plant/Machinery	0.33+	0.206+	-0.013
		(0.188)	(0.124)	(0.262)
	Elementary	0.352*	0.1	0.099
	Occu	(0.178)	(0.111)	(0.235)
Prop_SkilledEmp		-0.138	0.064*	0.921*
		(0.301)	(0.176)	(0.386)
Prop_WomenEmp		0.056	0.055	-0.377
		(0.304)	(0.176)	(0.416)
_cons		-4.735	-11.195**	-7.957**
		(7.751)	(1.265)	(2.019)
N		481	1698	643

Standard errors (in parenthesis). **p<0.01, *p<0.05, + p<0.1.
Base categories (in parenthesis): Gender/Head Gender(Male), MotherEdu\Head Edu(Pre school\Lower), ANcare(No), BirthSup(Supervised by HealthP), WealthQ/GND WealthQ(First), Ethnicity(Sinhalese), GND Mode occu(Managers and administrators)
NOTES: ANcare is on the antenatal care received by mother. Estimates for the ‘Not Supervised’ category of the Birth supervision variable is omitted for accuracy due to low counts. Prop_SkilledEmp refers proportion of HHreporting skilled employment in GND and Prop_WomenEmp refers to proportion of HH with working women in GND. MotherEdu\HeadEdu - N/C refers to not completed.

14.3.3. Tsunami Exposure Effects based on Geographic Location

A final robustness check was done to establish whether the overall results observed in Table 14-1 persist across more geographically restricted models. To this end, model M6 was first fitted for the three provinces (Western, Southern and Eastern) separately. As explained under the Data and Methods section, DS divisions (*Divisional Secretariat division*) form the second layer of local administration, above GN divisions in Sri Lanka. A typical of DS division oversees the administration of a group of GN divisions, where GN division officials report to the DS division. Therefore, in times of natural disasters GN division and DS division officials would be the first points of contact. Given this, a second location-based robustness test was done where models M2, M4 and M6 were fitted to a restricted sample which only included tsunami-exposed divisional secretariat divisions.

The tsunami exposure effects are not significant in the Western and Eastern province models. However, the community tsunami effect was negative and statistically significant in the Southern province and results suggest that a child living within a tsunami exposed GN division in the Southern province, has a height-for-age 0.212 SD units lower, on average, than a child living in a non-exposed GN division. This result is expected since the Southern province was the most heavily affected province (Kuhn, 2010).

DS division models show statistically significant negative effects of the community tsunami exposure, when fitted alone (M4) and together with the individual exposure variable (M6). The statistical significance and direction of the observed tsunami exposure variables even within geographically restricted samples further establish the robustness of the observed results in Table 14-1. Results of the above models are presented in Appendix E3.

Chapter 15: Discussion and Concluding Remarks

The analyses presented in this essay have many important implications with respect to both the impact of the 2004 Indian Ocean tsunami on the growth of children in impacted households and communities as well as certain aspects of the general disaster response post the tsunami, in Sri Lanka. The height-for-age models suggest that, while the individual tsunami exposure was not significant, two years post the event, the community exposure effect remained significant. This signals that adverse impacts of the exposure to the tsunami seem to materialize primarily at the community level, through children living within tsunami-affected GN divisions.

Results of wealth models show higher adverse impacts of community exposure to the tsunami on children living within median wealth HH and GN divisions whilst the birth cohort analysis suggest children born between 2006 and 2007 to be particularly vulnerable. A potential channel through which these effects manifest could be the post-tsunami recovery mechanism in Sri Lanka. The tsunami recovery process that took place in Sri Lanka has been documented in many different reports over the years (Carballo, Daita and Hernandez, 2005; Gunatillake, 2007; Jayasuriya et al., 2006; Mulligan and Nadarajah, 2012; Ratnasooriya, Samarawickrama and Imamura, 2007; United Nations Environment Programme, 2005). A key observation of most reports is that, most post-tsunami material and monetary aid were targeted specifically towards individuals who were injured and displaced due to damage caused to their households. In the immediate aftermath of the tsunami, several relief camps were set up across the island to house the displaced (Jayatissa et al., 2006). Over time, most of the survivors moved back to their hometowns or other locations together with their children. The government intervened by providing necessary housing through tsunami-housing projects (Gunatillake, 2007; Jayasuriya et al., 2006). Ratnasooriya, Samarawickrama and Imamura (2007) cites a Ministry of Finance and Planning report (MoFP, 2006) which states that approximately 85% of the affected families regained their main source of income one year after the tsunami (this observation backs the assumption that HH and GND wealth distribution particularly at median and upper quintiles would not have significantly changed due to the tsunami). The report further indicates that a significant proportion of men and women who lost their income were earning an income significantly higher one year after, than their pre-tsunami income level. Conversely, research reveals major delays in large scale construction projects to rebuild damaged health services with 50% of larger construction projects still awaiting initiation as of December 2006 (Ratnasooriya, Samarawickrama and Imamura, 2007). Ratnasooriya, Samarawickrama and Imamura (2007) further notes issues with restoring water channels in certain affected areas, where ground water and wells were contaminated and damaged.

Together, these reports suggest that the primary focus of aid was first towards individuals who were directly affected by the tsunami, while the rebuilding of damaged infrastructure such as roads, hospitals, regional medical centres, marketplaces etc., took considerably longer (United Nations Environment Programme, 2005). This provides one likely explanation for both the statistical significance of the community tsunami effect and the non-significance/positive impact of the individual tsunami effect observed in the models. If individual HHs directly affected by the tsunami received assistance, but the necessary aid was not delivered to the community as a whole, this would result in the observed adverse growth impacts at the community (GND) level. This is also in line with a general theme found across the disaster literature that differential access to recovery funding acts as a major determinant of the post-disaster economic dynamics of affected households and communities (Karim and Noy, 2016).

Patterns observed in the birth cohort analysis highlight possible weaknesses in monitoring and support mechanisms for pregnant women living in tsunami exposed communities, during the 2005-2006 period. Possible reasons again could be the more individual-focussed recovery process which particularly target HH directly impacted by the tsunami. Another possible reason could be that at the time of the tsunami, and in its immediate aftermath, children who were infants/toddlers at the time of the tsunami (i.e. born in 2001-2002), or those born immediately before/ after the tsunami (2003-2005), could have received assistance through targeted interventions (Jayatissa and Fernando, 2011; Jayatissa et al., 2012). These interventions could entirely offset or even promote the long-term growth of children belonging to these birth cohorts. However, children born a couple of years later (2006-2007) may not be beneficiaries of such targeted interventions, and this coupled together with possible deprivations faced in-utero would result in the negative community effect observed for this group.

The non-significance of the exposure effects observed in the weight-for-age and BMI-for-age models, suggest that, much of the impacts observed on height-for-age are carry-forward effects of deprivations faced at the time of the tsunami rather than any continuing structural adversities faced by these communities. Significant results observed in the geography restricted models establish the robustness of the observed results.

Overall, these findings provide some key policy insights in a couple of areas. First, given the persistent negative impacts of community exposure on the long-term growth of children detected in tsunami affected communities, necessary growth monitoring and intervention mechanisms should be set up within these communities, to detect and remedy any growth deficiencies faced by recent and future generations of children born in these areas. Secondly given that the tsunami occurred over 10 years ago, necessary health and nutrition interventions targeting teenagers and adolescents living within tsunami affected communities, would also be beneficial in remedying the negative growth impacts faced by them in their early childhood. A third and more important insight is the need for restructuring the national level disaster management mechanism, to correct for the noted weaknesses in the disaster recovery frameworks available in low- and middle-income countries like Sri Lanka. Often these frameworks place primary emphasis on individual rehabilitation as opposed to community rehabilitation. Therefore, necessary restructuring is required to design and implement national, provincial and local level disaster management policies and procedures which emphasise recovery both at individual and community levels.

Chapter 16: Thesis Conclusion

This thesis is structured as three different yet complimentary analytical essays which explore three aspects of child growth and nutrition in Sri Lanka. The first essay explores child malnutrition in context of the varied regional population of Sri Lanka, particularly focussing on rural and estate regions in the country. These two sectors report the highest prevalence of childhood stunting, wasting and underweight. To add to an already complex problem, the two sectors also show distinctly different population characteristics and economic parameters which would impact growth differently, within the two sectors. This formed the basis for the analysis in the essay which was aimed at identifying relationships between different growth outcomes and key variables of interest within sectors and to identify variables that drive growth differentials between sectors and across time. Essay 2 focussed particularly on the estate sector, with the aim of evaluating the effectiveness of a nutrition intervention operational within certain tea estates in the country. The programme reviewed was a children's mid-day meals programme which offered a balanced mid-day meal to children attending child development centres in certain tea estates. The final essay looked at child growth from a different lens, exploring the impacts of exposure to a natural disaster on the subsequent growth of children, focussing on the Indian Ocean tsunami as the backdrop. This chapter revisits each of the essays to highlight some of the main results, policy recommendations and future research possibilities derived from each essay.

16.1. Sectoral Variations in Child Growth in Sri Lanka

The broad aim of this essay was to explore variations in child growth across the rural and estate sectors of Sri Lanka with the objective of understanding, firstly the nature and drivers of child growth within each sector and secondly, which factors drive the gaps in child growth between the two sectors, and thirdly to explore the improving/declining growth patterns within each sector over time using DHS data 10-years apart (2006 and 2016). Weight-for-age, height-for-age and BMI-for-age of children below the age of 5 was analysed using a number of different techniques including linear and quantile regression and Blinder-Oaxaca and RIF-regression decompositions, to address a number of different research questions. The analysis was structured in two stages. The first stage analysis looked at determinants of growth within each sector and time period, and at different points of the growth distribution. The second stage of analysis focuses on decomposition of the growth differentials across sectors and time, as well as across the growth distribution to identify factor that drive growth differentials.

16.1.1. Summary of Results and Policy Insights

The analysis identified some key factors that drive both growth within sectors and growth differentials across the two sectors and two time periods. Birthweight and maternal BMI have a clear positive impact on children's height-for-age and BMI-for-age across both sectors and time periods, while maternal height shows a positive impact on children's height-for-age. Breastfed duration has a clear negative effect on the height-for-age of children, particularly within the rural sector. Female children show an advantage over male children with regards to long-term growth, particularly among the nutritionally at-risk cohort of children within the rural sector. Maternal education and the educational background of the HH Head are two variables which showed differential effects on long-term and short-term growth within the two sectors.

The decomposition analysis highlighted that the rural sector performed relatively better with regards to the long-term growth of children than the estate sector. However, the decomposition of BMI-for-age suggested the opposite was true with regards to short-term growth, with the estate sector performing better. Birthweight was again seen to be a key driver of sector growth gaps. Differences in the average levels of low birthweight children drove the growth gap up, in favour of the rural sector, whilst differences in returns to low birthweight was seen to be more detrimental to future growth, within the rural sector. Increasing the levels of education of estate mothers was seen to help in narrowing the gap in long-term growth between the two sectors while differences in returns to maternal education showed a complex relationship to both height-for-age and BMI-for-age growth differentials. The results generally show higher levels of education favouring the estate sector whilst the rural sector benefited more, through returns to maternal education. However, declining returns to maternal education within the rural sector over time, is a key observation that needs to be addressed through policy.

A few key policy prescriptions arising from the analysis are as follows:

- Breastfeeding awareness programmes particularly within the rural sector, to educate mothers on the importance of exclusive breastfeeding, as opposed to extended breastfeeding, and information on appropriate timeframes for weaning children off breastmilk.

- Investing in maternal health and wellbeing across both sectors, to improve growth outcomes of children, particularly in the long-run.

- Nutrition and supplementation programmes targeting pregnant mothers, particularly within the estate sector, to reduce the number of low weight births.

- Establishing continuous growth monitoring of low-weight babies, through the first 5 years of life and possibly beyond, particularly within the rural sector. Tweaking existing growth monitoring programmes to specifically target low-birthweight children through a growth subsidy (in the form of financial support to the families or direct food and nutrition packages for the child).

- Incentivising female education within the estate sector, to improve the levels of education among estate women.

- Interventions for improving positive returns of maternal education on child growth within the rural sector. This may be achieved through the supply of more skilled employment opportunities for rural women and by establishing the necessary child-care support structures for the care of children whose mothers choose to travel to urban areas or migrate to other parts of the country for skilled employment.

16.2. Survey and Evaluation of the MJF Mid-Day Meals Programme

This study had both a methodological and empirical contribution within child growth research, as the study involved both quantitative and qualitative analysis of a thusfar unevaluated nutritional intervention. The methodological contribution arises from the application of models used in epidemiological and clinical research, within a social and field research context, whilst the empirical contribution arises from the evaluation of the effectiveness of the programme, along with recommendations for improvements, based on the analysis. Whilst the overall results clearly indicate a positive impact of the programme on the growth of children, the analysis also reveals certain areas that require restructuring in order to improve the efficacy and equitability of the programme.

16.2.1. Summary of Results and Recommendations

The broad intention of this essay was to assess the effectiveness of the MJF mid-day meals programme which provided a balanced mid-day meal to all children attending child development centres within certain tea estates. The analysis was carried out in two stages and models were fitted for the weight-for-age, height-for-age and BMI-for-age of children, standardized following WHO guidelines. The first stage used an Intention-to-Treat approach with Instrument Variable modelling to assess whether living in an estate which hosted the mid-day meals programme, was beneficial to the growth of children living within the estate. Results clearly suggested a positive effect of living in a treatment estate, on both the short-run and long-run growth of children living within the estate, irrespective of whether they participated in the programme. However, models fitted on subsamples indicate that the treatment effects are mostly concentrated on children showing above average birthweights. This signalled the possibility that the impacts of access to the programme on improving child growth disproportionately favour those children showing relatively better growth than their peers. This might result in more vulnerable children specifically requiring attention (i.e. those born with lower than average birthweight) benefiting less from access to the programme.

The second-stage analysis looked at the effects of continuous programme attendance on the growth of children. Results again show a clear positive impact of regular attendance on both short-run and long-run growth of children. Subsample models again showed similar patterns to those observed in the ITT models where the impact of regular participation in the programme was seen to be significant only among children showing above average birthweight. This again suggests that children born with less than average birthweights could be missing out on the benefits of the mid-day meals programme. The birth-cohort analysis showed that regular participation in the programme benefitted children born between 2010-2012, compared to the older cohort of children who were part of the programme at the time of its implementations (i.e. children born between 2007-2009). This potentially suggests that the programme has matured well overtime, overcoming some of its initial problems at implementation.

The following are some key recommendations derived from the study which would help in improving the efficacy of the programme.

- Implementing an additional nutritional support programme to target programme participants born with low birthweight. This could help in improving programme outcomes for children born with low birthweights.

- Specifically, targeted growth monitoring of low-birthweight children through child development centres to improve growth outcomes over time.

- Streamlining the programme implementation and practices across different treatment estates to get more uniform and equitable programme outcomes.

16.3. Impacts of Individual and Community Exposure to the Tsunami on Child Growth

The final essay looked at a child growth along a relatively different axes by exploring child growth within communities distrupted or displaced by a natural disaster, focussing on the 2004 Indian Ocean Tsunami. Exploiting the near randomly distribution of the tsunami across the Eastern, Southern and Western coastal communities, the study used a range of different controls to establish the impact of the exposure to the tsunami on the growth of children, two years post the disaster. The significant contribution of this study came from the differentiation between individual (direct) and community (indirect) effects of exposure to the tsunami. Individual exposure effects were considered to arise by a child's own household being fully/partially damaged by the tsunami, while community exposure effects were considered to arise as a result of living in a village impacted by the tsunami. Using the 2006 DHS data, models were fitted for the weight-for-age, height-for-age and BMI-for-age of children living within the Eastern, Southern and Western provinces of Sri Lanka. Ordinary least squares and Heckman's modelling approaches were used to model the data.

16.3.1. Summary of Results and Policy Insights

Results of height-for-age models suggest that, while the individual tsunami exposure was not significant, two years post the event, the community exposure effect showed a significant negative impact on growth. This signalled that adverse impacts of the exposure to the tsunami seem to materialize at the community level, through children living within tsunami-affected GN divisions. Models on subsamples also presented some interesting results where higher adverse impacts of community exposure to the tsunami were observed on children living within median wealth HHs and GN divisions. Children born between 2006-2007 were also observed to be particularly vulnerable. Results broadly suggested weaknesses in the post-tsunami recovery mechanisms which focussed on individually affected people and HHs rather than on affected communities as a whole.

Following are a number of policy recommendations that can be drawn from the study.

- Necessary growth monitoring and intervention mechanisms should be setup within tsunami affected communities, to detect and remedy any growth deficiencies faced by recent and future generations of children born in these areas.

- Health and nutrition interventions targeting teenagers and adolescents living within tsunami affected communities, to address and possibly remedy negative growth impacts faced by them in their early childhood.

- An extensive restructuring of the national level disaster management mechanism, to incorporate community recovery and rehabilitation in to the disaster management frameworks. This would address limitations of the existing disaster recovery mechanism which focuses primarily on individual rehabilitation as opposed to community rehabilitation. Necessary adjustments to national, provincial and local level disaster management procedures, to enable and support recovery both at individual and community levels, post natural disasters.

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Appendix E1

Table E1-1: OLS and RIF Regression Decomposition of Rural-Estate Height-for-age Differential (2006) - Transformed Coefficient Estimates for Categorical Variables

2006		Rural-Estate Height-for-age Differential (2006)							
		OLS		Q10		Q50		Q90	
		Rural	Estate	Rural	Estate	Rural	Estate	Rural	Estate
Birthweight	Low	-0.42**	-0.851**	-0.419**	-0.721**	-0.367**	-0.155	-0.361*	-1.472
		(0.058)	(0.227)	(0.111)	(0.236)	(0.074)	(0.196)	(0.157)	(1.033)
	Normal	0.063	-0.32	0.203*	0.121	0.094	0.36*	0.025	-1.255
		(0.051)	(0.217)	(0.091)	(0.195)	(0.068)	(0.164)	(0.154)	(1.031)
	High	0.357**	1.171**	0.216	0.601	0.273*	-0.204	0.336	2.727
		(0.096)	(0.42)	(0.172)	(0.375)	(0.131)	(0.322)	(0.301)	(2.05)
Gender	Male	-0.017	-0.027	-0.075*	-0.239**	0.002	-0.089	0.041	0.085
		(0.018)	(0.064)	(0.03)	(0.089)	(0.021)	(0.077)	(0.035)	(0.12)
	Female	0.017	0.027	0.075*	0.239**	-0.002	0.089	-0.041	-0.085
		(0.018)	(0.064)	(0.03)	(0.089)	(0.021)	(0.077)	(0.035)	(0.12)
Birth supervision	Sup_HealthP	0.281+	-0.099	-0.425+	0.003	0.345+	-0.075	0.334**	-0.184
		(0.165)	(0.123)	(0.225)	(0.237)	(0.194)	(0.217)	(0.091)	(0.278)
	Sup_Non HealthP	-0.222	0.197	-0.074	-0.007	-0.09	0.151	-0.118	0.368
		(0.278)	(0.245)	(0.435)	(0.474)	(0.267)	(0.433)	(0.153)	(0.557)
Mother edu.	No edu	-0.544**	-0.233**	0.866**	-0.079	-0.701**	-0.146	-0.594**	-0.609**
		(0.092)	(0.084)	(0.152)	(0.142)	(0.094)	(0.125)	(0.165)	(0.158)
	Primary	0.214**	-0.233**	-0.197	-0.079	0.242**	-0.146	0.133	-0.609**
		(0.062)	(0.084)	(0.12)	(0.142)	(0.069)	(0.125)	(0.1)	(0.158)
	Secondary	0.284**	0.346*	-0.156+	-0.187	0.325**	0.58**	0.223*	0.837**
		(0.048)	(0.145)	(0.086)	(0.237)	(0.05)	(0.208)	(0.086)	(0.285)
	GCE(O/L)	0.321**	-0.233**	-0.165	-0.079	0.387**	-0.146	0.277*	-0.609**
		(0.062)	(0.084)	(0.106)	(0.142)	(0.067)	(0.125)	(0.117)	(0.158)
	GCE(A/L)	0.378**	0.139	-0.193+	-0.132	0.395**	-0.355	0.572**	0.878
		(0.075)	(0.281)	(0.114)	(0.252)	(0.075)	(0.343)	(0.137)	(0.585)
	Degree or above	-0.544**	-0.233**	0.866**	-0.079	-0.701**	-0.146	-0.594**	-0.609**
		(0.092)	(0.084)	(0.152)	(0.142)	(0.094)	(0.125)	(0.165)	(0.158)
	D/K	-0.11	0.448*	-1.021**	0.633*	0.052	0.361	-0.017	0.722+
		(0.1)	(0.19)	(0.282)	(0.309)	(0.113)	(0.298)	(0.147)	(0.425)

Table E1-1 *ctd*.

		Rural-Estate Height-for-age Differential (2006)							
		OLS		Q10		Q50		Q90	
		Rural	Estate	Rural	Estate	Rural	Estate	Rural	Estate
Mother emp.	Not employed	0.042	0.188+	0.028	0.169	0.074*	0.123	0.067	0.268
		(0.03)	(0.112)	(0.053)	(0.121)	(0.035)	(0.142)	(0.053)	(0.295)
	Working_Unskilled	-0.063	-0.24*	-0.068	-0.343**	-0.083	-0.123	-0.091	-0.243
		(0.045)	(0.111)	(0.085)	(0.125)	(0.054)	(0.153)	(0.067)	(0.27)
	Working_Skilled	0.021	0.052	0.041	0.174	0.01	-0.0005	0.024	-0.025
		(0.035)	(0.157)	(0.061)	(0.178)	(0.043)	(0.204)	(0.067)	(0.421)
WealthQ	Lowest	-0.048	-0.137	-0.006	0.194	-0.083	-0.173	0.007	-0.253
		(0.048)	(0.197)	(0.087)	(0.235)	(0.052)	(0.195)	(0.085)	(0.327)
	Second	-0.025	-0.035	0.056	0.243	0.014	-0.099	-0.164*	-0.313
		(0.036)	(0.14)	(0.063)	(0.186)	(0.044)	(0.179)	(0.064)	(0.3)
	Middle	-0.045	-0.039	-0.078	-0.041	-0.065	-0.266	-0.112	0.236
		(0.034)	(0.154)	(0.062)	(0.218)	(0.042)	(0.21)	(0.068)	(0.369)
	Fourth	-0.013	0.084	-0.07	-0.249	0.012	0.175	-0.06	0.093
		(0.037)	(0.251)	(0.058)	(0.32)	(0.042)	(0.303)	(0.074)	(0.398)
	Highest	0.131**	0.127	0.1	-0.146	0.122*	0.363	0.329**	0.239
		(0.044)	(0.26)	(0.061)	(0.212)	(0.055)	(0.32)	(0.11)	(0.74)
Ethnicity	Sinhalese	-0.006	0.093	-0.089	-0.162	0.206+	0.388+	-0.212	-0.107
		(0.086)	(0.137)	(0.104)	(0.232)	(0.124)	(0.231)	(0.281)	(0.235)
	SL Tamil	-0.21	-0.087	-0.334+	-0.205	0.041	-0.349	-0.318	0.262
		(0.137)	(0.16)	(0.192)	(0.243)	(0.158)	(0.261)	(0.335)	(0.314)
	Indian Tamil	-0.17	-0.031	-0.196	0.114	-0.181	-0.374	-0.025	0.264
		(0.208)	(0.148)	(0.448)	(0.196)	(0.222)	(0.241)	(0.378)	(0.309)
	SL Moor	-0.217*	-0.763*	-0.464**	-0.762	0.007	-0.919	-0.417	-0.203
		(0.095)	(0.359)	(0.126)	(0.638)	(0.131)	(0.575)	(0.29)	(0.48)
	Malay	0.537*	0.604+	0.244	1.34*	0.612+	0.478	0.466	-0.003
		(0.272)	(0.319)	(0.192)	(0.559)	(0.368)	(0.897)	(0.889)	(0.566)
	Burger	0.039	0.093	0.299+	-0.162	0.176	0.388+	0.88	-0.107
		(0.336)	(0.137)	(0.166)	(0.232)	(0.585)	(0.231)	(1.391)	(0.235)
	Other	0.026	0.093	0.539**	-0.162	-0.861**	0.388+	-0.374	-0.107
		(0.12)	(0.137)	(0.18)	(0.232)	(0.159)	(0.231)	(0.315)	(0.235)
Head gender	Male	0.009	-0.065	0.033	-0.291**	0.011	-0.059	-0.02	-0.027
		(0.024)	(0.089)	(0.038)	(0.094)	(0.027)	(0.117)	(0.049)	(0.188)
	Female	-0.009	0.065	-0.033	0.291**	-0.011	0.059	0.02	0.027
		(0.024)	(0.089)	(0.038)	(0.094)	(0.027)	(0.117)	(0.049)	(0.188)

Table E1-1 *ctd*.

