Human Development and Malnutrition: The Case of India

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Dedication

I dedicate this to all the children of the world!

To all my gurus, my friends, my family...

who shaped me to reach this stage...

to all the farmers for nourishing me, to all the soldiers for protecting me,

to Amma, Daddy, and Kuttan for bringing me up!

And to Easwar for recognising me!

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This is the most difficult part, nonetheless, I shall make an attempt...
My husband and companion for life, Easwar, for accepting the person I am. You are marvellous! We have so much to achieve together! My brother, Kuttan, who I have looked up to... my lighthouse... I swell with pride that I am a commando's sister.
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Abstract

Malnutrition, a rising global health concern and a public health priority, currently affects 155 million children from reaching their complete development potential. The human development approach recognises the attainment in three dimensions; a decent standard of living, a long healthy life, and knowledge as central to achieving human progress. The Indian case study in this thesis is an attempt to establish a connection between malnutrition and human development. Secondary data sourced from the Indian Human Development Survey has been used to determine the extent to which socio-economic variables affect this relationship. Primary data has been collected and used from a cluster randomised trial that was designed towards a possible fortified-food based intervention for *Anganwadi* (pre-school) attending children below 6 years.

Econometric modelling of the child health and income gradient using the spline regression technique showed that an income rise results in a marked improvement in child health status only beyond a threshold of 176.2 USD. Additionally, the transmission channels explained about 39 per cent of the overall income effect. A cluster randomised control trial in an urban slum which provided micronutrient fortified food as treatment to the enrolled children leveraged the strength of a multi-sectoral partnership model for community mobilisation. Person centred treatment effects analysis allowed the identification of heterogeneity in treatment which showed a significant improvement of 0.099 units on Weight-for-height z-score of children in the treatment group. A comparison between achievement across all states of India by constructing a household data based human development index provisions for analyses based on demographic characteristics. Importantly, an alternative nutrition index is proposed.

Focussing on the geography of under development based on measuring malnutrition and human development signified the extent of inequality in the three dimensions. Inequalities in education and distribution of income are major contributors to the poor human development outcomes and high malnutrition prevalence in several pockets of the country. The analysis clearly brings out that remedial actions through addressing distributional differences and robust implementation models are channels for improving the child malnutrition status in India and thereby the human development progress.

Contents

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List of Abbreviations

AHS Annual Health Survey. 67–69

ANM Auxiliary Nurse Midwife. 53

ASHA Accredited Social Health Activist. 53, 78

ATE Average Treatment Effect. 170, 175, 176

AWCs *Anganwadi* Centres. xx, 56, 73, 74, 76, 77, 81, 84, 88–90, 92, 151, 152, 154, 156, 157, 159, 160

AWWs *Anganwadi* Workers. 53, 56, 76–78, 95, 152, 157, 162, 163, 166, 223

BMI Body Mass Index. 7, 48, 195

CATE Conditional Average Treatment Effect. 165

CDPO Child Development Project Officer. 88

CHC Community Health Centre. 77

CIAF Composite Index for Anthropometric Failure. 114, 138, 139

CMAM Community Management of Acute Malnutrition. 57, 58, 147, 149, 151, 152, 178, 223

CONSORT consolidated statements for reporting trials. 147, 153, 178

CRT Cluster Randomised Trial. 95, 145, 156, 177, 223, 225

CSB Corn/soya blend. 149

DALYs Disability Adjusted Life Years. 27

DE Design Effect. 156, 157

DHS Demographic and Health Survey. 22, 186

DI Displaced ideal. 185, 245–248

DLHS District Level Household Survey. 67–69

DMO District Medical Officer. 88

EBF Exclusive breastfeeding. 50

ENA Emergency Nutrition Action. 90

FAO Food and Agriculture Organisation. 57, 59, 146

FCs Field Coordinators. 77, 89

GDI Gender Development Index. 5

GDP Gross Domestic Product. 26, 58, 67, 85

GEM Gender Empowerment Measure. 5

GHI Global Hunger Index. 61

GIS Geographical Information System. 160

GM Geometric Mean. 185, 245–247

GNI Gross National Income. 61, 187–189, 197

GOI Government of India. 17

HAZ Height-for-age z-score. 13, 113, 114, 122, 132, 136, 137, 222

HCM Hot Cooked Meals. 54

HDI Human Development Index. 3–6, 21, 23, 31, 61, 95, 179, 181, 183–187, 190, 192, 195, 197–199, 206, 217, 223, 245, 246, 248

HDPI Human Development Profile of India. 24

HDR Human Development Report. 2, 5, 61, 182, 187, 189, 191–193

HDRO Human Development Report Office. 4

HPI Human Poverty Index. 5

ICC Intra-cluster Correlation. 156, 157

ICDS Integrated Child Development Services. 19, 54, 56, 76, 87, 89, 91, 146, 151, 152, 154, 160–162, 222

ICT Information and Communication Technologies. 56, 219, 221

IFPRI International Food Policy Research Institute. 57

IHDI Inequality-adjusted HDI. 184, 185

IHDS-I Indian Human Development Survey-I. 112

IHDS-II Indian Human Development Survey-II. 22, 23, 67, 99, 100, 112, 114–116, 128, 187, 189, 191, 192, 217, 222, 224

IITB Indian Institute of Technology Bombay. 154, 161, 162

IMCI Integrated Management of Childhood Illnesses. 58

IMR Infant Mortality Rate. 75, 76

ISSNIP ICDS World Bank Assisted System Strengthening and Nutrition Improvement Project. 54, 56

IT Information Technology. 56

IUGR Intra-uterine Growth Restriction. 48

IYCF Infant and Young Child Feeding. 76, 149, 150, 223

LIV local instrumental variables. 165, 169, 170

LMICs Low and Middle Income Countries. 48, 49

LTMGH Lokmanya Tilak Municipal Medical College and Lokmanya Tilak Municipal General Hospital. 154, 157, 161

MAM Moderate acute malnutrition. 13, 149, 151, 152, 154, 155, 157, 161, 165, 171, 178, 222

MDMS Mid-Day Meal Scheme. 19, 220

MFF Micronutrient Fortified Food. 151, 154, 155, 160, 162, 165, 166, 176, 178, 223

MIS Management Information System. 68

MMN Maternal Multiple Micronutrient. 49

MMR Maternal Mortality Ratio. 6

MP Madhya Pradesh. 22, 73, 74

MUAC Mid-Upper-Arm Circumference. 12, 13, 163, 167, 171

mys mean years of schooling. 191

NCAER National Council of Applied Economic Research. 24

NFHS National Family Health Survey. 22, 23, 62–64, 67–69, 84, 153

NGO Non Governmental Organisations. 51, 146, 161, 162, 166, 178

NHM National Health Mission. 19, 53, 56

NI Nutrition Index. 188, 203, 211, 223

NLiS Nutrition Landscape Information System. 62

NNM National Nutrition Mission. 19, 56, 64

NNMB National Nutrition Monitoring Board. 59, 60, 67

NRC Nutrition Rehabilitation Centre. 87

NRRTC Nutrition Rehabilitation Research and Training Centre. 157, 158

NSS National Sample Survey. 23, 59, 67

NTDs Neural Tube Defects. 49

OBC Other Backward Castes. 78, 127, 128, 209, 224

P& NM Pregnant women and Nursing Mothers. 54, 55

PCA Principal Component Analysis. 193

PCM Protein Calorie Malnutrition. 11

PEM Protein Energy Malnutrition. 11

PeT person centred treatment. 146, 147, 165, 169, 170, 175, 176, 178, 223

PMMVY *Pradhan Mantri Matru Vandana Yojana*. 19, 227

RCTs Randomised control trials. 50

RDA Recommended Dietary Allowance. 55, 146, 151

REACH Renewed Efforts Against Child Hunger and Undernutrition. 57

RGSEAG Rajiv Gandhi Scheme for Empowerment of Adolescent Girls. 19

RNI Recommended Nutrient Intake. 12, 146, 151, 161

RTC Ready to Cook. 161

RTE Ready to Eat. 161

RuSF Ready to Use Supplementary Food. 149

RuTF Ready To Use Therapeutic Food. 147, 149

SAM Severe Acute Malnutrition. 12, 58, 87, 149, 152, 155

SC Scheduled Caste. 78, 84–86, 127, 128, 209, 224

SDGs Sustainable Development Goals. 231, 232

SGA Small for Gestational Age. 49

SNEHA Society for Nutrition, Education and Health Action. 154

ST Scheduled Tribe. 81, 84–86, 127, 128, 152, 209, 224

SUN Scaling Up Nutrition. 57

THR Take Home Ration. 54, 88, 145, 146, 151, 154, 160–162, 165, 166, 171, 176, 177, 223

TT effect on the treated. 170, 176

TUT effect on the untreated. 170, 176

U5MR Under 5 Mortality Rate. 6, 75, 76

UNDP United Nation's Development Programme. 182

UNICEF United Nations Children's Fund. 8, 52, 57, 67, 149

UTs Union Territories. 56

UW Underweight. 13, 92

WASH Water Sanitation and Hygiene. 57

WAZ Weight-for-age z-score. 13, 113, 114, 148

WBG World Bank Group. 57

WFP World Food Programme. 57

WHO World Health Organisation. 7, 12–14, 57, 58, 146, 149, 163, 194

WHZ Weight-for-height z-score. 12, 113, 114, 137, 146, 155, 166, 167, 171, 175, 176, 178, 231

YLDs Years Lived with Disability. 27

YLLs Years of Life Lost. 27

Chapter 1

Introduction

~ *A trans-disciplinary approach*

"The health of a nation depends on the health of a child", I wrote in standard eighth for a slogan writing competition. Little did I imagine that it would be the first sentence of my doctoral thesis.

This research thesis is an effort to systematically understand the intricate links between human development and child malnutrition. Although the thesis will delve into the framework of an academic exercise, it is an effort to describe a personal journey of relentless discovery of disciplines I had never studied about, curious explorations of on ground realities that go far beyond classroom teaching and indulging in nights of grappling with data (most of the time, 'disturbing' data). [1]

In the sections that follow, I shall discuss the main areas of research, formally introduce various definitions and concepts, describe the strands of literature referred to, give a concise overview of the main findings, and lay out the organisation of this thesis.

[1]Prof Angus Deaton, in a press conference at Princeton university, after receiving the Nobel Prize in 2015, said that sometimes his work leads him to "very uncomfortable" places. I could relate to this during the course of my work.

1.1 Human development

> Human development is a process of enlarging people's choices. In principle, these choice can be infinite and change over time. But at all levels of development, the three essential ones are for people to lead a long and healthy life, to acquire knowledge and to have access to resources needed for a decent standard of living. If these essential choices are not available, many other opportunities remain inaccessible.

There are multiple ways of defining human development, yet the first time a formal definition was provided in the Human Development Report (HDR), 1990, as quoted above (UNDP, 1990). In practice, there is possibly nothing that can be excluded from the ambit of what does or does not constitute development.

Matters pertaining to discussion on human development have revolved around economic sustainability widely perceived as a matter of intergenerational equity, however, the specification of what needs to be sustained is not always straightforward (Anand and Sen, 2000a). The discourse on rights and entitlements has continuously excluded, rather ostracised the less privileged classes and sequestered women and ethnic groups over centuries. This has left millions of people in a vicious cycle with no exit route.

In this sense there is very little departure from the claims that economic analysis and policy making contribute extensively to human development. As per Lewis (2013), the objective largely remains to increase 'human choice'. Wide discussion among development economists emphasises on the expenditure on public health as an influencing factor of life expectancy. Human development, in the form of people being more educated, less downtrodden, more healthy, leading a better quality of life and so on, is not only constitutive of a higher standard of living but encompasses the valuable contribution each individual can make to the progress of the society and material prosperity.

Deep focus on the human capital aspect of development has explained, for instance the so called 'East Asian Miracle'. It elaborates on the fact that an increasing clarity has been attained in the immensely far reaching role played by the enhancement of the quality and skill of labour (Stiglitz, 1996). The economic roles of better nourishment, well rounded schooling, widespread care and technical progress; all point to the importance of human agency as a prime mover of material progress (Anand and Sen, 2000a). Health, education, and quality of life have intrinsic value, while human development has direct and immediate importance.

Human development has a dimorphic functionality in the context of this thesis. As an approach it is employed to define the role of development for progress of societies and nations. As a method for measurement it assists in constructing meaningful indices for comparative purposes and benchmarking dimensional attainment.

1.1.1 Human development index

The Human Development Index (HDI) is seminal in nature, and ever since 1990 it is put to use with the prime objective of capturing many dimensions of human choices (UNDP, 1990).

The HDI serves as a composite statistic based on the three dimensions of human development: long and healthy life, knowledge, and a decent standard of living. It uses a 'goal post' method to benchmark the dimension indices, using maximum values observed in a country during a year, and a fixed lower bound, to construct a country-specific index for comparative purposes.

Since 1990, each year the Human Development Report Office (HDRO) publishes reports on a variety of central functionings. It reports human development progress across the world, publishes rankings of nations according to the levels of attainment seen in different countries, provides methodological appraisals and statistical notes. The aim is to orient the global community and policy makers towards critical development issues.

1.1.2 Concepts and advancements

The inception of the HDI lies in the deficiency of per capita income serving as the sole measure of development. In an effort by Mahbub ul Haq (an economist from Pakistan), along with scholars including Amartya Sen developed this new yard-stick of well being. The main reason for its popularity is linked to a key message—development is much more than just growth. As Ul Haq (1995) put it,

> [a]ny measure that values a gun several hundred times more than a bottle of milk is bound to raise serious questions about its relevance for human progress.

The data used to construct the HDI is published by international organisations and its simplicity remains a prime driver for its exhaustive use in several research and policy oriented initiatives. Upto 2010, other than being a response to the policy recommendations of the Bretton Woods Institutions, during the two decades the HDI was also criticised for being empirically unsound or for being too simplistic a representation. Among some constructive critiques have been the choice of variables and the functional form of the HDI (Kelley, 1991), (Srinivasan, 1994). Numerous changes were introduced to the variables used to construct the HDI. Specifically, the HDI was portrayed as an index of capabilities. According to the HDR 1990,

> an index that captures the three essential components of human life... longevity and knowledge refer to the formation of human capabilities, and income is a proxy measure for the choices people have in putting their capabilities to use.

The HDI has been subjected to rigorous methodological changes in choice of education indicators, the measurement of income, treatment of income variable, method of aggregation, and the functional form. Critiques of the HDI have noted that, aspects like rights, participation and non-discrimination are not captured in the HDI but are certainly very important for human development (Jahan, 2002). While the indices such as Human Poverty Index (HPI), Gender Empowerment Measure (GEM), and Gender Development Index (GDI) developed at different time points have served as powerful tools in measuring deprivation and inequality, the essence of human development is much broader. It has been observed that the HPI captures the aspect of social inclusion in terms of public provisioning which is more important than private income. Thus, in developing countries the access to health services, safe water, and prevalence of malnutrition capture deprivation in economical provisioning more meaningfully and practically than other indicators Jahan (2002). An elaborate discussion on the background of the HDI has been presented in chapter 6 of the thesis.

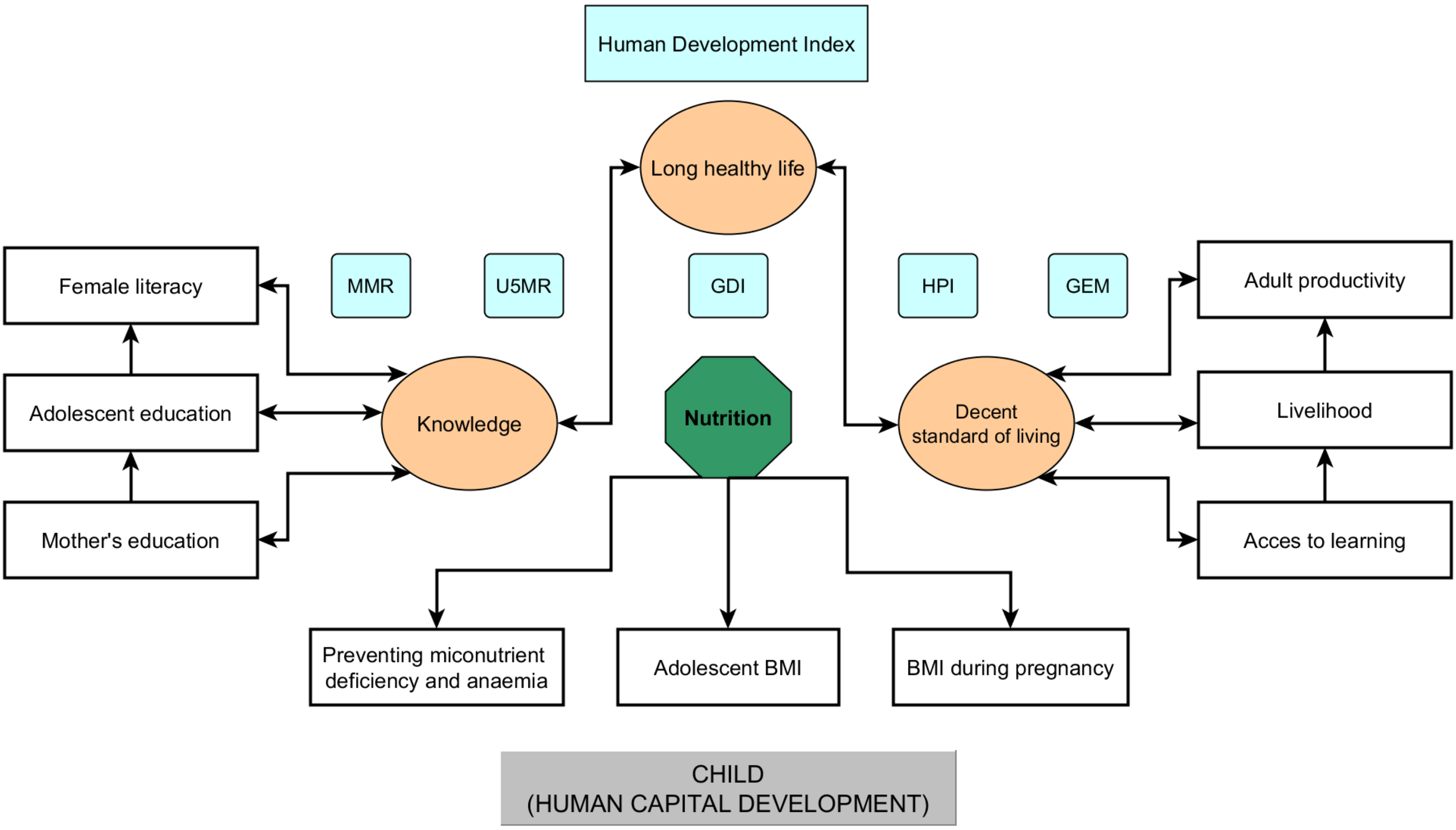

Figure 1.1: A Nutrition centric conceptual framework focussing on the child for human capital development and higher achievements. Maternal Mortality Ratio (MMR), Under 5 Mortality Rate (U5MR). This figure is the author's rendition of the way HDI and the child are related.

With this idea of human development as the basis for my research, I now introduce the conceptual meta-frame through which I position the work done as a part of this thesis. In figure 1.1 a nutrition-centric approach with the child at the foundation of 'human capital development' has been presented. The motivation behind this is to shift focus from an overly large importance on economic growth as the primary objective of development policies.

I propose here the need to place investments in all development activities from a 'child-centric' and 'nutrition-centric' standpoint. At the core is nutrition, which apart from being related to food, its access and availability, or as a discipline in science, encompasses linkages to the relevant dimensions of human development. I propose the following:

- Good nutrition will ensure prevention of diseases, a normal Body Mass Index (BMI) of the expectant mother, and the birth of a healthy child
- Good nutrition will ensure higher levels of schooling and female literacy
- Good nutrition through channels of improved access to learning, better incomes, and in turn increased productivity lead to better health and knowledge

Systematic unpacking of this relationship through indicators and indices that evaluate roles of female literacy, gender development, access to learning, and equality are meaningful when the focus shifts to a child-centric approach. In achieving human development, briefly described earlier, a major deterrent remains—malnutrition, which is introduced further.

1.2 Malnutrition

A paramount challenge the world faces is malnutrition, which deprives as of 2017, 155 million children from attaining their full development potential.[2] Malnutrition has been recognised as a public health priority to which one-third of child deaths can be attributed (Vesel *et al.*, 2010).

Nutrition as per World Health Organisation (WHO) is defined as the intake of food, considered in relation to the body's dietary needs. Good nutrition–is an adequate, well balanced diet combined with regular physical

[2] https://data.unicef.org/resources/joint-child-malnutrition-estimates-2017-edition/

activity–is a cornerstone of good health.[3] Poor nutrition can lead to reduced immunity, increased susceptibility to disease, impaired physical and mental development, and reduced productivity. In simple words, malnutrition connotes the state of 'poor nutritional status.'

Globally, undernutrition underlies 45 per cent of all child deaths among children below the age of 5 years (Black *et al.*, 2013). These undernourished children have an increased risk of mortality, illness and chronic conditions, late development, cognitive deficiency, low academic achievement and meagre labour market productivity in later life (Currie, 2009). These ill effects of malnutrition are primary causes of poor human development. In several discussions over roles of programmes for early childhood development, Myers (1992) wrote for the United Nations Children's Fund (UNICEF)

> ... we are victims of the age of specialization in which we live. Academic and bureaucratic divisions of labour cut the child into small pieces. The "whole single child," so often present in the rhetoric of child development, is slowly dissected in a series of unconnected, narrowly conceived analyses. Doctors, psychologists, nutritionists, sociologists, educators, anthropologists, economists, and others, each approach the topic from a distinct point of view.

His writings point to the indispensable requirement of multi-sectoral yet cohesive approach to tackle malnutrition.

[3] Standard definition from http://www.who.int/topics/nutrition/en/.

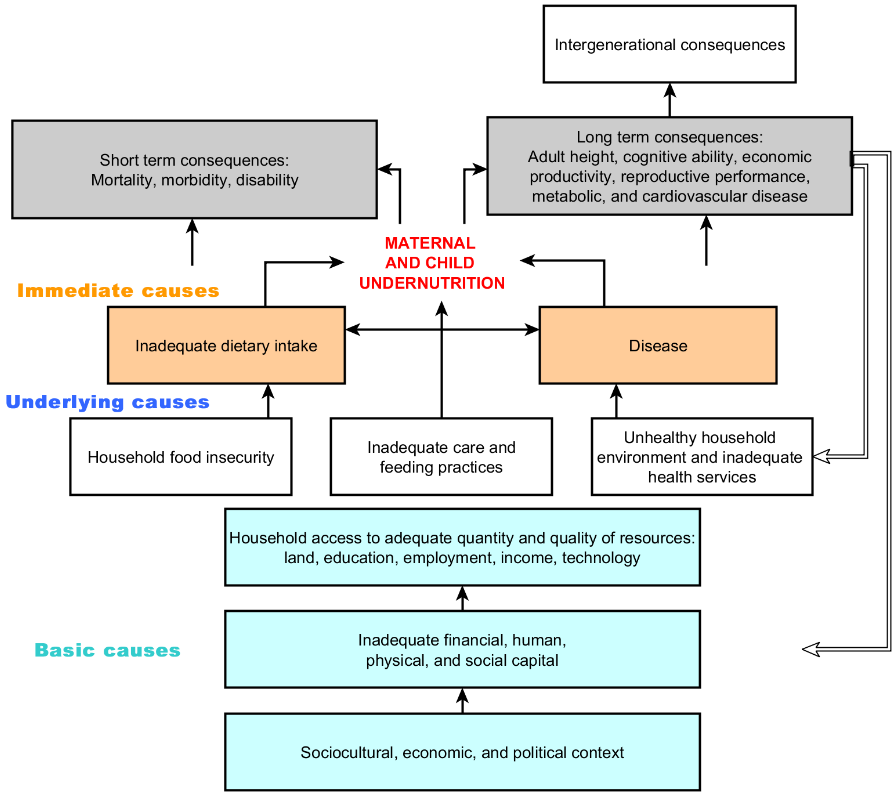

Figure 1.2: UNICEF conceptual framework of the determinants of child undernutrition. The block arrows show how consequences of undernutrition feed into basic and underlying causes leading to a perpetual cycle. Adapted from UNICEF (1990).

Causes of malnutrition as per the well-known UNICEF (1990) model are shown in Figure 1.2. There are basic, underlying, and immediate causes which lead to short term and long term consequences. Intergenerational transmission of poor nutrition, poverty, and inequities contribute immensely to economic losses. As also written by Deaton (2006), malnutrition is not about lack of food or care, rather a process which allows disease and deprivation to creep in, play a paramount and predominant role.

> Nutritional traps are much easier to understand once disease is given its proper place in the story. Disease interacts with nutrition, and each reinforces the other. Malnutrition compromises the immune system, so that people who do not have enough to eat are more likely to succumb to infectious disease. At the same time, disease prevents the absorption of nutrients so that, even when food is obtainable through own cultivation or in exchange for work, it cannot be turned into nutrition. A child who is suffering from acute diarrhoea cannot be cured by giving her more food.

Malnutrition manifests itself in several forms. Multiple burdens that countries experience are in the form of undernutrition, micronutrient deficiency, and child overweight, and adult obesity. These are often referred to in contemporary literature as 'triple burden of malnutrition'. Early childhood development is widely considered the most important developmental phase in an individual's lifespan. It influences physical and mental health, basic learning, school success, and economic and social participation. The development of a child's brain to its full potential also depends to a large extent on quality health care, breastfeeding, nutrition, stimulation, adequate hygiene and sanitation, and accident prevention during the early years (Lake, 2014). A fuller discussion on this is available in section 2.3 of chapter 2.

1.2.1 Identification of the condition

Clinical ramifications of malnutrition are well researched. Over several years, guidelines have been developed which assist medical practitioners, field workers, and caregivers to recognise malnutrition in children. What follows is a brief history of how malnutrition was classified earlier, the burden of micronutrient deficiency, and standard definitions used universally in the malnutrition and child health literature.

1.2.1.1 Protein Energy malnutrition

Before 1959, some insights were given by the seminal work done by Nevin Scrimshaw at Guatemala (Keusch, 2003). The work explained the close association between metabolic functions, immunity and progressive malnutrition, which were very common in the population of Guatemala. The scientific community's understanding of the immune system was largely primitive and limited to understanding humoral immunity [4]. It was only clear that antibodies are responsible for fighting infection and could be functionally measured *in vivo* for host's defence.