		Rural-Estate Height-for-age Differential (2006)							
		OLS		Q10		Q50		Q90	
		Rural	Estate	Rural	Estate	Rural	Estate	Rural	Estate
Head edu	No edu		-0.086*		0.005		-0.084+		-0.226**
			(0.035)		(0.055)		(0.047)		(0.058)
	Primary		0.519*		-0.03		0.506+		1.357**
			(0.211)		(0.328)		(0.284)		(0.346)
	Secondary		-0.086*		0.005		-0.084+		-0.226**
			(0.035)		(0.055)		(0.047)		(0.058)
	GCE(O/L)		-0.086*		0.005		-0.084+		-0.226**
			(0.035)		(0.055)		(0.047)		(0.058)
	GCE(A/L)		-0.086*		0.005		-0.084+		-0.226**
			(0.035)		(0.055)		(0.047)		(0.058)
	Degree or above		-0.086*		0.005		-0.084+		-0.226**
			(0.035)		(0.055)		(0.047)		(0.058)
	D/K		-0.086*		0.005		-0.084+		-0.226**
			(0.035)		(0.055)		(0.047)		(0.058)
Improved	Yes	0.021	0.008	0.041	-0.06	0.011	-0.029	0.041	0.108
drinking water		(0.019)	(0.088)	(0.034)	(0.134)	(0.023)	(0.112)	(0.039)	(0.171)
	No	-0.021	-0.008	-0.041	0.06	-0.011	0.029	-0.041	-0.108
		(0.019)	(0.088)	(0.034)	(0.134)	(0.023)	(0.112)	(0.039)	(0.171)
Hand washing	After toilet_Yes	-0.034	0.028	0.165	-0.064	-0.037	-0.055	-0.072	0.269
		(0.052)	(0.122)	(0.105)	(0.167)	(0.06)	(0.17)	(0.103)	(0.289)
	After toilet_No	0.034	-0.028	-0.165	0.064	0.037	0.055	0.072	-0.269
		(0.052)	(0.122)	(0.105)	(0.167)	(0.06)	(0.17)	(0.103)	(0.289)
	Before	0.014	0.105	-0.034	0.201*	0.028	0.045	-0.002	0.03
	cooking_Yes	(0.019)	(0.071)	(0.032)	(0.095)	(0.023)	(0.085)	(0.038)	(0.125)
	Before cooking_No	-0.014	-0.105	0.034	-0.201*	-0.028	-0.045	0.002	-0.03
		(0.019)	(0.071)	(0.032)	(0.095)	(0.023)	(0.085)	(0.038)	(0.125)
_cons		-9.151**	-4.462*	-9.596**	-7.066*	-9.74**	-6.667**	-7.796**	-1.076
		(0.721)	(2.259)	(1.011)	(2.707)	(0.742)	(2.539)	(1.34)	(3.968)

Table E1-2: OLS and RIF Regression Decomposition of Rural-Estate Height-for-age Differential (2016) - Transformed Coefficient Estimates for Categorical Variables

2016		Rural-Estate Height-for-age Differential (2016)							
		OLS		Q10		Q50		Q90	
		Rural	Estate	Rural	Estate	Rural	Estate	Rural	Estate
Birthweight	Low	-0.529**	0.244	-0.438**	-1.182*	-0.552**	0.317	-0.824**	0.389
		(0.073)	(0.278)	(0.1)	(0.472)	(0.055)	(0.249)	(0.157)	(0.594)
	Normal	0.095	0.507+	0.308**	-0.499	0.043	0.547*	-0.29+	0.696
		(0.069)	(0.271)	(0.081)	(0.458)	(0.048)	(0.235)	(0.154)	(0.574)
	High	0.434**	-0.751	0.13	1.68+	0.509**	-0.864+	1.113**	-1.084
		(0.132)	(0.51)	(0.143)	(0.856)	(0.088)	(0.448)	(0.3)	(1.09)
Gender	Male	-0.021	-0.025	-0.082**	-0.052	-0.025	0.006	-0.009	-0.022
		(0.019)	(0.088)	(0.03)	(0.135)	(0.02)	(0.081)	(0.039)	(0.181)
	Female	0.021	0.025	0.082**	0.052	0.025	-0.006	0.009	0.022
		(0.019)	(0.088)	(0.03)	(0.135)	(0.02)	(0.081)	(0.039)	(0.181)
Birth supervision	Sup_HealthP	-0.015	-0.239	-0.255	-0.333+	-0.072	-0.366	-0.365	-0.55
		(0.119)	(0.24)	(0.158)	(0.175)	(0.2)	(0.372)	(0.367)	(0.794)
	Sup_Non HealthP	0.293	0.478	-0.209	0.667+	0.297	0.731	1.441*	1.1
		(0.215)	(0.48)	(0.303)	(0.35)	(0.258)	(0.745)	(0.722)	(1.588)
Mother edu.	No edu	0.154	0.021	-0.496	-0.822	0.272	0.104	0.639	0.171
		(0.193)	(0.331)	(0.439)	(0.807)	(0.176)	(0.315)	(0.393)	(0.678)
	Primary	-0.124	0.258	0.343	0.596	-0.175	0.301	-0.38+	-0.072
		(0.107)	(0.229)	(0.236)	(0.425)	(0.111)	(0.222)	(0.197)	(0.483)
	Secondary	-0.109	-0.308	0.041	0.443	-0.169*	-0.122	-0.258	-0.112
		(0.085)	(0.238)	(0.185)	(0.394)	(0.08)	(0.203)	(0.171)	(0.516)
	GCE(O/L)	-0.044	-0.563*	0.183	0.714+	-0.128	-0.326	-0.207	-0.811
		(0.09)	(0.26)	(0.187)	(0.43)	(0.085)	(0.25)	(0.183)	(0.595)
	GCE(A/L)	-0.002	-0.032	0.163	0.874*	-0.068	0.23	-0.164	0.416
		(0.091)	(0.248)	(0.189)	(0.377)	(0.087)	(0.272)	(0.188)	(0.625)
	Degree or above	-0.029	0.604	0.262	-0.983	-0.003	-0.289	-0.27	0.238
		(0.115)	(0.818)	(0.218)	(1.264)	(0.117)	(0.792)	(0.264)	(1.953)
	D/K	0.154	0.021	-0.496	-0.822	0.272	0.104	0.639	0.171
		(0.193)	(0.331)	(0.439)	(0.807)	(0.176)	(0.315)	(0.393)	(0.678)

Table E1-2 *ctd*.

		Rural-Estate Height-for-age Differential (2016)							
		OLS		Q10		Q50		Q90	
		Rural	Estate	Rural	Estate	Rural	Estate	Rural	Estate
Mother emp.	Not employed	-0.006	0.06	0.033	0.131	-0.012	0.105	0.088	0.179
		(0.035)	(0.136)	(0.057)	(0.202)	(0.038)	(0.112)	(0.066)	(0.267)
	Working_Unskilled	-0.074	-0.045	-0.069	-0.12	-0.059	-0.216	-0.26**	-0.106
		(0.054)	(0.194)	(0.088)	(0.318)	(0.059)	(0.146)	(0.096)	(0.345)
	Working_Skilled	0.081+	-0.015	0.036	-0.011	0.071	0.111	0.172+	-0.073
		(0.045)	(0.196)	(0.07)	(0.343)	(0.05)	(0.165)	(0.095)	(0.376)
WealthQ	Lowest	-0.12**	-0.27	-0.156*	0.238	-0.122*	-0.183	-0.147+	-0.179
		(0.042)	(0.167)	(0.079)	(0.26)	(0.047)	(0.2)	(0.083)	(0.453)
	Second	-0.028	0.153	-0.024	0.269	-0.038	-0.108	-0.036	0.297
		(0.039)	(0.221)	(0.062)	(0.291)	(0.04)	(0.202)	(0.075)	(0.515)
	Middle	0.017	0.129	0.066	0.56+	0.018	0.335	-0.069	-0.798
		(0.038)	(0.242)	(0.056)	(0.3)	(0.04)	(0.257)	(0.078)	(0.796)
	Fourth	0.065	-0.422+	0.085	-0.702	0.103*	-0.429	0.009	1.4
		(0.04)	(0.255)	(0.056)	(0.45)	(0.041)	(0.281)	(0.082)	(0.927)
	Highest	0.065	0.41	0.029	-0.365	0.038	0.384	0.243*	-0.72
		(0.058)	(0.349)	(0.072)	(0.457)	(0.056)	(0.423)	(0.121)	(0.633)
Ethnicity	Sinhalese	0.393**	0.095	0.239	0.096	0.395**	0.29	0.41**	-0.228
		(0.055)	(0.197)	(0.189)	(0.239)	(0.122)	(0.19)	(0.091)	(0.528)
	SL Tamil	0.332**	0.006	-0.043	-0.29	0.447**	0.508**	0.599**	-0.735
		(0.088)	(0.207)	(0.229)	(0.284)	(0.141)	(0.184)	(0.175)	(0.526)
	Indian Tamil	-0.134	0.038	-0.281	0.276	-0.203	0.181	-0.141	-0.929+
		(0.169)	(0.211)	(0.522)	(0.293)	(0.227)	(0.199)	(0.26)	(0.523)
	SL Moor	0.313**	0.071	-0.045	0.6	0.363**	-0.947	0.407**	1.148
		(0.078)	(0.674)	(0.212)	(0.709)	(0.133)	(0.618)	(0.141)	(2.218)
	Malay	-1.091**	0.095	0.4+	0.096	-1.537**	0.29	-1.278**	-0.228
		(0.092)	(0.197)	(0.228)	(0.239)	(0.19)	(0.19)	(0.255)	(0.528)
	Burger	-0.207	-0.399	-0.508	-0.874	0.14	-0.614	-0.407	1.2
		(0.215)	(0.386)	(0.972)	(0.823)	(0.668)	(0.385)	(0.265)	(1.043)
	Other	0.393**	0.095	0.239	0.096	0.395**	0.29	0.41**	-0.228
		(0.055)	(0.197)	(0.189)	(0.239)	(0.122)	(0.19)	(0.091)	(0.528)
Head gender	Male	-0.016	-0.105	-0.038	-0.138	-0.006	-0.066	-0.038	0.1
		(0.024)	(0.114)	(0.036)	(0.175)	(0.026)	(0.091)	(0.052)	(0.208)
	Female	0.016	0.105	0.038	0.138	0.006	0.066	0.038	-0.1
		(0.024)	(0.114)	(0.036)	(0.175)	(0.026)	(0.091)	(0.052)	(0.208)

Table E1-2 *ctd*.

		Rural-Estate Height-for-age Differential (2016)							
		OLS		Q10		Q50		Q90	
		Rural	Estate	Rural	Estate	Rural	Estate	Rural	Estate
Head edu	No edu	-0.094	-0.725**	-0.066	0.134	-0.04	-0.394	-0.154	-0.813+
		(0.115)	(0.255)	(0.195)	(0.394)	(0.112)	(0.242)	(0.211)	(0.485)
	Primary	-0.011	-0.386+	0.001	-0.476	0.015	-0.191	-0.067	0.587
		(0.079)	(0.224)	(0.116)	(0.346)	(0.066)	(0.2)	(0.142)	(0.442)
	Secondary	0.046	0.313+	0.221*	0.292	0.003	-0.116	-0.096	0.578
		(0.066)	(0.172)	(0.098)	(0.271)	(0.056)	(0.147)	(0.124)	(0.366)
	GCE(O/L)	0.004	0.093	0.08	0.255	-0.017	-0.435+	-0.104	-0.141
		(0.077)	(0.233)	(0.11)	(0.305)	(0.067)	(0.236)	(0.147)	(0.552)
	GCE(A/L)	0.091	0.579+	0.287*	0.175	0.079	0.146	-0.29+	0.283
		(0.079)	(0.302)	(0.113)	(0.339)	(0.076)	(0.337)	(0.161)	(0.818)
	Degree or above	0.147	0.852*	0.049	-0.515	0.038	1.383**	0.063	0.319
		(0.143)	(0.35)	(0.19)	(0.612)	(0.127)	(0.448)	(0.317)	(0.761)
	D/K	-0.184	-0.725**	-0.573	0.134	-0.077	-0.394	0.647	-0.813+
		(0.321)	(0.255)	(0.469)	(0.394)	(0.246)	(0.242)	(0.568)	(0.485)
Improved	Yes	0.019	0.165	0.051	-0.035	0.027	0.183+	0.009	-0.106
drinking water		(0.021)	(0.161)	(0.034)	(0.211)	(0.022)	(0.105)	(0.044)	(0.257)
	No	-0.019	-0.165	-0.051	0.035	-0.027	-0.183+	-0.009	0.106
		(0.021)	(0.161)	(0.034)	(0.211)	(0.022)	(0.105)	(0.044)	(0.257)
Hand washing	After toilet_Yes	0.002	-0.041	0.149	0.297	0.026	-0.013	-0.166	0.005
		(0.072)	(0.183)	(0.113)	(0.322)	(0.055)	(0.156)	(0.114)	(0.341)
	After toilet_No	-0.002	0.041	-0.149	-0.297	-0.026	0.013	0.166	-0.005
		(0.072)	(0.183)	(0.113)	(0.322)	(0.055)	(0.156)	(0.114)	(0.341)
	Before	-0.014	-0.149	-0.01	-0.0003	-0.022	-0.049	0.021	-0.045
	cooking_Yes	(0.022)	(0.118)	(0.035)	(0.153)	(0.024)	(0.097)	(0.046)	(0.212)
	Before cooking_No	0.014	0.149	0.01	0.0003	0.022	0.049	-0.021	0.045
		(0.022)	(0.118)	(0.035)	(0.153)	(0.024)	(0.097)	(0.046)	(0.212)
_cons		-8.46**	-9.929**	-11.48**	-15.795**	-8.542**	-15.593**	-6.793**	0.807
		(0.74)	(3.266)	(0.992)	(3.994)	(0.656)	(2.308)	(1.35)	(5.713)

Table E1-3: OLS and RIF Regression Decomposition of Rural-Estate BMI-for-age Differential (2006) - Transformed Coefficient Estimates for Categorical Variables

2006		BMI-for-age (Rural-Estate Differential)							
		OLS		Q10		Q50		Q90	
		Rural	Estate	Rural	Estate	Rural	Estate	Rural	Estate
Birthweight	Low	-0.366**	-0.923+	-0.447**	-0.692*	-0.357**	-0.166	-0.475**	-1.628
		(0.082)	(0.519)	(0.119)	(0.309)	(0.081)	(0.465)	(0.158)	(1.21)
	Normal	0.069	-0.568	0.279**	-0.154	0.048	0.067	-0.112	-1.295
		(0.077)	(0.515)	(0.104)	(0.283)	(0.076)	(0.456)	(0.154)	(1.208)
	High	0.297*	1.492	0.168	0.846	0.309*	0.099	0.587+	2.923
		(0.151)	(1.023)	(0.198)	(0.531)	(0.146)	(0.905)	(0.304)	(2.399)
Gender	Male	0.007	-0.129+	-0.038	-0.253*	0.01	0.01	0.009	-0.336**
		(0.018)	(0.066)	(0.029)	(0.122)	(0.021)	(0.083)	(0.033)	(0.128)
	Female	-0.007	0.129+	0.038	0.253*	-0.01	-0.01	-0.009	0.336**
		(0.018)	(0.066)	(0.029)	(0.122)	(0.021)	(0.083)	(0.033)	(0.128)
Birth supervision	Sup_HealthP	0.109	0.281+	0.293	0.164	-0.026	0.157	0.249	0.217+
		(0.182)	(0.155)	(0.415)	(0.308)	(0.259)	(0.216)	(0.177)	(0.111)
	Sup_Non HealthP	0.213	-0.563+	0.25	-0.328	0.017	-0.314	0.383	-0.434+
		(0.236)	(0.31)	(0.505)	(0.617)	(0.322)	(0.433)	(0.334)	(0.223)
Mother edu.	No edu	0.282**	0.12	0.208	0.655*	0.747**	0.032	-0.527**	-0.482
		(0.081)	(0.18)	(0.133)	(0.297)	(0.096)	(0.215)	(0.153)	(0.295)
	Primary	-0.302**	-0.189	-0.32*	-1.388**	-0.636**	-0.024	0.394**	0.616
		(0.077)	(0.256)	(0.126)	(0.438)	(0.093)	(0.312)	(0.137)	(0.428)
	Secondary	-0.25**	-0.162	-0.271*	-0.796+	-0.597**	-0.045	0.446**	0.609
		(0.072)	(0.244)	(0.114)	(0.418)	(0.08)	(0.291)	(0.135)	(0.403)
	GCE(O/L)	-0.182*	0.12	-0.104	0.655*	-0.54**	0.032	0.345*	-0.482
		(0.082)	(0.18)	(0.133)	(0.297)	(0.093)	(0.215)	(0.151)	(0.295)
	GCE(A/L)	0.282**	0.12	0.208	0.655*	0.747**	0.032	-0.527**	-0.482
		(0.081)	(0.18)	(0.133)	(0.297)	(0.096)	(0.215)	(0.153)	(0.295)
	Degree or above	0.282**	0.12	0.208	0.655*	0.747**	0.032	-0.527**	-0.482
		(0.081)	(0.18)	(0.133)	(0.297)	(0.096)	(0.215)	(0.153)	(0.295)
	D/K	-0.111	-0.13	0.072	-0.436	-0.469**	-0.061	0.396+	0.702
		(0.124)	(0.321)	(0.175)	(0.461)	(0.146)	(0.373)	(0.207)	(0.604)

Table E1-3 *ctd.*

		BMI-for-age (Rural-Estate Differential)							
		OLS		Q10		Q50		Q90	
		Rural	Estate	Rural	Estate	Rural	Estate	Rural	Estate
Mother emp.	Not employed	-0.014	-0.16	-0.091+	0.378	0.016	-0.218	0.01	-0.474+
		(0.03)	(0.159)	(0.047)	(0.308)	(0.036)	(0.171)	(0.053)	(0.286)
	Working_Unskilled	0.015	0.072	0.102	0.544+	0.011	0.203	0.037	-0.299
		(0.044)	(0.156)	(0.066)	(0.327)	(0.055)	(0.169)	(0.078)	(0.294)
	Working_Skilled	-0.001	0.088	-0.011	-0.922+	-0.027	0.015	-0.047	0.773
		(0.037)	(0.261)	(0.055)	(0.546)	(0.045)	(0.26)	(0.065)	(0.498)
WealthQ	Lowest	-0.045	0.029	-0.001	0.372	-0.008	-0.062	-0.092	0.134
		(0.046)	(0.167)	(0.074)	(0.273)	(0.054)	(0.199)	(0.078)	(0.405)
	Second	0.016	-0.249+	0.062	0.191	-0.008	-0.275	-0.055	-0.408
		(0.036)	(0.135)	(0.059)	(0.231)	(0.044)	(0.179)	(0.066)	(0.331)
	Middle	-0.01	-0.344+	-0.039	-0.406	0.045	-0.332	-0.03	-0.412
		(0.037)	(0.185)	(0.06)	(0.363)	(0.043)	(0.211)	(0.066)	(0.356)
	Fourth	0.039	0.22	-0.011	0.253	0.047	0.421+	0.107	-0.124
		(0.037)	(0.238)	(0.056)	(0.31)	(0.042)	(0.255)	(0.07)	(0.563)
	Highest	0.0001	0.345	-0.011	-0.41	-0.076	0.248	0.07	0.81
		(0.05)	(0.287)	(0.07)	(0.566)	(0.057)	(0.373)	(0.09)	(0.816)
Ethnicity	Sinhalese	0.015	-0.328+	-0.422**	-0.166	0.036	-0.283	-0.039	-0.521
		(0.068)	(0.172)	(0.08)	(0.244)	(0.116)	(0.258)	(0.168)	(0.442)
	SL Tamil	0.185+	-0.118	-0.086	-0.029	0.213	-0.244	0.106	0.065
		(0.109)	(0.213)	(0.152)	(0.303)	(0.15)	(0.295)	(0.233)	(0.495)
	Indian Tamil	0.446*	-0.091	-0.147	-0.096	0.446+	-0.214	0.425	0.067
		(0.215)	(0.184)	(0.252)	(0.34)	(0.253)	(0.263)	(0.411)	(0.407)
	SL Moor	0.231**	0.989+	0.037	-0.003	0.23+	1.022+	0.242	2.681
		(0.077)	(0.518)	(0.092)	(0.595)	(0.124)	(0.593)	(0.181)	(1.81)
	Malay	0.537*	0.204	0.526*	0.627	0.293	0.285	0.546	-1.251
		(0.219)	(0.56)	(0.206)	(0.624)	(0.353)	(1.044)	(0.823)	(0.847)
	Burger	-0.229	-0.328+	-0.08	-0.166	-0.004	-0.283	-0.866**	-0.521
		(0.188)	(0.172)	(0.145)	(0.244)	(0.52)	(0.258)	(0.203)	(0.442)
	Other	-1.183**	-0.328+	0.172	-0.166	-1.213**	-0.283	-0.415+	-0.521
		(0.107)	(0.172)	(0.161)	(0.244)	(0.155)	(0.258)	(0.216)	(0.442)
Head gender	Male	-0.032	-0.027	-0.006	0.169	-0.037	-0.026	-0.055	-0.312
		(0.024)	(0.136)	(0.04)	(0.227)	(0.028)	(0.148)	(0.044)	(0.245)
	Female	0.032	0.027	0.006	-0.169	0.037	0.026	0.055	0.312
		(0.024)	(0.136)	(0.04)	(0.227)	(0.028)	(0.148)	(0.044)	(0.245)

Table E1-3 ctd.

		BMI-for-age (Rural-Estate Differential)							
		OLS		Q10		Q50		Q90	
		Rural	Estate	Rural	Estate	Rural	Estate	Rural	Estate
Head edu	No edu	0.054*	0.059	0.045	0.232+	0.168**	0.085	-0.157**	-0.137
		(0.023)	(0.067)	(0.036)	(0.122)	(0.026)	(0.08)	(0.043)	(0.102)
	Primary	0.054*	0.059	0.045	0.232+	0.168**	0.085	-0.157**	-0.137
		(0.023)	(0.067)	(0.036)	(0.122)	(0.026)	(0.08)	(0.043)	(0.102)
	Secondary	0.054*	0.059	0.045	0.232+	0.168**	0.085	-0.157**	-0.137
		(0.023)	(0.067)	(0.036)	(0.122)	(0.026)	(0.08)	(0.043)	(0.102)
	GCE(O/L)	0.054*	-0.353	0.045	-1.39+	0.168**	-0.509	-0.157**	0.823
		(0.023)	(0.402)	(0.036)	(0.734)	(0.026)	(0.482)	(0.043)	(0.613)
	GCE(A/L)	-0.325*	0.059	-0.272	0.232+	-1.01**	0.085	0.941**	-0.137
		(0.138)	(0.067)	(0.217)	(0.122)	(0.156)	(0.08)	(0.261)	(0.102)
	Degree or above	0.054*	0.059	0.045	0.232+	0.168**	0.085	-0.157**	-0.137
		(0.023)	(0.067)	(0.036)	(0.122)	(0.026)	(0.08)	(0.043)	(0.102)
	D/K	0.054*	0.059	0.045	0.232+	0.168**	0.085	-0.157**	-0.137
		(0.023)	(0.067)	(0.036)	(0.122)	(0.026)	(0.08)	(0.043)	(0.102)
Improved drinking water	Yes	-0.024	-0.092	-0.007	-0.235	-0.008	-0.078	-0.044	-0.092
		(0.021)	(0.089)	(0.032)	(0.165)	(0.024)	(0.128)	(0.037)	(0.158)
	No	0.024	0.092	0.007	0.235	0.008	0.078	0.044	0.092
		(0.021)	(0.089)	(0.032)	(0.165)	(0.024)	(0.128)	(0.037)	(0.158)
Hand washing	After toilet_Yes	-0.067	-0.192+	-0.132+	-0.202	-0.065	-0.135	-0.137	0.08
		(0.052)	(0.116)	(0.07)	(0.153)	(0.064)	(0.164)	(0.106)	(0.314)
	After toilet_No	0.067	0.192+	0.132+	0.202	0.065	0.135	0.137	-0.08
		(0.052)	(0.116)	(0.07)	(0.153)	(0.064)	(0.164)	(0.106)	(0.314)
	Before cooking_Yes	-0.005	-0.077	-0.035	0.038	0.003	-0.084	-0.006	-0.083
		(0.02)	(0.077)	(0.032)	(0.133)	(0.023)	(0.091)	(0.035)	(0.156)
	Before cooking_No	0.005	0.077	0.035	-0.038	-0.003	0.084	0.006	0.083
		(0.02)	(0.077)	(0.032)	(0.133)	(0.023)	(0.091)	(0.035)	(0.156)
_cons		-1.787**	-1.033	-2.18*	-3.171	-1.566*	-4.665+	-1.676	3.804
		(0.624)	(2.064)	(0.976)	(3.326)	(0.715)	(2.52)	(1.164)	(3.737)

Appendix E2

Table E2-1: Description of variables

Variable	Status	Description
Panel variables		
Child_ID	assigned	
Agemon	collected	
Outcome variables		
wei	collected	Weight (kg)
hei	collected	Height (cm)
bmi	derived	
WAZ	derived	Standardized weight-for-age (according to WHO)
HAZ	derived	Standardized height-for-age (according to WHO)
BMIZ	derived	Standardized BMI-for-age (according to WHO)
Treatment variables		
Trt1	collected	Is the MJF mid-day meals programme implemented in the estate the child lives in?
Trt2	derived	Number of days the child attends the CDC in each month (corrected for absent runs)
Tot_Trt2	derived	The total number of days attending the CDC up to the current month
L1_Trt2- L6_Trt2	derived	Lag1-lag6 values of *Trt2*
Tot_Trt2_L7	derived	Total number of days attending the CDC up to and including 7^{th} lag
Other controls		
Estate	collected	Estate ID
Division	collected	Division ID
Gender	collected	Gender of child
Birthweight	collected	BW in kg
firsttime	derived	The month at which the first weight record appears within the survey period
firstzweight	derived	Standardised value of the first weight on record (in-sample)
firstzheight	derived	Standardised value of the first height on record (in-sample)
zbirthweight	derived	Standardized value of birthweight
$propmeasure_{it}$	derived	Proportion of measured instances of weight up to the current month
S_{it}	derived	Continuous run of absence over 5 days of more in the current month
CDC_adj	derived	Did the child attend CDC at least once in the survey period
CDC_cat	collected	The Status of the CDC (old, upgraded, new)

Table E2-2: Stage 1 IV model: main-effects model results

		G2SLS RE (IV) REG		
		$WAZ_{i,t-1}$	$HAZ_{i,t-1}$	$BMIZ_{i,t-1}$
Treatment var				
Trt1		0.184**	0.102**	0.042
		(0.011)	(0.037)	(0.033)
Instrument variables				
zbirthweight		0.061**		0.107**
		(0.005)		(0.013)
firstzheight			0.726**	-0.458**
			(0.021)	(0.016)
propmeasure $_{t-1}$		0.313+	0.435**	0.841
		(0.172)	(0.137)	(0.559)
Child-level				
Age		-0.039**	0.002	-0.038**
		(0.001)	(0.003)	(0.005)
Age_sq		0.0004**	0.0002**	0.0001*
		(0.00002)	(0.0001)	(0.0001)
Gender	Male	-0.104**	0.015	-0.093**
		(0.01)	(0.028)	(0.024)
firstzweight		0.664**	0.201**	0.624**
		(0.005)	(0.017)	(0.014)
zbirthweight			-0.057**	
			(0.013)	
propmeasure		-0.363+	-0.048	-1.774**
		(0.187)	(0.143)	(0.609)
Ethnicity	Sinhalese	-0.015	0.195**	-0.381**
		(0.017)	(0.057)	(0.04)
CDC-level				
CDC_cat	New	-0.021	0.129**	-0.218**
		(0.015)	(0.04)	(0.034)
	Upgraded	0.006	0.041	-0.114**
		(0.014)	(0.039)	(0.032)
_cons		-1.001**	-2.812**	1.408**
		(0.045)	(0.094)	(0.119)
N		17214	10309	7780

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. Birthweight is not an instrument in the $HAZ_{i,t-1}$ model.

Table E2-3: ITT GLS regression model results- by *Age*

		GLS RE REG								
		0-6 mon			*6-36 mon*			*>36 mon*		
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
Treatment var										
Trt1		0.288**	-0.348+	0.102	0.061**	0.038*	-0.014	0.027*	0.031**	-0.011
		(0.046)	(0.21)	(0.186)	(0.013)	(0.017)	(0.031)	(0.011)	(0.011)	(0.026)
Instrumented var										
$WAZ_{i,t-1}$/ $HAZ_{i,t-1}$/		0.745**	0.881**	0.863**	0.781**	0.904**	0.765**	0.814**	0.952**	0.852**
$BMIZ_{i,t-1}$		(0.026)	(0.026)	(0.05)	(0.01)	(0.013)	(0.015)	(0.016)	(0.006)	(0.014)
Child-level										
Age		0.056	0.284	-0.551	-0.011**	0.005	-0.013	-0.003	-0.006	-0.009
		(0.075)	(0.238)	(0.357)	(0.002)	(0.005)	(0.008)	(0.008)	(0.01)	(0.022)
Age_sq		-0.004	-0.008	0.051	0.0002**	-0.00003	0.0001	0.00004	0.0001	0.0001
		(0.009)	(0.027)	(0.044)	(0.00004)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0002)
Gender		-0.071*	0.025	0.184	-0.018	-0.003	-0.014	0.023**	0.002	0.02
		(0.032)	(0.136)	(0.133)	(0.012)	(0.015)	(0.025)	(0.008)	(0.009)	(0.019)
firstzweight		0.071*	0.066	-0.204**	0.117**	0.041**	0.085**	0.115**	0.026**	0.065**
		(0.031)	(0.073)	(0.068)	(0.009)	(0.009)	(0.013)	(0.013)	(0.005)	(0.011)
propmeasure		0.483*	0.792+	-5.698**	0.08*	0.155**	-0.146	0.001	0.021	-0.05
		(0.208)	(0.433)	(0.487)	(0.039)	(0.052)	(0.102)	(0.033)	(0.031)	(0.077)
Ethnicity	Sinhalese	0.108+	-0.335*	0.355+	-0.009	0.03	-0.096*	-0.01	-0.013	-0.061+
		(0.061)	(0.169)	(0.199)	(0.023)	(0.023)	(0.045)	(0.013)	(0.013)	(0.032)
zbirthweight			-0.153			-0.004			-0.007	
			(0.129)			(0.009)			(0.004)	

Table E2-3 *ctd*.

		GLS RE REG								
			0-6 mon			*6-36 mon*			*>36 mon*	
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
CDC-level										
CDC_cat	*New*	-0.057	-0.163	0.382*	0.003	0.013	-0.08*	-0.008	0.009	-0.037
		(0.044)	(0.179)	(0.159)	(0.017)	(0.02)	(0.036)	(0.016)	(0.012)	(0.028)
	Upgraded	-0.136**	0.174	-0.295*	0.015	0.037	-0.084*	0.006	-0.023+	0.013
		(0.04)	(0.161)	(0.141)	(0.016)	(0.023)	(0.036)	(0.015)	(0.012)	(0.025)
_cons		-1.095**	-2.455**	7.225**	-0.349**	-0.458**	0.337*	-0.307+	0.02	0.131
		(0.246)	(0.672)	(0.583)	(0.05)	(0.074)	(0.134)	(0.184)	(0.232)	(0.502)
N		1422	94	86	10065	6306	4828	5727	3909	2866
σ_u		0	0.286	0	0.1	0.176	0.253	0.042	0.08	0.099
σ_e		0.456	0.380	0.712	0.305	0.263	0.518	0.224	0.103	0.395
ρ		0	0.362	0	0.098	0.31	0.192	0.034	0.375	0.06

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1.

Table E2-4: ITT GLS regression model results- by *Birth Cohort*

		GLS RE REG								
		2007-2009			*2010-2012*			*2013-2015*		
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
Treatment var										
Trt1		0.021	0.067**	-0.057	0.036**	0.064**	-0.031	0.231**	-0.031	0.191**
		(0.013)	(0.021)	(0.04)	(0.011)	(0.018)	(0.023)	(0.041)	(0.051)	(0.055)
Instrumented var										
$WAZ_{i,t-1}$/ $HAZ_{i,t-1}$/		0.793**	0.933**	0.831**	0.836**	0.909**	0.827**	0.699**	0.889**	0.766**
$BMIZ_{i,t-1}$		(0.035)	(0.017)	(0.02)	(0.01)	(0.012)	(0.011)	(0.016)	(0.017)	(0.033)
Child-level										
Age		0.006	0.001	-0.001	-0.002	0.005*	-0.013**	0.003	0.049*	-0.021
		(0.006)	(0.01)	(0.016)	(0.001)	(0.002)	(0.003)	(0.005)	(0.02)	(0.028)
Age_sq		-0.0001	0.000004	-0.00003	0.00003+	-0.0001	0.0001**	-0.0002	-0.001+	-0.0001
		(0.0001)	(0.0001)	(0.0002)	(0.00002)	(0.00003)	(0.0001)	(0.0002)	(0.001)	(0.001)
Gender		0.014	0.017	0.009	0.006	0.0002	0.006	-0.074*	-0.024	-0.03
		(0.012)	(0.014)	(0.027)	(0.009)	(0.014)	(0.019)	(0.03)	(0.048)	(0.054)
firstzweight		0.145**	0.05**	0.05**	0.084**	0.036**	0.074**	0.145**	0.011	0.055+
		(0.028)	(0.014)	(0.016)	(0.009)	(0.008)	(0.01)	(0.022)	(0.026)	(0.029)
propmeasure		0.061	0.096**	-0.095	0.043	0.138**	-0.144+	0.154	0.041	-0.308
		(0.042)	(0.031)	(0.109)	(0.033)	(0.052)	(0.077)	(0.098)	(0.262)	(0.261)
Ethnicity	Sinhalese	-0.056**	-0.017	-0.069+	-0.004	0.038	-0.08*	0.139*	-0.055	0.23*
		(0.019)	(0.019)	(0.041)	(0.018)	(0.026)	(0.036)	(0.061)	(0.06)	(0.114)
zbirthweight			-0.016*			-0.01			0.037	
			(0.008)			(0.007)			(0.043)	

Table E2-4 *ctd*.

		GLS RE REG								
			2007-2009			*2010-2012*			*2013-2015*	
		WAZ	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*	*WAZ*	*HAZ*	*BMIZ*
CDC-level										
CDC_cat	*New*	0.016	-0.022	-0.03	0.02	0.014	-0.056*	-0.05	-0.05	-0.068
		(0.041)	(0.041)	(0.064)	(0.014)	(0.019)	(0.028)	(0.04)	(0.046)	(0.066)
	Upgraded	0.022	-0.055	0.022	0.017	0.032+	-0.042	-0.046	0.028	-0.027
		(0.041)	(0.043)	(0.065)	(0.014)	(0.019)	(0.025)	(0.032)	(0.054)	(0.063)
_cons		-0.62**	-0.238	0.015	-0.35**	-0.449**	0.296**	-0.676**	-0.758**	0.484
		(0.16)	(0.245)	(0.404)	(0.049)	(0.079)	(0.106)	(0.113)	(0.243)	(0.318)
N		2468	1878	1282	11192	7562	5835	3554	869	663
σ_u		0	0.070	0.083	0.036	0.175	0	0.122	0.159	0
σ_e		0.234	0.098	0.420	0.289	0.230	0.820	0.391	0.337	0.594
ρ		0	0.336	0.038	0.015	0.366	0	0.089	0.182	0

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1.

Table E2-5: GEE Models with IPTW- by *Birth Cohort 2013-2015*

		GEE MODELS 2013-2015					
		WAZ		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var							
Trt2		0.002		0.001		-0.003	
		(0.008)		(0.009)		(0.013)	
Trt2_tot			0.001		0.001		0.0002
			(0.001)		(0.002)		(0.002)
Child-level							
Age		0.051	0.044	-0.328**	-0.335**	0.221**	0.221**
		(0.099)	(0.093)	(0.056)	(0.064)	(0.08)	(0.08)
Age_sq		-0.002	-0.002	0.008**	0.008**	-0.006*	-0.006*
		(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
Gender		-1.064**	-1.073**	-0.602**	-0.577**	0.219	0.221
		(0.272)	(0.277)	(0.215)	(0.215)	(0.334)	(0.299)
zbirthweight		0.551+	0.558+	0.19	0.196	-0.129	-0.117
		(0.311)	(0.307)	(0.294)	(0.299)	(0.374)	(0.4)
firstzweight		0.027	0.014	0.142	0.143	0.474**	0.471**
		(0.156)	(0.163)	(0.192)	(0.194)	(0.153)	(0.154)
firstzheight				1.049**	1.054**		
				(0.099)	(0.102)		
propmeasure		0.371	0.361	-2.885*	-2.847*	2.283+	2.292+
		(0.549)	(0.57)	(1.248)	(1.231)	(1.164)	(1.179)
S_{it}		-0.112+	-0.109*	-0.045	-0.047	0.025	0.044
		(0.063)	(0.051)	(0.108)	(0.114)	(0.124)	(0.133)
Ethnicity	Sinhalese	-0.396	-0.419	0.245	0.167	0.182	0.167
		(0.316)	(0.332)	(0.296)	(0.364)	(0.277)	(0.264)

Table E2-5 *ctd.*

		GEE MODELS 2013-2015					
		WAZ		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
CDC-level							
CDC_cat	New	0.322	0.377	0.354	0.43	-2.192**	-2.169**
		(0.296)	(0.327)	(0.402)	(0.522)	(0.715)	(0.674)
	Upgraded	0.064	0.09	0.401	0.424	-0.816	-0.811
		(0.22)	(0.223)	(0.306)	(0.338)	(0.662)	(0.633)
Estate	Holyrood	0.457+	0.399	-0.504	-0.558	1.635*	1.615*
		(0.244)	(0.253)	(0.342)	(0.406)	(0.694)	(0.649)
_cons		-1.683	-1.608	3.383**	3.392**	-3.989**	-4.04**
		(1.168)	(1.063)	(1.256)	(1.214)	(1.445)	(1.463)
N		975	975	309	309	292	292

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *CDC_adj* omitted due to multicollinearity. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

Table E2-6: Random Effects Models for *Trt2*- Overall sample

		RE MODELS					
		WAZ		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var							
Trt2		0.003+		0.004		-0.002	
		(0.001)		(0.003)		(0.003)	
Trt2_tot			0.0002		-0.001		0.001+
			(0.0002)		(0.001)		(0.001)
Child-level							
Age		-0.031**	-0.034**	0.026*	0.032*	-0.046**	-0.057**
		(0.004)	(0.004)	(0.012)	(0.013)	(0.012)	(0.014)
Age_sq		0.0004**	0.0004**	-0.0002	-0.0001	0.0004*	0.0003*
		(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Gender	Male	-0.166**	-0.167**	0.026	0.029	-0.182+	-0.186+
		(0.061)	(0.061)	(0.081)	(0.081)	(0.107)	(0.105)
zbirthweight		0.048*	0.045+	0.01	0.016	0.036	0.025
		(0.024)	(0.024)	(0.037)	(0.037)	(0.05)	(0.048)
firstzweight		0.614**	0.621**	0.155**	0.133**	0.404**	0.441**
		(0.029)	(0.029)	(0.043)	(0.045)	(0.05)	(0.051)
firstzheight				0.835**	0.835**		
				(0.063)	(0.064)		
propmeasure		-0.117	-0.121	-0.381	-0.41+	0.29	0.373
		(0.102)	(0.101)	(0.245)	(0.247)	(0.319)	(0.328)
S_{it}		0.014	0.011	0.046	0.022	0.001	0.027
		(0.018)	(0.016)	(0.037)	(0.036)	(0.048)	(0.046)
Ethnicity	Sinhalese	0.132	0.13	0.156	0.153	-0.129	-0.126
		(0.125)	(0.123)	(0.21)	(0.21)	(0.304)	(0.299)
CDC-level							
CDC_cat	New	-0.097	-0.068	0.009	-0.06	-0.669**	-0.547**
		(0.088)	(0.09)	(0.147)	(0.155)	(0.2)	(0.203)
	Upgraded	0.001	0.025	-0.004	-0.058	-0.303*	-0.205
		(0.074)	(0.076)	(0.094)	(0.099)	(0.144)	(0.149)
Estate	Holyrood	0.056	0.02	-0.051	0.023	0.43*	0.296+
		(0.072)	(0.072)	(0.112)	(0.126)	(0.168)	(0.175)
_cons		-0.939**	-0.856**	-2.331**	-2.356**	0.326	0.415
		(0.142)	(0.141)	(0.329)	(0.338)	(0.39)	(0.395)
N		6189	6189	4064	4064	3483	3483
σ_u		0.548	0.549	0.647	0.649	0.836	0.835
σ_e		0.293	0.293	0.473	0.472	0.576	0.575
ρ		0.778	0.779	0.652	0.653	0.678	0.679

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *CDC_adj* omitted due to multicollinearity. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

Table E2-7: Fixed Effects Models for *Trt2*- Overall sample

	FE MODELS					
	WAZ		*HAZ*		*BMIZ*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var						
Trt2	0.002 (0.001)		0.005 (0.003)		-0.002 (0.003)	
Trt2_tot		0.0001 (0.0002)		-0.001 (0.001)		0.001 (0.001)
Child-level						
Age	-0.031** (0.004)	-0.032** (0.005)	0.026* (0.013)	0.035* (0.017)	-0.044** (0.013)	-0.057** (0.019)
Age_sq	0.0004** (0.0001)	0.0004** (0.0001)	-0.0002 (0.0002)	-0.0001 (0.0002)	0.0004* (0.0002)	0.0003* (0.0002)
propmeasure	-0.106 (0.105)	-0.112 (0.105)	-0.412 (0.271)	-0.422 (0.272)	0.448 (0.361)	0.46 (0.364)
S_{it}	0.013 (0.017)	0.01 (0.016)	0.05 (0.038)	0.019 (0.037)	-0.002 (0.048)	0.027 (0.046)
_cons	-1.216** (0.136)	-1.147** (0.142)	-2.325** (0.358)	-2.433** (0.414)	-0.12 (0.433)	0.094 (0.493)
N	6189	6189	4064	4064	3483	3483
σ_u	0.813	0.814	1.158	1.150	0.983	0.983
σ_e	0.293	0.293	0.473	0.472	0.576	0.575
ρ	0.885	0.885	0.857	0.855	0.744	0.745

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

Table E2-8: Random Effects Models for *Trt2- zbirthweight<0*

		RE MODELS					
		WAZ		*HAZ*		*BMIZ*	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Treatment var							
Trt2		0.004*		-0.001		0.004	
		(0.002)		(0.005)		(0.005)	
Trt2_tot							
			0.0001		0.0002		-0.0003
			(0.0003)		(0.001)		(0.001)
Child-level							
Age		-0.037**	-0.039**	0.027	0.025	-0.051**	-0.048*
		(0.007)	(0.008)	(0.019)	(0.019)	(0.019)	(0.021)
Age_sq		0.001**	0.001**	-0.00002	-0.00003	0.0003	0.0003
		(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Gender	Male	-0.092	-0.088	0.078	0.087	-0.136	-0.15
		(0.088)	(0.089)	(0.13)	(0.135)	(0.161)	(0.153)
zbirthweight		-0.033	-0.038	-0.001	-0.007	-0.006	0.005
		(0.054)	(0.055)	(0.093)	(0.093)	(0.113)	(0.12)
firstzweight		0.674**	0.676**	0.156*	0.162**	0.46**	0.45**
		(0.039)	(0.04)	(0.061)	(0.061)	(0.068)	(0.071)
firstzheight				0.854**	0.855**		
				(0.066)	(0.066)		
propmeasure		-0.056	-0.063	-0.099	-0.1	0.113	0.129
		(0.153)	(0.148)	(0.39)	(0.389)	(0.549)	(0.546)
S_{it}		0.018	0.013	0.033	0.04	0.066	0.054
		(0.027)	(0.024)	(0.055)	(0.055)	(0.084)	(0.075)
Ethnicity	Sinhalese	0.059	0.049	0.053	0.041	-0.212	-0.196
		(0.201)	(0.202)	(0.311)	(0.321)	(0.4)	(0.414)
CDC-level							
CDC_cat	New	0.093	0.105	-0.158	-0.121	-0.453	-0.521+
		(0.113)	(0.117)	(0.267)	(0.278)	(0.31)	(0.291)
	Upgraded	0.124	0.134	-0.148	-0.129	-0.327+	-0.36*
		(0.096)	(0.099)	(0.132)	(0.139)	(0.175)	(0.181)
Estate	Holyrood	0.073	0.057	0.161	0.126	0.254	0.316
		(0.131)	(0.13)	(0.232)	(0.242)	(0.239)	(0.227)
_cons		-1.188**	-1.093**	-2.756**	-2.733**	0.665	0.646
		(0.21)	(0.206)	(0.454)	(0.47)	(0.55)	(0.565)
N		2848	2848	1830	1830	1645	1645
σ_u		0.509	0.511	0.630	0.632	0.719	0.740
σ_e		0.293	0.293	0.462	0.462	0.578	0.578
ρ		0.751	0.752	0.651	0.653	0.607	0.621

Robust standard errors in parenthesis, **p<0.01, *p<0.05, + p<0.1. *CDC_adj* omitted due to multicollinearity. *Model 1* fits the current periods treatment days. *Model 2* fits the total treatment days within the survey period

Qualitative Data Analysis

Bearwell Estate

This section presents a basic qualitative analysis on the data collected through the midwife and CDO questionnaires administered to the estate midwife and 3 CDOs heading the *Belgravia*, *Walaha* and *Fairfield* CDCs at the Bearwell estate. As noted earlier, due to adverse weather conditions which prevailed throughout the field study period, the *Bearwell* division at the estate could not be visited during the field visit.

CDO Questionnaire- Bearwell Estate

The CDO questionnaire included questions on the types of activities conducted at the CDCs and the types of services provided by the CDCs. All CDCs operated from 7.30 a.m. - 5.00 p.m. on all weekdays, and on Saturdays if plucking was scheduled on weekends. CDCs were usually closed on Sundays and public holidays. The activities and services provided by the CDCs can be broadly categorised into three groups.

Figure E2-1: Facilities and Services provided at CDCs

Usual pre-school activities such as drawing and handwork as well as indoor and outdoor play sessions were conducted at all CDCs. All three CDCs had outdoor play areas with swings and slides for the children to play. In addition to this, one CDO also noted that the children were taken out to visit the religious centre (kovil) as an outdoor activity. However, no note was made on organizing annual excursions.

With regards to the MJF mid-day meals programme, the meals were prepared by the CDO at each CDC and provided to the children on all days that the CDC usually operated. Details of the national nutrition supplementation programme also known as *Thriposha* programme was discussed in Essay 2. The programme provided a cereal supplement for children and pregnant women particularly from lower socio-economic strata of the country. Within tea estates, the distribution of the supplement among children registered at CDCs was usually done through CDCs while children who were not registered at the CDC were provided monthly supplements through the estate midwife. This meant that in addition to the mid-day meal provided, children also received *Thriposha* daily at the CDC. The CDOs noted that children were given *Thriposha* at around 9.00 a.m. after which they were given the mid-day meal between 12.30 p.m.- 1.00 p.m. at all CDCs. Children were trained to wash their hands using soap and water, after playing outside, or using the toilet and before taking meals. Children were also trained to eat their meals properly. Children wore uniforms to the CDC. All CDCs maintained home-gardens, where fruits and vegetables were grown, for consumption at the CDCs. One of the CDCs (*Walaha* division) had a separate room where mushrooms were grown paying careful attention to maintain the necessary hygiene. It was also noted that parents often provide vegetables (either home grown or bought at shops) to the CDCs to use in meals provided to the children. Figures E2-2 to E2-4 below show the outdoor play areas and home gardens maintained by each of the three visited CDCs.