Waterlow (1972) documents the works of several researchers including discussions in a colloquium in 1967 whereby standard definitions of protein-calorie malnutrition were provided (Gopalan, 1968). Studies were modelled on animals, incapable of replicating the perfect human situation. Thus, the condition of malnutrition was called Protein Energy Malnutrition (PEM) or Protein Calorie Malnutrition (PCM) as it was known then and principally attributed to dietary deficiency. The most common line of treatment was therefore, supplementing with diet alone.

1.2.1.2 Micronutrient deficiency

Micronutrients are defined as substances in food that are present in trace amounts and play a vital and irreplaceable role in development. They include all the known vitamins and minerals. About one-thirds to half of the world's population is affected by micronutrient malnutrition (WHO-FAO, 2006). In India alone, 62 million children below the age of 5 years have micronutrient deficiency (Von Grebmer *et al.*, 2014). The three most prevalent forms of micronutrient malnutrition are iron, iodine, and vitamin A deficiencies. Zinc and vitamin B-12 deficiencies are also widespread (WHO-FAO, 2006).

Consequences of micronutrient malnutrition include increased mortality rates, especially in women and children; poor pregnancy outcomes; increased morbidity; impaired mental and physical development in children;

[4]Humoral immunity refers to the macromolecules like antibodies present in humors, or body fluids.

and reduced work productivity in adults (Benoist *et al.*, 2008). A major cause of micronutrient malnutrition in low income populations is lack of access to a variety of foods. When incomes are low, people rely on inexpensive sources of calories, such as cereals and tubers, to meet energy needs. These foods tend to be poor sources of many micronutrients. More nutrient dense foods such as fruits, vegetables, and animal products are more expensive and, as a result, are often beyond the reach of the poor (Bouis *et al.*, 2011).

Informed by this, work done as a part of developing supplementary food (see chapter 5) for malnourished children follows the guidelines of Golden (2009) based on Recommended Nutrient Intake (RNI) [5].

1.2.2 Standard definitions

These definitions and terms have been used consistently in all the discussions that follow, therefore, have been introduced at the outset.

1.2.2.1 Wasting

Wasting reflects acute undernutrition. One way of detecting is using the Weight-for-height z-score (WHZ). It is defined as the percentage of children aged 0 to 59 months whose weight for height is below -2 standard deviations (moderate and severe wasting) and below -3 standard deviations (severe wasting) from the median of the WHO Child Growth Standards.

Severe Acute Malnutrition (SAM) is defined as the percentage of children aged 6 to 59 months whose weight for height is below -3 standard deviations from the median of the WHO Child Growth Standards, or by a Mid-Upper-

[5] RNI prescriptions of micronutrients for malnourished children includes protective nutrients (type 1) and growth nutrients (type 2). The exhaustive list is available in Golden (2009).

Arm Circumference (MUAC) less than 115 mm, with or without nutritional oedema (de Onis *et al.*, 2006).

Moderate acute malnutrition (MAM) is defined as the percentage of children aged 6 to 59 months whose weight for height is below -2 standard deviations from the median of the WHO Child Growth Standards, or by a MUAC between 115 mm to 125 mm, with or without nutritional oedema (de Onis *et al.*, 2006).

1.2.2.2 Stunting

Stunting reflects chronic undernutrition during the most critical periods of growth and development in early life. It is defined as the percentage of children aged 0 to 59 months whose height for age is below -2 standard deviations (moderate and severe stunting) and -3 standard deviations (severe stunting) from the median of the WHO Child Growth Standards (de Onis *et al.*, 2006).

In chapter 4, the Height-for-age z-score (HAZ) has been used to measure child health. Implications of stunting on child health and later life productivity find mentions in several sections throughout this thesis.

1.2.2.3 Underweight

Underweight (UW) is a composite form of undernutrition that includes elements of stunting and wasting. It is defined as the percentage of children aged 0 to 59 months whose weight for age is below -2 standard deviations (moderate and severe underweight) and -3 standard deviations (severe underweight) from the median of the WHO Child Growth Standards (de Onis *et al.*, 2006). This classification is based on Weight-for-age z-score (WAZ).

Weight for age was also used to classify first, second, and third degree malnutrition according to the Boston Standards (Gomez *et al.*, 1956) and (Stuart and Stevenson, 1959).

1.2.2.4 Overweight/Obesity

Overweight is defined as the percentage of children aged 0 to 59 months whose weight for height is above 2 standard deviations (overweight and obese) or above 3 standard deviations (obese) from the median of the WHO Child Growth Standards. Low birthweight is defined as a weight of less than 2,500 grams at birth (de Onis *et al.*, 2006).

1.3 Motivation driving this research

Having looked at the two broad areas so far, reasons driving this research study is the following. The primary arc involved attempting to address the research gaps, which are:

- association between concept of 'capabilities' and malnutrition through upward linkages
- limited evidence from developing and transitioning economies
- partially missing knowledge about community based solutions for reducing malnutrition
- documenting qualitative observations for integrating into policy framing
- identifying distinctive and viable pathways for investment to improve human development outcomes

- missing evidence on doable and practical implementation models

Other than the above, there were two experiences that motivated me to study human development and malnutrition. Both the examples are from my days of studying engineering as a graduate student.

1.3.1 Experience one

In 2013, I attended classes in a foreign university for the first time ever. I studied international policy and economic relations, specifically, relationships between the developed (largely North America and Europe) and developing world (South Asia and Africa). Amongst many strands that were discussed, a part that I wondered the most about were the stark differences in health status. Hundreds of statistical tables, charts, maps, and papers pointed at one common trend in all developing countries—below par standards of health services and unsatisfactory levels of education.

There was of course focus on economic cooperation, trade rules, food security, energy security, poverty rates, and climate change but not in a single discussion was there no mention of health. Up till then my research interests lay in genetics, stem cells, and neuropsychiatric disorders. Interestingly, readings from the class on policy opened my mind to one crucial aspect. It was the question—given the booming economic condition in India, having sustained the financial crisis, why is health status still so poor?

I did not have answers to that question, however, the spark to unravel another discipline of academics, study government schemes, policies, and analyse data was initiated after my exposure to those classes.

1.3.2 Experience two

This is from observations while conducting laboratory experiments on umbilical cord cells. Upon interactions with mothers there were evident differences in the birthweight of their children and variations in their own health status. Curiosity to examine these anomalies led me to into this field of research.

1.4 The task at hand

This thesis is quite some ways an attempt to answer a few problems my mind grappled with and the questions alluded to through my experiences. What role does initial exposure to nutritional input(s) that a child is exposed play on a country's progress? Why are certain sections, either democratically weak or marginalised residing in rural areas facing high levels of undernutrition?

Answering these questions involved explorations into why poverty and well-being are so highly dependent on inequalities in health, education, and income. Research here explores why poor human development is also an outcome of social disaggregation and how societal progress is a function of early life, the first thousand days, especially, that set course for an individual's development.

Hence, in the context of decreasing calorie intake over the decades, infections altering metabolic pathways, and low literacy rates in countless pockets of an extraordinarily diverse India, the task cut out was:

- test theories about 'capabilities' studied in literature, on ground;

- use data to analyse pathways to establish a link between malnutrition in children and human development;
- explore where caste and gender fit into the puzzle; and
- with the largest child development services in the world and a steadily growing economy, identify key contributors to inequalities

The core elements of work done include fieldwork and visits to child care centres, interactions with government functionaries, surveying through interviews, data collection, and analysis of household level data. All these elements shall be reinforced in sections that follow.

1.5 Methodology adopted

The following methodology was adopted. My research ably supported by several inputs from experts along the way, draws from literature of many kinds. I studied research papers, books by development economists and anthropologists, technical reports and guidelines of the world's development organisations, Government of India (GOI) press releases, and policy documents to formulate theories and hypotheses. I went on to use econometric models and carried out statistical analysis of both, primary and secondary data.

1.5.1 Literature review

I now briefly introduce the literature reviewed in chapter 2 with the intent of delineating certain theories on human development and malnutrition. Scholarship in this discipline is replete with literature on these topics spanning across various disciplines. I have summarised this vast literature by categorising it in relevance to the Indian case.

1.5.1.1 *Capability approach*

Individuals take decisions, decisions that are based on a set of 'functionings' and 'doings'. Human capabilities are closely connected to the perception of human development as it is seen to date. Attaining a basic minimum standard of living, accessing education, and health services are needs of human life. Having opportunities to exercise her or his freedom to choose between the different kinds of life centres the pursuit of human development. Maximising choices of those already well-off brings little or no marginal utility to their lives, however, expanding the choices of the less fortunate should be a prime objective of a society—and a very important one (Klugman *et al.*, 2011), (Sen, 2008), and (Sen, 2003).

1.5.1.2 *Grossman model of health*

Health is different than all other forms of human capital (Grossman, 1972). Improving on models by Ben-Porath (1967) and Becker (1964), this model addresses the demand for health in an investment model. Its applicability and underlying assumptions differ from earlier models of health, the latter being derivable from the Grossman model. Applicability to a wide range of problems and assisting in imparting a basis for economic explanations of health behaviour are reasons for its popularity (Muurinen, 1982).

1.5.1.3 *Setting course: The first 1000 days*

Malnutrition has a strong impact on brain development. The first 1000 days of life is an incomparable window of opportunity, both from a biological and a developmental perspective. Exposure to low socioeconomic status, poverty, and hidden hunger during the first 1000 days impede cognitive consequences throughout life. Inappropriate dietary diversity, lack of micronutrients, and awareness about feeding practices have a long-lasting impact on the growth of a child. Knowledge about strategic interventions and program based interventions hold the potential to improve health and prosperity of the next generation (Biesalski *et al.*, 2016).

1.5.1.4 *National nutrition policy and abatement initiatives*

Integrated Child Development Services (ICDS), National Health Mission (NHM), Mid-Day Meal Scheme (MDMS), Rajiv Gandhi Scheme for Empowerment of Adolescent Girls (RGSEAG) named SABLA, *Pradhan Mantri Matru Vandana Yojana* (PMMVY), and the recent National Nutrition Mission (NNM) (renamed *Poshan* mission) are the flagship programmes that operate within India aimed at malnutrition abatement. All services and schemes contribute to a wide spectrum of deliverables targeting the most vulnerable groups. Recognised as a national priority, these government schemes are steered on the foundation of human development (NITI aayog, 2017).

1.5.1.5 *Economic growth and malnutrition in India and the world*

A review of literature yields substantial evidence about the persistence of malnutrition in the face of wide economic growth given the inter-relatedness to aspects of poverty, food security, and development activities. Considering a time-span of close to three decades, despite resonance in the intent among national and global actors for curbing malnutrition rates, little global attention and development effort has been expended on tackling childhood undernutrition (Nisbett *et al.*, 2014). Findings highlighted give impressions that investments in health may lead to economic growth, rather than vice versa.

1.5.1.6 Data availability in India : Progress and concerns

Data plays a pivotal role in providing information on health and socio-demographic characteristics for effective policy decisions and understanding inherent deficiencies in the system. In the age of digital economy, numerous surveys in India including Census have evolved over the years, however, disaggregation of data beyond district level (with a few exceptions) and provision of publicly available standards remains drawbacks. Other than several macroeconomic indicators, health and human development outcomes measured through reliable data assist in coherent and evidence based policy directives (Dandona *et al.*, 2016).

1.5.2 Thematic approach

With the above in hindsight and combining the observations from fieldwork, on which chapter 3 has more details, three themes were identified for investigating the Indian case on malnutrition and human development.

Theme 1: Direct link between income and child health

Income, a proxy measure for standard of living in the HDI, is a direct determinant of one's economic circumstances and many capabilities are dependent on it (Anand and Sen, 2000b).

Therefore this theme, first, establishes a deeper understanding between child health and income gradient in India. Secondly, explores the mechanisms that underlie the relationship and carries out a body of sub-group analyses. Thirdly, we study the characteristics of the gradient by accounting for differences in income intervals, and finally simulate the effect of income rise on decrease in stunting which can translate into improving child health in India.

Theme 2: Governance and implementation

The second theme in this thesis is based on community feedback. People, especially those who face multi-dimensional poverty, rely heavily on state run schemes and services. To test the validity of 'community-involved' initiatives, supported by the government's existing machinery aimed at curbing malnutrition prevalence, strategic interventions present people with an opportunity to improve health outcomes.

This path is a function of governance and implementation which leads to improving attainments in health. Thus, this theme, first, brings to action a synergistic field trial, secondly, focusses on a socio-economically weaker section. Thirdly, provides an alternative food supplement (catering to community specific demands), and finally analyses individual level differences.

Theme 3: Pan-India performance and inequalities

India's states are as populous as many other countries thus masking the innate heterogeneity in achievement across the three dimensions of the HDI.

Culminating into an exercise that constructs a household based HDI for all states of India, theme three is focussed on using disaggregated data to rank states and overcoming limitations related to functional forms. Further, constructing a nutrition based index as an alternative to the life expectancy sub-component is a new methodological addition. Lastly, decomposing inequalities in the dimension indices and revealing differences in achievement based on demographic sub-groups are the strengths of this study.

1.5.3 Data collection and analysis

The themes outlined above warranted data that comprised modules related to child health, income, expenditure, women, gender relations, occupation, living conditions, education, religion, caste, and bear representation of India's states and population. However, for deconstructing this association between malnutrition and human development, the literature largely pointed at related evidence from developed countries. To begin with, publicly available data sets were first looked at, most of which were either dated or lacked child-wise health data that could be linked with household information.

The first step was to focus on village level information that helped gain insights into the kind of variables needed for this research. I therefore decided to explore the possibility of collecting primary data from rural India, which was done ably assisted by a team in Madhya Pradesh (MP). This has been detailed in chapter 3. Through straightforward descriptive and correlation analyses coupled with observations of the villages, identification of the key variables needed for prospective analysis was possible.

For carrying out the investigations described in the first theme (section 1.5.2), the foremost choice was to use National Family Health Survey (NFHS) which is a Demographic and Health Survey (DHS) of India, for which the data for 2005-06 was available at the beginning of my doctorate. Using suggestions from literature and supervisors, the decision for using the Indian

Human Development Survey-II (IHDS-II) was taken (Desai and Vanneman, 2015b).[6] Up till now, data from two rounds, 2005-06 and 2011-12 are available, the first nationwide panel survey, which presented an opportunity to conduct panel analysis. Since the focus is on children under 5 years of age, choosing a panel data model constrained us from choosing this age group for analysis. Due to this constraint, a cross sectional analysis was conducted.

The IHDS-II, 2011-12, had higher coverage of measuring anthropometry of children and women, an added advantage for investigating the income and child health gradient. Data cleaning with supplementary files were used to create a database for a sample of households from 28 states and 5 union territories of India. Econometric models, least squares methodology, and spline regression framework delineated in chapter 4 were used for analysis.

As per theme two, focussing on the channel of governance and implementation of schemes affecting human development outcomes and testing validity of a trial based evaluation of interventions, a primary data collection exercise was initiated. All tasks related to trial design, ethics approvals, food formulation, survey methodology, questionnaire design, data management, and statistical analysis were performed.

This study also offered the possibility of working with government functionaries working on malnutrition abatement. Consequently, a sizeable portion of the time was spent in collecting data from the field trial. Recently published analytical methods where individualised assessment of treatment can be effectuated was applied for analysis (Basu, 2014).

The third thematic area, a modification of the existing HDI which com-

[6]A review of comparative analysis of IHDS-II data with NFHS, National Sample Survey (NSS), and Census data showed consistent estimates across several indicators. This is also relatively newer high quality data which also motivated us to prefer this over other data sets.

pares all states of India, required comprehensive data with an appropriate sampling strategy. In the IHDS the rural sample contains half the households that were interviewed first by National Council of Applied Economic Research (NCAER) in 1993-94, in a survey called Human Development Profile of India (HDPI)(Shariff, 1999). For the remaining half, random draws from non-HDPI states following probability proportional to size approach was adopted. Additionally, urban block of all states has been represented too, making this data suitable for the construction of the index from household data.

1.6 Preliminary insights

Preliminary insights are structured as the following. Observational studies helped in understanding the scale of the challenge, especially in remote and inaccessible areas of rural India. Outreach and penetration of schemes was spurious while quality of training of ground workers was directly related to the nutritional status of the children. The first task: testing theories studied in literature, on ground, helped in isolating additional factors specific to the Indian scenario.

The trajectory of growth compared between children living in disadvantaged circumstances and those living in disease free environments began to diverge very early in life. The idea of integrating areas of research from biological and socio-cultural perspectives to understand why millions of children fail to reach their development potential was central to this field study.

Through simple econometric models (detailed in chapter 4), a definite answer that emerged was the strong association household income and stunting in children. It also appeared that when controlling for a set of health determining factors, the effect of income attenuates. Moreover, this route of connecting human development via income (assets and consumption based measurement is also available) to malnutrition is sensitive to breaks in the income distribution. In short, a rise in household income is likely to show a marked improvement in child health status only beyond a certain threshold of income. From the standpoint of this thesis, this finding has implications on public health policy and is valuable in its own right. This study is based on a model that justifies investment in health (Grossman, 1972).

The ecosystem needed for promoting community involvement in recovery of malnourished children was the second area of focus. Testing the efficacy of micronutrient supplementation showed that incessant child growth monitoring even in the face of social challenges is a viable and practical route for treating acutely malnourished children. Regression results from this study facilitated the understanding of the variation in supplementation impact due to unobserved confounders such as individual preferences of eating habits at household level.

The analytical exercise detailed in chapter 6 overcomes a major limitation of the HDI by deriving the index at the household level. Further, we include an additional dimension capturing child' s nutritional status at the household level. This is critical as child malnourishment and economic inequality continues to increase in India, leading to disparate development. This study helps in analysing differences based on population sub-groups and varying socio-economic status. Although inequality across Indian states is primarily driven by significant differences in the income and education component of the index, inequality based on the nutrition dimension is concentrated in households in the bottom most quantiles.

1.7 Bharat and India : A snippet into transience

The name 'Bharat'[7] here depicts the divide in the country's development landscape. On one side is rural *Bharat* and on the other, urban *India*. The post-independence and reform period has seen sectoral and divisive growth Drèze and Sen (2013). While some sections have experienced rapid improvement, others have been dismally side lined. Underdevelopment of social and physical infrastructure has threatened the feasibility of economic growth contrary to the East Asian model, resulting in neglect of human capabilities (Drèze and Sen, 2013). Patterns and process of India's growth pose challenges distinct to a transitioning economy (Chakravarty, 1998). International studies showed that the rate of decline in child undernutrition tends to be around half the rate of growth of per capita Gross Domestic Product (GDP). As (Dreze and Deaton, 2008) discerned, in India's case, per capita GDP of about 4.2 per cent during 1990 and 2005 was expected to reduce malnutrition by about 2.1 per cent per annum or 27 per cent during this period. Compared to this, the decline in malnutrition among children was only 10 per cent.

Deprivation in education contributes to 22.7 per cent in the overall deprivation index, while health and living standards contribute 32.5 per cent and 44.8 per cent, respectively (UNDP, 2015). Female workforce participation rate is 10.5 per cent and proportion of married women who have 10

[7]Bharat is India's name in the Hindi language (in Devnagri script, specifically)

or more years of schooling is 21.4 per cent (MOSPI, 2014) and (RSOC, 2014). While these are snippets into some crucial aspects of development in a transition economy, these indicators bring forth the real ground level impact of social schemes, ambitious employment guarantee programmes, and universal education initiatives.

It may be argued that with rising rural to urban migration resulting in urban poverty, policy response becomes a function of these rapid changes and thereby fails to provision for targeted evaluation of social outcomes. However, transition in both, the economic as well as policy framing sense necessitates creating solid evidence to understand how much progress is being made and where problems continue to persist.

Two maps of the country portray in terms of Disability Adjusted Life Years (DALYs),[8] the effect of maternal and child malnutrition (in figure 1.3) and that attributable to unsafe water, sanitation, and handwashing (in figure 1.4). Both these maps showcase in a single glance the geography of underdevelopment, an aspect that has been emphasised in chapter 6 as well. The power of visualising existing conditions in this manner intertwined with analytical robustness assists in diagnosing the patterns of transition, an aspect that India's governance cannot ignore as it compromises the country's growth and status in the current century.

[8] It is a universal metric that allows researchers and policymakers to compare very different populations and health conditions across time. DALYs equal the sum of Years of Life Lost (YLLs) and Years Lived with Disability (YLDs). One DALYs equals one lost year of healthy life. DALYs allow us to estimate the total number of years lost due to specific causes and risk factors at the country, regional, and global levels. (Retrieved from http://www.healthdata.org/gbd/faq)

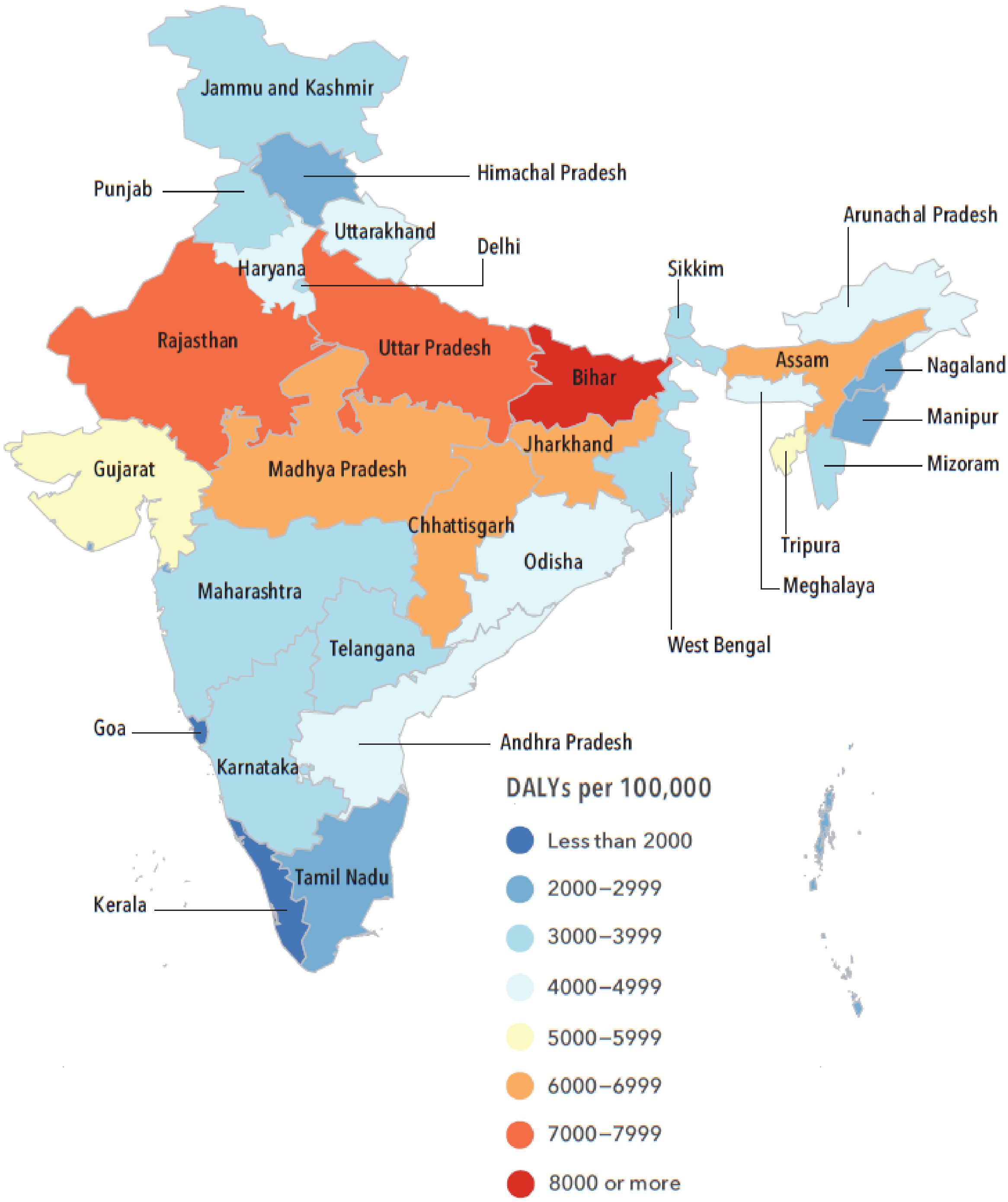

Figure 1.3: Disability adjusted life years per 100,000 rate attributable to child and maternal malnutrition in states of India, 2016. This map has been sourced from ICMR-PHFI-IHME (2017) and is not to scale.

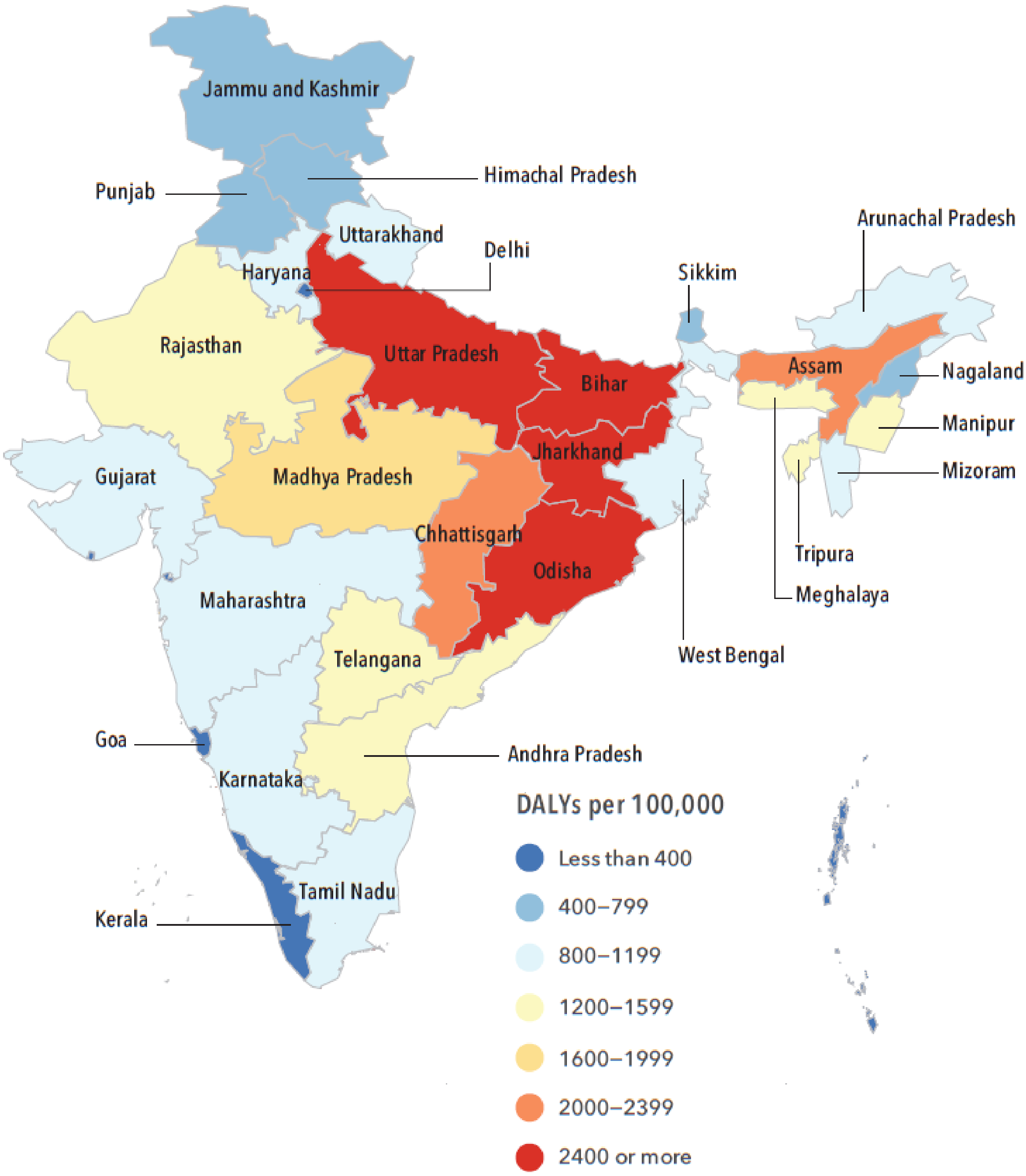

Figure 1.4: Disability adjusted life years per 100,000 attributable to unsafe water, sanitation, and handwashing in states of India, 2016. This map has been sourced from ICMR-PHFI-IHME (2017) and is not to scale.

1.8 Summary and organisation of thesis

In summary, at the crux this thesis is about the sophisticated and complex link between malnutrition and human development. While attainments in income, knowledge, and health are central to the concept of human development, much will remain unachieved if malnutrition continues to stall progress at rampant rates.

The complexity of the challenge is multi-fold and obligates action through a multi-faceted strategy. Millions of children are affected by various manifestations of malnutrition before the age of 5 years, restraining their future well-being, health, economic productivity, and overall achievement. Establishing pathways that facilitate reducing inequalities and protect from entering the cycle of inter-generational transmission of poverty and malnutrition is critical to reaping benefits of the current wave of demographic dividend in India. Theoretical associations between medical studies and economic evidence strengthened with reproducible on-ground implementation models hold key to reducing malnutrition rates. In all this, data quality and reliability remain central to putting pressure on those entrusted with improving public health and nutrition (Desai *et al.*, 2016).

The thesis is aimed at enabling the reader to understand the necessity to focus on human development, create awareness about the perils of malnutrition, investigate policy implications, and highlight the methods used to conduct analyses. It begins with a literature review in chapter 2 providing discussions of research centred around six key strands, which include the capability approach, the Grossman model[9], the importance of first 1000

[9]A short explanation has been given in section 1.5.1.2

days, a summary of national malnutrition abatement initiatives, the dichotomy of economic growth and persisting malnutrition, and the decisive role data plays in advocacy. In chapter 3, an account of encounters from rural India which helped in identifying the key themes have been detailed with focus on village level observations. A discussion on the role of women's agency and the class ladder has also been presented which led to providing conjectural triggers for choice of variables in the subsequent research themes.

Chapter 4 uses secondary data to investigate the association between household income and child health by employing regression models, enabling empirical verification of theoretical concepts. A comprehensive body of sub-group analyses has been conducted suggestive of the various factors influencing a child's nutritional status. Chapter 5 is a field study from an urban slum, pertinent to the centre-point of governance and policy in promoting human development progress. In this study different civil society sectors and agencies galvanised to mobilise a community towards reducing malnutrition levels.

Further, chapter 6 details a country level HDI based on household data and nutrition indicators. It includes vigorous statistical procedures using micro-level data and investigates inequalities based on socio-demographic characteristics of households. At the end, chapter 7 presents a technology based solution, recapitulates the findings from all the studies in this thesis, and concludes with limitations, implications on policy, and future directives for research.

Chapter 2

Literature review

The first chapter introduced the concepts of human development and how malnutrition, when left unaddressed cripples individuals from achieving maximum adult potential, thereby diminishing growth and progress of nations on the whole. While comparisons between countries are subjected to intensive statistical procedures, sometimes also revealing contradictory claims, the fact remains : there is a certain level of well-being that all humans must experience, regardless of any influencing factor that may be used to discriminate/categorise them.

In his discourse on Human Development : Means and Ends, Streeten (1994) said,

> A well-nourished, healthy, educated, skilled, alert labor force is the most important productive asset. This has been widely recognized, though is odd that Hondas, beer, and television sets are often accepted as final consumption goods, while nutrition, education, and health services have to be justified on grounds of productivity.

Crucial to the synthesis of themes introduced earlier, is an exploration into many strands of literature that form the foundation of linking human development and child malnutrition. There are, undoubtedly, numerous ways of explaining this connection, however, in the context of the kind of field work and analysis carried out, I have identified and reviewed (with brevity) six relevant bodies of research literature, beginning with the theoretical basis and ending at the power of data in promoting evidence based advocacy.

I discuss each in the subsequent sections of this chapter, also highlighting the relevance and interconnectedness among them for the purpose of this thesis.

2.1 Capability approach

Capability—the power or ability to do something.[10]

Conceptual roots of the 'capability approach' date back to Aristotle, where in his works, *Nicomachean Ethics*, he uses the word "eudaimonia", which is often loosely translated to "happiness", refers to attaining a fulfilment in life that stretches far beyond the utilitarian perspective.[11] The goal of human beings is to achieve/fulfil the needs of their own and the ones who live with them, within available resources.

I begin my investigations by citing works that shed light on this concept of 'capability approach' in unique ways and gradually proceed to delineate how it eventually formed the basis of 'human development'as we know of it today.

Human beings are the ends and the means. This duality was written about by Immanuel Kant in *Grundlegung zur Metaphysik de Sitten*, where he

[10]Oxford dictionary meaning of the word 'capability'.
[11]See Ross (1980) for insights into Aristotle's writings on the conceptual beginnings of "fulfilment".

posits for the need to view human beings as the ends in themselves rather than as means to other ends.

> So act as to treat humanity, whether in thine own person or in that of any other,in every case as an end withal, never as means only.

When closely looked at, this becomes a ripe ground for confusion, as both, planning and policy making, depend on what will be the means and what will be the ends. Human beings are the beneficiaries, the decision makers, the proponents of ideas, the receivers of what those ideas translate into, and thus, the doers and the doings. It is in this duality that in the process of achieving the highest levels of productivity and prosperity, human beings are treated as the means to do so. Instead, lives of people should be the ultimate concern, production, and prosperity the means to those lives (Sen, 1989).

Grounded in the works of Aristotle, the view taken by political economists like Karl Marx and Adam Smith, as described by Amartya Sen, brings to the front; concepts of 'functionings' and 'capability to function' as precursors for well-being (Sen, 1989). Necessary here is to note the philosophical stand point taken by Marx (1844) on the issue of *poverty*, *wealth*, and the manifestations of *need*.[12] He wrote;

> The *rich* human being is simultaneously the human being *in need* of a totality of human manifestations of life–the man in whom his own realization exists as an inner necessity, as *need*. Not only *wealth*, but likewise the poverty of man –under the assumption of socialism –receives in equal measure a human and therefore social significance. *Poverty* is the passive bond which causes the human being to experience the need of the greatest wealth –the *other* human being.

[12] The entire collection of manuscripts can be found online as well on https://www.marxists.org/archive/marx/works/download/pdf/Economic-Philosophic-Manuscripts-1844.pdf

Having taken a note of the roots, I now move to the rich contemporary literature on the 'capability approach'. A vast collection of essays, lectures, and papers by Amartya Sen outline his astute development of this theory. He gives an account of how he contrived it and focussed on the quality and richness of human life. Nonetheless, Sen has been criticised for a certain level of deliberate vagueness and under-elaboration of the structure.

In light of what is being pursued here, the concept of 'entitlements' needs special attention. Apart from being conceptually related to the alternatives that a person can access to maximise his capabilities, it is also derived from legal rights and not human rights. On one hand thinking of development as providing for people's basic needs in life is an entitlement and on the other Devereux (2001) has criticised it for exclusion of non-market institutions in determining entitlements. [13]

Sen introduced this concept for the first time during a Tanner lecture on Human Values titled, "Equality of What?", in Stanford University in 1979.[14] He began by questioning the three specific types of equality, namely,

- utilitarian equality;
- total utility equality; and
- Rawlsian equality

He argued that these types of equality have serious inadequacies and even a combination of all three will fail to form a sound theory (Sen, 1979). The fundamental premise of dismissing the first type of equality was— utility

[13]Several other philosophical accounts by economists and social scientists have provided highly systematic organisation of this approach. John Alexander, Sabina Alkire, Elizabeth Anderson, Martha Nussbaum, and Ingrid Robeyns are some of the authors who have worked in this space.

[14]For the entire notes on this lecture refer to Sen (1979)

increases only at a diminishing rate when the share goes up and the main purpose of utilitarian equality is to treat all individuals' interests similarly (Harsanyi, 1975). In the context of total utility equality, his disagreement lies in the incapacity to separate out moral claims and the distribution of the public goods in a society (Sen, 1979). His contention remained that ranking focused only on maximising the total amount of welfare in the society, regardless of how it is distributed. This results in the moving of resources only to those who are more capable of converting it into utility, more efficiently. In critiquing the Rawlsian equality, he says that there is too much attention on commodities rather than on the freedom to achieve (Sen, 1979).[15]

The case for focussing on capability was introduced here in the specific context of evaluating inequality. While functionings may be seen as states of 'being' and 'doing', 'capability' is about having access to valuable functionings. Therefore, a person's capability is about the different choices an individual can exercise between various available options—between different kinds of life, which she/he has sound reason to value. Thus, functionings can be applied to different aspects of life. These could be the capability of nutrition, health, political freedom or literacy.

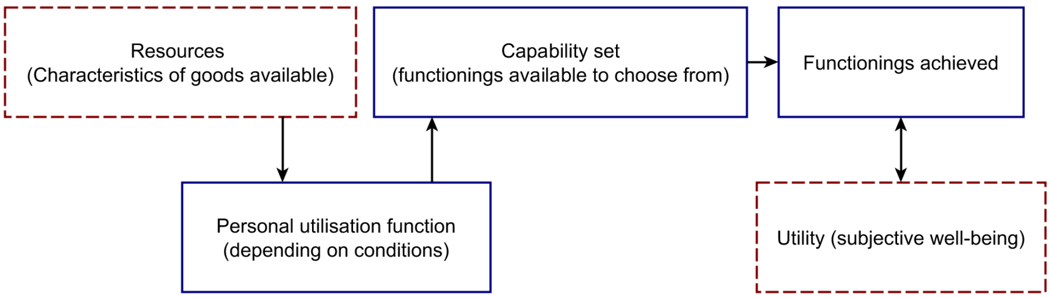

Figure 2.1: Outline of the core relationships in the capability approach.

[15]For references made to Rawl's theories, refer to Rawls (1971), A theory of Justice

His core concepts of this approach are illustrated in Figure 2.1. Not surprisingly, each person's capability set will be different from the other and be dictated by the environment and/or circumstances the individual lives in or chooses to live in. Sen's concerns about the evaluation of contemporary ways of looking at the ultimate utility i.e., 'well-being', may be summarised as follows.

First, for any given input, different individuals will vary greatly in converting or translating it into valuable 'doings' and 'beings'. For instance, the needs of a malnourished child are different from those of a healthy child. She/he will need extra nutrients/care to achieve a status of normal health. Essentially, evaluation that only focuses on *means* without taking into account what other people can do with them, is inadequate.

Secondly, individuals in most cases accept the discordant conditions in which they live, leading to a phenomenon called 'adaptive preferences', whereby, they do not have the desire to achieve what they can never expect to achieve. Once again, evaluation should not be based on just subjective reporting, rather the level of its matching an objective view or disposition of an unbiased observer's perception about the conditions.

Lastly, apart from being related to how people's lives are progressing, this approach also establishes a strong connection between valuing quality of human life.[16]

In what follows next, is how this approach is applied to human development in what is among Sen's most influential work—*Development as Freedom*. He, very carefully asserts that 'capability approach' helps in addressing some evaluation concerns of human development. He emphasises that in-

[16]For a technical elaboration of Sen's capability approach, see Sen (1985).

stead of being a mechanical evaluation, it must be a reflective one, whereby olden concepts of welfare economics and utilitarianism are adapted for the task of fruitfully analysing human development in the contemporary world (Sen, 1999).

The theory of expanding people's choices, giving the freedom to choose the lives they desire to lead, receiving the education that enables them to exercise that choice, and establishing foundational connections to the 'capability approach' is where the modern interpretation of quality of life and human development stems from. Through this it is conceptually easier to make several interconnections such as, good health being instrumental in attaining higher levels of productivity (realised achievements) and the enhanced ability to convert resources (like income) into better living. Sen writes in his paper on *Development as Capability Expansion*;

> One of the most important tasks of an evaluative system is to do justice to our deeply held human values. The challenge of "human development in the 1980s and beyond" cannot be fully grasped without consciously facing this issue and paying deliberate attention to the enhancement of those freedoms and capabilities that matter most in the lives that we can lead. To broaden the limited lives into which the majority of human beings are willy-nilly imprisoned by force of circumstances is the major challenge of human development in the contemporary world. Informed and intelligent evaluation both of the lives we are forced to lead and of the lives we would be able to choose to lead through bringing about social changes is the first step in confronting that challenge. It is a task that we must face.

At the end of this transitioning from Aristotle's idea of 'fulfilment' to Sen's approach on 'human development', I make an attempt to position my understanding of these theories into this thesis. Figure 2.2 shows a schema for perspicacious analysis of data in Chapter 6, gather insights on field in Chapter 3, and use one aspect of it, viz. increased income (resource for conversion into better states of well-being) in Chapter 4. In Chapter 5 we look at the systemic instrumentalities that determine people's choices, all of which will be elaborated upon in the respective chapters.

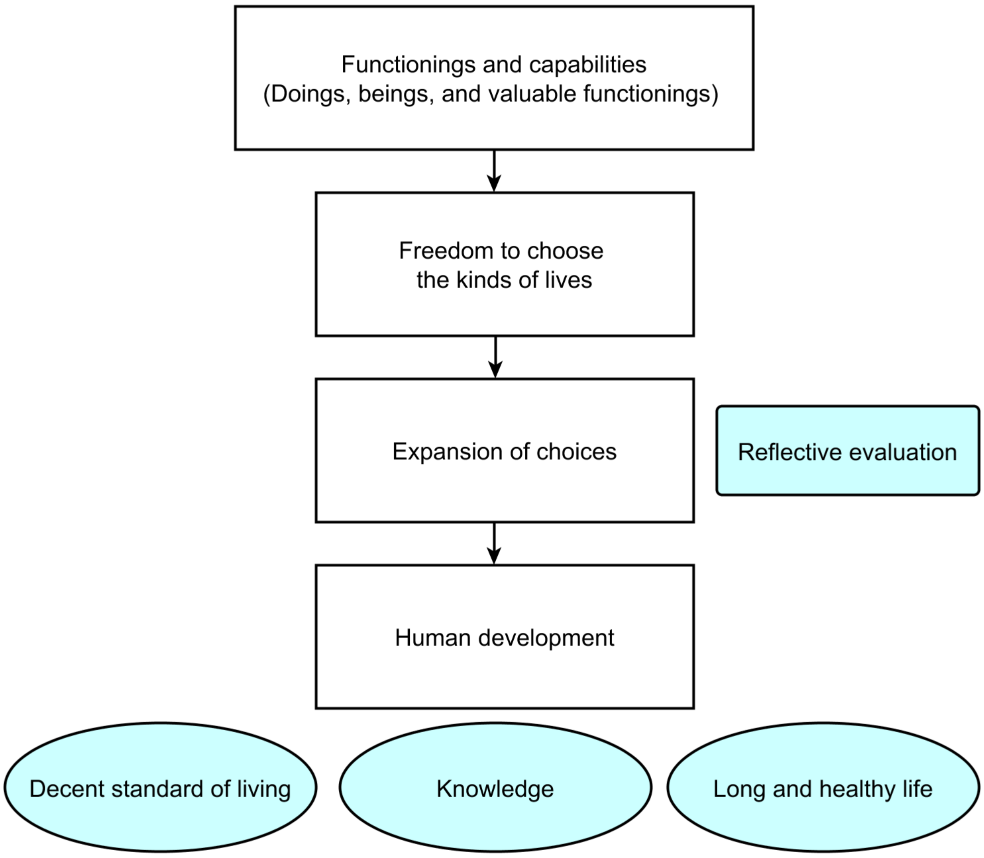

Figure 2.2: Human development and conceptual roots.

2.2 Grossman model of health

In this part of the review, I look at the first theory constructed to model the 'demand of good health'. After seeing that attaining a state of good health is a well justified 'end' , the 'demand' for it is placed as a 'commodity' by Grossman (1972). An interpretation of this is, it is the 'means' by which that 'end' may be attained.

In his work, which continues to maintain its iconic status in enabling health economists analyse what consumers demand when seeking medical services, Micheal Grossman was the first to construct a model of the demand of health capital itself. Many other authors before him suggest that health by itself is one form of human capital. According to him, the decision to invest in health can be studied by investigating models developed by Becker (1964) and Ben-Porath (1967), if an increase in health stock led to an increase in wage rates. However, in the case of this model, health capital is considered to be different than other forms of human capital. For instance, stock of knowledge will determine the extent of market and non-market productivity, while an individual's stock of health will govern the amount of time available for producing that income or earnings/commodities. This is the core justification for demand of health and how it differs from any other form of human capital. Within the framework of this argument, he wrote;

> ...it is assumed that individuals inherit an initial stock of health that depreciates over time—at an increasing rate, at least after some stage in the life cycle—an can be increased by an investment.

Further, the gross investments in health capital are also a function of the household's production function. Various inputs coming in from a household include food choices, medical care, recreation, and housing. These are a combination of both, the time spent by the individual and market goods. Crucial to this entire process is the efficiency of translating these resources into *good health* and therefore, the influence of education on the production process. More formally, health is seen as both, as a consumption commodity it goes into the preference functions, or, in other words, more like a disutility (like in the case of morbidities) and also as an investment commodity it determines the time at an individual's disposal for market and non market productivity.

Mathematically, Grossman (1972) expresses the intertemporal utility function of an individual as;

$$U = U(\phi_0 H_0, ..., \phi_0 H_n, Z_0, ..., Z_n) \tag{2.1}$$

where, H_0 is the inherited stock of health, H_i is the stock of health in the i^{th} time period (i is age), ϕ_i is the service flow per unit stock, $h_i = \phi_i H_i$ is total consumption of another commodity of "health services", and Z_i is the total consumption of another commodity in the i^{th} period.

Using a detailed mathematical model entailing assumption such as: a.) rate of depreciation during i^{th} period is exogenous, although they vary with age; b.) shift in the human capital changes the efficiency of the production process in the non-market sector (analogous to how shift in technology changes the efficiency in the market sector); and c.) all production functions are homogeneous in the goods and time inputs, in equations these are represented as:

$$H_{i+1} - H_i = I_i - \delta_i H_i \tag{2.2}$$

where, I_i is gross investment and δ_i is the rate of depreciation in i^{th} period. Thus, net investment is equal to gross investment in health minus the depreciation. The production of gross investments in health in utility functions is written as:

$$I_i = I_i(M_i, TH_i; E_i) \tag{2.3}$$

$$Z_i = Z_i(X_i, T_i; E_i) \tag{2.4}$$

In equations 2.3 and 2.4, M_i is medical care (this has been assumed to be the most important market good in this model), X_i is the goods input in the production of commodity Z_i, TH_i and T_i are tie inputs, and E_i is the stock of human capital. Considering the assumptions and the equations above, the gross investment production function can be written as,

$$I_i = M_i g(t_i; Ei) \tag{2.5}$$

where $t_i = TH_i/M_i$. Following a set of equilibrium conditions a sophisticated derivation for the marginal monetary return on an investment in health is provided in the paper by Grossman (1972).[17]

The question that arises now is—what happens to the influence of amount of health capital on wage rates? To answer this, one must bear in mind that investments in other forms of human capital like education, extra hours of training and skill development increase wages, however, health capital also influences the time lost from all activities due to illness or injury. This brings us back to why health differs from all other forms of human capital. Stock of health directly determines how much time can be spent in both market and non-market productivity. Precisely for this reason, those who are not in the labour force also have an incentive to invest in health, as both market and non-market time are important.

[17] This paper was first published in Journal of Political Economy and to date forms the basis for several analytical exercises. To avoid restating the entire derivation just the primary equations have been provided in the literature review.

Another very important insight from the model is, the demand/supply of health capital. I discuss this here because the behaviour of individuals (let us call them health seeking consumers) depends on the simple laws of demand and supply. Let us consider a scenario; the available health capital stock falls over a life-cycle, although, gross investment may increase, decrease, or remain constant. Now, in the case of these consumers, for a certain amount of gross investment, the rise in rates of depreciation will reduce the amount of health capital demanded and also reduce the amount of health capital supplied to them. Therefore, if individuals see that a change in supply exceeds the change in demand of health, they will invest into health to close this gap. Else, if the change in demand surpasses the change in supply, gross investment will continue to decline over a life cycle.

In this light, the role of governments and other agencies in promoting health seeking behaviour turns pivotal. Since consumers tend to make a decision based on the quality, accessibility, affordability, and availability of health care, strategic long term investments in health care infrastructure is a crucial aspect of building human capital. I use the Grossman model as the theoretical basis for the study on the association between household income and child health, which will be presented in Chapter 4.

2.3 Setting course: The first 1000 days

Having already established that health is at the core of human development in previous sections of the review, we now refer to literature that is indicative of the evidence related to the impact the first 1000 days have on adult health and human capital.

I elucidate the importance of the "first 1000 days of life". In the last decade or so, this term has been used regularly to lay emphasis on this critical window of opportunity, for growth and development of an individual. 270 days of regular full term foetal period and two years after birth are 1000 days (approximately). From the biological perspective, in this phase the neuroepithelium (brain after birth) and major physiological systems are formed. The expression of genes controlling growth is at its peak thereby contributing to motor skills, cognitive abilities and overall learning faculties. Being able to learn is largely dependent on socio-economic stability, which among other factors, is affected by iron deficiency, poor stimulation, environmental toxins, anaemia and other infectious diseases. It is in this light that nutrition plays a major role in a person's lifetime.

As pointed out in section 1.7, developing countries face tremendous implementation challenges, depriving children from receiving an ideal start to their lives. Faced by poverty, lack of access to food, other such deficiencies in the system, and the attendant condition of malnutrition, undermines the potential of this early window of opportunity. Consequently, there is in the apparent sense an immediate rise in morbidities and an underlying, unnoticed significant loss in neurodevelopmental capacity.

While the evolutionary process of how the brain grows are not in the purview of this review, it will suffice to say that from a bi-lobed bean like structure to a highly complex organ, the brain requires nutrients at different times, in different quantities and the formation of each epoch in it follows a unique growth trajectory.[18] In figure 2.3 a pictorial graph shows, in brief, the

[18]Proliferation, differentiation, myelination, and **synaptogenesis** are the main processes that take place during the formation of the brain.

lengths of various processes that occur in the brain's development during the course of a lifetime.

The absence/presence of specific nutrients govern regular or under development of cognitive and behavioural outcomes in adults. Thus, the vulnerabilities to nutrient deficiency in these sensitive periods of growth have been well documented, making reduction in ill-effects a real possibility through sustained, well-planned interventions, including quality of maternal care, during the first 1000 days. Therefore, even though all effort must be directed in preventing these early malignancies, remarkable possibilities exist that can compensate for the losses (Black *et al.*, 1998) and (Bredy *et al.*, 2003). [19]

[19] Animal studies have enabled the identification of these growth trajectories.