Figure E2-2: Outdoor Play Area and Home Garden- *Belgravia* Division CDC

Figure E2-3: Outdoor Play Area and Home Garden- *Fairfield* Division CDC

Figure E2-4: Outdoor Play Area and Home Garden- *Walaha* Division CDC

When considering the medical services provided through the CDC, it was noted that the CDCs at Bearwell estate provided de-worming medication through the midwife. The CDCs also held monthly parent meetings, where the mothers met with the CDOs and the midwife to discuss health and nutrition concerns. The midwife noted that parents were advised against smoking and use of alcohol. In addition to this, one CDO indicated that a 10-day Health and Nutrition Awareness Programme was held where mothers were advised on hygiene, nutrition and cooking. The following figure depicts some photos of one of these workshops that was available at the CDCs.

Figure E2-5: Photos of the 10-Day Health and Nutrition Workshop- Bearwell Estate

Food Storage and Preparation Facilities

Figure E2-6 below presents photos of the food storage and preparation facilities at the 3 CDCs visited in Bearwell estate. Two of the CDCs had gas cookers and LP gas cylinders apart from the normal fire wood cooking facilities. However, it was noted that firewood was the preferred and most frequently used fuel for cooking. The cooking space in all three CDCs are small and compact but was clean and well maintained. All CDCs used boiled and filtered water for drinking. It was also interesting to note that one of the CDCs had a filtering system installed to one of its taps so that children could drink water straight off the tap.

Figure E2-6: Food Preparation and Storage Facilities at Bearwell CDCs

All CDCs followed a fixed meal plan. Parent were also given the opportunity to provide food to all the children on special occasions (e.g. birthdays, special festival days etc.). The following figure shows the standard menu followed at the Bearwell CDCs, when preparing the mid-day meals. From the responses provided by the CDOs and the menu in Figure E2-7, it is clear that different sources of protein are used in preparing meals. However most of these sources are vegetable based (e.g. lentils, chickpeas, gram, soy etc.). The only non-vegetable protein source used is dried sprats (type of dried fish). Red rice is the main staple (apart from wheat noodles provided on one of the days) food. Vegetables are part of the meal on all six days. The meal on Saturday included a vegetable soup with gram (either green gram, brown gram or chickpeas) as the main source of protein.

Figure E2-7: MJF Mid-Day Meal Menu- Bearwell Estate

The CDC provides meals according to the above fixed menu on all days apart from Sundays and public holidays. When estate work is scheduled on a Sunday or a public holiday, the CDC remains open, but parents are required to provide meals for their children. From observation, the portion size was seen to be approximately 250g-350g in weight. *Thriposha* was provided to all children on all days that the CDC operated. From the responses provided by the CDOs it was noted that *Thriposha* was usually given in the mornings between 8.30 a.m.– 9.30 a.m. The CDOs also noted that children were occasionally given fruits as dessert after the main meal. However, it was not indicated whether this was a permanent component of the mid-day meals. As mentioned earlier, fruit plays an integral part in providing children with the necessary vitamins and should typically be provided on a daily basis.

Feeding Patterns of Children and Parent Meetings

The CDO questionnaire collected information on the feeding patterns of children by their age, at the CDC. Infants below the age of 6 months were only fed breast milk and no other food was provided by the CDC. The mothers of these infants visited the CDCs every 2-3 hours to feed their babies (at 9.30 a.m., 12.30 p.m. and 3.30 p.m.). It was also noted by both the CDOs and the midwife that mothers coming to feed their children were given strict guidelines to clean themselves and wear new clothes prior to feeding the child.

Infants aged between 6-12 months, were provided both breast milk and pulp food at the CDCs. It was also noted that some mothers left a bottle of pumped breastmilk and home prepared pulp vegetables/fruit to be fed to the child when required. In addition to this the CDC also provided pulp food (a small portion of food cooked for the usual mid-day meal is squashed and made in to a pulp) to all children in this age group. Children were also fed *Thriposha* in the morning.

Children above the age of 12 months were provided *Thriposha* mixed with sugar and grated coconut in the morning and the usual mid-day meal at noon. The children sit together around the table when having the meal. This was done in order to promote unity and good eating habits among the children. The figure below features a typical meal provided and children having the meal.

Figure E2-8: Children having the Mid-Day Meal- Bearwell Estate

All CDOs noted that meetings were held regularly for the mothers of the CDC registered children. This allowed them to meet the CDO and the midwife in order to discuss issues relating to the health of their child. CDOs also noted that each CDC had a parent committee where a number of mothers were selected each year as committee members. Parents contributed a nominal monthly fee of LKR 100 which was collected for the CDC Development Fund and used for refurbishment activities of the CDCs. At meetings, mothers discussed a range of issues including problems arising due to low household income and alcoholism.

General Environment

Observations were made on the general environment of each of the visited CDCs. Two of the CDCs (*Belgravia* and *Walaha*) were classified as upgraded while the other was classified as old (*Fairfield*). The *Fairfield* division CDC was observed to be slightly smaller than the other two. The table and figure below indicate some key observations made on the general environment of the visited CDCs. It was interesting to note that the *Fairfield* division CDC (classified as old) still used baby hammocks with only a few cots were used. In contrast the other two CDCs had more cots and cradles. The two smaller CDCs also appeared to be somewhat cluttered with less space for children to move around.

Table E2-9: General Environment of CDCs-Bearwell Estate

Observations	CDC1	CDC2	CDC3
CDC Status	Upgraded	Upgraded	Old
Clean	■	■	■
Welcoming	■	■	■
Untidy			
Organized	■	■	■
Well-Managed	■		■
Cluttered	■		■
Safe	■	■	■
Happy	■	■	
Friendly	■	■	■
CDO Experienced and knowledgeable	■	■	■
CDO Young and less experienced			

Belgraviya Division CDC

Walaha Division CDC

Fairfield Division CDC

Figure E2-9: Snippets of *Belgraviya*, *Walaha* and *Fairfield* CDCs- Bearwell Estate

Midwife Questionnaire- Bearwell Estate

The midwife questionnaire was administered to the estate midwife at Bearwell. The first section of the questionnaire collected information on the background of the estate and duties performed by the midwife. The midwife at Bearwell had nearly 35 years of experience working as an estate midwife. The following table summarises her responses for this section. The figures provided were those quoted by the midwife (hence approximate) and the table notes down the duties based on the ranking given to each item by the midwife.

Table E2-10: Midwife Background and Duties- Bearwell Estate

Estate Background	**Approximate Figures Reported by Midwife**
Population	3482 approx.
# of children under midwife supervision	244
Average # of children per HH in estate	More than 3
Average # of pregnancies monitored per annum	300 approx.
Average age at which estate women have their first child	21 approx.
Average teenage pregnancies per annum	2-3 approx.
Midwife Duties	**Description (Rank)**
Monitor the health and nutrition of pregnant mothers	Main duty (1)
Providing antenatal care to pregnant mothers and babies	Main duty-Conducting antenatal clinic (2)
Assisting with hospital births	(3)
Providing postnatal care and advice to new mothers and infants	Conducting postnatal clinic (4)
Carrying out routine vaccinations and de-worming programmes Updating vaccination and growth cards of children Measure and monitor the heights and weights of children between age 0-5 years	Services are provided at CDCs and the estate medical centre (5)
Visiting and Monitoring CDCs*	Regular visits and monthly meetings at CDCs (6)
Meeting parents of 0-5 year old children living within estate	(7)
Monitoring older children	School health programmes (8)

*It should be noted that the estate midwife employed by the estate management had the authority to monitor the CDCs unlike the MoH midwives

The second part of the questionnaire noted the views of the midwife on the health status and nutrition of children below the age of 5, living at the estate. The following table summarises her responses for this section.

Table E2-11: Midwife Comments on Estate Child Nutrition- Bearwell Estate

Child Nutrition	Description and Comments
Average duration of exclusive breastfeeding in estate and nutrition of 0-6 month olds	First 6 months (prior to 2010 exclusive breast feeding was limited to the first 4 months)
Main health issues (0-6 month olds)	Respiratory issues and fever are common, due to vaccinations and the cold climate.
Nutrition of 6-12 month olds	Main staple food is red rice. Mothers are usually advised to follow guidelines provided in the growth card when weaning. Infants are only fed baby formula as an alternative to breast milk.
Average age at which children are introduced to solid food	Usually after the first 6 months
Types of solids popularly introduced (after first 6 months)	Rice porridge, squashed rice and vegetables are first introduced. Egg yolk and small portions of dried fish are introduced after 8-10 months.
Main health issues (6-12 months)	Diarrhea is very common due to introduction of solid food for the first time
Nutrition of 1-2 year olds	Rice, Noodles, Cereal (such as *Thriposha*). Vegetable proteins are frequently offered. Fruits and fruit juice are provided when possible. Meat and fresh fish are rarely provided. Vegetables and eggs are the main sources of protein. Yoghurt and powdered cows milk are the main dairy products used.
Nutrition of 2-5 year olds	Rice/noodles are the main staple foods eaten. Basic vegetables are eaten. Greens and a little bit of fruit is consumed. Families are encouraged to maintain home gardens and some families have cattle which provides fresh milk. The Department of Agriculture together with the ChildFund NGO has a programme which provides seeds to families of children with low weight and technical support is given to them to maintain home gardens. Vegetables provide the main source of protein (soya, lentils, chickpeas etc.). The most frequent animal protein provided is egg. Consumption of fish and meats is very low because most houses don’t have freezers or refrigerators. Dried fish (e.g. sprats) is the most widely consumed sea food.
Main health problems of estate children in general	The midwife does not note any major health issues apart from respiratory infections and intestinal worm problems.

The final section of the midwife questionnaire looked at the main drivers of child malnutrition in the estate, on social issues faced by the estate population and improvements that should be made to the CDCs at the estate, from the point of view of the estate midwife. The table below summarises her responses to this section.

Table E2-12: Midwife Comments on General Health, Social Issues and CDC Improvements within Bearwell Estate

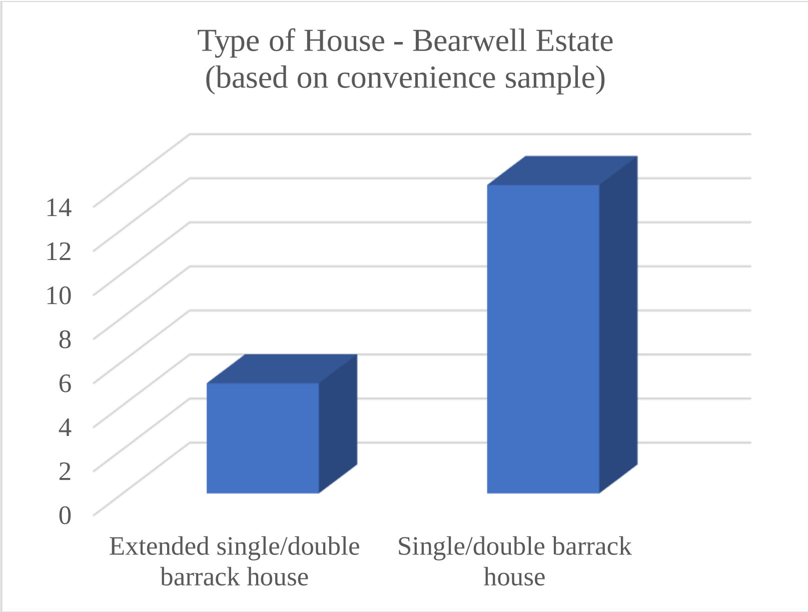
General Health and Social Issues	Description and Comments
Main drivers of child malnutrition in the estate	• Limited access to food due to low household income • Intake of imbalanced meals due to low household income • Frequent illness due to cold climate – High prevalence of respiratory diseases • Having 3-4 close pregnancies cause children to have both low birthweight as well as low weight through the years- the midwife noted that this was seen often within the estate
Main social problems that estate families face	• Poverty due to poor income • Alcohol abuse – this has been declining but still exists within the estate • Lack of support given by husbands to care for their children – The midwife noted that husbands often coax their wives to go to work daily despite having very small children
Improvements to CDCs	• The midwife noted that all the CDCs needed to be better maintained
Importance of the mid-day meals programmes and the importance of sending children to the CDCs	• Midwife notes that she sees a big improvement in health and growth in children attending CDCs

Housing Quality Questionnaire- Bearwell Estate

The poor state of estate housing within the estate sector of Sri Lanka is a widely researched topic (Ilyas, 2014). Much of the housing in the estates follow a traditional pattern; commonly known as line housing. Traditional line houses are identical barrack type houses typically 200 square feet in area. The maintenance of these houses is the responsibility of the estate management. Newer more spacious housing has been built under various building projects over the years. However, a majority of the housing used is still old. The report published by the Institute of Social Development (Institute of Social Development, 2008) gives a thorough overview of the laws governing the construction and maintenance of the traditional estate housing. According to the report the Gazette No. 10168 of 1950 and the Estate Labour (Indian) Ordinance act set out rules and guidelines for constructing the traditional barrack style houses known as line rooms. Based on these laws, a single line room should consist of an open/enclosed veranda, living room, back veranda and a kitchen and should not be occupied by a family consisting of more than two adults and 3 children under 12 years. Rules also dictate the provision of suitable toilet facilities. According to the report (Institute of Social Development, 2008), current estate housing could be categorised broadly in to two categories as permanent structures and temporary structures. Permanent structures could be further classified as single/twin cottages, single lines (single barrack) or double lines (double barrack). Temporary structures consist of shanty type housing or sheds. As mentioned above, the traditional barrack line rooms were quite small with most not exceeding 200 square feet in area. The single/twin cottages were usually built with more floor area, depending on funding available.

In order to get a general idea of living conditions within the sampled estates, a convenience sample of houses were selected and visited within each estate. A checklist of questionnaire was used to collect data from the sample of houses selected. In the questionnaire, housing quality was represented as ‘good’, ‘medium’ or ‘poor’ based on the overall observations made on the house. A house was categorised as ‘good’ if it was either a new or refurbished house usually built as a single/twin house or a line room which was extended and refurbished. A house was categorised as ‘medium’ if the unit was a usual single/double barrack house with average quality material used in the roof, walls and floor. A house classified as ‘poor’ would be a very low level, poorly maintained housing unit.

This section presents a basic analysis of the HH data collected within the Bearwell estate. Nineteen houses were selected into the sample. Six houses each were selected from the *Belgravia* and *Fairfield* divisions while seven houses were sampled from the *Walaha* division. Figure below provides details of the type and quality of housing based on the convenience sample.



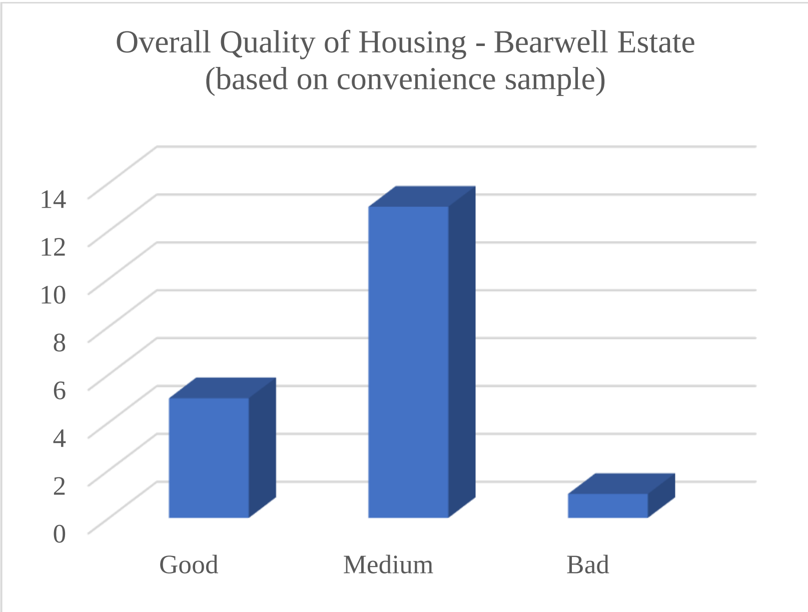
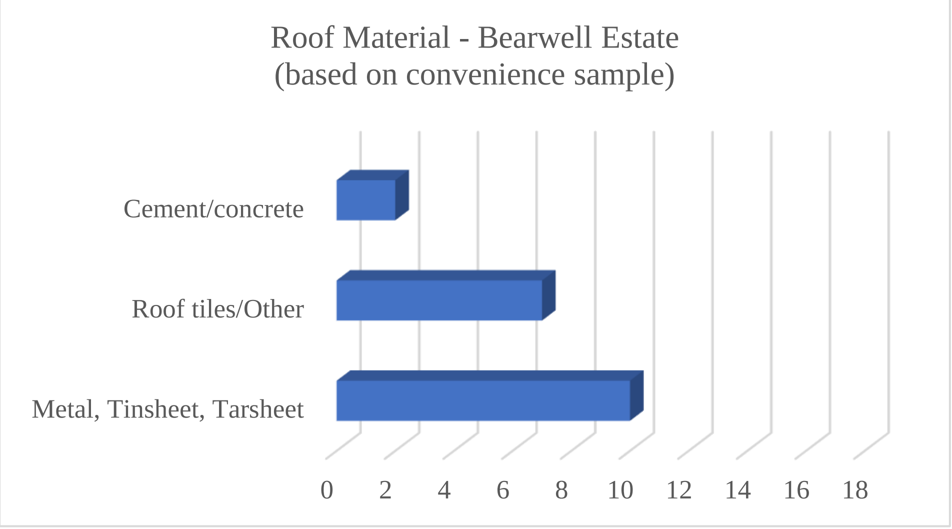


Figure E2-10: Type and Overall Quality of Housing- Bearwell Estate Convenience Sample

It should be noted that none of the houses in the sample were separately standing single/twin houses and a majority of the houses in the sample were of medium quality. The few houses classified as ‘good’ were single/double barrack houses which were refurbished and extended to include slightly more floor area. One of the houses in the sample was similar to a basic shed and was clearly not suitable for living (house classified as ‘poor’ quality).

Details of the materials used to build the floor, walls and roof of each house as well as sanitation facilities available for the house were also noted. All houses in the sample had floors constructed using cement/concrete. It should be noted that one of the houses even had polished floors. The following figure shows the different material used to construct the roofs and walls of the sampled houses.



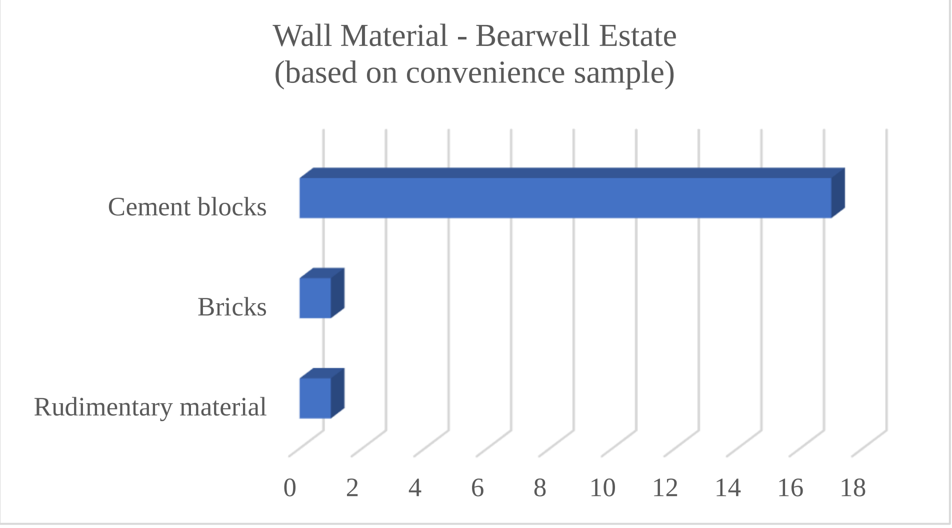


Figure E2-11: General Household Characteristics- Bearwell Estate Convenience Sample

A majority of houses in the sample had roofs constructed using basic metal sheets. Some of the roofs appeared to be very old and rusted. Some of the houses classified as 'good' in Figure E2-10 also had metal sheets on their roofs. However, these were observed to be of better quality. Two of the houses also had roofs constructed using concrete. A clear majority of the houses had walls built using concrete blocks. It should also be noted that the house which was classified as 'poor' had walls made of clay/mud. The figure below depicts sanitation facilities available for the sampled houses. Most toilets in sampled HHs were pit-latrines, and some of the sampled houses shared toilet facilities with other households. Shared toilets were similar to public toilets and were built by the estate management to be used by the general public living within the estates.

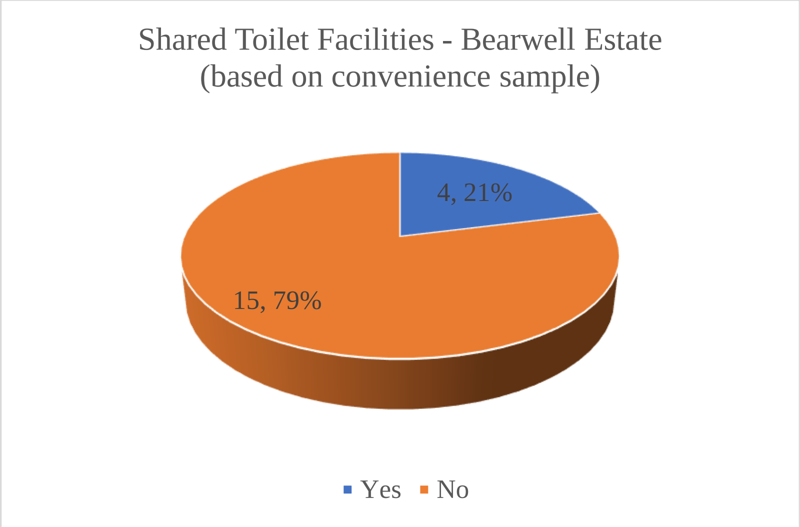


Figure E2-12: Type of Toilet- Bearwell Estate Convenience Sample

The next section of the questionnaire looked at the main source of water and the main type of fuel used for cooking in the house. Six of the houses in the sample used public taps to collect water for daily needs. It was also noted by some of those interviewed that water was only available for 45 minutes in the morning and afterwards was only available in the afternoon.

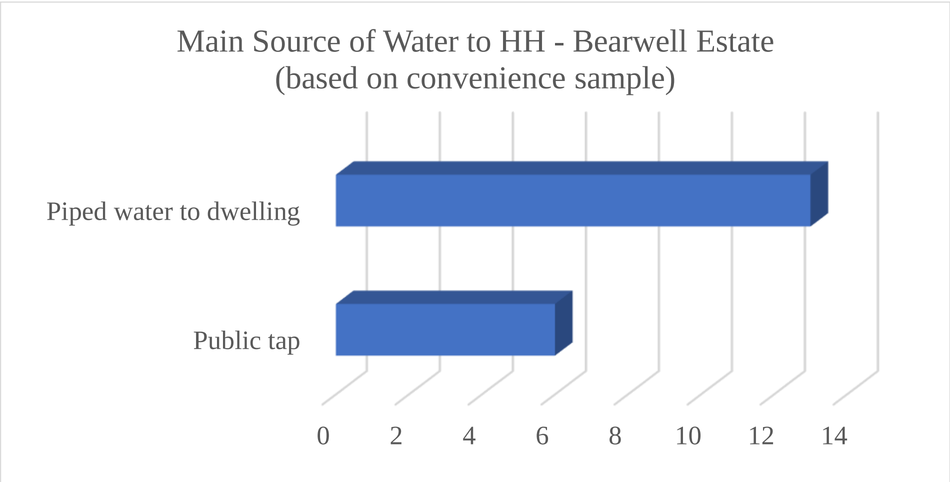


Figure E2-13: Main Source of Water- Bearwell Estate Convenience Sample

All houses in this sample used fire wood as the main fuel for cooking. However, six of the houses did have gas cookers and LP gas cylinders for cooking when required. It was also noted whether each of the houses had a window or set of windows at the front and proper guttering in the roof for disposal of rainwater. Whether the house had at least one window in the front was a proxy for the house having necessary ventilation while having proper guttering was a sign that the members of the house were aware of the threat of mosquito borne diseases such a dengue and malaria. Apart from one house (the house classified as 'poor' in quality) all other houses had at least one window on the front wall of the house. The figure below shows the percentage of houses that did and did not have proper guttering on the roof for rain water to flow.