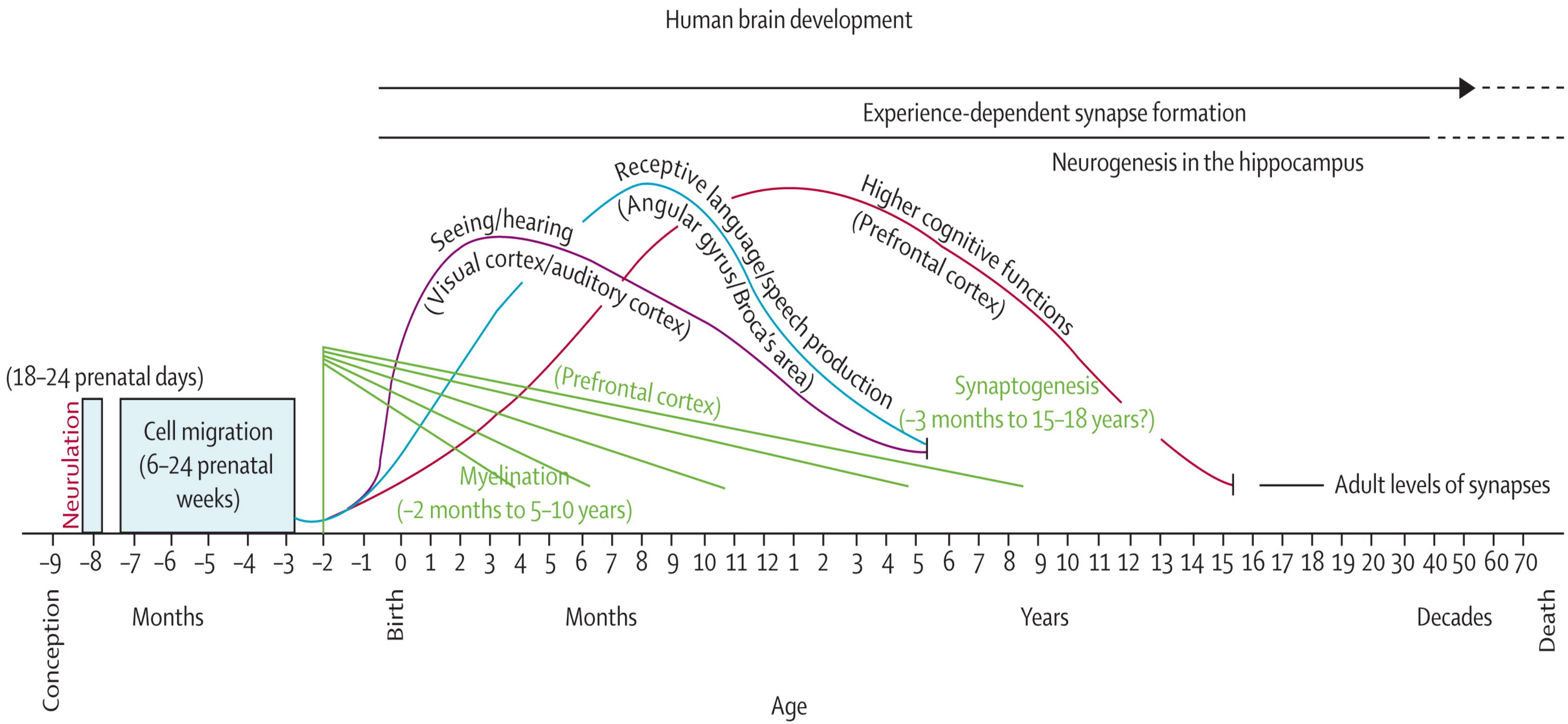

Figure 2.3: Human brain development showing the lengths of various processes that occur in the human brain. The rates are the highest in the first 1000 days, the first five years, and upto adolescence. The image has been sourced from Grantham-McGregor *et al.* (2007). The original version is from the *American Psychological Association* paper by Thompson and Nelson (2001).

Burden of malnutrition in Low and Middle Income Countries (LMICs) is very high, a fact that is well accepted. An analysis of long-standing prospective cohort studies from Brazil, Guatemala, India, the Philippines, and South Africa was conducted by Victora *et al.* (2008) in a Lancet series. This research group chose 14 adults outcomes,viz.; height; achieved schooling and educational performance; income and assets; birthweight in the off spring; body-mass index, body composition, and obesity; blood lipids; insulin resistance and type 2 diabetes; blood pressure; cardiovascular disease; lung function; immune function; cancers; bone mass, fracture risk, and osteoporosis; and mental illness. They indicate that damage suffered in early life leads to permanent impairment, which might also affect the future generations.

I now list some of the important findings from this study. Out of the 445-3035 males whose data was available for Brazil, the average years of attained schooling was 9 years (mean), and their mean birth-weight was 3.25 kg. In the case of Guatemala, 356-878 females were a part of the study sample, out of which 86.3 per cent were stunted as children (at about 2 years of age). As adults their mean monthly income was 3.7 (log USD) and they attained only 4.7 years (mean) of schooling. In the case of Indian females (513-626 sample size), 40 per cent of them had Intra-uterine Growth Restriction (IUGR). As adults, 45.4 per cent of them were overweight (BMI$\geq$ 25kg/m^2). These poor educational outcomes are because undernutrition can affect cognitive development by causing direct structural damage to the brain which impairs infant motor development and curbs exploratory behaviour (Wintour-Coghlan and Owens, 2007) and (Brown and Pollitt, 1996). In the long term, due to persistence of early deficits, partially because of the lack of remediation in constrained and deprived environments, there is an alteration in learning abilities of the brain (Pollitt *et al.*, 1996).

In the next part of the evidence, I point to the type of interventions needed for maximising the benefits of these 1000 days. Even though most of the work is not in the category of controlled trials, these are convincing results. Bhutta *et al.* (2013) chose 34 countries that have 90 per cent world's stunted children and concluded that deaths of children under 5 years can be reduced by 15 percentage points, if populations can access 10 evidence based nutrition interventions at 90 per cent coverage rate.

Any effort to improve nutritional status will have to be looked at from the inter-generational aspect. The papers referred to below highlight the intervention and the outcome attained. The emphasis is on the type of intervention provided and the medical condition it helps ameliorate.

I first summarise the results from interventions for women of reproductive age and pregnant women. Risk of Neural Tube Defects (NTDs) were found to be reduced by 72 per cent on providing **folic acid**[20] supplements to women of reproductive age (De-Regil *et al.*, 2009). In the case of developed countries, a review of 31 trials by Lassi *et al.* (2013) showed that mean birthweight of babies improved on giving folic acid supplements to pregnant women.

Maternal Multiple Micronutrient (MMN) supplementation helped women report a 3-11 percentage points reduction in both, low birthweight and Small for Gestational Age (SGA) conditions, from 23 trials (Haider and Bhutta, 2012). Since LMICs have a high proportion of women with multiple micronutrient deficiencies which are exacerbated during pregnancy, MMN has proved to

[20]The bold font indicates the type of intervention. This has been done to serve as an easy identification of the kind of intervention that when done at the right time can reduce the burden of malnutrition setting in the first 1000 days.

be highly effective. In the case of **calcium and iodine** supplementation/fortification, 13 trials showed that pre-term births reduced by 24 percentage points (calcium) and 10-20 percentage points increase in developmental scores of children (iodine) (Imdad and Bhutta, 2012a) and (Zimmermann, 2012). By providing supplements with **balanced energy and protein**, in a review of 16 trials from developing and developed countries indicated that risk of stillbirths incidents decreased by 45 percentage points (Imdad and Bhutta, 2012b).

Moving on to the interventions for neonates, it was seen that **delayed cord clamping** improves haemoglobin concentration and **Vit K** administration reduced clinical bleeding in babies(McDonald and Middleton, 2009) and (Ardell *et al.*, 2010). **Vit A** supplementation in very low birthweight infants reduced the deaths of babies and also the requirement of oxygen at 1 month of age (Darlow and Graham, 2007). **Kangaroo care for breastfeeding promotion** increased the mean duration of feeding by 42.55 days (Moore *et al.*, 2012).

The research studies that follow next are for trials in which children (aged between 6 months to 15 years) were enrolled. Results from the 110 Randomised control trials (RCTs) on an extremely important intervention, **Exclusive breastfeeding (EBF)** showed that educational and counselling programs increased EBF by 90 percentage points between first six months after birth (Haroon *et al.*, 2013). **Preventive Vit A supplementation** in children aged between 6-59 months reduced diarrhoea-related mortality by 28 percentage points (Mayo-Wilson *et al.*, 2011) and a crucial micronutrient, **iron** when given to children aged below 2 years as reported by 33 different trials, reduced the risk of anaemia by 49 percentage points and iron deficiency by 76 percentage points (De-Regil *et al.*, 2011). **Zinc** supplementation in children for upto 24 weeks increased their mean height by 0.37 cm and incidence of pneumonia by lessened by 19 percentage points (Imdad and Bhutta, 2011) and (Yakoob *et al.*, 2011).

In all these intervention programmes several statistically non-significant improvements were also observed. Mental development measured by psychological test scores, motor coordination, and increased activity by children are also highly dependent on such interventions (Gogia and Sachdev, 2009).

Following this extensive reporting of published work that reiterates the necessity to focus on the first 1000 days, several nutrition sensitive schemes and programmes have been developed world over. Whilst, in this section I provided an overview of the tangible interventions, the first 1000 days of life is a golden opportunity for harnessing the potential in adult life. Other than these kind of interventions a vast majority of the effort is directed towards creating a nutrition sensitive ecosystem. I shall discuss those in the subsequent sections.

Indeed, the first 1000 days are about setting the course for human capital development, in all domains.

2.4 National nutrition policy and abatement initiatives

Globally, fighting malnutrition is a challenge, especially when the burden is high in developing nations. In this effort, several international organisations lead the way in formulating guidelines, which they do through consultation with governments, Non Governmental Organisations (NGO), academicians, and other experts. A look at the latest joint estimates of malnutrition published by UNICEF in 2017, show that in South Asia, 35.8 per cent and in the least developed countries 34.8 per cent children are stunted. On the other hand obesity has risen in children to 4.3 per cent and 4.2 per cent of the population in both these regions, respectively.[21]

Historically speaking, in India, the National Policy on Health was adopted in 1983 and the National Nutrition Policy in 1993. The salient features of the National Nutritional Goals identified in line with the world summit on children in 1990 were as follows (GOI, 1993):

- Reduction in moderate and severe malnutrition among pre-school children by half ;
- Reduction of low weight babies below 10 per cent;
- Eliminate blindness due to vitamin A deficiency ;
- Reduce iron deficiency anaemia in expectant women to 25 per cent ;
- Universal iodisation of salt and virtual elimination of iodine deficiency disorders;
- Promoting appropriate diets and healthy lifestyles;
- Achieving production of 250 million tonnes of food every year; and
- Improving household food security through poverty alleviation programmes in rural and urban areas.

[21] This data is available on a dashboard maintained and hosted by UNICEF https://data.unicef.org/resources/joint-child-malnutrition-estimates-2017-edition/

For operationalising each scheme the government has appointed frontline workers known as *Anganwadi* Workers (AWWs) and Accredited Social Health Activist (ASHA) who act as the first point of contact for the beneficiaries and are an interface between the district level administration and the people. The functions of these workers is to act as the instrument of bringing the necessary social change by engaging closely with the children, girls and women of the village. The efficacy of each scheme at the grass root level is directly in the hands of these workers and are responsible for mass community involvement, data recording, home visits, nutrition education, and new born care.

To facilitate a safe birth procedure the government also appoints a special Auxiliary Nurse Midwife (ANM) whose most important task is to implement the Reproductive Child Health component under NHM. The counselling of pregnant and lactating mothers, micronutrient supplementation, antenatal and post natal care are the roles performed by an ANM. Coordination among these three front-line workers is the mechanism through which all programmes pertaining to malnutrition and health are implemented in the country.

In what follows next, is a synopsis of the various initiatives, schemes, policies, and programmes that are in place, in India and the world. I will begin with India and then present a summary of the world-wide initiatives.

The operational schemes in India are presented in Table 2.1. Each target group has been mentioned with the scheme/service that they receive benefits from also indicated.

Table 2.1: Services administered to target beneficiaries as per respective schemes aimed at tackling malnutrition in India.

Services	Target group	ICDS	SABLA	NHM	PMMVY	MDMS
Intangible services						
Counselling/Guidance on family welfare, ARSH, child care practices and, home management	A		✓			
Pre-school education and non-formal education	C	✓				
Nutrition and Health education	A, P& NM	✓	✓			
Life Skill Education and accessing public services	A		✓			
Health Check up	A, C, P& NM	✓		✓		
Referral	A, C, P& NM	✓		✓		
Vocational training for girls aged 16 and above under National Skill Development Program	A		✓			
Tangible services						
Iron and Folic Acid (IFA) supplementation	A, P& NM	✓	✓	✓		
Conditional maternity benefit (cash transfer)	P& NM			✓	✓	
Supplementary Nutrition Support*	A, C, P &NM	✓	✓			
Immunisation	C, I, P &NM	✓		✓		
Mid-day meal	S					✓
Data						
Data capturing,(manual; pen and paper)	For all	✓	✓	✓	✓	✓

∗ Includes Take Home Ration (THR) and Hot Cooked Meals (HCM).
A (Adolescent girl); C (Child (6 months-6 years)); I (Infant (0-6 months)); Pregnant women and Nursing Mothers (P& NM); S (School going children (6 years to 14 years))

As shown, all services provided require multi-sectoral coordination and ICDS bears the onus as the nodal agency. To this effect the World Bank had partnered in 2012 for a six year long project with the ICDS to formulate guidelines under the ICDS World Bank Assisted System Strengthening and Nutrition Improvement Project (ISSNIP) (World Bank and Government of India, 2012). The two key functions outlined were:

- strengthen the ICDS policy framework, systems and capacities, and facilitate community engagement, to ensure greater focus on children under three years of age; and

- strengthen convergent actions for improved nutrition outcomes.

The updated allowances under all food security initiatives are shown in tables 2.2 and 2.3. All these guidelines comply with the Recommended Dietary Allowance (RDA) and each state is responsible for delivery of supplements and meals.

Table 2.2: Integrated Child Development Services-Supplementary Nutrition Programme for all beneficiaries.

Age category	Mode	Dietary Allowance/child	Cost/ head /day
6-36 months	THR	500 cal/day, 12-15 g protein/day	INR 6
6-36 months (if malnourished)	THR	800 cal/day, 20-25 g protein/day	INR 9
3 to 6 years	Morning snack and HCM	500 cal/day, 12-15 g protein/day	INR 6
3 to 6 years (if malnourished)	Morning snack, HCM and additional supplement	500 cal/day, 12-15 g protein/day 300 cal/day, 8-10 g protein/day	INR 9
P& NM	THR	600 cal/day, 18/20 g protein/day	INR 7
11-14 years girls (out of school)	THR or HCM	600 cal/day, 18-20 g protein/day	INR 5
14-18 years girls (all)	THR or HCM	600 cal/day, 18-20 g protein/day	INR 5

Inputs taken from GOI (2014), Ministry of Women and Child Development (2017) , and Ministry of Women and Child Development (2010)

Table 2.3: Mid-day meal scheme allowances.

Age category	Mode	Dietary allowance/child
Class 1 to 5	HCM in school 100 g rice/flour 20 g pulses 50 g vegetables 5 g oil	450 cal/day, 12 g protein/day
Class 5 to 8	HCM in school 150 g rice/flour 30 g pulses 75 g vegetables 7.5 g oil	700 cal/day, 20 g protein/day

Inputs taken from Mid day meal scheme (2015)

Following the last national health policy adopted in 2002, a new framework has been established called National Health Policy, 2017 (GOI, 2017a). Recently, a national nutrition strategy has been formulated along with the launch of the NNM (GOI, 2017b). With a three-year budget of 9,046 crores (~1.4 billion USD), commencing from 2017-2018, this mission aims to reduce stunting to 25 per cent by 2022. Among the 9 areas of focus mentioned in the proposal, the crucial ones are listed below.

- introducing a very robust convergence mechanism;
- Information and Communication Technologies (ICT) based real time monitoring system;
- incentivising AWWs for using IT based tools;
- eliminating registers used by AWWs; and
- introducing measurement of height of children at the *Anganwadi* Centres (AWCs)

Under the framework of the National Nutrition Strategy (NITI aayog, 2017), a comprehensive list of 'focus districts'[22] based on indicators of the NHM (184 districts), the ICDS (200), ISSNIP (162), has been published. Convergence has been recognised as a significant area of concern, as in only 39 districts all three programmes were running simultaneously.

As I write this review on the malnutrition-tackling related mechanisms in place in India, a new National Health Protection Scheme for about 100 million rural Indians has been announced in the Union Budget (2018-2019).[23]

[22] India has 29 states and 7 Union Territories (UTs). Each state and UT is further divided into a number of districts and each district into sub-divisions.

[23] This is a new announcement and the details of it can be found in the union budget document 2018-19.

Several other sectoral interventions by various states such as Maharashtra's state nutrition mission,[24] launched in 2005 are also in place, which have served as role models in the implementation of certain schemes.

Among global interventions, WHO, UNICEF, FAO, International Food Policy Research Institute (IFPRI), and World Bank Group (WBG) publish guidelines regularly, and countries are signatories to it. Apart from the World Food Programme (WFP) which aims at achieving 'Zero hunger', the two other programmes are Scaling Up Nutrition (SUN) and Renewed Efforts Against Child Hunger and Undernutrition (REACH). The SUN movement Lead Group was established in 2012 by the United Nations Secretary-General to improve coherence, provide strategic oversight, improve resource mobilisation, and ensure collective accountability (UNICEF, 2013). India is not a member of the SUN programme as yet.

REACH helps to coordinate multiple agencies and governments, including ministries of health, agriculture, education and finance, as they design and implement national child undernutrition policies and programmes. The focus of this programme is to strengthen nutrition management and governance. It also has set an aim to address sensitive issues like design of nutrition programmes. It envisages to act the framework under which SUN shall function to build capacity and bringing nutrition into a mainstream developmental challenge. REACH is currently operational in 12 countries; Bangladesh, Burundi, Chad, Ethiopia, Ghana, Mali, Mozambique, Nepal, Niger, Rwanda, Tanzania and Uganda.

Other scaled up abatement strategies include the Water Sanitation and Hygiene (WASH) programme, Community Management of Acute Malnutri-

[24] http://www.mahnm.in/

tion (CMAM) programmes, facility based management of SAM according to the WHO's protocol (followed in all nutrition rehabilitation centres of districts in India), and Integrated Management of Childhood Illnesses (IMCI).

In Chapter 5, the work done as a part of the controlled trial involved coordinating with various aspects of the in-place machinery and an understanding of these schemes' guidelines was helpful in that effort.

2.5 Economic growth and malnutrition in India and the world

World hunger has risen, and the total number of undernourished people rose from 777 million in 2015 to 815 million in 2016 (FAO-IFAD-UNICEF-WFP-WHO, 2017). On the other hand, world GDP increased from 115.5 trillion to 120.6 trillion in PPP USD terms. [25] These two contrasting estimates call for a study to assess the extent up to which growth in income/GDP translates into decreasing hunger, improving food security, and reducing malnutrition.

The Indian economy on the whole has continued to record high growth rates, historically unprecedented, and is among the fastest growing economies of the world. World bank data estimated the poverty head count ratio to be 16.46 per cent (19.29 for rural India) at national poverty lines in 2013 [26]. To depict the correlations between economic growth and poor nutrition outcomes, I will first, explain the trends observed related to calorie intake, including hunger and then move to India specific and world-wide estimations

[25] Data obtained from https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.CD

[26] PovCalNet publishes the poverty rates for all countries (http://iresearch.worldbank.org/PovcalNet/povDuplicateWB.aspx)

for various manifestations of malnutrition.

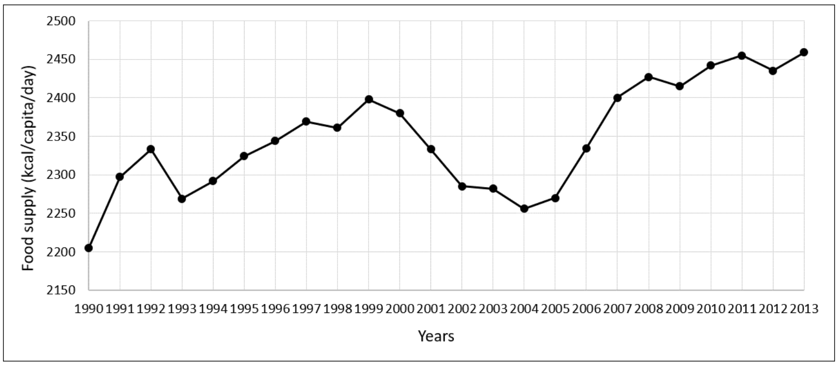

Figure 2.4: Food supply in India, 1990-2013. Data obtained from Food and Agriculture Organisation, "Food Balance Sheets" (http://faostat.fao.org).

In terms of food supply between the years 1990 and 2013, the per capita intake in kcal per day in India as per FAO data has been presented in Figure 2.4. There seems to be a contradiction to the results emanating from National Nutrition Monitoring Board (NNMB) and NSS data.

Table 2.4: Mean per capita consumption of calories, protein, and fats using NSS and NNMB data

		Calories(kcal)		Protein(g)		Fats(g)	
Year	Round	Rural	Urban	Rural	Urban	Rural	Urban
1993-94	50	2,153	2,073	60.3	57.7	31.1	41.9
1999-2000	55	2,148	2,155	59.1	58.4	36	49.6
2000-01	56	2,083	2,027	56.8	55.3	34.6	46.1
2001-02	57	2,018	1,982	54.8	54.2	33.6	46.1
2002(2)	58	2,025	2,014	55.4	54.9	34.7	47
2003	59	2,106	2,020	58	55.5	36.4	46.7
2004(1)	60	2,087	2,036	56.9	55.9	35.5	46.8
2004-05	61	2,047	2,021	55.8	55.4	35.4	47.4

Borrowed from Deaton and Drèze (2009) in which the details of conversion to calories have also been explained.

This was elaborated by Deaton and Drèze (2009) wherein in exactly the same period (see between 2004-06) that FAO reports an increase in calorie intake, they show using NSS and NNMB a decrease in calories intake across rural and urban areas alike. In a comprehensive exercise which entailed a complete documentation of poverty, nutrition, and growth in India Deaton and Drèze (2009) point to how there is no tight link between number of calories that are consumed and the nutritional status of people. Over a period of 1983 to 2004-05, in rural areas alone, the average calorie intake declined by 10 per cent with the decline being higher for the upper end of the expenditure distribution.

On similar lines, Basole and Basu (2015) also found that between 1987-88 and 2009-10, the average calorie intake in rural areas reduced to 1,971 kcal per day from 2,291 kcal per day, which translates to a 14 per cent decline. Also, in the same period the average expenditure per capita (adjusted for inflation) increased by 28 per cent. Among the many unresolved puzzles written about in the Deaton and Drèze (2009) paper, they hypothesise that a plausible explanation could be the rise in real wages and incomes coupled with decreasing physical activity, more sedentary lifestyles, and overall improvement in the health environment. Nonetheless, their analysis does not conclude that there are no calorie deficits in the Indian population.

Further, time trends across several NNMB surveys revealed a gradual decline in household intake of cereals and millets accompanied with a marginal improvement in the intakes of vegetables in households (Shankar *et al.*, 2017). Several explanations have been provided to reason out this decline in calorie intake. Diversification of diets as noted by Landy (2009),Mittal (2007) and preferential buying of luxury items over food proven by Banerjee and Duflo (2011) are two lines of thought. Following the recent studies, one-fifth of this decline is likely to be explained by the slow improvement of disease environment in India (Duh and Spears, 2017). Another possible account for this ambiguous decrease is the complex manner in which households substitute food items to counter the price rise of specific food groups (Gaiha *et al.*, 2013).

An under reporting due to meals eaten away from home and the difficulty of being able to capture this aspect through mainstream expenditure surveys are also some factors that have been proposed to explain this puzzle (Smith, 2015). Concomitantly, it is important to see how rising incomes have affected nutrition status in terms of micronutrient deficiency, whereby Meenakshi (2016) reports the decrease in the intake of iron in the two higher tertiles over 1991-92 and 2011-12. This evidence fits in well to explain the triple burden of malnutrition given its influence of childhood mortality which also points to the rise in anaemia in India.

On reporting the levels of hunger, according to the Global Hunger Index (GHI), India ranked 100$^{\text{th}}$ out of 119 countries. This index is based on proportion of people who do not get sufficient calories, proportion of children who are underweight and mortality rate for children under five (von Grebmer *et al.*, 2017). As already discussed above, the calorie intake puzzle may also contribute to the low rank on the hunger index, however, performance in these peak periods of economic growth have continued to startle many experts. In the latest version of the HDR 2016, India is ranked 131 out of 188 nations, remains in the category of 'medium' human development and records a Gross National Income (GNI) per capita of 5,663 (2011 PPP $). Adult mean years of schooling is at an abysmally low 6.3 years and life expectancy is 68 years (UNDP, 2016). Looking at a more temporal trend, one notices that from 1990 (year of ground-breaking economic reforms) to 2015, India's HDI has gradually risen from 0.428 to 0.624, however, relative standings continue to remain very low.

In what follows next are mentions of works that show the levels up to which malnutrition in India has been reduced during these highly consistent periods of economic growth. As per the UNICEF (2012) report on child nutrition status, in 2005-2006, 48 per cent of children under age 5 in India were stunted, while according to NFHS 4 (2017) conducted in 2015-2016, 38.4 per cent are stunted, 35.7 per cent children are underweight, and 21 per cent are wasted. Moreover, 43.7 per cent of adolescent girls are thin and close to 50 per cent are anaemic (RSOC, 2014). On the other hand, there is also the risk of rising obesity among children and teenagers in the country (UNICEF, 2016). Tarozzi and Mahajan (2007) found that in the nineties, while poverty reduced considerably, short term measures of child health showed improvement but mostly only in urban areas. Over the years beginning 1996-97 till 2014-2015, as per Nutrition Landscape Information System (NLiS) and NFHS-4, figure 2.5 shows the status of anthropometry status for Indian children.

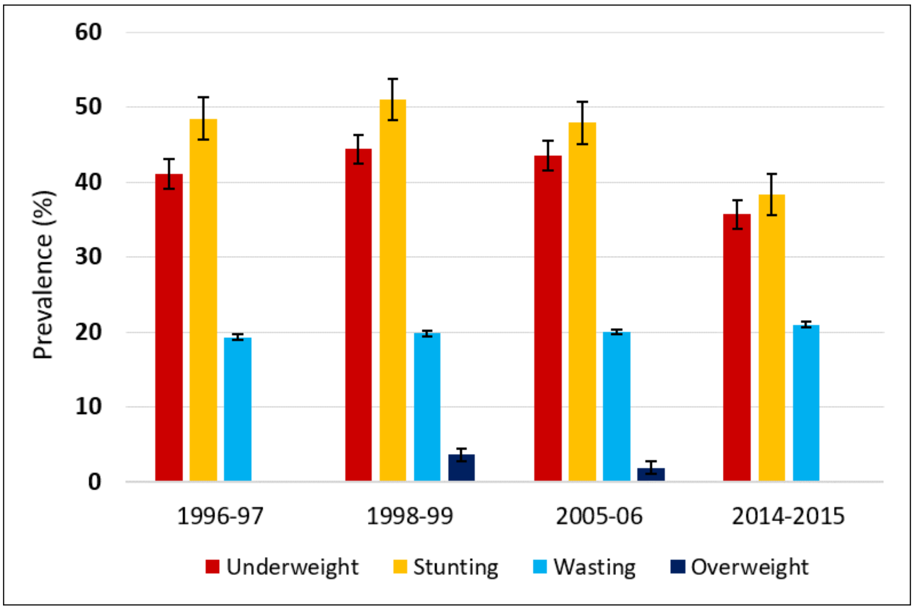

Figure 2.5: Children (< 5 years of age) anthropometry status in India from 1996 to 2015. Error bars indicate 95% confidence interval. Estimates for overweight not available for 1996-97 and 2014-15. Data obtained from `http://www.who.int/nutrition/nlis/en/` and `http://rchiips.org/NFHS/factsheet.shtml`

Stunting and wasting levels have reduced gradually, however, between the 10 years that lapsed between NFHS-3 and NFHS-4, wasting levels have increased. Measured by degree of stunting, Brennan *et al.* (2004) reported that close to half of India's children suffer from chronic malnutrition and about a quarter from severe chronic malnutrition. Pathak and Singh (2011) used concentration indices that between 1992 and 2006 very sluggish improvement was noticed in child malnutrition, accompanied by corresponding rise in economic inequalities. On conducting a decomposition study it was seen that inequality in wealth distribution and inequality in maternal education were two largest contributors to disparities in child health (Chalasani, 2012). Social Statistics Division (2012) reported that at the national level infant mortality rate was 47 and varies from 51 in rural areas to 31 in urban areas.

In the face of rising multi-dimensional poverty, which is at 55.3 per cent of the population with a weighted deprivation score of at least 33 per cent as per (UNDP, 2016), the recently released Global Nutrition report also brought forth positive trends and showed that nearly all Indian states reported a decline in stunting rates between 2006 and 2014 (Haddad *et al.*, 2015). Subramanyam *et al.* (2011) analysed three rounds of the NFHS data to find no evidence of economic growth alone leading to reduction in child undernutrition. They recommend that direct investments in specific health interventions would be a more efficient route to curb undernutrition in the Indian context. Before them Smith and Haddad (2002) had studied 63 countries using ecological models which showed and inverse relationship between economic growth at national levels and child undernutrition. In section 2.4 the strategy adopted in the National Nutrition Mission has been acknowledged, which is concurrent with the recommendations of higher investments in the nutrition specific interventions. Under the stewardship of this programme with higher mobility of financial resources, more evidence will assist in determining the success of this strategy adopted by the NNM .

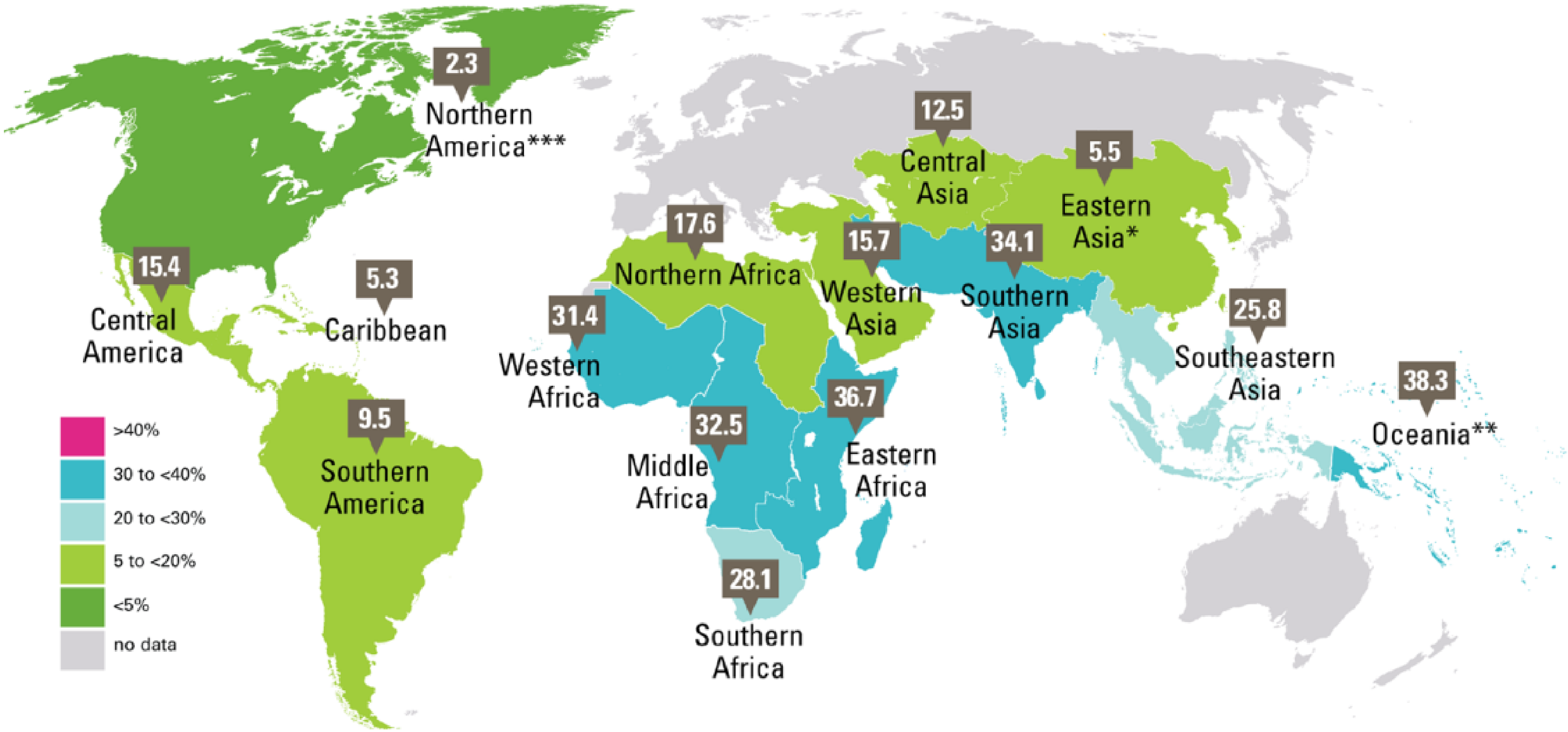

Figure 2.6: Global prevalence of stunting rates in children under 5 years of age as per the joint estimates published by UNICEF, WHO, WBG, 2017 edition Eastern Asia excluding Japan, **Oceania excluding Australia and New Zealand, *** Northern America regional average based on United States data. The legend contains a category for >40 per cent (pink) but there is no sub-region with a rate this high.
These maps are not to scale and are stylised versions.
Retrieved from `https://data.unicef.org/resources/joint-child-malnutrition-estimates-2017-edition/`

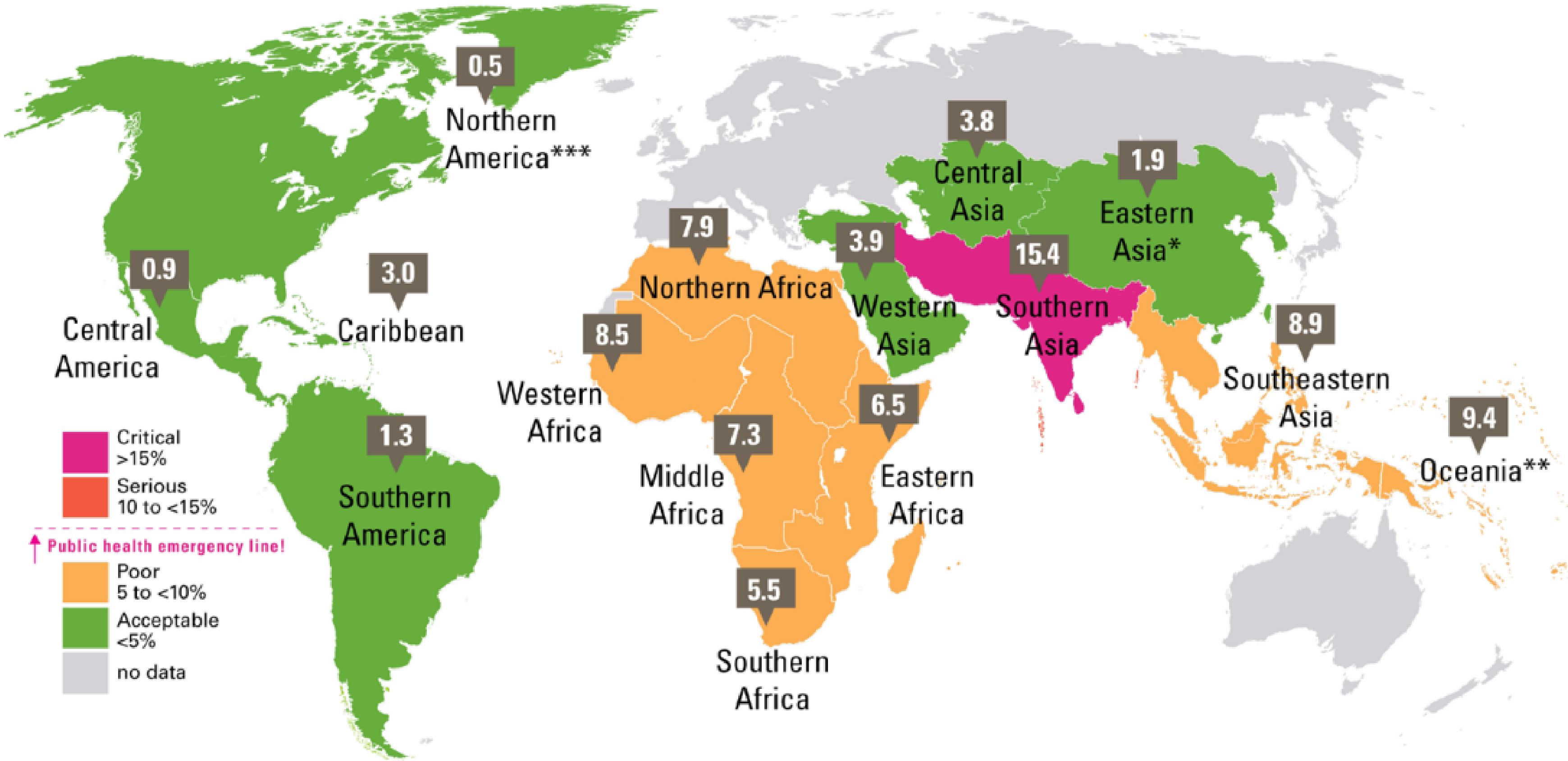

Figure 2.7: Global prevalence of wasting rates in children under 5 years of age as per the joint estimates published by UNICEF, WHO, WBG, 2017 edition
* Eastern Asia excluding Japan, **Oceania excluding Australia and New Zealand, *** Northern America regional average based on United States data.
These maps are not to scale and are stylised versions.
Retrieved from `https://data.unicef.org/resources/joint-child-malnutrition-estimates-2017-edition/`

Globally, in its recent reports, UNICEF estimates that under-nutrition contributes to nearly half of the deaths of children under 5 years of age (UNICEF, 2013) and (UNICEF, 2016). In both, figures 2.6 and 2.7, using updated data, maps of the global status are shown. In the case of wasting, only South Asian countries report prevalence above the public health emergency line, while a majority of African nations and South Asia's nations report stunting levels between 20 per cent to 40 per cent. Both, Spears (2012) and Spears *et al.* (2013b) note the linkages of undernutrition to significant economic costs associated with below-par learning outcomes and adult productivity. A study by Crosby *et al.* (2013) estimates that the economic burden of malnutrition is expected to be between 0.8 to 2.5 per cent of the GDP. Given all the above, various programmatic responses to undernutrition and synergistic collaboration between government and development stakeholders will be crucial in translating economic growth to better child health at commensurate rates.

2.6 Data availability in India : Progress and concerns

Thus far, it is discernible that to establish connections between human development, economic growth, role of governance, and child malnutrition, data plays a key role. Monitoring activities are among the pivotal functions of data collection efforts strengthened only by repeated improvement in survey methodology and sampling strategies. In India, useful insights have been drawn on using the Census data, NFHS, District Level Household Survey (DLHS), AHS, NSS, NNMB, and more recently IHDS-II data. Whilst all scheme related information pertaining beneficiaries is collected through a

Management Information System (MIS) maintained at district level, the health information system data has not kept pace with the epidemiological transition in the country (Raban *et al.*, 2009). The aim of all population based surveys is to provide high-quality reliable data to guide planning, devise policy, and evaluate transitions over time.

In this last section of the review, I lay emphasis on the concerns that need to be addressed for making data more usable while underscoring the progress made in this respect. The first NFHS was held in 1992-93, while the next three rounds were conducted over intervals of 6 to 9 years. In the case of DLHS, four rounds have been completed with the first round overlapping with NFHS-2 and the remaining three rounds were held with close proximity. In short, frequency of data collection has remained a major concern and none of these surveys have collected longitudinal data. However, the AHS held first in 2010-11, interviewed the same set of households consecutively in the next two years as well.

With respect to uniformity in the questionnaire, irrespective of the improvements there have been instances where crucial themes like quality of public sector health services were dropped out in the third and fourth round of DLHS. Although each survey is conducted to fulfil a specific need or address a data gap, there are overlapping modules, spurious inclusion or exclusion of questions, discrepancies in the age limits of the type of respondents (especially women), and inconsistency in representation of males in surveys. For instance, the AHS has so far never interviewed men. The repercussions of such issues are noticed when a continuity cannot be maintained in analysing the trend for a specific outcome for a specific age group. Imminently, most studies end up with cross-sectional information only, which in turn hampers progression into holistic policy design.

Furthermore, only in NFHS-3 and 4, a certain degree of similarity has been noticed in terms of the themes/modules and men have been interviewed about their contribution to healthcare, attitudes towards autonomy of women, and domestic violence. Regarding anthropometry, remarkable changes have been recorded over the last decade and a half. Barring a few surveys, all others have recorded height and weight data for children (upto 60 months), women, and men to monitor improvements in nutrition status.

Regarding biomarker data, which is an extremely recent addition to surveys, anaemia, HIV tests, blood pressure, and test of fasting plasma have been included in NFHS-3 and 4, DLHS-2 and 4, and the AHS.

Table 2.5: Data collection by various surveys in India.

Survey	Years	Households surveyed	Data available*	Months passed**
NFHS				
NFHS-1	Apr'92 to Sep'93	88,652	Aug'95	22
NFHS-2	Nov'98 to Dec'99	91,196	Oct 2000	9
NFHS-3	Nov'05 to Aug'06	1,09,041	Sep'07	12
NFHS-4	Jan'15 to Dec'16	6,01,509	Jan'18	12
DLHS				
DLHS-1	May'98 to Oct'99	5,29,817	Aug'01	21
DLHS-2	Mar'91 to Jun'05	6,20,107	Aug'06	13
DLHS-3	Dec'07 to Dec'08	7,20,320	Apr'10	15
DLHS-4	Aug'12 to Feb'14	3,50,000	Dec'15	21
AHS				
Baseline	Jul'10 to Mar'11	41,40,000	Nov'15	55
AHS update 1	Oct'11 to Mar'12	42,80,000	Nov'15	42
AHS update 2	Nov'12 to May'13	43,20,000	Nov'15	29

Inputs from Dandona *et al.* (2016) and NFHS 4 (2017) have been taken for this table.
* Indicates the date when individual level data was publicly available
** Indicates the number of months between data collection completion and publicly available data

A critical pitfall still remains the time lag between completion of data collection and making it available publicly. Table 2.5 presents information about the number of households surveyed and number of months that have passed until individual level data is published for each survey. Although these are systemic challenges, the cost borne by the public health system in informing policies based on old data is a matter of grave concern. Providing data on social and development indicators enables quicker target identification for resource mobilisation.

There also lies enormous possibilities for improving the predictability in timing of the surveys and learning from countries like Australia, Canada, and Korea (ABS, 2015), (NHANES, 2014), and (KHANES, 2013). These will ensure availability of single large source of data with optimum resources and prevent redundancy. In the long term, a continuous design may be considered for refining survey management (Clark *et al.*, 2013).

2.7 Summary of literature review

The review above provides us with ample rationale for why malnutrition is critical for human development. Expansion of choices for humans and attaining a basic standard of living have to be at the soul of all development activities. Investment in health, especially child health is paramount for widespread and equitable economic growth. As discussed, the early years of an individual dictate to a large extent the outcomes in adult life. Earnings, availability of labour hours, learning, and cognition depend deeply on nutrition in the first 1000 days. Mapping of biological pathways that affect learning and behaviour outcomes have enabled devising of precise interventions for compensating losses.

Recognised as a public health burden, malnutrition abatement initiatives, currently operational in India and the world struggle with convergence and on-ground coordination of multiple partners. Delays in nutrition delivery systems hinder harnessing the potential of crucial windows of opportunity in child growth. As discussed, economic growth has not resulted in commensurate amelioration of malnutrition, hunger has risen, and calorie intakes have decreased in both, rural and urban India. Data availability concerns related to survey methodology and public accessibility preclude problem identification, thereby impeding robust policy decisions.

Therefore, as represented in figure 2.8, it is from this perspective that the analysis included in this thesis report proceeds to investigate the human development progress in India. For this investigation, a look at some of the ground level realities is necessary. Aspects of these will be discussed in the following chapter.

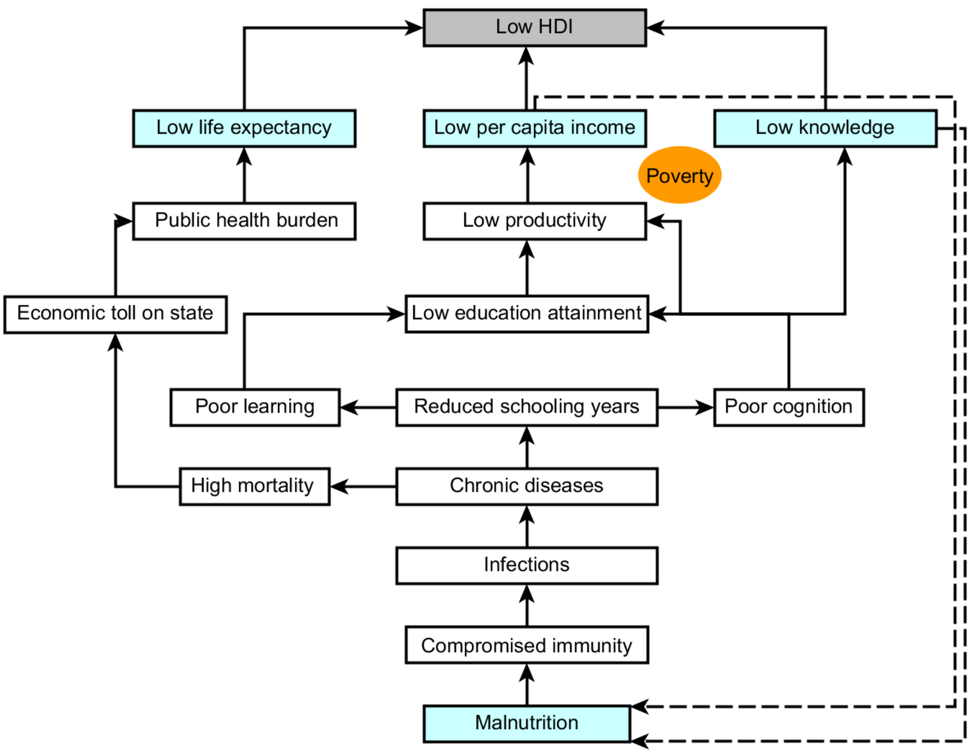

Figure 2.8: Upward linkages between human development and malnutrition.

Chapter 3

Field Study in rural India

~ ***Seeing is believing***

With a fairly well versed understanding of the theoretical linkages between human development and malnutrition, I set out with a colleague to a backward part of northern MP in the summer of 2015 to test my well formed notions on ground. There was a deep realisation that scale of outreach, sheer geographical vastness, inaccessible terrain, accompanied with multidimensional poverty force many a people into a vicious warp, which to make matters worse, somehow persists through generations.

In this chapter, a first hand account of a 7 weeks long stay in rural Sheopur, a district of India's second largest state by size and fifth largest by population, has been presented. This was the first field work conducted as a part of this thesis. The objectives were:

- meet people who live in areas where the problem of malnutrition persists;
- observe the conditions of AWCs

- interact with women, adolescent girls, and children to gauge their perception about *kuposhan*;[27]
- meet government officials to gain a sense of the lacunae;
- learn to collect primary data (anthropometric data) of children in the age group of 0-60 months; and
- identify themes that can be researched for proposing solutions.

Section 3.1 describes the sites chosen and the modus operandi of working with field coordinators, section 3.2 records the first-hand observations of eight different villages (including one urban set up), in section 3.3, I present a discussion on the realisation experienced with a focus on the lives of tribals along with references to academic insights, in sections 3.4 and 3.5, basic descriptive statistics of the data collected has been shown, and lastly, section 3.6 concludes this chapter with a discussion on finalising of the themes for further research.

3.1 Site for the field stay

I will give a brief outline of the geographical location, highlight facts from Census and health survey data, and give a few demographic details of the site chosen for the field work.

Sheopur is a district located in the north-west region of MP, bordering Rajasthan to the west, and was carved out of Morena district in 1998. We chose to primarily visit AWCs in 8 different villages (one semi-urban site included) to carry out the field work. All the sites we went to were charac-

[27] In Hindi, *kuposhan* means malnutrition, *ku* is bad and *poshan* is nutrition

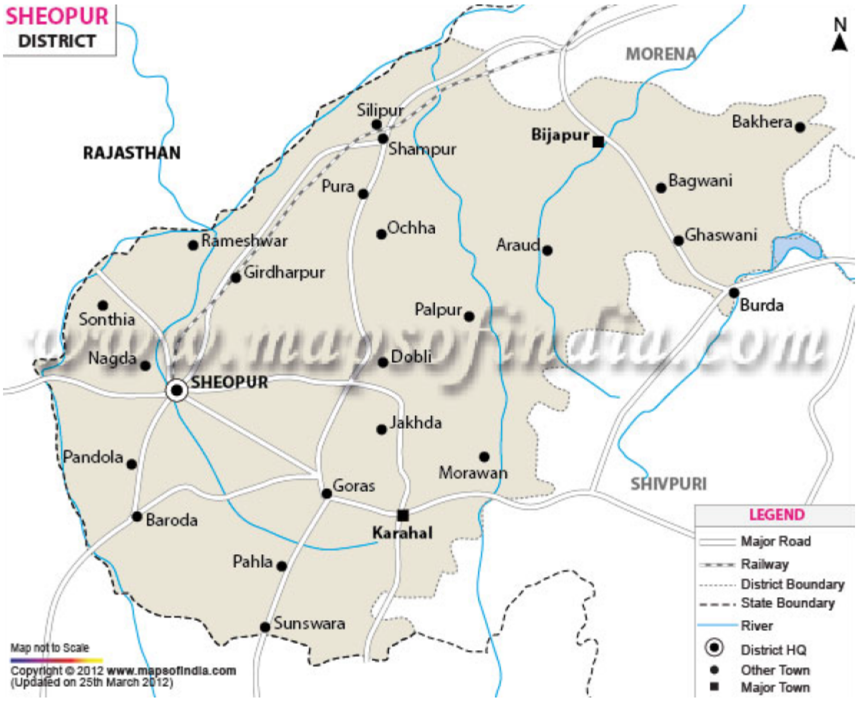

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Figure 3.1: Sheopur district map (Sourced from https://www.mapsofindia.com/maps/madhyapradesh/districts/sheopur.htm)

terised by lack of several social services like schooling and medical care and paucity of physical services like safe water, drainage, sanitation, electricity, and transportation.

Sheopur district has a total population of 17, 26, 050 and is divided into five *tehsils*,[28] viz.; Sheopur, Badoda, Vijaypur, Veerpur, and Karahal (Census, 2011). Among some key indicators of the district's status of children in rural areas are an Infant Mortality Rate (IMR)[29] of 75 per 1,000 live births and U5MR[30] of 105 per 1,000 live births (MHA, 2014). Out of the five *tehsils*, we chose Sheopur *tehsil* for our survey. Sheopur (henceforth, all data and observations will be w.r.t Sheopur *tehsil*), between the years 2000 and 2011, i.e., a decade, recorded a growth rate of 21.96 per cent. The *tehsil* had a much

[28]A *tehsil* is a sub-division within a district, consisting typically 200 to 600 villages.

[29]IMR is defined the number of deaths per 1,000 live births of children under one year of age. The rate for a given region is the number of children dying under one year of age, divided by the number of live births during the year, multiplied by 1,000

[30]U5MR is the probability (expressed as a rate per 1,000 live births of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates

lower IMR and U5MR than the district, at 10.5 and 7.5, respectively (Census, 2011). There were at that point 766 schools (government and private put together) and the total literacy rate was 51.9 per cent, while the female literacy rate was 40.91 per cent (Census, 2011).

The chief crops grown in the region were mustard, millets, and irrigation was canal dependent. People living in villages were largely dependent on wages, working either on farms of upper-caste *Zamindars*[31] or employed through employment guarantee schemes. A large number of families living in the peri-urban areas surrounding towns were also dependent on wooden handicraft.[32]

Given all the above, it was obvious that without the help of people who live there and speak the language of the rural people, we would not be able to make in-roads in getting a first hand account of the condition of the AWCs and collect primary data.

3.1.1 Liaising with field workers

In organising the whole effort, we coordinated with the NAANDI foundation.[33] In Sheopur, their work was spread across 3 out of the 6 ICDS projects in 2015. A total of 5 sectors constituted by 153 AWCs were covered by the foundation. In these 5 sectors, activities such as nutrition counselling, awareness campaigns of government schemes, training of AWWs, encouraging mothers to comply with Infant and Young Child Feeding (IYCF) guidelines, and growth monitoring of children were conducted. In the remaining 10 sec-

[31] *Zamindars* are land-lords. In Persian *Zamin* means earth and *dar* is holder.

[32] A lot of information provided in this section and those that follow have been recorded during interactions with residents of the *tehsil*. Most of it was noted down and sometimes also videotaped with a verbal consent of the people.

[33] NAANDI means a new beginning in Sanskrit. It is a social sector organisation operational across 16 states in India since 1998, currently serving a population of 5 million.

tors (~440 AWCs), NAANDI only collected data on growth status of children. The foundation had appointed male Field Coordinators (FCs) for conducting these activities. Most of them were residents of the same *tehsil*, while a few belonged to more developed parts of MP. Our daily routine included travelling with these FCs to various sites, interviewing people, and meeting with functionaries from different government offices. During all the visits, we avoided intimating AWWs or the village *sarpanch* in advance. None of the visits were intended to be surprise-checks, rather only diary and pen based friendly conversations.

3.1.2 Selecting the 8 villages

We surveyed 6 villages from the sectors where NAANDI conducted its sessions, 2 villages from NAANDI un-served sectors and visited a Community Health Centre (CHC) in a neighbouring *tehsil*. Apart from the AWCs in these 8 sites, we would also stop by schools, primary health centres, community health centres, and the district hospital to gain a sense of the daily proceedings of these establishments. The data was collected along with the designated FCs. Anthropometric measurements were taken for a total of 205 children, all of them in the 0-5 years age group.