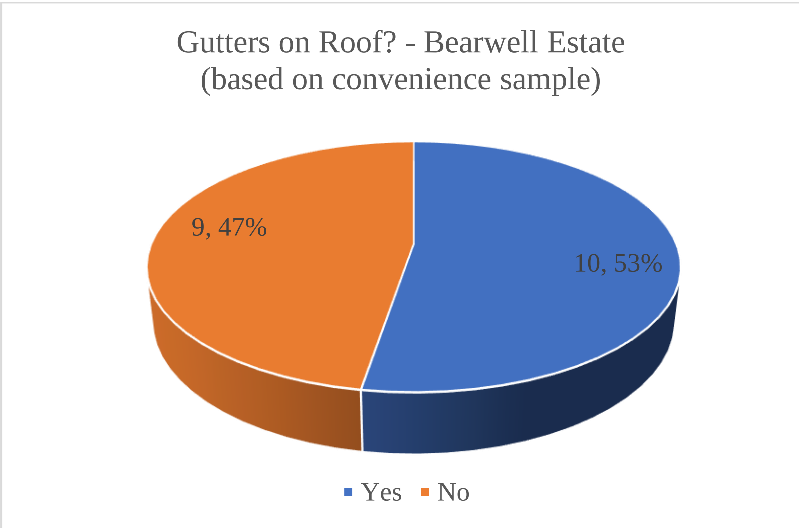


Figure E2-14: Proper Gutters on Roof- Bearwell Estate Convenience Sample

Nine of the nineteen sampled houses did not have proper guttering for rainwater to flow down. In addition to this, most houses using metal sheets on roof, used weights to stop sheets being blown off during strong winds (e.g. old tires, heavy pots or bricks, etc.). This signalled the possibility of rain water accumulating on roofs providing breeding grounds to mosquitoes and other insects.

The last section of the questionnaire looked at the number of people living in each household and some general assets that each household had. Overcrowding of houses was a serious issue within the sample, since most households had at least five members. The graph below shows the spread of household size in the sample. It is also interesting to see that the sample also had a relatively high number of 2-member households.

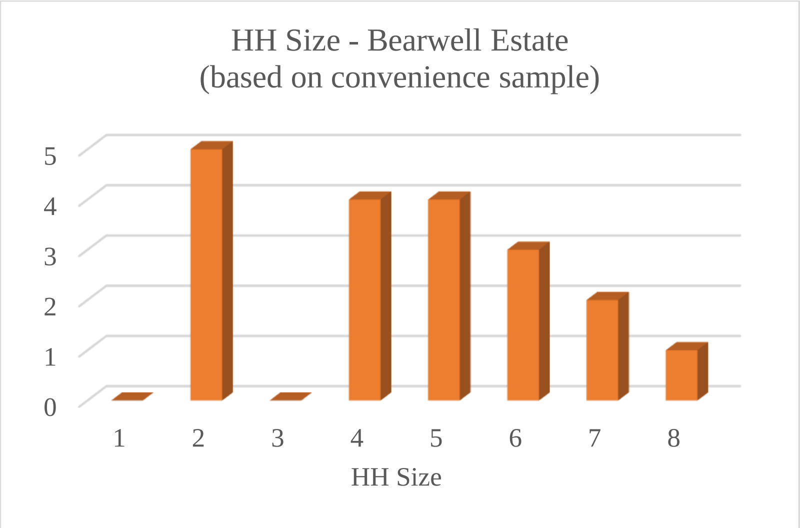


Figure E2-15: HH Size- Bearwell Estate Convenience Sample

All sampled households had electricity whilst one household also had a vehicle (three-wheeler). It is interesting to note that approximately 90% of the sampled houses owned a television set and approximately 58% of the households also had a dish/cable TV connection. The household which owned the vehicle also maintained a considerably big vegetable patch adjacent to it. However, only two types of vegetables were grown indicating that the growing was done more for commercial purposes than for home consumption. Overall only four of the nineteen houses stated that they did maintain a home garden with vegetables. One household also noted that they collected fresh cow's milk and sold to the village grocery.

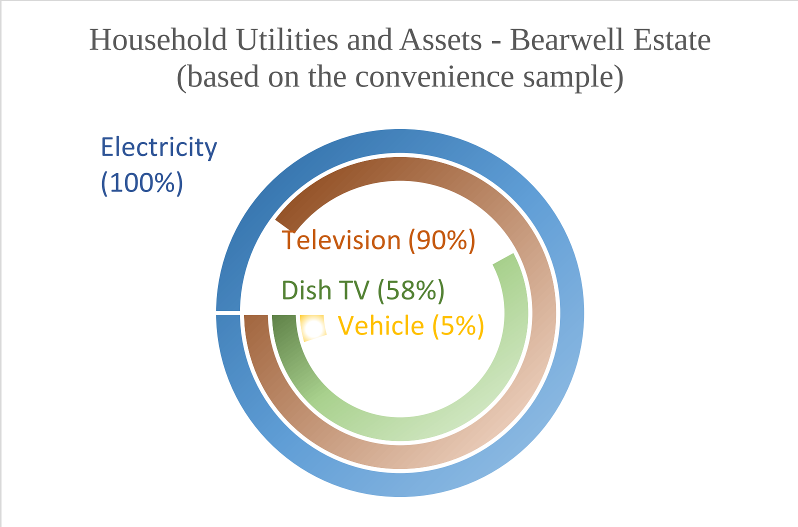


Figure E2-16: Distribution of Utilities and Assets- Bearwell Estate Convenience Sample

The following figures show some of the visited houses as well as snippets of our field visit to Bearwell estate








Figure E2-17: Snippets of Field Visit- Bearwell Estate

Holyrood Estate

The following sections present a basic qualitative analysis done on the data collected through the Midwife, CDO and HH Quality questionnaires administered at Holyrood estate.

CDO Questionnaire- Holyrood Estate

The CDO questionnaire was presented to all 5 CDOs heading the 5 CDCs at Holyrood estate. As indicated in Figure E2-1, general activities conducted at the CDCs could be broadly categorised as pre-school activities, food and nutrition related activities and medical services. Usual pre-school activities include drawing and handwork, a one hour TV slot, playing with toys and where available, playing in the outdoor play area. Three of the five CDCs had a small outdoor play area built as part of the CDC, while one CDC had a playground nearby, to which the children were taken daily. One CDC however had no facilities for the children to play outdoors. All CDCs organize an annual excursion, where the children are taken to visit the town of Nuwara Eliya, which is nearby. Nuwara Eliya is a main tourist attraction of the country and has beautiful parks and gardens and therefore provide an ideal location for the children to enjoy.

Similar to Bearwell, mid-day meals were prepared by the CDO at each CDC and provided to the children. However, contrary to Bearwell, children were given a glass of milk in the morning (9.00 a.m.) and *Thriposha* was provided to them at tea time (3 p.m.-3.30 p.m.) at all five CDCs. Among the hygiene activities, children were trained to wash their hands using soap and water, after playing outside or using the toilet and before taking meals. Children were also trained to eat their meals properly, without spilling food around the plates. All CDCs maintained home-gardens, where fruits and vegetables were grown, for consumption at the CDCs. The CDCs provided de-worming medication through the midwife. Monthly parent meetings were held at each CDC, where the mothers met with the CDOs and the midwife to discuss health and nutrition concerns. In addition to this, one CDO indicated that Health and Nutrition Awareness Programmes were held three times a year at the CDC. Figures E2-18 and E2-19 provide snippets of the basic CDC setup and recreational activities organized by the CDCs annually. The CDCs organize an annual trip usually to Nuwara Eliya Gardens, and also organize annual concerts.

Figure E2-18: Holyrood CDC Setup

Figure E2-19: Outdoor Excursions and Concerts Organized by Holyrood CDCs

Food Storage and Preparation Facilities

Figure E2-20: Food Preparation and Storage Facilities at Holyrood CDCs

The figure above presents photos of the food storage and preparation facilities available at the CDCs. The new CDCs had more spacious kitchens and used LP gas for cooking while the upgraded CDCs had smaller more compact kitchens and used fire wood as cooking fuel. In addition to this, all CDCs maintained food supplies in a very clean and organized manner, with proper labelling. All CDCs used boiled or filtered water for drinking. All CDCs also maintained a 'food sample' of each day's mid-day meal, for a period of 24 hours. This was done in case any food poisoning occurs where the food sample could then be produced for medical testing. The CDCs also maintained a proper list of the food provided at the CDC each day. The figure below is an example of the monthly menu planned for the month of July (2015), at the CDCs.

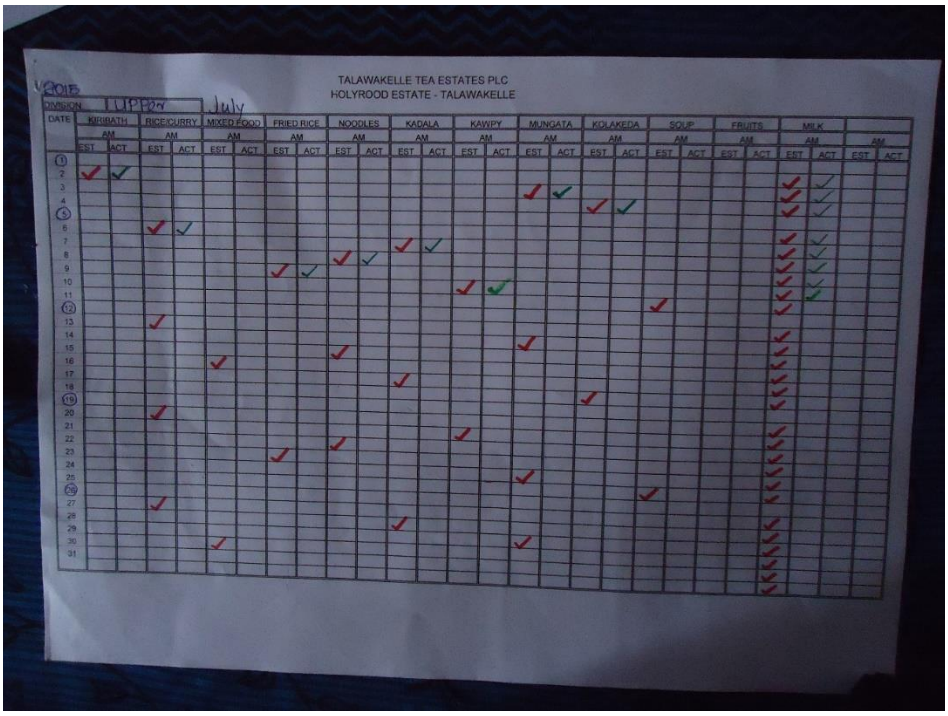


Figure E2-21: Menu Plan for July 2015- Holyrood CDCs

The following table summarises the types of food provided at the CDCs in Holyrood (according to documentation provided by the CDCs) under the mid-day meals programme. The CDC provides meals on all days apart from Sundays and public holidays. If estate work was scheduled on a Sunday or a public holiday, CDC remained opened. However, meals had to be provided by the parents when dropping them off at the CDCs. It was noted by the CDOs that parents were given strict instructions on the type of food to provide on these occasions. It was also noted by them that parents tend to follow these instructions since they only provided meals on these rare occasions. From observation, the portion size was seen to be approximately 250g-300g in weight. As mentioned before, a glass of milk and *Thriposha* was provided to all children on all days that the CDC operated. Another important point to note was that, fruits were not provided as part of the meal planned for July. Fruits form an integral part of a balanced meal and omitting this from the planned mid-day meal over an entire month can result in the children missing out on some critical nutrition groups such as Vitamins and Minerals.

Table E2-13: Food Components provided under the Mid-day Meal Programme - July 2015 Holyrood Estate

Food Type	Frequency	Percentage %	Time served
Milk (Powdered Cows Milk)	27	100%	9.00 a.m.-9.30 a.m.
Milk Rice (Rice cooked in coconut milk)	1	3.7%	12 noon- 1.45 p.m.
Rice and Curry (rice, lentil curry and sprats)	4	14.8%	12 noon- 1.45 p.m.
Mixed Food (vegetable rice, noodles, roti etc.- provided by parents)	2	7.4%	12 noon- 1.45 p.m.
Fried Rice with vegetables	2	7.4%	12 noon- 1.45 p.m.
Noodles with vegetables	3	11.1%	12 noon- 1.45 p.m.
Boiled chickpeas with grated coconut	3	11.1%	12 noon- 1.45 p.m.
Boiled gram with grated coconut	2	7.4%	12 noon- 1.45 p.m.
Boiled green gram with grated coconut	4	14.8%	12 noon- 1.45 p.m.
Porridge (made with rice and green leaves)	2	7.4%	12 noon- 1.45 p.m.
Vegetable Soup	2	7.4%	12 noon- 1.45 p.m.
Fruit	0	0%	12 noon- 1.45 p.m.
Thriposha	27	100%	3.00 p.m.-3.30 p.m.

Feeding Patterns of Children at CDCs

The CDO questionnaire collected information on the feeding patterns of children by their age, during their daily stay at the CDC. According to the responses provided in the five CDO questionnaires, infants below the age of 6 months were only fed breast milk and no other food was provided to them by the Holyrood CDCs. The mothers of these infants visited the CDCs every 2-3 hours to feed their babies.

Infants aged between 6-12 months, were provided both breast milk and pulp food at the CDCs. In their questionnaires, the CDOs noted that some of the mothers whose children belonged to this age group visited the CDC between 9.00-10.00 a.m. to feed their babies. It was also noted that most mothers either provided a bottle of pumped breastmilk or pulp food prepared by them, to the CDO, to be fed to the child when required. In addition to this the CDC also provided pulp food (a small portion of food cooked for the usual mid-day meal was squashed and made in to a pulp) to all children in this age group.

Children above the age of 12 months were provided cows milk (powdered cows milk) and the mid-day meal prepared at the CDC. In addition to this, some mothers provided baby formula to be prepared and given to their children. All children above the age of 6 months were fed *Thriposha* mixed with sugar and grated coconut.

Regular Parent Meetings

All CDOs noted that parent meetings were held regularly for the mothers of registered children. Some CDC held monthly meetings while others held tri-monthly or quarterly meetings. The CDOs and the estate midwife was usually present at the meetings. CDOs noted that each CDC had a parent committee where a number of mothers were selected each year as committee members. Parents contributed a nominal monthly fee between LKR 50- LKR 100 which was collected for the CDC Development Fund and used for refurbishment activities of the CDCs. At meetings, mothers discussed a range of issues such as low-income problems and alcoholism.

General Environment

Observations were made on the general environment of each of the visited CDCs. One of the new CDCs was very spaciously built with good lighting and upgraded facilities. The upgraded CDCs were seen to be clean yet generally cluttered due to limited space.

Table E2-14: General Environment of CDCs at Holyrood Estate

Observations	CDC 1	CDC 2	CDC 3	CDC 4	CDC 5
CDC Status	New	New	New	Upgr.	Upgr.
Clean	■	■	■	■	■
Welcoming	■	■		■	■
Untidy					
Organized	■	■	■	■	■
Well-Managed	■	■	■	■	■
Cluttered					■
Safe	■	■	■	■	■
Happy	■	■		■	■
Friendly	■	■	■	■	■
CDO Experienced and Knowledgeable	■	■	■	■	■
CDC Young and Inexperienced					

Midwife Questionnaire- Holyrood Estate

The midwife questionnaire was administered to the estate midwife at Holyrood estate. The first section of the questionnaire was based on collecting information on the background of the estate and duties performed by the midwife. The following table summarises her responses for this section. It should again be noted that the figures provided were those quoted by the midwife and should be considered approximate. Duties are noted down in order of importance based on the rank provided by the mid-wife.

Table E2-15: Midwife Background and Duties- Holyrood Estate

Estate Background	**Approximate Figures Reported by Midwife**
Population	3857 approx.
# of families	1028 approx.
# of children under midwife supervision	351
Average # of children per HH in estate	3 or more
Average # of pregnancies monitored per annum	70 approx.
Average age at which estate women have their first child	Between 24-25 years
Average of teenage pregnancies per annum	5-6 approx.
Midwife Duties	**Description (Rank)**
Measure and monitor the heights and weights of children between age 0-5 years	Main duty (1)
Monitor the health and nutrition of pregnant mothers	Main duty (2)
Visiting and Monitoring CDCs[8]	Regular visits and monthly meetings at CDCs (3)

[8] It should be noted that the Estate Midwife employed by the estate management had the authority to monitor the CDCs unlike the MoH Midwives

Meeting parents of 0-5 year old children living within estate	
Providing antenatal care to pregnant mothers	Conducting Antenatal Clinic (4)
Assisting in home births	Homebirths were prevalent in the past, but are currently decreasing (5)
Providing postnatal care and advice to new mothers and infants	Conducting Postnatal Clinic (6)
Carrying out routine vaccinations and de-worming programmes	
Updating vaccination and growth cards of children	
Home visits to monitor pregnant mothers	HHs visited once in three months (7)
Monitoring school children	School Medical Inspections (8)

The second part of the questionnaire was based on the views of the midwife on the nutrition and health status of estate children belonging to various age groups. The following table summarises her responses for this section.

Table E2-16: Midwife Comments on Estate Child Nutrition- Holyrood Estate

Child Nutrition	**Description and Comments**
Average duration of exclusive breastfeeding in estate and nutrition of 0-6 month olds	First 3 months Estate mothers usually stay back from work for three months for their first two pregnancies. However, for the third pregnancy, they usually go back to work after the first 42 days. Most infants are fed baby formula after the first three months.
Main health issues (0-6 month olds)	Respiratory issues and fever are common, due to the cold climate. Reports of Diarrhoea in this age group is going down.
Nutrition of 6-12 month olds	Main staple food is red rice. Use of rusks/biscuits have declined due to better awareness from mothers attending nutrition programmes. Mothers are advised not to give fresh cows milk because they do not follow the correct boiling and sterilization procedure. Infants are also fed baby formula.
Average age at which children are introduced to solid food	Usually after the first 6 months
Types of solids popularly introduced (after first 6 months)	Rice porridge, squashed rice and vegetables are first introduced. Egg yolk and small portions of boiled chicken are introduced after 10 months. Use of fruit is very low. Mothers are cautious in giving dairy products such as yoghurt due to the cold climate.
Main health issues (6-12 months)	Fever and skin conditions are often reported. However, reports of skin rashes are decreasing. Respiratory diseases are reported.
Nutrition of 1-2 year olds	Rice, Noodles, Cereal (such as *Thriposha*). Lentil curry and potatoes are widely fed. Eating green leaves and fruit is very low. Meat and fresh fish are rarely eaten. Vegetables and eggs are the main sources

	of protein. Yoghurt and powdered cows milk are the main dairy products used.
Nutrition of 2-5 year olds	Rice/noodles are the main staple foods eaten. Basic vegetables are eaten. Low consumption of fruits and green leaves. Fresh milk and powdered cows milk are consumed. Vegetables provide the main source of protein (soya, lentils, chickpeas etc.). Eggs, chicken and dried fish are the commonly consumed non-vegetable proteins. However, these foods are not often consumed.
Main health problems of estate children in general	Low weight is a significant issue. Prevalence of low birthweight is decreasing. However, infants born with normal weight maintain their weight for the first 6 months and once weaned, the weight of babies begin to fall below the recommended weight. From this point their weight steadily decreases. Estate children are also unnaturally short. Their BMI is often normal however they are severely stunted. Mothers of toddlers and young children going abroad to work as housemaids, leaving their children in the care of fathers and grandparents is a serious issue (currently 22 mothers of toddlers are reported to be abroad). Sending children to preschool at a very small age (approximately 2.5 years) is another serious problem prevalent in the estate.

The final section of the midwife questionnaire was on the main drivers of child malnutrition in the estate, on social issues faced by the estate population and improvements that the midwife felt were necessary to the CDCs at the estate. The table below summarises her responses to this section.

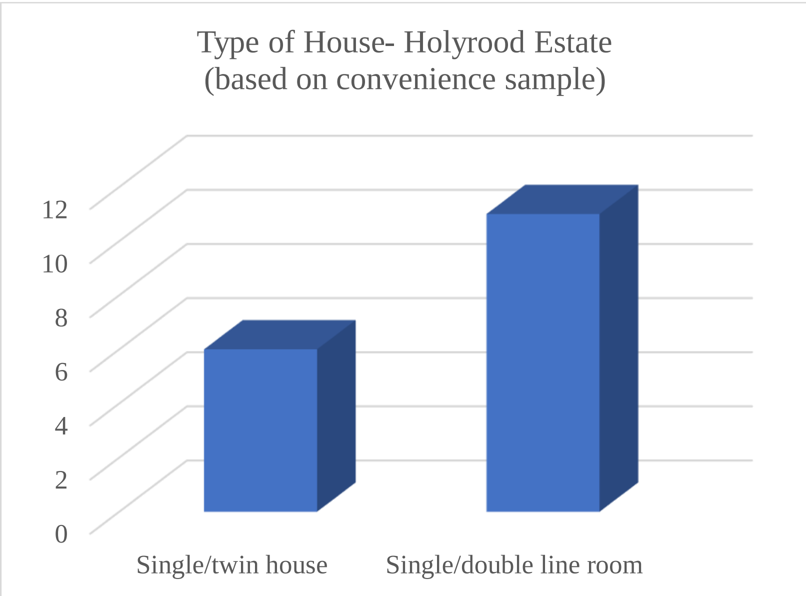
Table E2-17: Midwife Comments on General Health, Social Issues and CDC Improvements within Holyrood Estate

General Health and Social Issues	**Description and Comments**
Main drivers of child malnutrition in the Holyrood estate	• Lack of adequate postnatal care for the 3rd pregnancy -short duration of breastfeeding the third child • Lack of care during infancy due to the mother's work patterns- increasing trend of mothers working late in estates and also leaving the estate to go to Colombo or abroad for work • Intake of imbalanced meals due to family poverty- poor cash management is identified as the main cause of poverty • Lack of knowledge of parents regarding balanced nutrition- wrong meal attitudes of parents • Frequent illness due to cold climate- high prevalence of respiratory diseases • Food not prepared in an attractive manner to tempt children to eat • Fathers not being supportive in caring for children

Main social problems that estate families face	• Poverty mainly due to poor income management as opposed to inadequate pay or availability of work - The midwife states that on average a family would receive at least LKR 27,000 a month and more depending on the hours of work. However, income is not managed well. Most families do not even maintain a basic bank account and have no proper mechanism to save money. Money is not spent on food but on other trivialities • Addiction to excessive use of alcohol – females using alcohol is a main issue • General lack of knowledge and awareness regarding health and sanitation issues
Improvements to CDCs	• Replace all baby hammocks with proper baby cots – Hammocks made from sarees are still in use in some of the CDCs
Importance of the mid-day meals programmes and the importance of sending children to the CDCs	• Midwife notes that she sees an improvement in health and growth in children attending CDCs • She accounts this both to the availability of mid-day meals at the CDCs as well as the inclusive environment maintained at the CDCs • Togetherness and nurturing among children are seen at CDCs with older children caring for the younger children • Children become more flexible and learn good principles such as sharing • Good manners and behaviour are promoted at the CDC • CDCs have many activities that keep children alert and active throughout the day

Housing Quality Questionnaire- Holyrood Estate

Similar to the procedure carried out in Bearwell estate, a convenience sample of houses were selected from Holyrood estate in order to assess the quality of housing at the estate. The sample consisted of 17 houses spread across all 5 divisions of the estate.



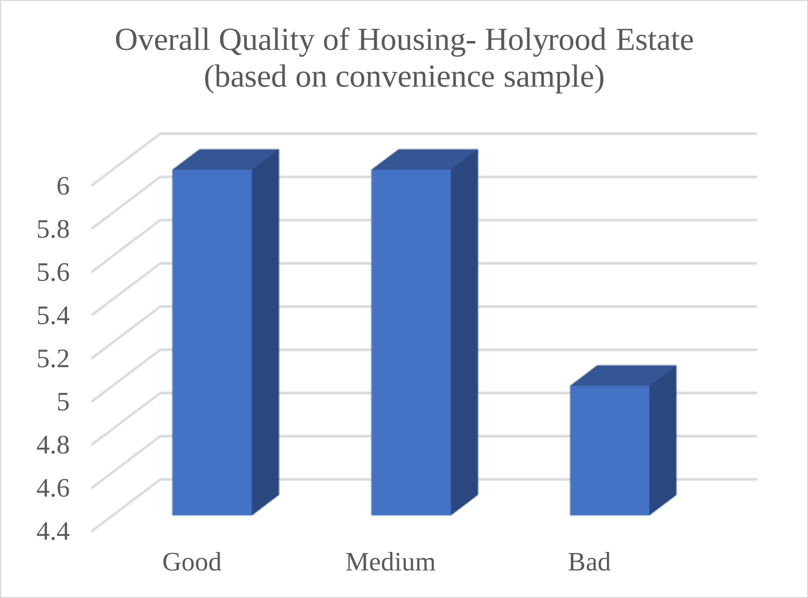
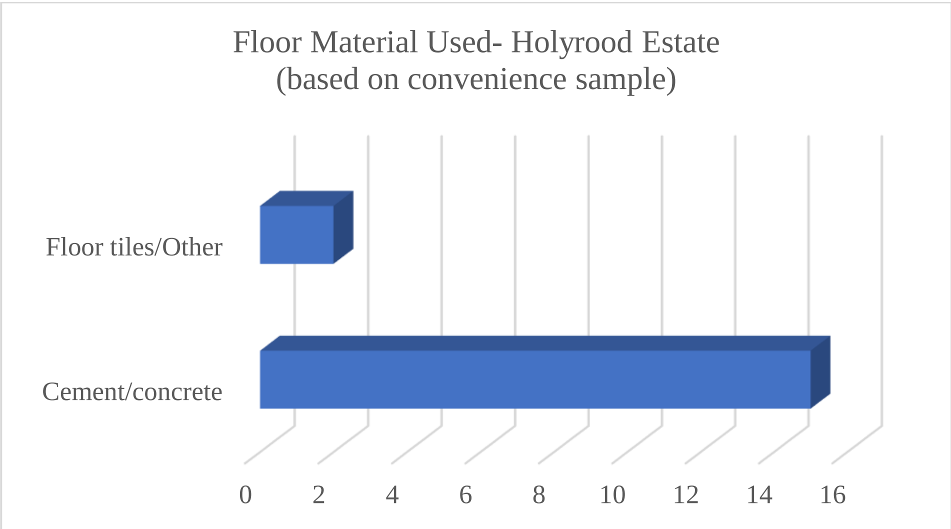
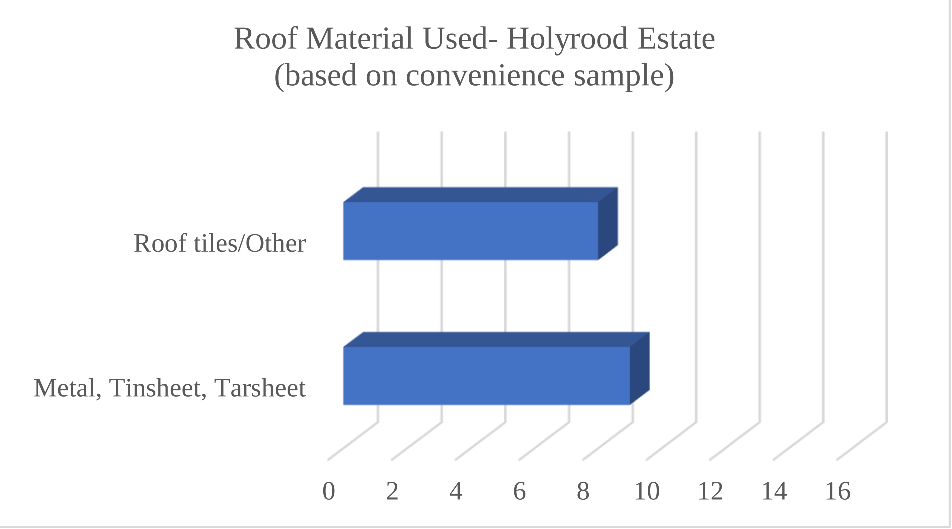


Figure E2-22: Type and Overall Quality of Housing- Holyrood Estate Convenience Sample

Majority of the houses in the sample were classified as 'medium'. Six of the seventeen houses in the sample were new single houses. The materials used to build the floor, walls and roof of each house as well as sanitation facilities available for the house was noted under the second section of the questionnaire.





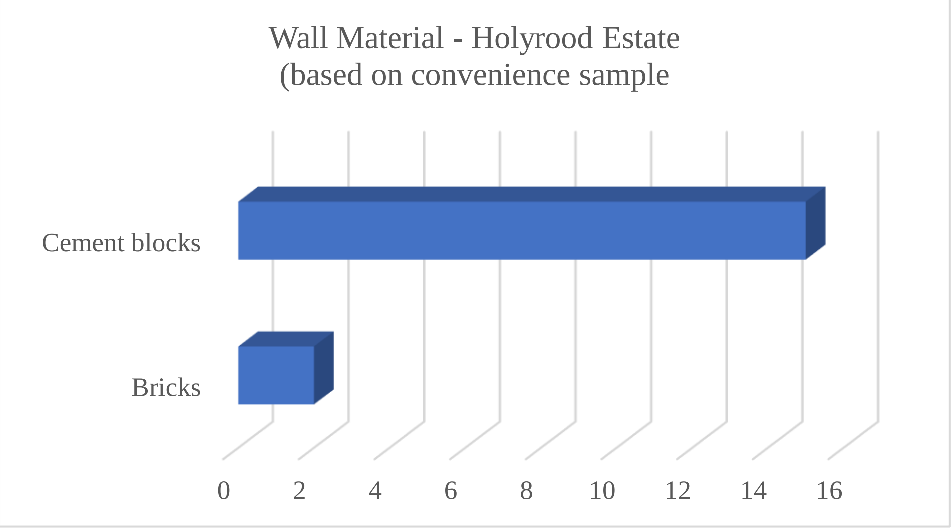


Figure E2-23: General Household Characteristics-Holyrood Estate Convenience Sample

None of the houses in the sample had natural or rudimentary materials used for floor, roof or walls. All houses except for two had cement/concrete as the floor material. The sample included some new houses as well. Two of these houses were very spacious and had floor tiles. Most houses used basic roof tiles or asbestos while a few used metal sheets as the roof material. Nearly all houses used cement block walls apart from two of the new houses, which used bricks.

When looking at the sanitation facility available for each household, the type of toilets used as well as whether the household shared the facility with any other family or families was considered. It should be noted that, none of the houses in the sample shared their toilet with any other household. From Figure E2-24, it is clear that a majority of the households used pit-latrines toilets. Upon inspection, it was seen that most of them were built with proper sealing to ensure some degree of hygiene.

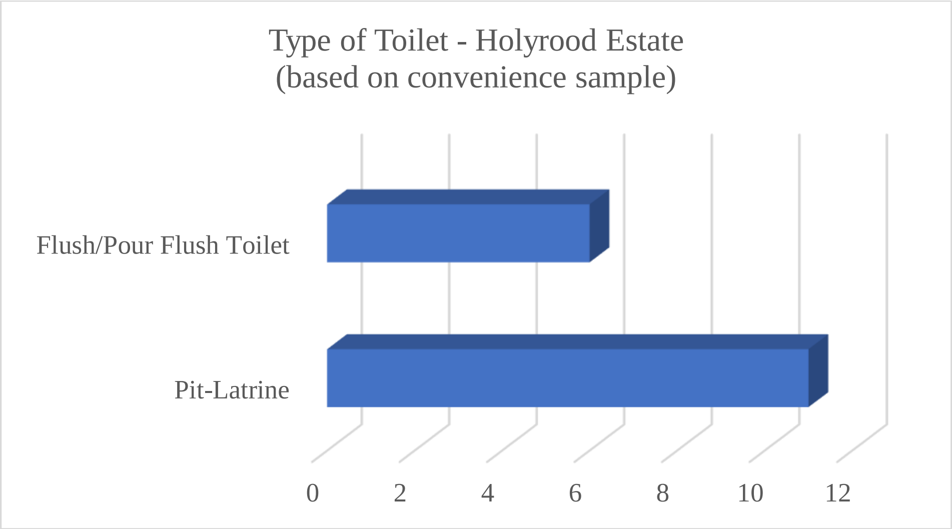


Figure E2-24: Type of Toilet Used- Holyrood Estate Convenience Sample

The next section of the questionnaire looked at the main source of water and the main type of fuel used for cooking in the house. Figure E2-25 below shows the main source of water used by the sampled households. A clear majority of houses in the sample used a public tap in order to collect water for their daily household needs. A public tap was usually provided for each line of houses, with some lines having two taps to be shared between approximately 6 houses. The newly built single houses each had its own water line, which provided water in to the dwelling.

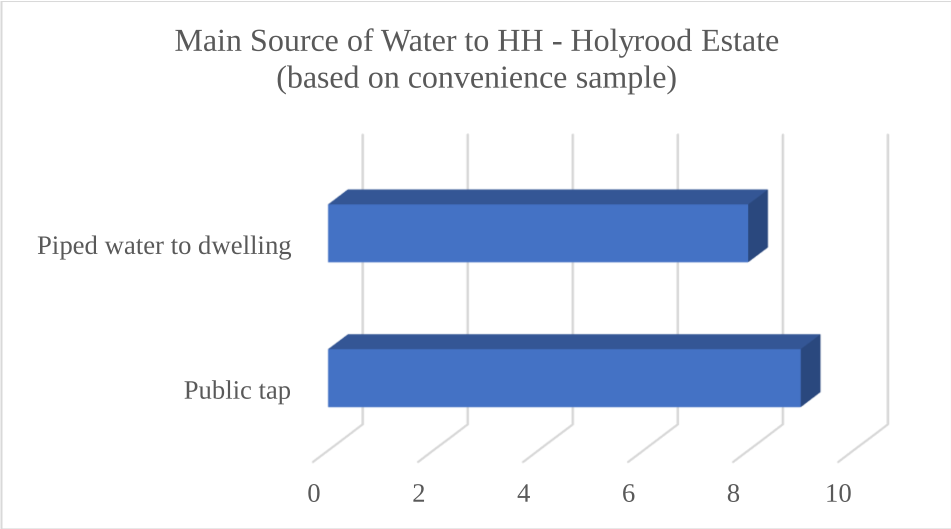


Figure E2-25: Main Source of Water- Holyrood Estate Convenience Sample

All houses in the sample used firewood for daily cooking. It was interesting to note that 5 of the 17 houses in the sample also had a gas cooker and a cylinder of LP gas. However, upon inquiry they stated that this was only used on special occasions when cooking for large crowds or in an emergency. The preferred cooking fuel was fire wood.

When considering the windows and gutters, it was noted that all houses in the sample had at least one window in front of the house. However, 9 of the 17 houses did not have proper guttering in the roof to dispose of rainwater. This is a serious issue since these tea estates receive rain through much of the year and rainwater collecting in corners of the roof could provide breeding grounds to mosquitos and other types of insects. The last section of the questionnaire looked at the number of people living in each household and some general assets that each household had. The graph below clearly shows that a majority of houses in the sample had 5 or more members living in it with five houses each having 7 or more house members. Even though this may not be generalizable, this observation clearly back past research that notes overcrowding as a major issue when considering estate housing (Institute of Social Development, 2008).

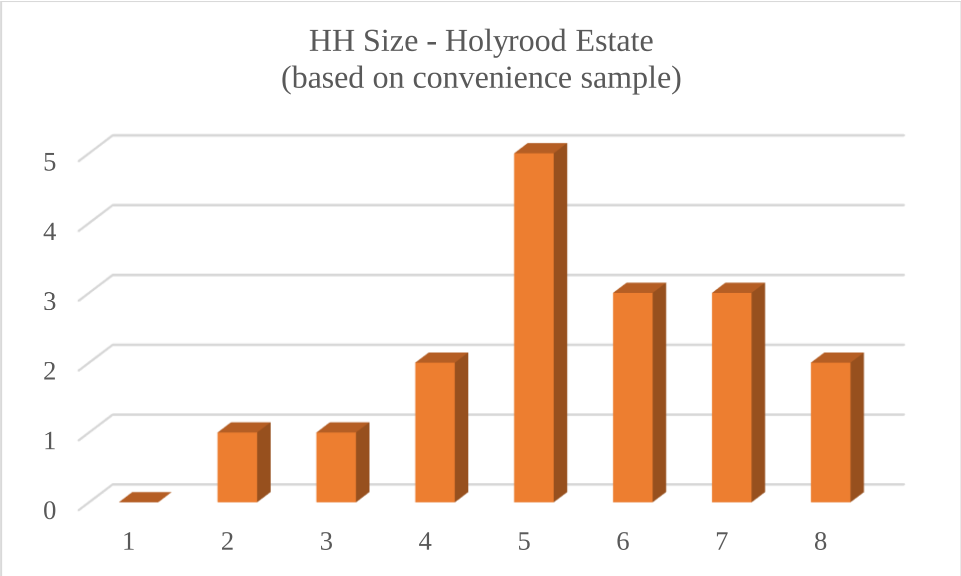


Figure E2-26: HH Size- Holyrood Estate Convenience Sample

The graph below shows the distribution of utilities and assets considered in the questionnaire. All houses in the sample had electricity and nearly 90% of the households had a television set. It is also interesting to note that approximately 30% of the 17 houses in the sample had a subscription for dish/cable television service. Cycles, motor cycles and three-wheelers, are among the most commonly owned vehicles among the estate populous of the country. In this sample, six of the 17 households (35%) owned one of these three vehicle types. It should also be noted that 8 of the 17 households maintained a small home-garden either in a space separately provided to them by the estate management or in the limited space available in their backyard. Some of the households indicated that, the vegetables produced is usually sold at the village fare with little being consumed at home.

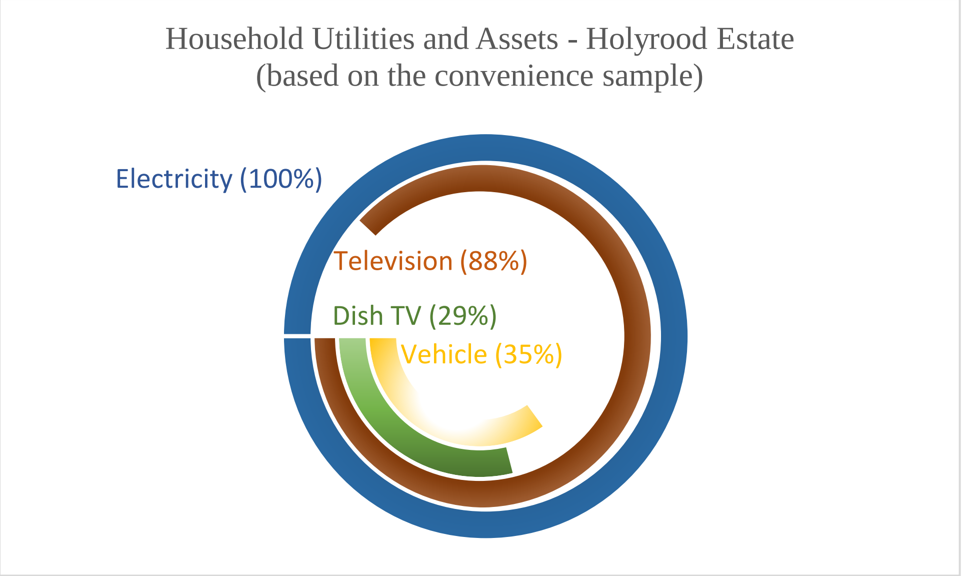


Figure E2-27: Distribution of Utilities and Assets- Holyrood Estate Convenience Sample

The following figures show some of the visited houses as well as snippets of our field visit to Holyrood estate.


Talawakelle
HOLYROOD ESTATE
MATERNITY WARD
UPGRADED IN 2002 WITH THE
ASSISTANCE OF THE PHDT NUWARA ELIYA


WELCOME
HEALTH STATICS
MCH/FM


LABOUR ROOM

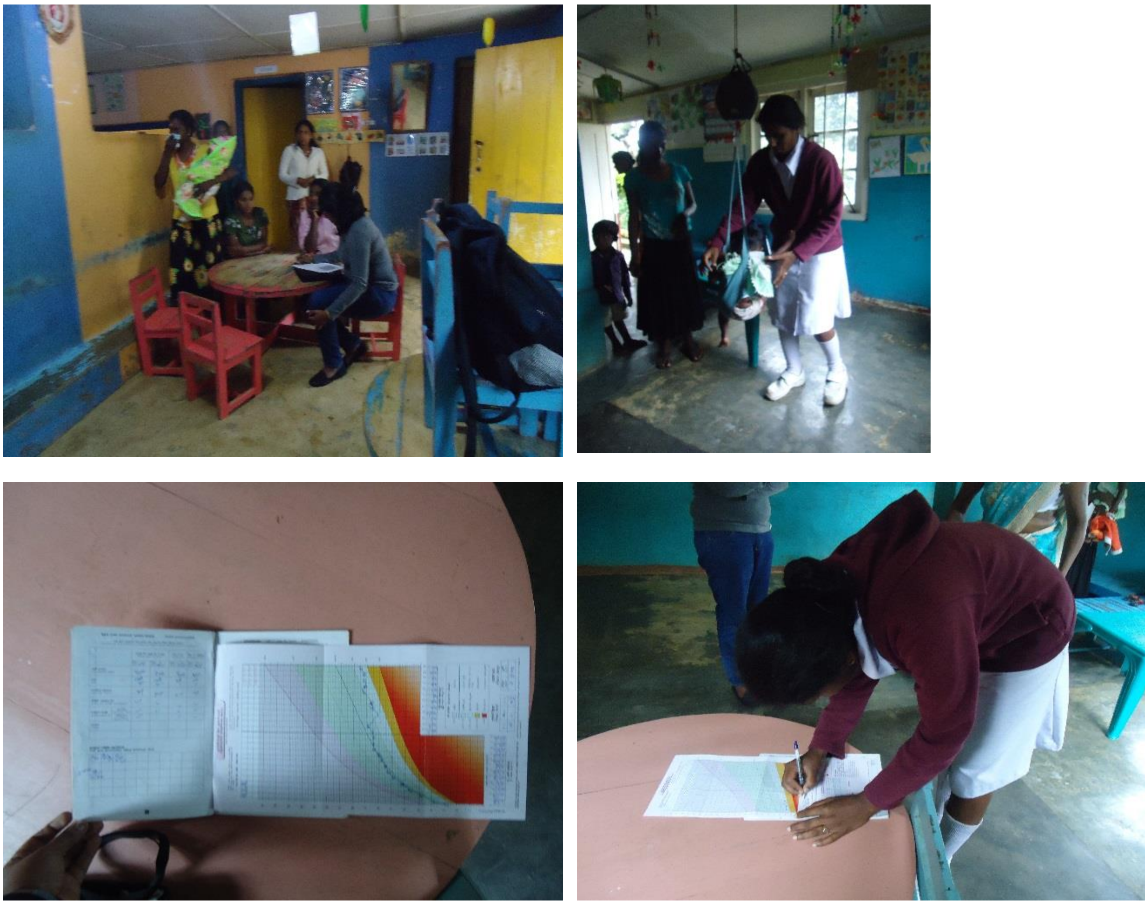


Figure E2-28: Snippets of Field Visit- Holyrood Estate

Dessford Estate

The CDO, Midwife and HH Quality questionnaires were also administered at Dessford estate. The HH Quality questionnaire was tested on a convenience sample of 15 houses within the estate. However, while the CDOs of the CDCs were able to provide responses to the CDO questionnaire, problems arose when interviewing the estate midwife. The reason for this was a change to the estate health monitoring system which was put in to place by the MoH and implemented in tea estates across the country (explained in Essay 2). Under the initiative, the Dessford estate midwife was also replaced a few weeks prior to the survey. Therefore, even though she was willing to take part in the survey it was clear that the midwife lacked local knowledge of the estate population and the children who fell under her purview. Due to this reason, details collected via the midwife questionnaire is not included in this section.

CDO Questionnaire- Dessford Estate

Functioning of the CDCs at Dessford estate was very similar to the Bearwell and Holyrood estates. CDCs operated from 7.30 a.m. - 5.00 p.m. on all weekdays, and on Saturdays if plucking was scheduled on weekends. Usual pre-school activities carried out at the CDCs include drawing and handwork, playing with toys and where available, playing in the outdoor play areas. Similar to the other two estates, *Thriposha* was provided to children at tea time (3 p.m.-3.30 p.m.) at all CDCs. Among the hygiene activities, children were trained to wash their hands using soap and water, after playing outside or using the toilet and before taking meals. Given that the CDCs did not cook food within premises, CDOs were not able to provide precise information regarding the types of food provided by parents to their children. However, the following observations were made by the CDOs regarding feeding patterns of children.

Feeding Patterns of Children at CDCs

Similar to the other estates, children below the age of 6 months were only breastfed, and no other food was provided to them by the CDCs. The mothers of these infants visited the CDCs every 2-3 hours to feed their babies. For children above 6 months, mothers usually provided packed meals (pulp food for very small children) to be fed to children at lunch time while mothers of children between 6-12 months continued to visit the CDCs during work, to breastfeed their children. All children above the age of 6 months were fed *Thriposha* mixed with sugar and grated coconut. With regards to the type of food provided to children by parents, most CDOs noted that *roti* and *rice* were the most frequently provided food. However, a troubling point was noted by the CDOs and even the midwife, where despite advice to include high fat substances such as shredded coconut, and vitamin rich vegetables when preparing *roti*, mothers continue to make plain *roti* using only flour and water. CDOs also noted that food provided to children as lunch by parents, generally lacked variety especially with regards to protein-rich foods.

Medical and Other Services

As in the other two estates, the CDCs provided de-worming medication through the midwife. Regular parent meetings were also held at each CDC. Health and Nutrition Awareness Programmes were held annually at the estate. The following figure provides snippets of the basic CDC setup and programmes organized by the CDCs annually.

Housing Quality Questionnaire- Dessford Estate

A convenience sample of 15 houses were selected from Dessford estate in order to assess the quality of housing at the estate. The following graphs give a breakdown of houses by house type and quality.