3.2 Village level observations

Although just a few visits to a village are not sufficient to discern the prevalent socioeconomic or cultural norms, a fair assessment acquired through interviews has been presented in a matrix in Table 3.1. For the ease of comprehension, we divided the observations into three categories, namely; *An-*

ganwadi related, Village related, and Children related. A survey of the general characteristics of the village was conducted encompassing the following parameters:

- *Anganwadi* maintenance, availability of toilets and hygiene conditions;
- Village observations, such as connectivity, roads, electricity supply, water supply, presence of alcohol shops, livelihood options, drainage and types of houses; and
- Maternal health and menstrual hygiene.

We met the *Sahariya* , *Gond*, and *Banjara* tribes, the *Jats*, *Meenas* from Other Backward Castes (OBC) community, and *Bervas* from the Scheduled Caste (SC) community.[34] There were noticeable differences between all the villages, distinct inter-group disparities, and a mixed response to the perception about *kuposhan*. Most women were aware of the frequent illnesses their children succumbed to, however, were inadequately equipped to provide treatment or prevent the illness in the first place.

A few women told us that since wherever they looked everyone appeared 'equally frail' or 'equally short', there was no urgency to address the situation, while some girls (in their late adolescence) due to a little exposure by travelling to towns, noticed that their younger siblings were 'thinner' than the children they saw in schools elsewhere. The perception about *kuposhan* was largely associated to loss of appetite in children or an episode(s) of diarrhoea. On the necessity of EBF, majority of the women expressed their views about how discontented the older women become when AWWs or the ASHA encourage them to not feed jaggery water or cow's milk to babies before they

[34] For a fuller discussion on tribals and caste, see section 3.2.1 and 3.3.1.

are 6 months old. There were opposing views on this from women of higher caste, who categorically mentioned that during the second or third child's birth, listening to the AWW's advice on child care turned to be more helpful that resorting to practices of the olden times. These contradictory views exist within the same village, the same smaller part of a village, and sometimes in neighbouring houses.

Largely our encounters were remotely close to how the Indian village was envisaged by M K Gandhi (Gandhi, 1937), when he said,

> An ideal Indian village will be so constructed as to lend itself to perfect sanitation. It will have cottages with sufficient light and ventilation built of a material obtainable within a radius of five miles of it. The village lanes and streets will be free of all avoidable dust. It will have wells according to its needs and accessible to all. It will have houses of worship for all; also a common meeting place, a village common for grazing its cattle, a co-operative dairy, primary and secondary schools in which industrial education will be the central fact, and it will have *panchayats* for settling disputes. It will produce its own grains, vegetables and fruit, and its own *khadi*. This is roughly my idea of a model village.

Table 3.1: Observations matrix of villages in Sheopur *tehsil*.

Village name	Village related	*Anganwadi* related	Children related
Bandikheda	Stringent division as per caste, *Meenas* and *Bervas*, two separate regions within the village, *purdah**** system practised, *Bervas* sceptical about ORS, men highly involved in household work, no drains and open defecation only in SC area	AWW, ASHA and helper, all were present, AWC well maintained, growth charts used regularly, open dispoal of medical waste after check-ups and vaccination	Visit AWC, Poor personal hygiene, high diarrhoeal incidents, all adolescents attend school upto class 10, girls drop out earlier due to lack of company for travelling to school
Dadoni	*Meenas*, No open defecation, all pakka houses, high tobacco consumption, medium size land holding, cattle in each household visited	Located near primary school, well maintained, high hygiene standards, toilet outside, regular THR distribution, helper appointed in AWC Active centre	*Laadli Lakshmi Yojana** active, lesser children in each household, find THR very non-pallatable, high attendance for hot cooked meals and other activities
Hirapur (NAANDI un-served)	Border of MP and Rajasthan, *Banjara* tribe, unsure of entitlements, weighing being done first time in many years, confused about entitlements as some families are enrolled in schemes of Rajasthan government	AWC building empty, no THR distribution (mostly expired sacks lying), no activities at all	Very few children present on days of visit
Jaida	*Sahariya* tribe and *Bervas*, dependent on wells for water, 2-3 hours of electricity, toilets used as storage rooms, abysmal financial condition of all except 2-3 families, open defecation, serious hygiene concerns	AWC is functional, residents not interested in receiving information/benefits of any scheme, THR distributed occasionally, used as feed for goats	Children fed biscuits and other snack items only, adolescents do not attend schools, only *Berva* children go to private schools
Mau ka tapra	*Sahariya* tribe, open defecation, only daily wage labourers, land held by Sikh community, no menstrual hygiene, breast feeding limited to only first two months, NRLM** active	Only meant for THR distribution, good infrastructure	On an average 5 children in each household, first meal at 5 p.m., high incidence of death during child birth, vaccination drives unsuccessful
Radep	Scheduled caste, 7 months of water logging high incidence of drug peddling, medium land holding less cattle (sold because of water logging)	Shut due to space constraints and seepage, operational in the courtyard of AWW's house regular handwashing, Zn supplementation and ORS demonstration	Child marriage at 10-12 years diversity in diet improvise THR for suiting children's preferences
Sowbhagyapura	*Banjara* tribe, extreme interiors, not connected by road, seasonal migration lasting upto 7 months, open defecation, domestic violence, high consumption of country alcohol	Not active, no facilities, AWW lives 25 km away, THR used as cattle feed	Diseases treated through black magic, SABLA scheme unheard of
Urban (Maldweep) (NAANDI un-served)	Semi-urban location, open drainage, satisfactory financial condition, no family holds below BPL card	Deficient infrastructure, meals served daily, weighing regular	Visit only for food, 10 year olds also avail meal services, attend private schools

* *Laadli Lakhsmi Yojana* is a scheme introduced by the MP government intended to provide girls with national savings certificate.
**NRLM is the National Rural Livelihoods Mission, primarily a poverty alleviation project under the Ministry of Rural Development (MoRD) targeted to promote self-employment and organisation of the rural poor. www.nrlm.gov.in
*** *Purdah* refers to a 'curtain' in Persian. In the South Asian countries it is a practice in which women cover their faces when in public places or while speaking to men other than husbands/brothers/fathers/sons. In the cultural context, it has deeper roots as it socially excludes women.

3.2.1 Tribals in rural Madhya Pradesh

The tribals of MP constitute 21.1 per cent of the total population of the state. In all 46 Scheduled Tribe (ST) have been recognised, out of which *Bharia*, *Baiga*, and the *Sahariya* are "Special Primitive Tribal groups" (Census, 2011). We pre-dominantly came across the *Sahariya* tribe, who have historically lived along the MP-Rajasthan border, more so in Gwalior, Shivpuri, Morena (Sheopur included), and Bhind. This area forms a huge part of the notorious Chambal division. In last two generations or so, they have sparsely undertaken agriculture related activities, only to procure items that were not obtained from forests any more and to marginally support their livelihood needs. They were mostly occupants of the Kuno wildlife sanctuary. Among the most primitive tribal groups of MP, the *Sahariya* were only forest and hunting dependent (Debnath and Yadav, n.d.). Most *Sahariyas* faced mass displacement, are now caught in between two polar schools of thought. One that supports their integration into mainstream society and the other paternalistic phenomenon which exhibits deep-rooted ignorance to their lifestyle (Kabra, 2003).

On speaking with them, nearly each one resented the idea of visiting an AWCs or being vaccinated to protect their children from diseases. One lady condemned most governments' services, saying [35]

> ...they are always meant for a 'different' kind of people, those who can live in cities, not for us, we are meant to be living in forests!

Understandably, tribals are burdened with unemployment, marginal access to reliable health services, nearly no schooling, high rates of severe malnutrition, and frequent deaths of children. Mostly child deaths in areas in-

[35] transcribed to English with least possible error

habited by tribals lead to controversies whereby government departments have disowned responsibility of such deaths (Mishra, 2017).

3.3 Beginnings of a realisation

In so far, the experiences magnify the problems that rural and tribal Indians face in everyday life. In this section, I discuss the impressions it created while simultaneously grounding it to academic work. Particularly, it is necessary to theoretically associate various conjectures that are formed, for better policy framing.

Nobel laureate Robert W Fogel in his account *The Escape from Hunger and Premature Death* placed great emphasis on nutrition, not only from the historical perspective of health, but for understanding aspects of current health, wherein he talks of a period between 1700 to 2100. Deaton (2006) in his review of Fogel's work calls this 'escape from hunger and premature death' a 'great escape'. These massive changes have led to longer lives, taller children, and many more people being able to read and write than ever. It is not possible to miss these changes in demographic data.

Seen already in section 2.3, better early life means, better learning, better earning, and a better future for the upcoming generations. Along side this great escape there is also widening inequality, which was visible during our stay in rural Sheopur. A striking example of which was the access to basic sanitation and toilets. In table 3.2, for each village there is a remark on the situation of open defecation and hygiene. In their book, Coffey and Spears (2017b) call this 'an increasingly Indian problem'. Going by the estimates of Census (2011) 13 per cent of urban households do not have a latrine/toilet, vis-à-vis 70 per cent of the rural households. Although the focus here is not entirely on open defecation or access to toilets, there are common threads that connect the lives of these malnourished children and families. I will primarily answer the question 'who are these malnourished people ?' and elucidate the role governance plays in their everyday lives through my observations.

3.3.1 Who are these malnourished people?

Malnutrition or poor health status is not unique to rural India alone. What remains distinct about it are the channels through which generations remain marginalised and deprived of a basic set of 'capabilities'. Undoubtedly, links between levels of income, education attainment, and delivery of public health services to malnutrition are adequately reported, the social belonging of people adds to the factors aggravating nutritional inequalities (Sabharwal, 2011).

To answer the question, two notions are presented next. The first being: position on the 'class' ladder and the second being: woman's role.

3.3.1.1 Class ladder

Caste, was first used by the Portuguese to name the complex social mechanisms encountered by them when they first came to India (Mathew, 2011). Somehow, over the centuries this has now become a way in which Indians identify themselves. [36] In Sheopur, we witnessed how caste had intricately made its way into the preferences of diet, types of homes people built, the

[36] *Varna* system in the classical way of classifying based only on occupation. It comes from the Sanskrit term which means 'arrangement'. *Jati* or caste is distinct from this. The former was used to unify *jatis* into four groups: Shudra, Vaishya, Kshatriyas, Brahmins.

schemes they registered for, whether or not a girl went to school, and the probability of finding a malnourished child/children in their homes. Beyond caste, there are STs, a special group, at the bottom most position of the 'class' ladder. This hierarchy overarches much of the way benefits reach the STs and the human development emergency they face.

In studying the linkages between caste, religion, and malnutrition, Sabharwal (2011) found as per the NFHS-3 data that children from the SC/ST category are 1.4 times more likely to be malnourished than any other category on this ladder. In villages like Mau ka Tapra and Bandikheda which had a mixed population, within a matter of a few hundreds of metres contrasting situations emerged. SC/ST children stood in separate queues for receiving food distributed in AWCs and girls and women used taps on the edges of the villages for fetching water. The hamlets with SC/ST population defecated in the open, unaware of how it affects health, washed their hands the least, and on being educated about these practices would not be able to integrate it in their lives on a regular basis. On asking questions about why they could not, some reasons were:

- using a pit toilet meant they would have to empty it on their own (manual scavenging), which ostracises them
- their children would not then be allowed to sit inside AWCs because everyone would know what their parents did
- to escape social exclusion, they see remaining unhygienic as a better option

Inevitably, access to any sort of public health service diminishes when their position and status in the village is targetted. Stressing on faecal management is essential because germs spread, infections rise, people remain chronically ill, pregnant women live in unhealthy environments, and eventually children become shorter. Biological pathways of the human gut, diarrhoea episodes, and long-term transmission of poor health are attributable to widespread open defecation which leads to stunting. Percentage of population practising open defecation is higher in India compared to countries with lower GDP (shown in Figure 3.2), indicating the apathy of regional practices and caste discrimination. There are some fallacies Coffey and Spears (2017c) write about.[37] Other than the GDP per capita argument, in terms of access to improved water, adult literacy rates, and poverty rates, India's position continues to remain lower than nations with comparable or lower inputs of these social parameters. It has now been widely acknowledged that 90 per cent of countries poorer than India also record much lower prevalence of open defecation.

Two facts become clear here, first, the upper castes could afford constructing a flush toilet (only in some houses, this was observed), if they could not, open defecation was the norm because SC/ST families would not clean it for them. Secondly, the lower castes even if were subsidised for the construction of a latrine, did not use it. *Swachh Bharat Abhiyan* (SBA) constructed toilets were either fodder/ dung storage rooms in almost every hamlet of the villages studied during the field stay.[38]

Furthermore, other than surviving on meagre incomes and accessing

[37] Coffey and Spears (2017c) show three plots in their book, comparing India's open defecation rates to countries that have similar access to water, comparable literacy rates, and similar poverty rates (nation's living on less than 1.25 USD per day). In all the three plots open defecation prevalence is at the higher end.

[38] The SBA or Clean India Mission has construction of toilets to end open defecation as of its aims. Launched in 2014, this mission was ~6 months old at the time of this field study. Details of the mission are available on https://swachhbharat.mygov.in/.

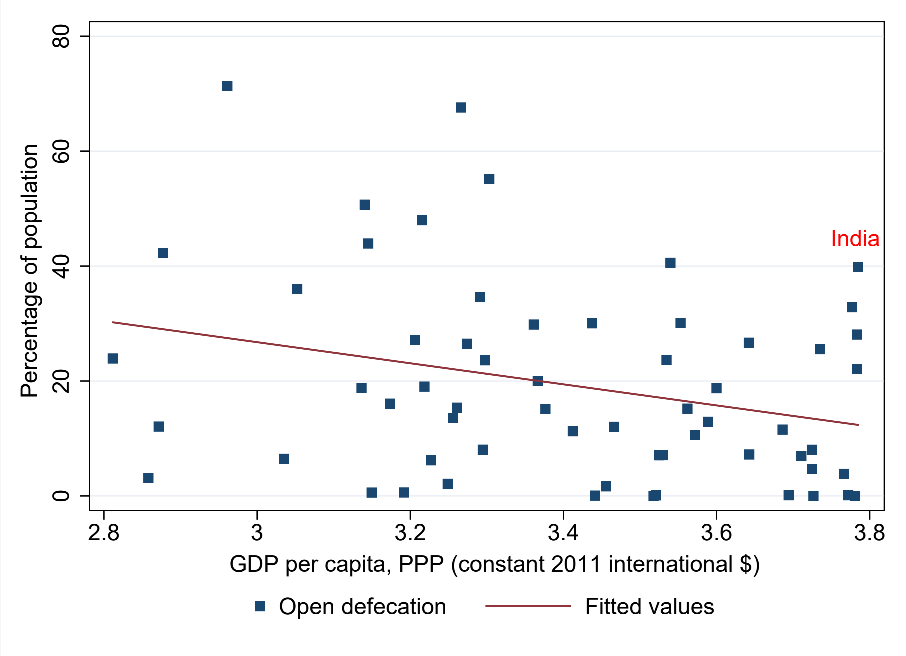


Figure 3.2: Open defecation in India is more than countries with lesser GDP per capita. Each square represents a country. Data sourced from https://data.worldbank.org/. Open defecation percentage values are as of 2016.

very limited nutritious food, the families on top of the ladder still find ways to sustain, while the bottom ones additionally face social exclusion. Acharya (2010) showed how lower utilisation of critical health services stemmed from discrimination. Thorat and Lee (2010) and Sahas (2009) report in two separate studies focussing on SC/ST population that all government food security programmes such as mid-day meal schemes turn ineffective due to discrimination, adversely affecting food intake and consequentially, nutritional status of children.

Therefore, in answer to ‘who are these malnourished people?’, the first proposition is about lack of social belonging and being burdened under structured hierarchical deprivation.

3.3.1.2 Woman's role

The second notion: role of woman is elaborated next. Women's nutritional status, as studied in the "Baker's hypothesis", also called the "womb with a view" hypothesis, is about events within the womb affecting health throughout life (Barker, 1994) and (Deaton, 2006). To put it in simple words, *in utero* conditions which curb complete development, cause a selective abandonment of function, such that evolution disfavours those features which were primarily meant to prevent disease later in life (Deaton, 2006).

We do not have data for women's health in this study but it was quite visible that most of them were too thin, short, faced domestic violence, were illiterate, and caught in a 'decision trap'. This decision trap refers to being fully aware about ICDS services' purpose, but being unable to access them. Moreover, if they had a SAM child, mothers were not allowed to spend 14 days at a Nutrition Rehabilitation Centre (NRC) with the child. A cash incentive is provided by the government in MP to compensate for the loss of labour hours and wages. Even then, husbands, older women, and men prevent mothers from attending to the child as it compromises her availability for household work. In this regard, illiterate mothers are twice more likely to have malnourished children than those who complete secondary or higher education. Also, Hindu women are 1.5 times more likely to be malnourished than rest of the religious categories (Sabharwal, 2011).

Briefly, all the literature regarding women's role in human capital formation directs to the significance of women's social status in a household, a neighbourhood, and a society. Sheopur showed us how imbalance within the household in decision making powers has given rise to an array of instruments for intergenerational malnutrition.

3.3.2 Governance failure in everyday life

In this section I discuss how governance failure over and above exclusion due to attitude towards caste and women's agency is a major concern. Government-civil society partnership through social audits and community led movements can present enormous possibilities in bridging the malnutrition gap (Swain and Sen, 2009). The role of governance at the village level reinforces the receipt of several tangible and intangible services. Upon failure and less accountability at the government's part, malnourished families have few avenues to access food, healthcare, and livelihood options. As noted by World Bank (2006),

> Malnutrition is usually invisible to malnourished families and communities. Families and governments do not recognise the human and economic costs of malnutrition... The malnourished have little voice.

In the previous sections we have looked at how amenities like toilets are amiss, discrimination afflicted by caste in accessing food security programs are curtailing nutrition, and that women have very little say in such matters. In addition, families living in villages of Sheopur are handicapped when inventory management of de-worming tablets is absent, frequent stock out of THR is common, procurement of raw material for cooking is delayed due to tendering issues, and commitment from the Child Development Project Officer (CDPO) is unsatisfactory. To this effect, we met with the District Medical Officer (DMO) to gain insights on some reasons behind these gaps. It became clear that location of the AWCs (barring a few villages) was not based on proximity or ease of access, but on political patronage. This disconnect between high-level policy gains and ground level realities has been discussed at length by Nisbett *et al.* (2014). We return to this discussion towards the end of this thesis in section 7.4.

Briefly, interviews with families that have remained undernourished for at least a couple of generations, crystallise the inter-play of underlying, immediate, and basic causes of malnutrition (UNICEF, 1990).

3.4 Primary data collection

To validate the extent to which the fallouts discussed above translate into poor nutritional status of children, we measured the length/height, weight, and MUAC of children who were present in the villages on the days of our visit.[39] Height was measured using a stature meter (least count 1mm), weight was measured using a digital scale, MUAC was measured using the standard WHO MUAC tapes (red, yellow, and green markings) and age was recorded using the ICDS register maintained at each AWC.

A challenge in measuring height in a rural set up is not being able to find a flat surface. In Jaida, Radep and Sowbhagyapura, the AWCs had mud-flooring, which is inevitably not even. To overcome this problem, we placed concrete slabs and made children (more than 2 years of age) to stand on them such that error in measurement was attenuated. Each value was recorded twice by the same person is all the 8 AWCs.

Age was not recorded for 12 children as their dates of birth were missing from the registers. We attempted to ask the mothers, however, failed in getting consistent responses. For analysis purpose we use data of 192 children

[39]As NAANDI FCs were present with us, we requested them to seek consent from mothers/guardians of the children to allow us to take measurements

for constructing measures based on weight and age. We also exclude data of infants (0-6 months), to construct the measure based on height and weight. In all, there were 23 infants for whom we could not measure the recumbent length and MUAC.[40] That left us with 169 observations for the HAZ and WHZ measures.

Data was recorded manually and then entered (to be doubly sure, we entered it twice) into a computer. We used the ENA Software made available by WHO for the calculation of z-scores and further analysis.[41]

3.5 Descriptive statistics

In the discussions in section 3.3, a multitude of factors that demote and promote child health status proffered every reason for us to expect a trend—but will it show in the data? This section shall provide insights that help us fit some pieces of the puzzle. We substantiate our encounters using anthropometry data. Table 3.2 shows the number of boys and girls on-roll and the number measured. Clearly, the coverage was quite low, except in Bandikheda and Mau ka tapra, where ~66 per cent of the children were present in the village. Almost all the AWCs had an equal number of boys and girls enrolled. In our sample too, a fair gender distribution was obtained. A look at the bar chart in Figure 3.3 corresponds to the village wise observations recorded earlier. Although coverage rates are not consistent and sample size in Hirapur is below par, a trend still emerges.

[40] Most babies cried when we tried to measure the length or MUAC. This is a problem in most rural areas, as there is a lack of infantometers in AWCs and children do not cooperate when the MUAC tape is measured. Most of them feel as if an injection is being used and refuse to fold the arm.

[41] ENA for SMART has been developed by Dr. Juergen Erhadt in collaboration with Prof. Michael Golden, Dr. John Seaman, and Dr. Oleg Bilukha, August 2014. SMART stands for Standardized Monitoring and Assessment of Relief and Transitions

Table 3.2: AWC wise number of children measured during the survey in Sheopur *tehsil*, 2015.

AWC	On roll			Part of study*			% covered
	Boys	Girls	Total	Boys	Girls	Total	
Bandhikheda	35	27	62	22	19	41	66.13
Dadoni A	30	25	55	14	14	28	50.91
Hirapur**	NA	NA	NA	4	5	9	NA
Jaida A	41	39	80	14	13	27	33.75
Mau ka tapra	32	36	68	18	27	45	66.18
Radep C	25	20	45	6	6	12	26.67
Sowbhagyapura	62	40	102	17	14	31	30.39
Urban (Maldweep)	94	79	173	4	8	12	6.94
Total		585			205		

* Children who were present on the days of the visit were measured.
** We could not find out the number of children enrolled in Hirapur as the records were not maintained at the AWC.

Dadoni and Radep are two contrasting scenarios. In our sample, both these centres have the lowest relative prevalence of all three growth failure conditions. In both these places, stunting was close to 30 per cent. On one hand Dadoni had a close to perfectly functioning AWC and on the other Radep's AWC was shut down due to water-logging. Nonetheless, Radep's children still fair well. We make this comparison to allude to the notable role of an AWW in monitoring and management of a centre. In Radep's case AWC activities were still being conducted (only in a courtyard), relevant demonstrations of ORS use and Zn were held, and all other ICDS based services were being provided. We do not make any causal claims here, instead draw on the eminence of how much nutritional outcomes in villages are dependent on the AWW.

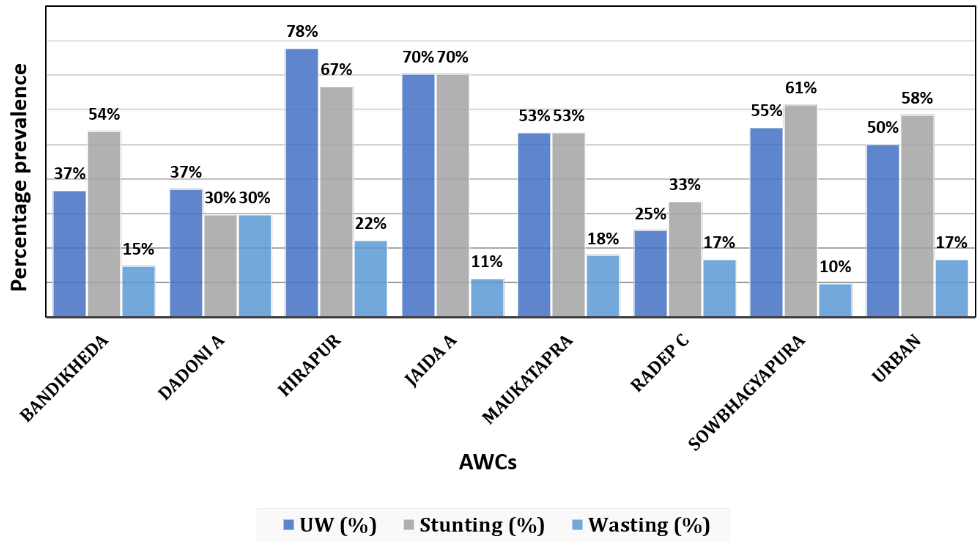


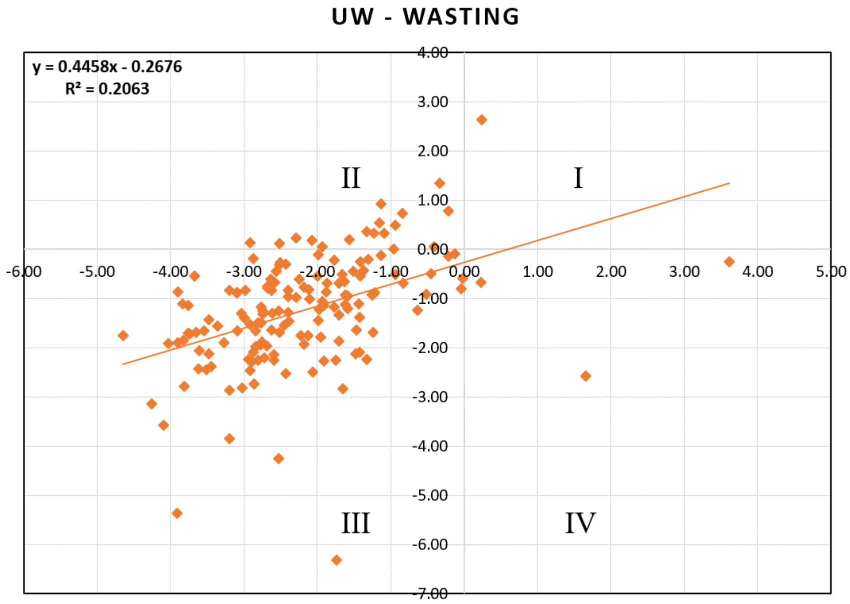
Figure 3.3: Prevalence of UW, stunting, and wasting in children (0-60 months) from 8 AWCs of Sheopur *tehsil* in 2015. Only WHO growth standard definitions have been used for classification into UW, Stunting, and Wasting.