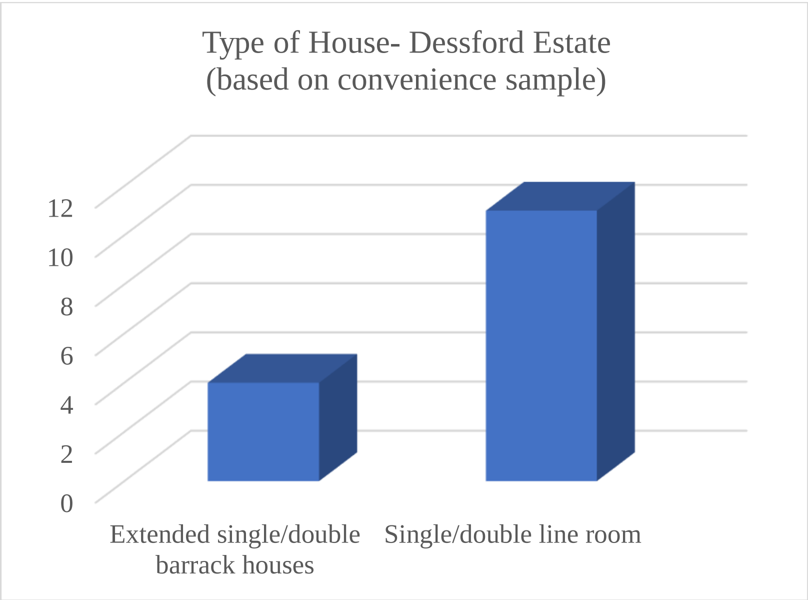
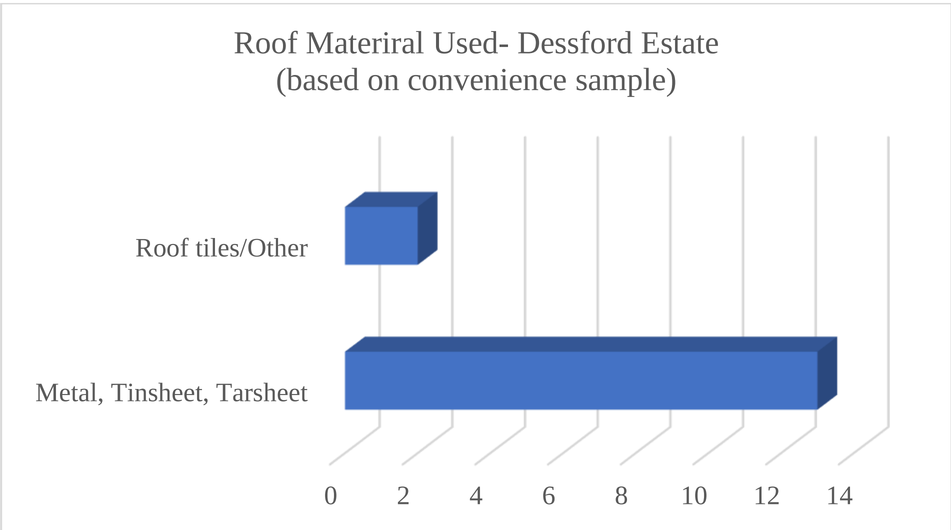


Figure E2-29: Type and Overall Quality of Housing- Dessford Estate Convenience Sample

Majority of the houses sampled were single/double line rooms. Close to half of the sampled houses were of medium quality, while a few houses were newer and of better quality. Seven of the fifteen houses in the sample were classified as ‘medium’ while Six of the seventeen houses in the sample were new single houses. All houses had floors constructed of either cement or concrete.



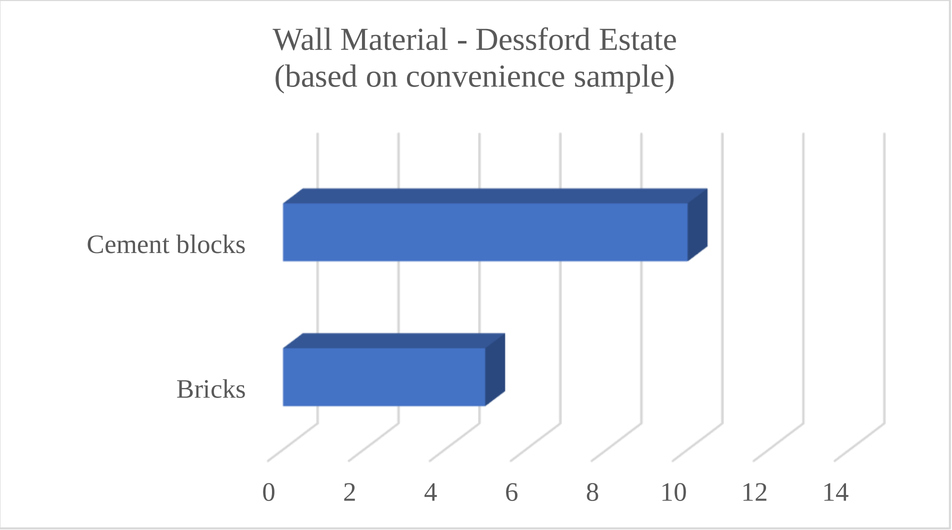
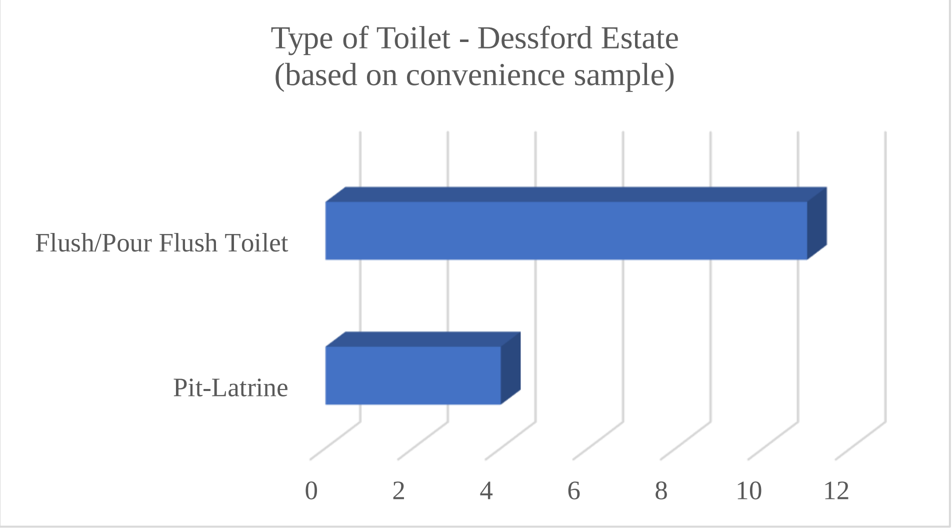


Figure E2-30: General Household Characteristics-Dessford Estate Convenience Sample

Most houses in the sample used metal/tinsheets on their roof while a few used roof tiles. Majority of houses had walls built of cement blocks. Most houses had flush or pour flush toilets while four of the fifteen houses shared their toilet facilities with other households.



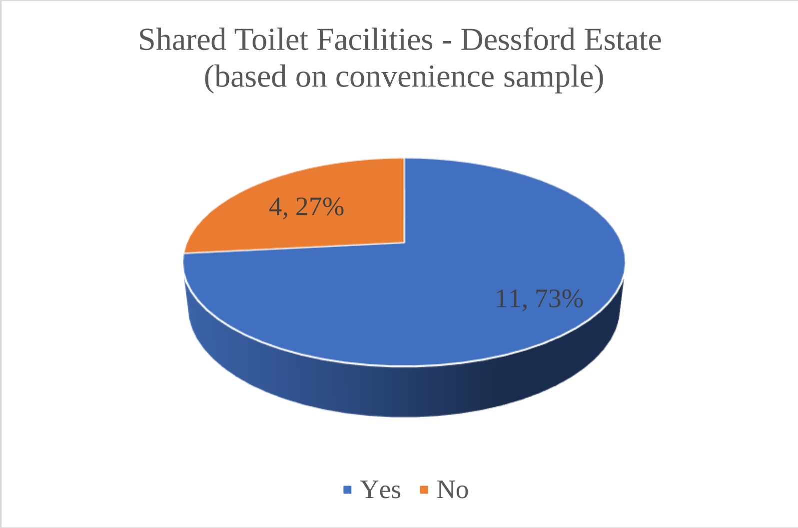


Figure E2-31: Type of Toilet Used- Dessford Estate Convenience Sample

Figure E2-32 below gives a breakdown of the main source of water used in the HH. It was interesting to note that nearly half of the sampled houses had access to tube wells that provided water to the household. Eight of the sampled houses had piped water to the dwelling. Most houses sampled use firewood as the main fuel for cooking while a few houses also use gas cookers.

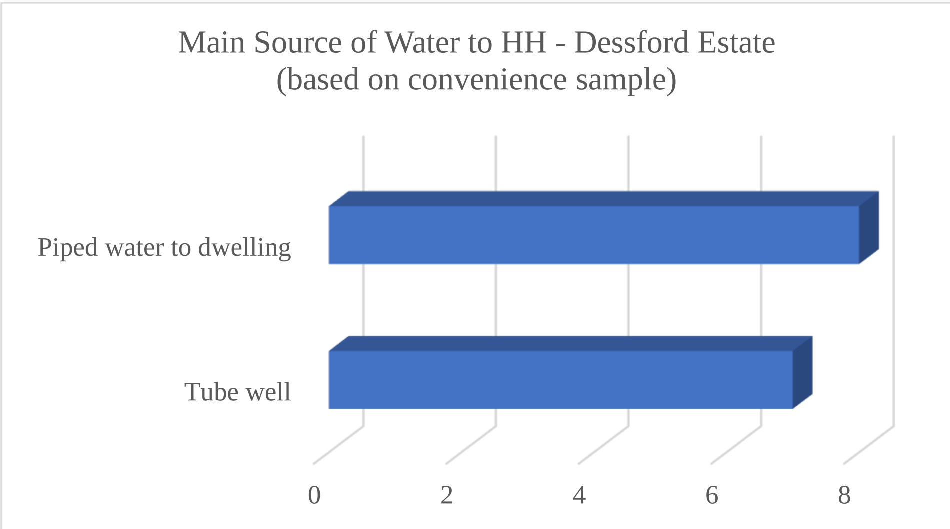


Figure E2-32: Main Source of Water- Dessford Estate Convenience Sample

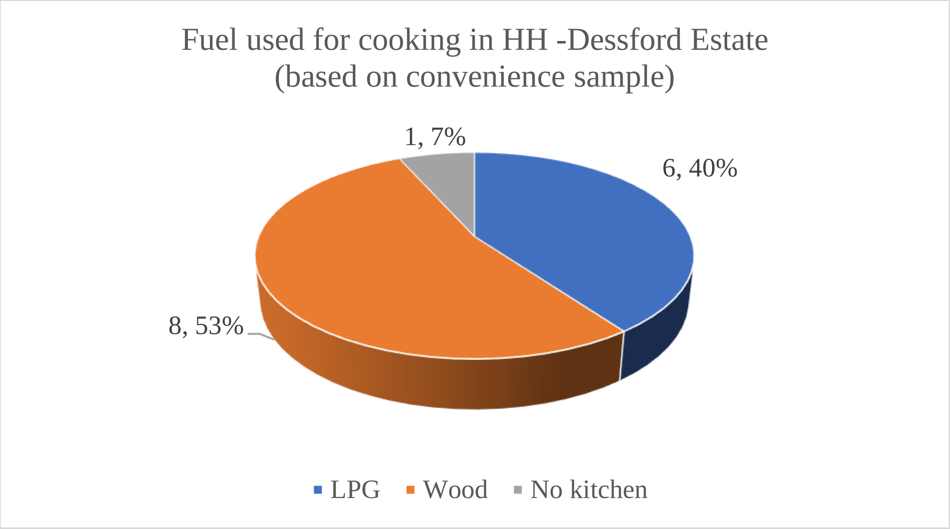


Figure E2-33: Fuel used in HH - Dessford Estate Convenience Sample

When considering the windows and gutters, it was noted that all except one house in the sample had at least one window while ten of the fifteen houses had gutters fitted on to the roof. Most households have at least 5 members while there were no households with less than three members.

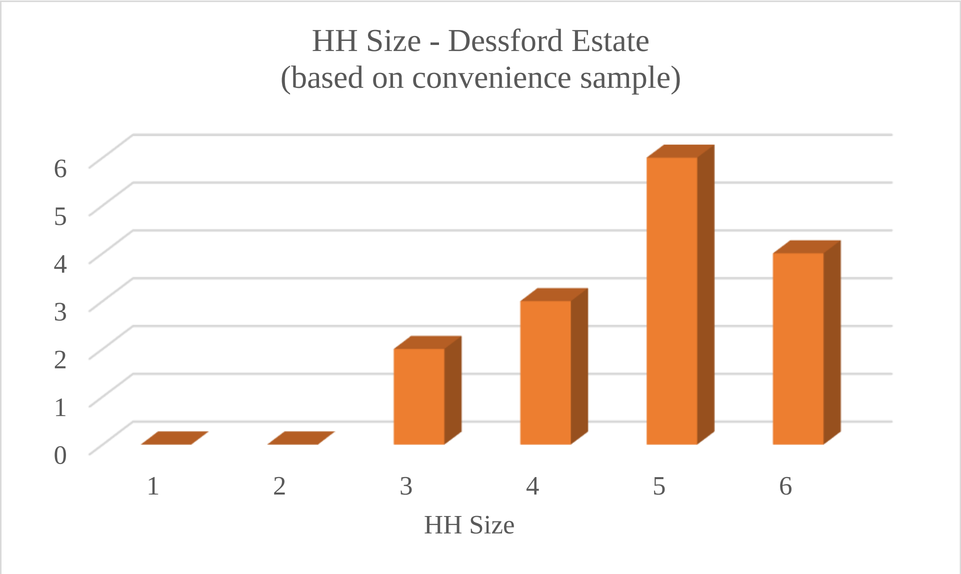


Figure E2-34: HH Size- Dessford Estate Convenience Sample

The graph below shows the distribution of utilities and assets within the sampled households. All houses in the sample had electricity and a television set, while 20% of sampled HHs also had a dish/cable television service. None of the sampled HHs owned a vehicle. Seven of the 15 sampled households maintained a small home-garden.

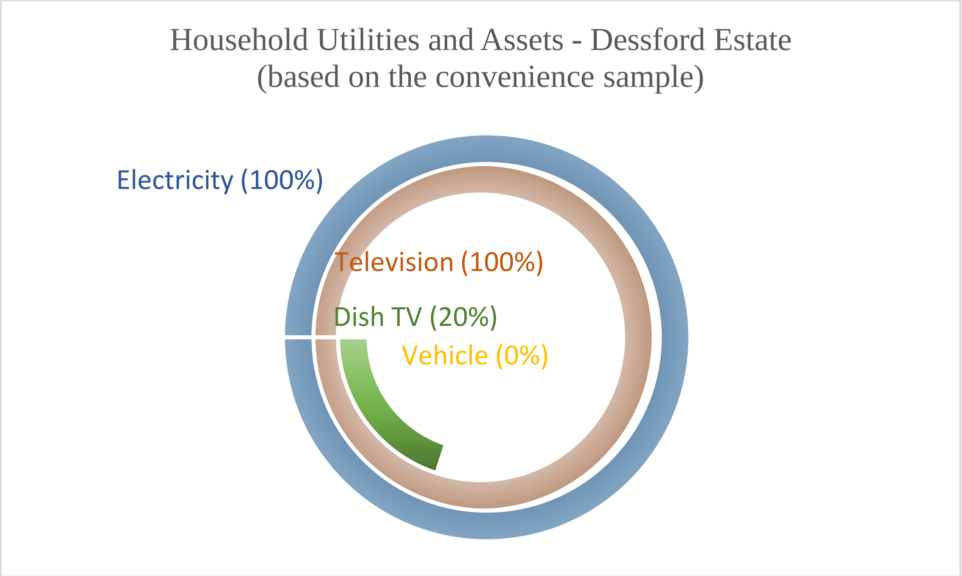


Figure E2-35: Distribution of Utilities and Assets- Dessford Estate Convenience Sample

The following figures show some of the visited houses as well as snippets of our field visit to Dessford estate.

Figure E2-36: Snippets of Field Visit- Dessford Estate

Appendix E3

Creating HH and GN Division Level Wealth Variables

Principal Components Analysis (PCA) is a standard approach used for constructing HH level wealth indices using survey data (Filmer and Pritchett, 1999; Rutstein and Johnson, 2004; Vyas and Kumaranayake, 2006). This approach was adopted to construct the HH and GN division wealth indices in this study. Among other variables, the quality of materials used in constructing the dwelling, general facilities available within the HH and the ownership of assets by each HH was considered in constructing the HH level wealth index. The proportion of HHs satisfying each condition (materials used for building, asset ownership etc.) at the GN division level, was calculated and used in deriving the GN division level wealth index, again through a PCA. The following table gives details of the variables used in constructing the two indices.

Table E3-1: Description of PCA variables - HH and GND w ealth index

Variable	Description
HH Wealth Index	
Utilities	
Water_1	HH's main source of drinking water is piped/bottled
Water_2	HH's main source of drinking water is from a well
Water_3	HH's main source of drinking water is from a spring/river
Water_4	Other main source of drinking water
Water location	HH's main source of drinking water is within dwelling
Toilet_1	HH has a modern flush toilet
Toilet_2	HH has a traditional flush toilet
Toilet_3	HH has a pit-latrine toilet
Toilet_4	HH uses bush/field as toilet
Shared_toilet	HH shares a toilet facility with other HHs
Housing Characteristics	
ownhouse	Dwelling owned by family member
servants	HH employs domestic help
memperroom	Number of members per room
Head_age	Age of HH head
Head_female	Female HH head
HeadEd_1	HH Head education_Preschool or lower
HeadEd_2	HH Head education_Not completed primary education
HeadEd_3	HH Head education_Completed primary education
HeadEd_4	HH Head education_Not completed secondary education
HeadEd_5	HH Head education_Completed secondary education

Table E3-1 *ctd*

Variable	Description
Durable Assets	
B_11b	HH has electricity
B_11d	HH has a radio
B_11e	HH has television
B_11f	HH has a mobile phone
B_11g	HH has landline phone
B_11h	HH has a refrigerator
B_16	HH has a kitchen
B_17	Material used to build floor of dwelling
B_18	Material used to build roof of dwelling
B_19	Material used to build walls of dwelling
B_21a	HH member owns a bicycle
B_21b	HH member owns a motorcycle
B_21c	HH member owns a trishaw
B_21d	HH member owns a tractor
B_21e	HH member owns a car
B_22	HH member owns agriculture land
B_24	HH member owns livestock
B_26	HH member has a back account
GND Wealth Index	
GND Utilities Profile	
propwater	Proportion of HHs with piped water
propwaterloc	Proportion of HHs with piped water in to dwelling
proptoilet	Proportion of HHs with flush toilets
propsharedtoi	Proportion of HHs sharing toilet facilities
GND Housing Characteristics	
propownhouse	Proportion of HH who own a dwelling
propservant	Proportion of HH with domestic help
propfemhead	Proportion of HH with a female head
avgmemperroom	Average members per room
GND Asset Profile	
Propkitchen	Proportion of HHs with a kitchen
Propfuel	Proportion of HH using electricity/gas for cooking
Propwatch	Proportion of HHs with a watch
Propelec	Proportion of HHs with electricity
Proptele	Proportion of HHs with a television
Propradio	Proportion of HHs with a radio
Propmobphone	Proportion of HHs with a mobile phone
Proplandphone	Proportion of HHs with a land line
Propfridge	Proportion of HHs with a refrigerator
Propbike	Proportion of HHs owning a bicycle
Propmobike	Proportion of HHs owning a motorcycle
Proptrishaw	Proportion of HHs owning a trishaw
Proptractor	Proportion of HHs owning a tractor
Propcar	Proportion of HHs owning a car
Propagri	Proportion of HHs owning agriculture land
Proplivestock	Proportion of HHs owning livestock
Propbank	Proportion of HHs with a bank account

Heckman Stage-1 models for Height-for-age

Table E3-2: Heckman stage-1 model results- *HAZ*

		Individual Tsunami Exposure	*Community Tsunami Exposure*	*Combined Exposure*
Tsunami Effect				
Individual	Affected			-0.22
				(0.241)
Community	Not affected	0.07	0.07	-0.013
		(0.151)	(0.151)	(0.179)
Child-level				
Gender	Female	0.391**	0.391**	0.393**
		(0.133)	(0.133)	(0.133)
Age		0.05**	0.05**	0.05**
		(0.005)	(0.005)	(0.005)
Birth order		0.988**	0.988**	0.985**
		(0.147)	(0.147)	(0.147)
Maternal-level				
Mother age at birth(yr)		0.004	0.004	0.004
		(0.014)	(0.014)	(0.014)
Mother height (cm)		0.02+	0.02+	0.019+
		(0.011)	(0.011)	(0.011)
Mother BMI		-0.016	-0.016	-0.016
		(0.016)	(0.016)	(0.016)
Mother edu.	N/C Pri_edu	-0.12	-0.12	-0.152
		(1.9)	(1.9)	(1.854)
	Comp Pri_edu	0.512	0.512	0.485
		(1.933)	(1.933)	(1.889)
	N/C Sec_edu	0.09	0.09	0.046
		(1.899)	(1.899)	(1.854)
	Comp Sec_ edu		0.294	0.243
			(1.916)	(1.872)
HH-level				
WealthQ	Second	0.068	0.068	0.066
		(0.23)	(0.23)	(0.23)
	Middle	0.094	0.094	0.106
		(0.252)	(0.252)	(0.254)
	Fourth	0.143	0.143	0.144
		(0.262)	(0.262)	(0.263)
	Highest	0.357	0.357	0.361
		(0.314)	(0.314)	(0.314)
Ethnicity	SL/Indian Tamil	-0.265	-0.265	-0.277
		(0.219)	(0.219)	(0.219)
	SL Moor/Malay	-0.005	-0.005	-0.014
		(0.2)	(0.2)	(0.2)
	Other	-2.138**	-2.138**	-2.17**
		(0.716)	(0.716)	(0.717)
Head age(yr)		0.006	0.006	0.006
		(0.005)	(0.005)	(0.005)
Head gender	Female	0.039	0.039	0.036
		(0.175)	(0.175)	(0.175)

Table E3-2 *ctd*.

		Individual Tsunami Exposure	*Community Tsunami Exposure*	*Combined Exposure*
Head edu	N/C Pri_edu	-0.032	-0.032	-0.002
		(1.922)	(1.922)	(1.878)
	Comp Pri_edu	-0.492	-0.492	-0.468
		(1.933)	(1.933)	(1.89)
	N/C Sec_edu	0.021	0.021	0.057
		(1.924)	(1.924)	(1.881)
	Comp Sec_ edu	-0.292	-0.292	-0.258
		(1.938)	(1.938)	(1.895)
Total_children		-1.049**	-1.049**	-1.048**
		(0.136)	(0.136)	(0.136)
GND-level				
GND WealthQ	Second	0.195	0.195	0.204
		(0.255)	(0.255)	(0.257)
	Middle	0.018	0.018	0.021
		(0.27)	(0.27)	(0.271)
	Fourth	0.072	0.072	0.061
		(0.284)	(0.284)	(0.286)
	Highest	-0.121	-0.121	-0.149
		(0.332)	(0.332)	(0.335)
GND mode occu	Professionals	0.156	0.156	0.163
		(0.33)	(0.33)	(0.33)
	A/Professionals	0.254	0.254	0.251
		(0.277)	(0.277)	(0.276)
	Clerical/Sup staff			
	Services/Sales	0.077	0.077	0.073
		(0.265)	(0.265)	(0.265)
	Agri/Forestry	0.409	0.409	0.415
		(0.307)	(0.307)	(0.308)
	Carftsman	0.338	0.338	0.338
		(0.269)	(0.269)	(0.269)
	Plant/Machinery	0.856*	0.856*	0.846*
		(0.371)	(0.371)	(0.371)
	Elementary Occu	0.408	0.408	0.425+
		(0.256)	(0.256)	(0.257)
Prop_SkilledEmp		0.263	0.263	0.284
		(0.453)	(0.453)	(0.454)
Prop_WomenEmp		0.045	0.045	0.055
		(0.461)	(0.461)	(0.461)
_cons		-2.561	-2.561	-2.325
		(2.185)	(2.185)	(2.193)
N		76	76	76

OLS Regression models for DS Division Restricted Sample- Height-for-age

Table E3-3: OLS Regression results for DS Division restricted sample- *HAZ*

		Individual Tsunami Exposure	*Community Tsunami Exposure*	*Combined Exposure*
Tsunami Effect				
Individual	Affected	-0.085		-0.01
		(0.101)		(0.108)
Community	Affected		-0.111+	-0.107+
			(0.06)	(0.064)
Child-level				
Birthweight		0.001**	0.001**	0.001**
		(0.0001)	(0.0001)	(0.0001)
Gender	Female	0.054	0.057	0.056
		(0.053)	(0.053)	(0.053)
Age		-0.055**	-0.055**	-0.055**
		(0.006)	(0.006)	(0.006)
Age_sq		0.001**	0.001**	0.001**
		(0.0001)	(0.0001)	(0.0001)
Antenatal care	Yes	0.02	0.02	0.02
		(0.062)	(0.062)	(0.062)
Birth supervision	Sup_NonH	-0.724	-0.699	-0.697
		(0.684)	(0.693)	(0.695)
Maternal-level				
Mother age(yr)		0.005	0.005	0.005
		(0.005)	(0.005)	(0.005)
Mother height (cm)		0.048**	0.048**	0.048**
		(0.007)	(0.007)	(0.007)
Mother BMI		0.008	0.008	0.008
		(0.006)	(0.006)	(0.006)
Mother edu.	N/C Pri_edu	0.708**	0.744**	0.741**
		(0.235)	(0.233)	(0.235)
	Comp Pri_edu	0.868**	0.903**	0.9**
		(0.254)	(0.25)	(0.254)
	N/C Sec_edu	0.959**	0.995**	0.991**
		(0.236)	(0.231)	(0.235)
	Comp Sec_ edu	1.095**	1.129**	1.125**
		(0.259)	(0.253)	(0.258)
HH-level				
WealthQ	Second	-0.118	-0.115	-0.115
		(0.126)	(0.125)	(0.125)
	Middle	-0.025	-0.024	-0.024
		(0.123)	(0.123)	(0.123)
	Fourth	-0.001	0.002	0.002
		(0.126)	(0.126)	(0.126)
	Highest	0.119	0.123	0.123
		(0.135)	(0.135)	(0.135)

Table E3-3 *ctd.*

		Individual Tsunami Exposure	*Community Tsunami Exposure*	*Combined Exposure*
Ethnicity	SL/Indian Tamil	0.099	0.103	0.104
		(0.096)	(0.095)	(0.095)
	SL Moor/Malay	-0.158*	-0.153*	-0.153*
		(0.073)	(0.073)	(0.073)
	Other	0.249	0.295	0.293
		(0.28)	(0.275)	(0.277)
Head age(yr)		-0.001	-0.001	-0.001
		(0.002)	(0.002)	(0.002)
Head gender	Female	-0.009	-0.003	-0.004
		(0.073)	(0.073)	(0.073)
Head edu	N/C Pri_edu	0.127	0.12	0.122
		(0.187)	(0.185)	(0.186)
	Comp Pri_edu	0.123	0.117	0.118
		(0.2)	(0.197)	(0.198)
	N/C Sec_edu	0.237	0.228	0.229
		(0.181)	(0.178)	(0.179)
	Comp Sec_ edu	0.26	0.247	0.248
		(0.205)	(0.204)	(0.204)
GND-level				
GND WealthQ	Second	0.165	0.167	0.168
		(0.147)	(0.145)	(0.145)
	Middle	0.168	0.169	0.169
		(0.133)	(0.131)	(0.131)
	Fourth	0.097	0.094	0.094
		(0.139)	(0.137)	(0.137)
	Highest	0.169	0.169	0.169
		(0.146)	(0.145)	(0.145)
GND mode occu	Professionals	0.065	0.066	0.066
		(0.14)	(0.139)	(0.139)
	A/Professionals	0.048	0.044	0.044
		(0.107)	(0.107)	(0.107)
	Clerical/Sup staff	0.07	0.065	0.067
		(0.241)	(0.246)	(0.245)
	Services/Sales	-0.061	-0.064	-0.064
		(0.124)	(0.124)	(0.124)
	Agri/Forestry	0.07	0.078	0.078
		(0.117)	(0.114)	(0.114)
	Carftsman	0.049	0.053	0.054
		(0.104)	(0.102)	(0.103)
	Plant/Machinery	0.195+	0.19+	0.19+
		(0.102)	(0.102)	(0.102)
	Elementary Occu	0.177+	0.175+	0.175+
		(0.099)	(0.099)	(0.099)
Prop_SkilledEmp		0.223	0.211	0.212
		(0.184)	(0.185)	(0.184)
Prop_WomenEmp		0.02	-0.0003	-0.0001
		(0.186)	(0.186)	(0.186)
_cons		-10.721**	-10.757**	-10.75**
		(1.078)	(1.093)	(1.074)
N		1908	1908	1908

MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number: CF15/1502 - 2015000740

Project Title: Nutritional Status of Children Living in Estates and Assessing the Effectiveness of Nutritional Interventions

Chief Investigator: Prof Brett Inder

Approved: **From:** 28 May 2015 **To:** 28 May 2020

Terms of approval - ***Failure to comply with the terms below is in breach of your approval and the Australian Code for the Responsible Conduct of Research.***

1. The Chief investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must include your project number.
6. **Amendments to the approved project (including changes in personnel):** Require the submission of a Request for Amendment form to MUHREC and must not begin without written approval from MUHREC. Substantial variations may require a new application.
7. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
8. **Annual reports:** Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
10. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by MUHREC at any time.
11. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

Professor Nip Thomson
Chair, MUHREC

cc: Mrs Udeni De Silva Perera

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ABN 12 377 614 012 CRICOS Provider #00008C

Memorandum of Understanding

Between
Monash University
(Prof. Brett Inder & Mrs. D. B. U. S. De Silva Perera)
and
Plantations Human Development Trust
(Dr. Ravi Nanayakkara – Director/Health)

SUBJECT: Access to Data

This Memorandum is in relation to granting Mrs. D. B. U. S. De Silva Perera and Prof. Brett Inder

- access to existing Estate Data collected by the PHDT through Estate Mid-Wives
- access to collecting primary data at specific Estates for research purposes.

The data is for use in the Monash University Ph.D. research of D. B. U. S. De S Perera, titled "Developing Suitable Predictive Models for Child Malnutrition in Sri Lanka".

We sincerely thank Dr. Ravi Nanayakkara and the Plantations Human Development Trust (PHDT)- Sri Lanka, for providing us with the required data to carry out the statistical analysis. This MOU is to fulfill any legal obligations that might arise during the course of this project and after its conclusion.

The PHDT has access to data already collected on tea estate workers and their families that can be used for statistical research and analysis purposes. The PHDT is also in a position to sanction the collection of primary data at the estates for research purposes. Access to available secondary data as well as permission to collect primary data at the estates will be given to Mrs. D. B. U. S. De Silva Perera, but only if the data are used and protected in accordance with the terms and conditions stated in this Memorandum of Understanding (MOU).

Prof. Brett Inder, Mrs. D. B. U. S. De Silva Perera (hereinafter referred to as the "Contracting Party") and Dr. Ravi Nanayakkara (on behalf of the PHDT-SL) agree that:

I. INFORMATION SUBJECT TO THIS MOU

A. All data collected by or on behalf of PHDT, that are provided to the Contracting Party are referred to in this MOU as "subject secondary data", while primary data collected at the Estates will be referred to as "subject primary data"

B. Subject data (both primary and secondary) under this MOU may be in the form of a soft copy or hard copy. The Contracting Party may only use the subject data in a manner and for a purpose consistent with the limitations imposed under the provisions of this MOU.

II. INDIVIDUALS WHO MAY HAVE ACCESS TO THE SUBJECT DATA

A. There are two categories of individuals that the Contracting Party may authorize to have access to subject data. The two categories of individuals are as follows:

1. The Co- Supervisor Prof. Ranjan Ray who may provide advisory consultation on the research
2. Internal/External examiners appointed by the Department of Econometrics and Business Statistics-Monash University, to assess the Ph.D. work carried out.

III. LIMITATIONS ON DISCLOSURE

A. The Contracting Party shall not use or disclose subject data (both secondary and primary) for any commercial or administrative purposes nor may they be applied in any manner to change the status, condition, or public perception of any individual/ estate/company regarding who subject data is maintained.

B. The Contracting Party shall not disclose subject data referring to fine levels of geography, through their analysis, but would use this information in a coded form as and when analytical requirements occur.

C. The Contracting Party shall not make any publication or other release of the subject data provided by the PHDT or collected at the Estates.

D. The Contracting Party will share any significant findings derived through the analysis of subject data (both primary and secondary) with the PHDT through the before proceeding to publications.

We agree to adhere by all conditions and limitations stated in this MOU

U. S. De Silva

D. B. U. S. De Silva Perera

Prof. Brett Inder

On behalf of Monash University

Dr. Ravi Nanayakkara

on behalf of the Plantations Human Development Trust (SL)

MONASH University

CONSENT FORM

(Child Development Officer)

Project: Nutritional Status of Children Living in Estates and Assessing the Effectiveness of Nutritional Interventions

Chief Investigator: Udeni De Silva Perera

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

I consent to the following:	Yes	No
Taking part in an interview where I will be questioned on certain aspects pertaining to the functioning of the CDC	☐	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐

Name of Participant ____

Participant Signature ______________________________________ Date __________

MONASH University

CONSENT FORM
(Estate Mid-Wife)

Project: Nutritional Status of Children Living in Estates and Assessing the Effectiveness of Nutritional Interventions

Chief Investigator: Udeni De Silva Perera

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

I consent to the following:	Yes	No
Taking part in an interview where I will be questioned on certain aspects pertaining to the research	☐	☐
Sharing individually non-identifiable height and weight information on children monitored by me	☐	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐

Name of Participant ______________________________

Participant Signature ______________________________ Date ______________

Survey of Child Development Officers

CDC Questionnaire

Part-1 A : To be filled by CDC Head/Supervisor

1. CDC Name

[ ]

2. Number of staff/child-carers

[ ]

3. Does the CDC operate daily?

- ○ Yes
- ○ No

3.1. If no, how often does the CDC function?

- ○ Only on week days
- ○ On 3-4 days a week
- ○ On 2-3 days a week
- ○ Once a week
- ○ A few days a month
- ○ Other (please specify)

[ ]

3.2. What are the usual operating time of the CDC ?

- ○ 8.00 a.m.- 5.00 p.m.
- ○ 8.00 a.m.-1.00 p.m./ 1.00 p.m.-5.00 p.m. or half day
- ○ 8.00 a.m.-8.00 p.m./ extended hours
- ○ The CDC runs on flexible times
- ○ Other

[ ]

4. Number of children registered in CDC

5. Age distribution of children

0-6 months

6-12 months

12-24 months

24-60 months

> 60 months

6. Does the CDC provide any medical services for the children?

- Yes
- No

6.1. If 'Yes', what type of services are provided?

- Medical attention to sick children
- Vaccination programmes
- De-worming programmes
- Providing Vitamin A suppliments
- Other (please specify)

7. Normal daily activities carried out at CDC

Educational Activities

Health & Hygiene Training Activities (e.g. Washing Hands before meals/ after using toilets)

Outdoor Activities

Other Activities

8. Does the CDC provide any mid-day meal to the children?

- Yes
- No

8.1. If 'Yes' how often does the CDC provide the mid-day meal?

- On everyday that the CDC operates
- On some of the days that the CDC operates

8.2. If the CDC provides a mid-day meal only on certain days, please elaborate on this:

9. If the CDC provides mid-day meals, where are these meals prepared?

- The meals are prepared within the CDC it self
- The meals are prepared else where and brought to the CDC

9.1. If the meals are prepared within the CDC who prepares them?

- ○ CDC employees a separate staff member/s to prepare meals
- ○ The teachers attached to the CDC prepare meals themselves
- ○ Other (please specify)

9.2. Observe facilities available at CDC for preparing meals and comment:

10. Does the CDC hold child health/safety and nutrition awareness programmes for parents?

- ○ Yes
- ○ No

10.1. If 'Yes' explain the nature of these programmes and their frequency

OBSERVATIONAL

11. The Center is: (select all applicable options)

- ☐ a) Clean
- ☐ b) Welcoming
- ☐ c) Untidy
- ☐ d) Organized
- ☐ e) Well-managed
- ☐ f) Cluttered
- ☐ g) Safe
- ☐ h) Happy
- ☐ i) Friendly
- ☐ j) Other (please specify)

Children Aged 0-6 Months

1. If the CDC has children in this age group, explain their meal patterns

- [ ] Mothers come to the CDC at regular intervals to feed their babies
- [ ] Mother prepare baby formula milk and provide to the CDOs to feed the baby
- [ ] Mother provide powdered milk to the CDOs to feed the baby
- [ ] Center provides babies with baby formula milk
- [ ] Center provides babies with fresh cows/goat milk
- [ ] Center provides babies with podered cows milk
- [ ] Other (please specify)

1.1 If mothers come to feed their babies can you indicate how often they are fed?

1.3. If center provides baby formula,fresh or powdered milk,

Number of serves of milk given

Average serve size (ml/feeding bottle)

1.2. If parents provides baby formula,fresh or powdered milk to be given to baby,

Number of serves of milk given

Average serve size (ml/feeding bottle)

CDC Questionnaire: Mid Day Meals Programme

Children Aged 6-12 Months

1. If the CDC has children in this age group, explain their feeding patterns

- [ ] Mothers come to the CDC at regular intervals to feed their babies
- [ ] Mother prepare baby formula milk and provide to the CDOs to feed the baby
- [ ] Mother provide powdered milk to the CDOs to feed the baby
- [ ] Center provides babies with baby formula milk
- [ ] Center provides babies with fresh cows/goat milk
- [ ] Center provides babies with powdered cows milk
- [ ] Other (please specify)

1.1 If mothers come to feed their babies can you indicate how often they are fed?

1.2. If parents provides baby formula,fresh or powdered milk to be given to baby,

Number of serves of milk given

Average serve size (ml/feeding bottle)

1.3. If center provides baby formula,fresh or powdered milk,

Number of serves of milk given

Average serve size (ml/feeding bottle)

1.4. Does the center provide any types of milk substitutes?

- [ ] Soya bean milk
- [ ] Goat milk
- [ ] Evaporated/ Condensed milk (milkmaid)
- [ ] Other (please specify)

1.5. If so,

Number of serves of milk given ____________

Average serve size (ml/feeding bottle) ____________

Children Aged 12-24 Months

1. If the CDC has children in this age group, explain their feeding patterns

- [ ] Mothers come to the CDC at regular intervals to feed their babies
- [ ] Mother prepare baby formula milk and provide to the CDOs to feed the baby
- [ ] Mother provide powdered milk to the CDOs to feed the baby
- [ ] Center provides babies with baby formula milk
- [ ] Center provides babies with fresh cows/goat milk
- [ ] Center provides babies with powdered cows milk
- [ ] Other (please specify) ____________

1.1 If mothers come to feed their babies can you indicate how often they are fed?

____

1.2. If parents provides baby formula,fresh or powdered milk to be given to baby,

Number of serves of milk given ____________

Average serve size (ml/feeding bottle) ____________

1.3. If center provides baby formula,fresh or powdered milk,

Number of serves of milk given ____________

Average serve size (ml/feeding bottle) ____________

1.4. Does the center provide any types of milk substitutes?

- [ ] Soya bean milk
- [ ] Goat milk
- [ ] Evaporated/ Condensed milk (milkmaid)
- [ ] Other (please specify)

1.5. If so,

Number of serves of milk given

Average serve size (ml/feeding bottle)

2. Does the CDC provide children with any solid food daily?

- ( ) Yes
- ( ) No
- ( ) Parent's prepare and send food to be given to child

2.1. If 'Yes' what type of solid food is usually given?(select all applicable options)

- [ ] a) Rice porridge: Size of Serve _______g/ml Number of Serves_________
- [ ] b) Squashed Rice&Vegetables: Size of Serve _______g/ml Number of Serves _________
- [ ] c) Squashed Fruit/Fruit Juice: Size of Serve _______g/ml Number of Serves_________
- [ ] d) Yoghurt/Cheese or other milk solids : Size of Serve _______g/ml Number of Serves _________ (daily/ weekly)
- [ ] e) Boiled Chicken/Fish
- [ ] f) Boiled Eggs
- [ ] g) Other (please specify)

CDC Questionnaire: Mid Day Meals Programme

Children aged 24 months or more

1. Does the CDC provide a routine mid-day meal to children in this age group?

- ◯ Yes
- ◯ No

2. If yes, please explain the typical meals provided.

Survey of Child Development Officers

Food provided by parents

1.Can you comment on the types of food that parent provide their children with (either for breakfast only or lunch or both)

- Cereal- (e.g. thriposha, samaposha)
- Grains (mungata, kadala, kaupi)
- Sandwiches
- Boiled vegetables

Other (please specify)

Midwife Survey

Midwife Background

1. Name of Estate:

2. Name of Estate Company

3. Apart from this Estate, are you responsible for the welfare of children in any other Estates?

4. If yes, how many Estates?

5. On average, how many children fall under your health purview?

6. According to your experience what is the average number of children in a HH in your area?

7. How many pregnancies do you monitor per year on average?

8. According to your experience what is the average age at which Estate mothers have their first child?

Midwife Survey

Midwife Background

9. Can you please briefly explain your duties and responsibilities in a typical work month

- ☐ Measure and monitor the heights and weights of children between the ages 0-5
- ☐ Monitor the health and nutrition of pregnant mothers
- ☐ Visiting CDCs and creches monthly to observe
- ☐ Meeting with parents of 0-5 year old to monitor their nutrition
- ☐ Providing Ant-natal care to pregnant mother and babies
- ☐ Assisting with home births
- ☐ Assisting with hospital births
- ☐ Providing post-natal care and advice to new mothers and infants
- ☐ Carrying out routine vaccination programmes
- ☐ Carrying out routine de-worming programmes
- ☐ Monitoring vaccination and growth cards of children

Other (please specify)

10. Are routine house visits part of you duty?

- ☐ Yes, I visit all houses within my monitory area once a month
- ☐ Yes, I visit all houses within my monitory area once in 3 months
- ☐ I only visit houses with pregnant mothers or new borns
- ☐ I don't visit houses as oart of my normal routine

Midwife Background

11. Do you monitor the health and nutrition of older children?

- ○ Yes
- ○ No

12. If yes, what age ranges fall under your purview?

- ○ 5-10 year olds
- ○ All children below the age of 15
- ○ All children below the age of 17
- ○ Other (please specify)

13. What type of health monitory programmes do you run for older children?

Midwife Survey

Early Childhood Nutrition in Estates

0-6 Months

1. It is prescribed by the WHO that mothers should exclusively breast feed their babies at least in the first 6 months after birth. According to your observations, how many months on average do mothers exclusively breast feed their children within the estate community

- ○ First 3 months
- ○ Between 3-5 months
- ○ 6 months or more

2. What advice do you give to mothers that want to wean their children before the first 6 months?

3. What are the main types of health problems you come across in estate children between the ages of 0-6 months

6-12 Months

1. What weaning food do estate mothers mostly use for their children?

2. What types of milk do estate mothers use mostly when weaning?

- ☐ Fresh cow's milk
- ☐ Goat's milk
- ☐ Baby formula milk
- ☐ Powdered cows milk
- ☐ Condensed milk or other milk substitutes
- ☐ Other (please specify)

3. What is the average age at which Estate mothers usually start their children on solid food?

- ○ Usually after 4 months
- ○ Usually after 6 months
- ○ Usually after 8 months
- ○ Usually after 12 months

4. What solids do Estate mothers usually use for weaning purposes in the first 4-8 months

- ☐ Rice porridge (Kanda)
- ☐ Cereal
- ☐ Squashed rice and vegetables
- ☐ Squashed fruit/fruit juice
- ☐ Small portions of well cooked meat (chicken or fish)

Other (please specify)

5. From your experience when do Estate mothers usually start their newborns on meat/dairy products

- ○ Between 6-8 months
- ○ Between 8-10 months
- ○ Between 10-12 months
- ○ After the first year

6. In your experience, what animal and dairy products do Estate mothers usually feed their children aged 6-12 months?

- ○ Yogurt/Cheese or other Dairy Products
- ○ Egg yolk
- ○ Chicken
- ○ Fish

7. What main types of health problems do you come across in estate children between the ages of 6-12 months?

1-2 year olds

1. In your view what types of solid food do estate mothers mainly feed their children between the ages of 1-2 years

- ☐ Cereal, Rice, Noodles
- ☐ Vegetables
- ☐ Fruit/Fruit Juice
- ☐ Vegetable proteins (soy meat, dhal, chickpeas, beans etc)
- ☐ Chicken
- ☐ Fish
- ☐ Egg
- ☐ Yogurt/Cheese and other Dairy
- ☐ Other (please specify)

2-5 year olds

1. In your experience could you explain the typical meal (excluding proteins) that estate mother can afford to give her child on average? (for children aged 2-5 years)

- ☐ Rice/Noodles or other staples
- ☐ Vegetable
- ☐ Greens (Salad, Leaves etc.)
- ☐ Fruit
- ☐ Fresh milk
- ☐ Powdered milk

Other (please specify)

2. In your experience which sources of protein do Estate mothers able to **afford to mostly provide** their children with?

- ○ Non veg proteins **mostly** (eggs, fish, chicken etc)
- ○ Vegetable proteins **mostly** (dhal, chickpeas, beans, soyameat)
- ○ Both vegetable and non-veg sources of proteins equally
- ○ Other (please specify)

3. In your experience what sources of non-vegetable proteins are Estate mothers able to afford to provide for their children?

- [ ] Eggs
- [ ] Chicken
- [ ] Red meat (pork, mutton)
- [ ] Fish
- [ ] Dried fish

Other (please specify)

4. What are the main types of health problems you come across in estate children between the ages of 1-5 years

Midwife Survey

General Health Issues

1. In your experience, what are the main drivers of child malnutrition in Estate children that you monitor?

- ☐ Lack of adequate ante-natal care (required nutrition during pregnancy etc)
- ☐ Lack of adequate post-natal care (required duration of breast feeding etc)
- ☐ Lack of care in infancy due to mothers work patterns
- ☐ Limited access to food due to family poverty
- ☐ Intake of imbalanced meals due to family poverty (lack of necessary carbohydrates, proteins, fats etc)
- ☐ Parents lack of knowledge regarding balanced meals
- ☐ Frequent illness arising from poor sanitary conditions (e.g. Diarrhea)
- ☐ Frequent illness due to cold climatic conditions

Other (please specify)

2. In your experience what are the main social problems that estate families face?

- ☐ Poverty due to inadequate pay for work
- ☐ Lack of opportunities for better paid jobs
- ☐ Lack of educational opportunities
- ☐ Addiciton to excessive use of alcohol
- ☐ General lack of knowledge and awareness regarding health and sanitation issues
- ☐ Other (please specify)

Midwife Survey

CDC and Mid day meals programmes

1. In your view what can be done to improve the CDC programmes run within your estate?

2. Certain estates have a child mid-day meals programme executed through CDCs, where children registered at the CDC are provided a balanced midday meal. Do you monitor any CDCs both with and without this programme?

- ○ Yes
- ○ No

3. If 'yes', in your view, have you noticed an improvement in the health standard of children attending compared to those who do not attend such CDCs?

- ○ Yes these children show better growth patterns
- ○ No these children don't show a difference in growth patterns

Other (please specify)

Housing Quality Questionnaire

Estate:_______________________ **CDC Name:__________________________**

Aspect	Scale	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10
Type of House											
Newly built single/double story housing units	Good										
Refurbished/re-roofed single barrack line houses	Medium										
Double barrack line houses/Temporary sheds	Bad										
Main material of floor	Natural Floor (sand,dung)										
	Rudim. Floor (Wood, bamboo)										
	Cement or concrete										
	Floor Tiles/Other										
Main material of roof	Natural roofing (straw, palmleaf etc.)										
	Rudim. Roof (cardboard, carton)										
	Metal,Tinsheet,Tarsheets										
	Roof tiles/ Asbestos										
	Cement/concrete										
	Other										
Material of Walls	Natural walls (palm,trunk)										
	Rudim. Walls (bamboo&mud,plywood,cardboard etc)										
	Bricks (Limestone, cement)										
	Cement Blocks										
	Other										

Toilet	Flush or pour flush toilet										
	Pit Latrine										
	No toilet/Other										
Share toilet with another HH	Indicate Y for 'Yes' and N for 'No'										
Main source of water	Piped water (in to dwelling, in to garden, public tap)										
	Tube well										
	Dug well										
	Water from natural spring										
	Rain water/surface water/other										
What type of fuel does your HH mainly use for cooking	Electricity										
	LPG										
	Kerosene										
	Wood										
	No food cooked in HH/Other										
Does the house have windows	Y-Yes N-No										
Does the house have guttering for roof water to flow	Y-Yes N-No										
Notes											