Table 3.3: Prevalence of underweight in children (0-60 months) in 8 villages of Sheopur *tehsil*, 2015.

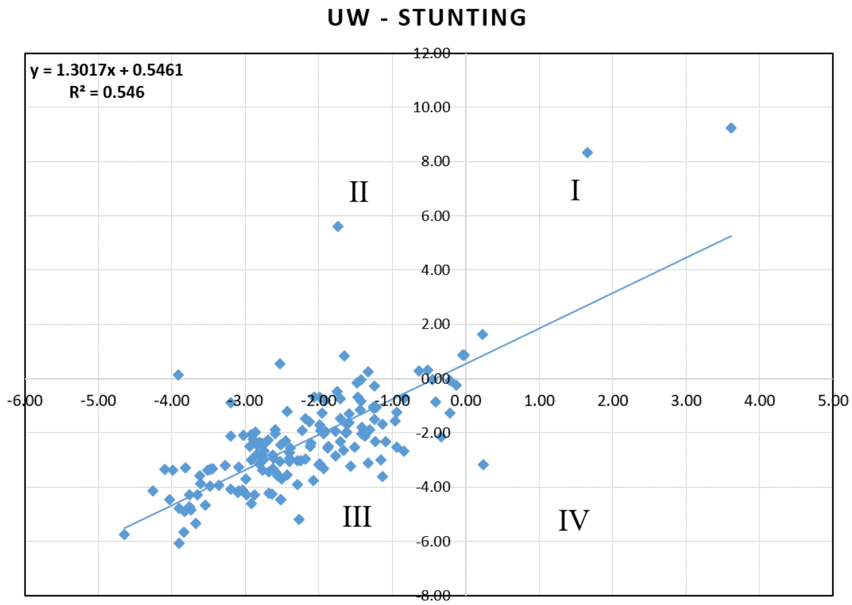
Prevalence	All n*=192	Boys n=95	Girls n=97	p-val By gender
Underweight (<-2 z-score)	51.6% (44.5-58.5)**	50.5% (40.6-60.4)	52.6% (42.7-62.2)	0.92
Moderate underweight (<-2 z-score and >=-3 z-score)	33.3% (27.0-40.3)	28.4% (20.3-38.2)	38.1% (29.1-48.1)	0.20
Severe underweight (<-3 z-score)	18.2% (13.4-24.1)	22.1% (14.9-31.4)	14.4% (8.8-22.8)	0.10

p-values reported are for a two sample t-test
* n stands for number of observations
** Values in parenthesis is the 95 per cent confidence interval

Further, table 3.3 shows the prevalence of UW in all 192 children (these include infants too). 52.6 per cent girls were UW compared to 50.5 per cent of boys. Severe UW prevalence was higher among boys at 22.1 per cent, about 8 percentage points higher than girls. A reason why values are so high is because many children suffer from multiple growth failure conditions. However, none of the difference in prevalence rates between boys and girls attained statistical significance (see last column in table 3.3). We explore the level of correlation between these three conditions as shown in figure 3.4. The slopes of the two lines; relationship between UW and wasting in figure 3.4a and relationship between UW and stunting in figure 3.4b, vary substantially. The gradient between UW and wasting is less steep, i.e., an increase in weight will reduce wasting levels, which is not so in the case of stunting. Almost all children lie in the third quadrant, clearly indicating the severity of their condition.



(a) **Correlation between UW and wasting**



(b) **Correlation between UW and stunting**

Figure 3.4: Correlation between UW, wasting and stunting in children (0-60 months) in Sheopur *tehsil*, 2015. In figure 3.4a the Y- axis is z-score for wasting and in figure 3.4b, the Y-axis is z-score for stunting. In both figures, 3.4a and 3.4b, the X-axis is z-score for UW.

3.6 Formalising the challenges towards choosing themes

In all, this first hand account contributed largely towards formalising the three core ways of connecting malnutrition and human development. Thematic areas introduced in section 1.5.2 were an outcome of this village stay in Sheopur. Interactions with people living in remote areas provide insights to address key challenges and conduct relevant data analysis. Underlying social constraints such as discrimination due to caste and status of women assisted in identifying crucial patterns that data analyses reveals, as explained in subsequent chapters.

First, chapter 4 investigates the association between income and child health. The transmission channels, variables for household controls, and the basis for all sub-group analyses relate to the observations in Sheopur, apart from drawing from literature.

Secondly, as several abatement initiatives provide supplements in the form of rations (see table 2.1) which in most of our interactions were not well received by children and mothers, a Cluster Randomised Trial (CRT) study was conducted using alternative food formulations. This was a community based approach to assist AWWs and mothers in integrating nutrition promoting activities in their daily lives.

Lastly, an alternative HDI has been presented in chapter 6, whereby distributional differences owing to heterogeneity have been highlighted amongst states of India. Inequality decompositions and sub-group analyses based on demographic characteristics, such as gender of household head and education accomplishment has been conducted.

Each chapter has been supported with research literature relevant to the main areas of focus, respectively.

Chapter 4

Impact of change in household income on child health

~ A comprehensive analysis for the Indian case

4.1 Introduction

This chapter focusses on the first theme, relationship between household income and child health, as outlined in section 1.5.2. It is the first econometric study conducted in this thesis.

The growing body of literature focussing on the relationship between household income and child health provides evidence mostly from developed countries. Most of these studies find a significant positive effect of income on child health, potentially leading to improved health outcomes in adulthood (Alderman, 2006).

The seminal Grossman model (Grossman, 2000) provides the theoretical mechanism linking child health and parental income. The basic premise of the model is that, individuals inherit an initial stock of health that depreciates with age and can be increased by an investment. The primary focus of previous studies has been to test for the presence of income-health gradient and then subsequently test if this relationship varies among children in different age groups. However, to the best of our knowledge, there are no studies focussing on the variation of gradient across income distribution that has the potential of predicting effect of "household income shocks" on child health. Our study helps fill this gap in the literature. Specifically i) we test for the child health and income gradient; ii) establish the mechanisms that underlie this relationship and undertake sub-group analysis; iii) explore the gradient further by allowing it to vary across income distribution using spline functions; and iv) for policy purposes simulate the effect of increase in income on child health, specifically reduction in stunting.

Undernutrition in the first thousand days after conception is known to have irreversible effect on adult life as it curbs attaining maximum human potential (Adair *et al.*, 2013). It is in these early days of life that the body prepares for brain development, which in turn is crucial for better learning, higher adult income, and increased off-spring birth weight. Stunting among children is a critical policy issue in India. A child is considered to be stunted if his/her height-for-age Z - score (HAZ) is below -2 standard deviations from median height for age of reference population (de Onis *et al.*, 2006). According to the UNICEF report (UNICEF, 2012) on child nutrition status, in 2005-2006, 48 per cent of children under age 5 in India were "stunted", while according to National Family Health Survey conducted in 2015-2016 NFHS 4 (2017), 38.4per cent were stunted. These undernourished children have an increased risk of mortality, illness and chronic conditions, late development, cognitive deficiency, low academic achievement and meagre labour market productivity in later life (Currie, 2009). Globally, undernutrition underlies 45 per cent of all child deaths among children below age of 5 (Black *et al.*, 2013).

Our study aims to contribute to the literature, by investigating the effect of household income on the health of children (prevalence of stunting) up to 5 years of age. We use data from IHDS-II for year 2011-2012 for our empirical analysis. Methodologically our empirical analysis goes beyond establishing a gradient, and uses a linear and cubic splines based regression technique to emphasise on the need to concentrate on households belonging to different income levels in order to capture significant income inequality in India. We use splines to answer the question - do households belonging to different income levels necessarily respond to an increase in income in a similar manner? An econometric technique such as this, enables us to advocate for the income groups that need most attention and will benefit from a well structured government policy catering to their needs. As restricted cubic splines are linear in the coefficients estimated, it is easy to implement and interpret. Thus far, most studies have focussed on the attributes of the gradient in the context of its variation over children's age and carried out parametric estimations under a linearity assumption. Our analysis goes a step further by analysing the effect of breaks in the income distribution on the gradient, without assuming a linear relationship.

Further, contrary to the other studies in the child health and income gradient discourse, which use self-reported measures of health, we use an objective measure, height-for-age Z - score (HAZ, henceforth) based on the measurement of height by a nurse, as our main dependent variable. This is an improvement over self reported measures that potentially suffer from reporting bias, can be misleading and may have limitations as people perceive health differently depending upon their socioeconomic status (Subramanian *et al.*, 2009).

One important aspect of our empirical analysis is analysis of the various channels that can influence child health through income. Since a gradient exists even in countries with universal health care and financing services (e.g. the UK, Canada, USA) the consensus is that, many country specific mechanisms underlie the relationship between household income and child health. We also conduct a body of sub-group analysis to delineate the differences in the gradient depending upon gender, caste status and area of residence.

We further undertake sensitivity analysis to conduct several robustness checks by taking different proxies to capture household income and child health. We include consumption expenditure and assets based index as proxies for income. We also look at the response to an income rise if the households are above or below the poverty line. We also include two alternative measures of child health - the weight-for-length/height Z score (WHZ) as a measure of acute malnutrition and the Composite Index for Anthropometric Failure (CIAF) to capture the overall extent of poor child health.

The remainder of this chapter is organised as follows. We begin by reviewing previous studies and highlight the originality of our method in Section 4.2. Section 4.3 presents the econometric model in detail and strategy for spline regression. Section 4.4 describes the IHDS-II data and choice of variables. Section 4.5 describes the transmission channels, sections 4.6, and 4.7 give a sense of the sample characteristics. Section 4.8 presents the results from regressions, sub-group analysis, spline estimation, sensitive checks and reduction in stunting by simulation of rise in income. Section 4.9 discusses the implications of our findings and concludes.

4.2 Linking child health and income

We begin by discussing the literature focussing on the five main aspects relevant to the context of this study. These are: i) association between child health and income emerging from other countries; ii) the status of child health in India; iii) the need to cater to heterogeneity in response to rise in income and iv) the advantages of choosing HAZ as an appropriate measure and v) the potential transmission channels that can explain the income effect in the Indian context.

4.2.1 Evidence from developed countries

One of the first studies on this topic by Case *et al.* (2002) used cross sectional survey data from USA and established that, general health is positively associated to family income and the relationship becomes more profound as children grow older. Currie and Stabile (2003) found almost similar results for Canada with the slope of the gradient being larger for older children than younger children. Subsequently later studies explored the gradient further and found that effective timing of interventions is pivotal in sustaining child health over the long run and positive significant association is influenced by the onset of chronic conditions and their long lasting impact (Condliffe and Link, 2008). Propper *et al.* (2007) further argue that there are additional factors other than income that explain the increase in gradient for older children and found that once these controls are used there is no increase in gradient from birth to age 7 for English children a finding confirmed by Apouey and Geoffard (2013) who find the emergence of a gradient only after age 2, which then remains consistent till age 17. The results also vary by different settings. For example, using the Longitudinal Survey of Australian Children, Khanam *et al.* (2009) found that on controlling for variables addressing the endogeneity of income, the gradient disappears. Fletcher and Wolfe (2014) find that the income gradient of health steepens as children age, regardless of the exact measure of family income used.

A major caveat in most studies is the inability to find a causal implication due to endogeneity of income. Most studies prefer to not control for endogeneity mainly due to lack of data and consensus on "appropriate instrument"for income (Carrieri and Jones, 2017). Few exceptions include a study by Kuehnle (2014) that uses data for local unemployment rates in the UK as an instrument for income and find a very small but significant causal effect on subjective health, but no effect on chronic conditions.

Most studies broadly conclude that socioeconomic status of the household impacts child health. These authors have argued that the impact of family income on child health can be driven by either a greater vulnerability of children from poorer families to health shocks or the inability of these children to cope with a severe shock, resulting in a higher gradient at older ages.

A major caveat in most studies is the inability to find a causal implication due to endogeneity of income. Most studies prefer to not control for endogeneity mainly due to lack of data and consensus on "appropriate instrument"for income (Carrieri and Jones, 2017). Income is considered endogenous because it is possible that reverse causality can confound the effect of household income on child health. For instance, a child in poor health may reduce labour supply hours and decisions (participation, wages earned, hours worked etc.) of parents, thereby reducing the income of the household. On the other hand, excessive labour hours may increase income but reduce time spent for child care, thereby resulting in poor child health. Only a few exceptions such as study by Kuehnle (2014) use data for local unemployment rates in the UK as an instrument for income, succeed in establishing a very small but significant causal effect on subjective health, but no effect on chronic conditions. The study presented in this chapter is not a causal analysis, however, it presents a statistical association.

Notably, mixed results have appeared over time as this growing body of literature has evolved, indicative of the differences in hypotheses and assumptions made to study this crucial relationship.

4.2.2 Child health status in India

Measured by degree of stunting, Brennan *et al.* (2004) reported that close to half of India's children suffer from chronic malnutrition and about a quarter from severe chronic malnutrition. Tarozzi and Mahajan (2007) found that in the nineties, while poverty reduced considerably, short term measures of child health showed improvement but mostly only in urban areas. Similarly Pathak and Singh (2011) used concentration indices to find that between 1992 and 2006 very sluggish improvement was noticed in child malnutrition, accompanied by corresponding rise in economic inequalities. They further conduct a decomposition analysis and find that inequality in wealth distribution and in maternal education were two largest contributors to disparities in child health (Chalasani, 2012). The recently released Global Nutrition report brought forth positive trends and showed that nearly all Indian states reported a decline in stunting rates between 2006 and 2014 (Haddad *et al.*, 2015).

4.2.3 Heterogeneity in association between child health and income

Alderman (2012) suggests that, development priorities in India need to be guided by understanding how much monetary transfer is necessary to see a meaningful change in health seeking behaviour. In the Indian context, data from the three different cross sectional waves of the National Family Health Survey (NFHS) indicate stark inter-state and inter-regional disparities in infant and under five mortality in India, owing mostly to vast diversity in consumption behaviour and socioeconomic differences among states. According to Deaton and Drèze (2009) prevalence of malnutrition in India remains higher than Sub-Saharan nations even though the latter have grown economically at a much slower rate than India and record higher levels of child and infant mortality. The income based heterogeneity in association between child health and income can potentially change the nature of response to change in income. For example, in Indian context Subramanyam *et al.* (2011) argue that no assuring evidence was available to suggest that economic growth leads to reduction in child undernutrition in India. They recommend that direct investments in health interventions may be necessary to reduce child undernutrition in the country. In order to accommodate such possibility and heterogeneity in response, our empirical methodology uses transformed spline functions (linear and cubic) which allow us to analyse the effect of the variation in the income distribution on child health. A possibility of non linear relationship between income and health has been discussed in the literature. For example Goode *et al.* (2014) used the unconditional quantile regression technique, to find possible explanation to the heterogeneous income gradients at different parts of the health distribution. Similarly Carrieri and Jones (2017) bring forth new evidence about non-linear relationship between income and biomarkers, by decomposing income related health inequalities. Above studies focus on varying health distribution whereas our approach focusses on varying income distribution specifically breaking down the income distribution into intervals and estimating the increase in child height corresponding to each interval.

It has been advocated that regular monitoring of inequalities, promoting awareness, and better decision making are urgently needed for improving child health (Victora *et al.*, 2003). Also, **?** describes the impact female literacy may have on improving child health status along with fiscal spending. Thus, it is imperative to explore if a rise in income can serve well as a preventive and curative intervention to improve child health.

4.2.4 HAZ as a measure of child health

HAZ captures stunting, which reflects a process of failure to attain potential linear growth as a result of poor suboptimal health and/or nutritional conditions. In terms of studying a population, high levels of stunting reflect poor socioeconomic conditions and greater risks of exposure to adverse conditions such as illness, frequent infections, improper calorie intake (often associated with inappropriate feeding practices) and/or low socioeconomic status (WHO, 2016). In order to mitigate the subjectivity associated with measurement of child health, we posit that, HAZ serves as an effective indicator for child health and contributes to a consistent estimation of stunting rates.

According to Deaton and Arora (2009) taller people benefit more from life, attain better overall health and earn more. Stunting, a function of height and age, hinders developmental potential and human capital of entire societies due to its long lasting impact on cognitive functioning and adult economic productivity; it is therefore well accepted as the best marker for child health inequality. After many years of neglect, stunting has been now identified as a major global health priority, with the World Health Assembly aiming to reduce stunting by 40 per cent between 2010 and 2025 (Onis *et al.*, 2013).

Further, stunted children are categorised depending upon comparison with a reference population, thus the standards do not specifically raise the matter of short stature as an area of major concern. Instead, it is a phenomenon referred to as "stunting syndrome" in the context of developing countries. It is defined as a series of multiple pathological changes marked by linear growth retardation which increase morbidity and mortality. The repercussions of which are largely seen as reduced physical, neuro-developmental and economic capacity (Prendergast and Humphrey, 2014).

Stunting is seen as a cyclical process because women who were themselves stunted in their childhood tend to have stunted offspring, creating an inter-generational cycle of reduced growth leading to poverty and poor human capital that is often difficult to break, although a few windows of opportunity have been identified. As observed by Prentice *et al.* (2013), interventions outside the first thousand days of life should not be ignored or overlooked. These windows also present opportunities for bringing about substantial changes to these intergenerational effects. Coffey *et al.* (2013) point out that widespread growth faltering can result in a human development disaster. Therefore, capturing the impact of improved HAZ and thereby reduced stunting in children, can prove to be extremely beneficial in improving general health of individuals.

4.2.5 Identifying the income effect

Related studies in the literature use a wide range of explanatory variables (in addition to income) in order to establish a robust health income gradient. For example, Case *et al.* (2002) show that better health at birth, medical insurance and genetics could not explain the relationship of health and income in their sample and concluded that further inspection is called for in this direction. Similarly Currie *et al.* (2007) used data from the Health Survey for England to examine the effect of child nutrition and family lifestyle on choices of child health. Propper *et al.* (2007) find that maternal health and parental behaviour influence child health, and that the relationship between child health and income diminishes when controls for parental health were added to their models. However, Dowd (2007) found no such underlying mechanism for the child health-income relationship.

Khanam *et al.* (2009), Goode *et al.* (2014), and Kuehnle (2014) use parental behaviour, mental health, exposure to media, housing quality, nutrition (for example, measured by consumption of fruits, vegetables etc.), medical insurance, sanitation and access to water as possible channels of transmission. Additionally, country level analysis of 116 countries (including India) categorised into regions draws attention to the role underlying determinants like, access to safe drinking water and sanitation have played in reducing stunting over 40 years (Smith and Haddad, 2015). Our model specification also uses additional covariates based on suggestions in the literature and subject to data availability to estimate the health income gradient.

4.3 Analytic framework

We specify a linear model that estimates the association between child health and household income as follows:

$$H_i = \alpha_o + \alpha_i Y_i + \beta_s X_i^s + \epsilon_i \tag{4.1}$$

where we first estimate the association (α_i) between child health (H) and household income (Y) of child i. We also account for additional covariates (X_i^s) through multiple model specifications. Specification (i) includes household characteristics similar to those used by Currie *et al.* (2007) and Cameron and Williams (2009). These are child age, gender (whether male), household size, residence type (urban/rural), caste, religion, and area (district combined with primary sampling unit) level fixed effects.[42]

In addition to covariates used in specification (i), specification (ii) also includes parental age, education and employment status as additional covariates. We hypothesise that as discussed in the literature part of health income relationship might be explained by these variables and thus ignoring them might potentially overestimate the gradient. For example, it is established that better earning, well educated and healthier individuals are

[42]The Indian Human Development Survey has sampled households from rural and urban areas. Each household is classified into a primary sampling unit (PSU) which helps in identifying the cluster for statistical analysis. Each PSU is a cluster of villages that form part of a district within a state. We combine the unique identifier for each district with the unique identifier for each PSU. This gives a unique district-PSU identifier to account for heterogeneity.

likely to nurture their children better and provide higher quality medical care (Davis-Kean, 2005). Specifically we use mother's age, father's age, mother's employment, father's employment, mother's education, and father's education denoted by the vector (X_i^p) in equation below:

$$H_i = \alpha_o + \alpha i Y_i + \beta_s X_i^s + \beta_p X_i^p + \epsilon_i \tag{4.2}$$

We refer to the model in Eq.(4.2) as Specification (ii). In both Eq.(4.1) and Eq.(4.2), β_s, β_p are vectors of parameters to be estimated respectively and ϵ_i is a random error.

Specification (iii) includes proxy variables capturing various transmission channels (TC) through which household income could potentially affect child health. These channels have been selected following literature about the potential determinants of child health. These are discussed in detail in section **??**. The equations we estimate are as follows:

$$H_i = \alpha_o + \alpha_i Y_i + \beta_s X_i^s + \beta_p X_i^p + \beta_k TC_{ik} + \epsilon_i \tag{4.3}$$

$$H_i = \alpha_o + \alpha_i Y_i + \beta_s X_i^s + \beta_p X_i^p + \sum_{k=1}^{K} \beta_k TC_{ik} + \epsilon_i \tag{4.4}$$

where, every group k of TC is denoted by a vector TC_{ik} and is added separately to Specification (ii) as shown in Eq.(4.3). These groups of k comprise maternal health, housing quality, sanitation, non-infectious environment, media exposure to women, and safe neighbourhood. This method allows us to disintegrate the income effect as mediated by each group of TC. Finally, we add all TC variables simultaneously, to examine the change in association between child health and income. We refer to this extended model in Eq.(4.4) as Specification (iii).

4.3.1 Spline regression

The main objective of our empirical analysis is to examine the differential effect of income on child health. In a scenario where this effect varies over income distribution, a standard analysis assuming a linear relationship and reporting the income effect at sample mean may be potentially misleading. Hence we use a spline regression framework that allows us to estimate the effect along the income distribution without requiring any strong restrictions on underlying relationship (non-parametric analysis).

A spline is a numeric function that is piecewise defined by polynomial functions and displays a very high degree of smoothness at points where the polynomials connect (called "knots") (Schumaker, 2007). It allows us to introduce smoothness to the income-health distribution while manipulating the points at which knots are introduced. By employing a non parametric method, we make no assumption about the underlying relationship between the dependent and independent variables. Data drives the functional form of "basis functions"entirely determined from the regression data. We use both linear and a cubic (non-linear) expansion for approximating the relationship between child health and household income.

Linear splines

We first divide the entire sample into quintiles (20^{th}, 40^{th}, 60^{th} and 80^{th} percentile) of our main explanatory variable, log per capita income. This gives us five linear "basis functions" and results in the income distribution being segmented at the following positions; viz. 8.64 equal to 5,685.35 INR or 106.53 USD (at 1 USD=53.37 INR in the year 2011-2012), 9.12 (176.2 USD), 9.52 (176.12 USD) and 10.04 (435.16 USD). We run a regression using all controls of Specification (ii) that uses all household characteristics discussed above, all parental characteristics and area level fixed effects.[43]:

$$H_i = \alpha_o + f(Y_i) + \beta_s X_i^s + \beta_p X_i^p + \epsilon_i \tag{4.5}$$

Variables V_i, $i = 1,...5$ are created, k_i, $i = 1,...,4$, are the corresponding knots; and Y is the original variable. V_1 to V_5 is given by

$$V_1 = min(Y, k_1)$$

$$V_i = max\{min(Y, k_i), k_{i-1}\} - k_{i-1} \quad i = 2,...n-1$$

$$V_n = max(Y, k_{n-1} - k_{n-1})$$

We include all control variables in Specification (ii) in this model. Coefficients on V_1 to V_n are the marginal effects $\frac{d(H_i)}{d(Y_i)}$ for each income interval.

Cubic splines

We further choose polynomials of degree 3 to generate restricted cubic splines of the income variable. The key issue in estimating normal cubic splines is the inability to deal with extreme values of the main explanatory variable (Y). We therefore force linearity at the outer most upper and lower values of Y to generate restricted cubic splines. A data driven process places knots at these five values of log income (in INR); 7.84, 8.84, 9.33, 9.81 and 10.86. We control for all variables as in Specification (ii). Let k_i, $i = 1,...5$, be the knot values; once again V_i, $i = 1,...n-1$, be the variables to be created; and Y (income in this case) be the original variable. Then

[43]We include district and primary sample unit fixed effects in all estimations to control for heterogeneity.

$$V_1 = Y$$

$$V_{i+1} = \frac{(Y-k_i)_+^3 - (k_n - k_{n-1})^{-1}\{(Y-k_{n-1})_+^3 (k_{n-1}-k_i) - (Y-k_n)_+^3 (k_{n-1}-k_i)\}}{(k_{n-1}-k_1)^2} \quad \text{for } i = 1, \ldots n-2$$

Further, after estimating a model that used restricted cubic spline of income as an explanatory variable we substitute the mean values of all other variables to predict the values of HAZ and represent them graphically for all ages.

4.4 Data source

IHDS-II conducted in 2011-12, is a nationally representative, multi-topic survey of 42,152 households in 384 districts, 1,503 villages and 971 urban areas all over India. Two one hour face to face interviews consisting of questions related to health, education, employment, economic status, marriage, fertility, gender relations and social capital provide diverse information for analysis (Desai and Vanneman, 2015b). This data set assembled three separate data sets, namely; individual, household, and eligible women. The survey spread over January 2011 to March 2013. The data collection methodology included a re-interview of households of IHDS-I with a response rate of 85 per cent. In case the households had divided, all split households were re-interviewed if located in the same village/neighbourhood. In case of urban areas, it was difficult to contact some old households, therefore, new households were randomly selected and interviewed. Since we are analysing the data for children up to the age of 5 years, it is not possible to set up a panel data estimation model.

We match individual level information for children upto age 5 years with household information and obtain a sample of 20,810 observations. We apply two restrictions on our sample for feasibility purposes. First, all households that reported an income of more than 1,000 Indian rupees (18.73 USD) were selected, to eliminate households that reported a low/negative income due to agricultural losses or crop failure, that dropped 276 observations.

Second, we drop observations for which information on variables used in the analysis (height and weight) was missing and/or information for household characteristics (including father's and mother's information) were unavailable (this dropped 10,152 observations). A final sample of 10,382 for children till age 5 years was obtained.

4.4.1 Choice of variables

4.4.1.1 Measurement of child health

Our main dependent variable, HAZ is representative of generational transmission of health, provides a comparable measure for both sexes and has been accepted as a suitable, objective, short and long run health indicator for children upto age 5 (Venkataramani, 2011). HAZ is defined as: HAZ=$\frac{h_{ij}-h_j}{\sigma_j}$, where h_{ij} is the height of the child i in group j defined by the child gender and age measured in months. h_j and σ_j are the, median and standard deviation (S.D.) of the height for the reference group j of the children with the same gender and age. We take into account anthropometric position (lying/standing) for measuring height as prescribed by the WHO. Several studies by Glewwe *et al.* (2001), Alderman (2006), Venkataramani (2011), Goode *et al.* (2014), and Sepehri and Guliani (2015) have used HAZ as a sole measure of child health. In comparison to HAZ, measures such as WAZ and WHZ are seen as short term indicators of child health status (Maitra *et al.*, 2013).

However, WAZ reflects both acute and chronic malnutrition (Deaton and Drèze, 2009). All measurements of height and weight were conducted twice by trained field workers. Age in months of children was calculated based on date of interview and date of birth of each child.

A CIAF measure, first proposed by Svedberg (2000) as a combined anthropometric proxy for malnourished children has been used for robustness check. Based on HAZ, WHZ, and WAZ we calculate three measures of undernutrition namely; stunting, underweight and wasting. We follow a similar approach as that of Nie *et al.* (2016) and combine Nandy *et al.* (2005) Group Y, underweight only, with six of Svedberg (2000) groups: group A, no failure; group B, wasting only; group C, wasting and underweight; group D, wasting, stunting and underweight; group E, stunting and underweight; and group F, stunting only. CIAF is then constructed as a dummy variable with a value of 0 if there is no failure and 1 if there is one or more anthropometric failures.[44] In an attempt to see the effect on a short-term indicator, we also carry out regressions using WHZ as a dependent variable.

4.4.1.2 Measurement of income

Household income, a constructed variable already available in IHDS-II, is the summation of wages (agricultural and non-agricultural), salaries, business income, remittances, government benefits, farm income and property/other income. The survey included 50 different income sources to arrive at a house-

[44]For details regarding the calculation of the HAZ, WHZ and WAZ as prescribed by the WHO in the Multicentre Growth Reference Study(MGRS), see WHO Child Growth Standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age:methods and development, Mercedes de Onis et.al. (2006). We use the STATA package “zscore06”for calculating the HAZ, WHZ and WAZ. (Leroy, Jef L (2011), zscore06 : STATA command for the calculation of anthropometric Z-scores using the 2006 WHO child growth standards (`http://www.ifpri.org/staffprofile/jef-leroy`).

hold income. Following literature, we take natural logarithm of per capita household income (in real 2012 prices as per urban/rural residency).

4.4.1.3 Alternative measures of household resources

Alternative measures of household resources have been used previous studies related to the child health and income gradient literature (Cameron and Williams, 2009). Wagstaff and Watanabe (2003) postulate that the measure of socioeconomic status either by consumption or an asset based wealth index is in most part likely to make little difference to the degree of inequality. Due to the IHDS-II's elaborate data on income, consumption expenditure and ownership of assets, we use these to measure a household's economic status. Household consumption is a constructed variable measuring expenditure based on a series of 52 questions designed to estimate total expenditure. We calculate annual household per capita consumption and take natural logarithm.

4.4.1.4 Variables in Specification (i)

The primary arc of the analysis is to determine the association between income and health of children (age group wise), however, we also complement our analysis with a rich set of controls previously found to be important determinants of child health. These are a binary variable for male, household size, a binary variable for place of residence (urban/rural). We include two binary indicators, one for being a Hindu, and another for belonging to a backward caste to account for religion and caste status in our estimations. We include district and primary sample unit fixed effects in all estimations to control for heterogeneity.[45]

4.4.1.5 Variables in Specification (ii)

Apart from all explanatory variables of Specification (1), we additionally control for mother's age and father's age. In order to capture the bias resulting from the unobserved ability of parents in nurturing children, controls for parental education are included. The education level of both, father and mother is controlled for separately, by including indicators equal to 1 if the father has completed 10 years or more and the mother has completed 5 or more years of formal education; 0 otherwise. Additionally control for parental employment equal to 1 if employed and 0 otherwise.[46] All PC variables are conditional on them being present in the household at the time of survey.

4.5 Transmission channels

Income is likely to systematically correlate with indirect determinants of child health. The main purpose is to disentangle the overall income effect into sub-components. The IHDS-II data provides sufficient information on family practices and adequately represent the living conditions. We examine whether a moderation effect is seen on the apparent child health-income

[45]The Indian Human Development Survey has sampled households from rural and urban areas. Each household is classified into a primary sampling unit (PSU) which helps in identifying the cluster for statistical analyses. Each PSU is a cluster of villages that form part of a district within a state. We combine the unique identifier for each district with the unique identifier for each PSU. This gives a unique district-PSU identifier to account for heterogeneity.

[46]The variables for parental characteristics were positively correlated with the correlation coefficient being 0.41 for education levels and 0.06 for employment. Both were significant at 95% confidence interval

gradient for Indian children by including TC that may translate income into improved child health.

4.5.1 Mediating effect

4.5.1.1 Maternal health

Vast evidence has been documented about the prominence of maternal health in contributing to enhancement of child health. Poor maternal health can result in a low-birth weight baby, thereby pre-disposing the child to weak growth. This can result in incapability on part of the mother to provide care owing to her own poor health. As maternal body composition partly determines size and body proportions at birth, maternal height has been the strongest predictor of neonatal length (Leary *et al.*, 2006). Moreover, Özaltin *et al.* (2010) in a study of 54 low to middle income countries found that maternal stature was inversely associated with stunting in infancy and childhood. To account for the "foetal origin hypothesis"(Barker and Osmond, 1986) Barker (1994) which confirms that degenerative conditions revealed at adulthood may be triggered by circumstances decades earlier, *in utero* nutrition in particular, we choose maternal height in centimetre (cm) as a control for maternal health. Foetal shocks can have a long standing impact on later life outcomes as also studied by Almond and Currie (2011). Yet another validation for using maternal height as control is that taller mothers assist in better cephalopelvic growth of the foetus, amelioration of disproportion and thereby resulting in healthier birth weight and development of the infant (Black *et al.*, 2008)

4.5.1.2 *Housing quality*

In India, continuous supply of electricity is perceived as an encouraging indicator of infrastructure reform (Ahluwalia, 1998). Study on child nutrition in India also employs availability of continuous electricity as a proxy for assessing housing quality (Government of India (GOI), 2009). To add another dimension relevant to health, we use the presence of a concrete roof in the house as a proxy for good living conditions. It has been noted by Yé *et al.* (2006) that strong roof conditions reduced malarial infections. We thus control for housing quality by using indicator variables for receiving continuous electricity supply and presence of a concrete roof as a gauge of good, overall living conditions.

4.5.1.3 *Sanitation*

Vast evidence suggests that poor sanitation is linked to poor health outcomes and is closely linked to stunting in children. Open defecation pollutes the environment with spread of pathogenic agents, increases diarrhoeal incidence and pre-disposes children and adults alike to colitis and\or gastroenteritis. In a study conducted by Cairncross *et al.* (2010), hand-hygiene, water and toilet usage were prime drivers of preventing diarrhoea. More specifically, in an ecological analysis of about 112 districts in India, Spears *et al.* (2013a) found that with increasing distance of availability of a toilet, stunting rates among children increase. Supporting evidence was also provided by Chambers and Von Medeazza (2013) about the debilitating effects open defecation has on child health given the Indian conditions. Thus, we use “not defecating in the open”, “hand hygiene”captured by use of soap in washing hands and the “availability of piped water supply”as indicators for satisfactory levels of sanitation in the household.

4.5.1.4 Non-infectious environment

It has been noted that virus caused infections have resulted in maximum death in children under 5 years of age worldwide, with no exception in India (Parashar *et al.*, 2006). Cairncross *et al.* (2010) provide evidence that poor drainage and water-borne diseases are leading causes for early child mortality. We therefore use the information about absence of stagnation of water outside the household (binary indicator) as a proxy for non-infectious environment.

4.5.1.5 Media exposure

We use a dichotomous variable equal to 1 if women in the household watch television to capture the potential advantages of creating awareness through broadcasting of information about government schemes, policies and child health benefits that citizens are eligible for. For example, the Ministry of Women and Child Development extensively advertises about the pivotal role breast feeding plays in child development. We believe that women are likely to be more aware if they watch television, especially when most television channels broadcast such advertisements for free.

4.5.1.6 Safe neighbourhood

The effect quality of neighbourhoods have on behaviour patterns of children, especially adolescents, including their educational and health related habits has been documented by Leventhal and Brooks-Gunn (2000). Residential instability, community clashes and insecure environments are unproductive for child health. We use a proxy measure equal to 1 if a household reports no conflict in its surroundings, to evaluate the impact of a safe environment on child health.

4.6 Sample characteristics

Summary statistics are shown in Table 4.1. Children in the lowest quintile have a HAZ of -1.446, around two S.D. shorter than the reference population and much lower than those belonging to the other end of the income distribution. Around 41 per cent of children till age 5 are stunted in the lowest income quintile, while prevalence of stunted growth in the highest income quintile is 25 per cent.

The difference in per capita income between households in the lower most first quintile and the ones in the upper most fifth quintile is close to 12 per cent. About 52 per cent households belonging to the highest income category live in urban areas with the majority of the poorer populations residing in rural regions. As seen in other published studies, fathers are more educated than mothers. Only 39 per cent of mothers in the first quintile of the income distribution have completed 5 years or more of formal education compared to 86 per cent in the fifth quintile. 97 per cent of all fathers were employed in all households across the five quintiles. Contrastingly, of all the households in the first quintile, 59 per cent of the mothers were employed. However, for households in the fifth quintile, 33 per cent of the mothers were employed. The average height of mothers belonging to households of the fifth quintile was 153 cm. 84.7 per cent households in first

Table 4.1: Summary statistics for the child health and gradient study.
Data source: IHDS-II (2011-12)

	Q1	Q2	Q3	Q4	Q5
HAZ	-1.446	-1.317	-1.237	-1.028	-0.664
Stunting (%)	0.417	0.380	0.365	0.330	0.250
CIAF	0.550	0.512	0.502	0.479	0.384
Height (cm)	86.810	87.407	87.435	87.723	89.905
Household income (INR*)	25,013.250	49,456.780	75,112.580	119,515.500	320,900.500
Per capita income (INR)	3,747.309	7,683.710	11,830.160	18,478.390	51,091.320
Log per capita income	8.104	8.937	9.372	9.813	10.667
Male	0.509	0.513	0.524	0.525	0.543
Age (years)	2.970	2.979	2.935	2.891	2.948
Urban	0.101	0.196	0.302	0.392	0.515
Household size	6.709	6.429	6.367	6.465	6.370
Hindu	0.830	0.796	0.763	0.801	0.809
Backward caste	0.847	0.819	0.794	0.735	0.596
Father's age (years)	33.451	32.468	31.975	31.695	32.656
Mother's age (years)	29.258	28.117	27.449	27.048	28.042
Father employed	0.970	0.975	0.983	0.979	0.977
Mother employed	0.589	0.493	0.419	0.396	0.330
Father's education (>=class 10)	0.169	0.196	0.252	0.366	0.659
Mother' education (>=classs 5)	0.398	0.458	0.543	0.697	0.865
Maternal height (cm)	150.134	150.641	151.016	151.635	153.445
Household has electricity	0.669	0.767	0.864	0.930	0.977
Has concrete roof	0.206	0.246	0.321	0.400	0.618
Has no open defecation	0.209	0.329	0.468	0.584	0.829
Has piped water supply	0.175	0.303	0.417	0.515	0.568
Soap use	0.482	0.572	0.666	0.757	0.874
Has non-infectious environment	0.815	0.813	0.826	0.832	0.892
Has media exposure: women	0.527	0.629	0.768	0.844	0.946
Has safe neighbourhood	0.476	0.545	0.590	0.602	0.635

*INR: Indian National Rupees
Mean values have been reported for each quintile.

quintile belong to the backward caste and 79 per cent of households in the first quintile defecate in the open. 95 per cent of women from households in the fifth quintile reported having exposure to media(proxy for measure of accessing electronic media information).

4.7 Raw gradient

A histogram of HAZ is provided in Figure 4.1. HAZ values appear to cluster around the -2 S.D. region of the scale. This suggests that in our sample considerable number of children have HAZ lower than 2 S.D. and thus are prone to stunted growth. Figure 4.2 illustrates the average HAZ against log per capita income for children aged 0-5, aged 0-2 and aged 3-5 separately. A more positive value of HAZ depicts better health, that is upward sloping lines depict better health with rising income. Raw data suggests that the youngest children (0-2 years) are the most influenced by increasing income indicating towards a potential income gradient. As is seen, there is a systematic decrease in mean HAZ as households get richer.

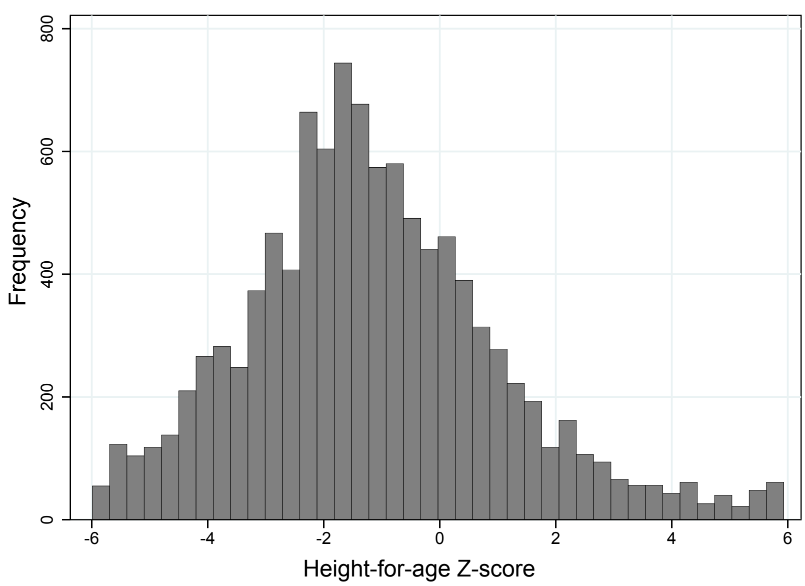


Figure 4.1: Distribution of HAZ for children aged 0-5 years of the gradient study.

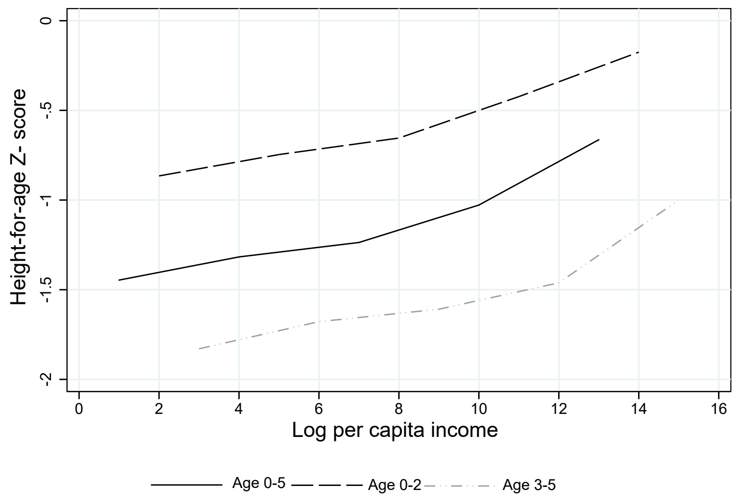


Figure 4.2: Child health and household income for all ages. This figure shows a raw gradient between child health (HAZ) on the y-axis and log per capita income on the x-axis. Solid black line is for the children aged 0-5, long dash line depicts the gradient for children aged 0-2, and dot dash grey line is for children aged 3-5.

4.8 Estimation results

4.8.1 Overall regression

The results for Specification (i) are presented in Table 4.2. Consistent with the current literature, we present results for 0-5, 0-2 and 3-5 years separately. We choose to analyse children in the age category 0-2 separately, following the theory of “first 1000 days”accepted by the World Health Organisation as the “window of opportunity” for significant impact on child’s physical and cognitive development. We find a positive and significant association between household income and child health for the entire sample. A one log point increase in income is associated with 0.214 S.D. increase in child height from median of reference population for children aged 0-5. This is slightly higher than estimates by Goode *et al.* (2014), who find a 0.146 S.D. growth in child height for Chinese children. Based on our estimate, a 0.214

S.D. increase in height will translate into a 3.069 cm increment in height for children up to 5 years of age. The magnitude of the gradient is highest for children in the 0-2 years category with the predicted increase in height equal to 2.46 cm. We find that children belonging to households from urban areas are likely to grow 0.201 S.D. (2.88 cm) taller if income increases by one log point. Also, we see expected negative sign on the coefficient for backward caste indicating that children belonging to a lower socioeconomic status are likely to be in poorer health.

Results for the child health and income gradient after controlling for parental characteristics are reported in Table 4.2 (see last three columns). We account for the omitted variable bias by including controls for parental age, education and employment. We find a 0.150 S.D. (2.15 cm) increase in child height for entire sample. The point estimates for all ages have reduced in magnitude, however, remain significant. The advantages of living in urban areas are still significant and positive. However, after controlling for parental characteristics, the coefficient on backward caste continues to be significant and still has a negative sign *ceteris paribus*. An explanation for this could be that, even after accounting for better educated parents, the effect of belonging to a weaker social class continues to have an impact on child health.

Children of fathers who have completed at least 10 years of formal education are likely to be 0.276 S.D. (3.96 cm) taller if between ages 0-5 and 0.297 S.D. (4.26 cm) taller if between ages 0-2, relative to children with less educated fathers (less than 10 years of education). Similarly, mothers who complete 5 years of education are also likely to contribute positively to child health. The relative increase in height is estimated to be 0.287 S.D. (2.6 cm)

Table 4.2: Household income and child health by age group.
Data source: IHDS-II (2011-12)

	Specification (i)				Specification (ii)		
	0-5	0-2	3-5		0-5	0-2	3-5
Log per capita income	0.214***	0.229***	0.210***		0.150***	0.167**	0.148***
	(0.032)	(0.055)	(0.040)		(0.033)	(0.056)	(0.042)
Male	0.028	0.000	0.071		0.022	-0.018	0.068
	(0.051)	(0.096)	(0.061)		(0.051)	(0.095)	(0.061)
Urban	0.201**	0.010	0.292***		0.150*	-0.023	0.231**
	(0.066)	(0.127)	(0.079)		(0.070)	(0.131)	(0.082)
Backward caste	-0.233***	-0.314**	-0.217**		-0.143*	-0.221*	-0.126
	(0.068)	(0.122)	(0.079)		(0.069)	(0.123)	(0.080)
Hindu	0.061	0.071	0.056		-0.023	-0.028	-0.024
	(0.070)	(0.131)	(0.086)		(0.072)	(0.136)	(0.088)
Father's age					-0.002	-0.018	0.002
					(0.008)	(0.014)	(0.009)
Mother's age					0.016	0.031	0.012
					(0.009)	(0.016)	(0.011)
Father employed					0.137	0.139	-0.098
					(0.189)	(0.310)	(0.218)
Mother employed					0.077	0.081	0.052
					(0.058)	(0.104)	(0.071)
Father's education					0.276***	0.297***	0.280***
					(0.065)	(0.119)	(0.079)
Mother's education					0.323***	0.342**	0.287***
					(0.062)	(0.114)	(0.072)
R^2	0.300	0.416	0.182	R^2	0.308	0.423	0.193
N	10,382	4,148	6,234	N	10,382	4,148	6,234

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Dependent variable in OLS regressions is height-for-age Z - score (HAZ) as defined by the WHO. Variables in specification (i) are full set of dummies for child age, male, household size, urban/rural, caste, religion, and area (district combined with primary sampling unit) level fixed effects. Specification (ii) has additionally father's age, mother's age, father's education, mother's education, father's employment, mother's employment (all conditional on them being present in the household at the time of survey). Robust Huber-White standard errors are in parenthesis.

higher for children aged 3-5.

4.8.2 Sub-group analysis

Having examined the effect of income on child health using three different model specifications, we expand our analyses to see if any differences in the gradient emerge depending on the child's gender, social caste or area of residence.

First, we look at the gradient, separately, for boys and girls. We estimate the relationship between income and child health for all three model specifications. Table 4.3 shows the results from the first part of the sub-group analyses. It is clear that the association remains positive and significant irrespective of the gender for all ages when controlling for variables in Specification (i). The coefficient on income for both, boys and girls, aged 0-5 is 0.218 (3.13 cm increase).

Looking at the youngest children (aged 0-2), the increase in height is maximum for boys, at 0.269 S.D. (2.84 cm) more than median height, while for girls it is 0.235 S.D. (2.54 cm).

The association continues to remain significant even after controlling for parental characteristics, it is higher for boys at 0.149 (2.10 cm) S.D. than for girls at 0.138 S.D. (2 cm) Further, on controlling for all regressors (Specification (iii)) we do not find a significant association for either gender.

Table 4.3: Gender based sub group analysis.
Data source: IHDS-II (2011-12)

	Boys			Girls		
	0-5	0-2	3-5	0-5	0-2	3-5
Income	0.218***	0.269**	0.207***	0.218***	0.235**	0.215***
	(0.046)	(0.088)	(0.057)	(0.045)	(0.079)	(0.058)
Income+PC†	0.149**	0.219*	0.123*	0.138**	0.129	0.168**
	(0.047)	(0.090)	(0.061)	(0.046)	(0.081)	(0.061)
Income+PC+TC‡	0.086	0.124	0.079	0.076	0.096	0.109
	(0.049)	(0.093)	(0.063)	(0.048)	(0.084)	(0.062)
N	5,421	2,131	3,290	4,961	2,017	2,944

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Dependent variable in OLS regressions is height-for-age Z - score (HAZ) as defined by the WHO.
All estimates are marginal effects of log per capita income.
Income refers to Specification(i) and controls for full set of age dummies, dummies for religion, caste, control for household size, urban/rural, and fixed effects for district and primary sampling unit.
†: Parental controls(PC), this refers to Specification (ii). Controls include all variables of Specification (i) and additional controls for father's age, mother's age, father's education, mother's education, father's employment and mother's employment (all conditional on them being present in the household at the time of survey).
‡: Transmission channels (TC), this refers to Specification (iii). Controls include all variables of Specification (i), Specification (ii) and additional controls for maternal health, household quality, sanitation, non-infectious environment, media exposure to women and a safe neighbourhood.
Robust Huber-White standard errors in parentheses.

Second, we look at children belonging to households from non-SC/ST/OBC households and those who belong to SC/ST/OBC households. While the caste system in India has deeper roots in the country's socio-demographic profile, it has been well accepted that, traditionally, individuals from the backward castes have faced social exclusion manifesting in various forms (Mehta and Shah, 2003). Table 4.4 reports results from the second part of our sub group analyses. In our sample 76.34 per cent of children belong to SC/ST/OBC community. In the context of this study too, it is evident that children (aged 0-5) belonging to a SC/ST/OBC caste are likely to benefit less from a rise in income (0.196 S.D. or 2.8 cm), as opposed to their counterparts (0.285 S.D. or 4.15 cm).

Poor anthropometric outcomes reflect that even after controlling for PC and TC (see Table 4.4), do not seem to ameliorate the effects of belonging to a weaker socio-economic strata of the society.

Table 4.4: Caste based sub group analysis.
Data source: IHDS-II (2011-12)

	Non-SC/ST/OBC			SC/ST/OBC		
	0-5	0-2	3-5	0-5	0-2	3-5
Income	0.285***	0.461***	0.177	0.196***	0.237***	0.195***
	(0.069)	(0.119)	(0.092)	(0.037)	(0.067)	(0.045)
Income+PC†	0.241**	0.430**	0.115	0.134***	0.174**	0.137**
	(0.071)	(0.124)	(0.097)	(0.039)	(0.068)	(0.049)
Income+PC+TC‡	0.111	0.280*	0.039	0.088*	0.122	0.098
	(0.072)	(0.127)	(0.099)	(0.040)	(0.070)	(0.050)
N	2,456	995	1,461	7,926	3,153	4,773

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Note: Dependent variable in OLS regressions is height-for-age Z - score (HAZ) as defined by the WHO.
All estimates are marginal effects of log per capita income.
Income refers to Specification(i) and controls for full set of age dummies, dummies for male, religion, control for household size, urban/rural, and fixed effects for district and primary sampling unit.
†: Parental controls(PC), this refers to Specification (ii). Controls include all variables of Specification (i) and additional controls for father's age, mother's age, father's education, mother's education, father's employment and mother's employment (all conditional on them being present in the household at the time of survey).
‡: Transmission channels (TC), this refers to Specification (iii). Controls include all variables of Specification (i), Specification (ii) and additional controls for maternal health, household quality, sanitation, non-infectious environment, media exposure to women and a safe neighbourhood.
Robust Huber-White standard errors in parentheses.

Finally, we estimate the gradients for urban and rural areas, shown in Table 4.5. The relationship remains stronger for children living in urban areas. Rural children are likely to benefit less from an increase in income compared to those living in urban areas.[47] Though the gradient is not monotonic for both urban and rural areas, after controlling for maternal health, housing quality, sanitation, media exposure for women, a non-infectious envi-

[47] Though the IHDS-II comprises more number of rural households, the urban areas covered in the survey are as per census profile of the country and are well representative of the prevalent conditions.

ronment and a safe neighbourhood, the gradient becomes insignificant for children aged 0-5 living in urban areas but predicts a 0.088 S.D. increase in height for children living in rural areas of the same age group.

Table 4.5: Residency based sub group analysis.
Data source: IHDS-II (2011-12)

	Urban			Rural		
	0-5	0-2	3-5	0-5	0-2	3-5
Income	0.304***	0.326**	0.281***	0.202***	0.253***	0.181***
	(0.060)	(0.120)	(0.076)	(0.038)	(0.064)	(0.048)
Income+PC†	0.164**	0.232	0.133	0.153***	0.197**	0.141**
	(0.064)	(0.128)	(0.078)	(0.039)	(0.065)	(0.051)
Income+PC+TC‡	0.112	0.157	0.108	0.088*	0.121	0.080
	(0.064)	(0.131)	(0.078)	(0.041)	(0.069)	(0.054)
N	3,040	1,166	1,874	7,342	2,982	4,360

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Dependent variable in OLS regressions is height-for-age Z - score (HAZ) as defined by the WHO.
All estimates are marginal effects of log per capita income.
Income refers to Specification(i) and controls for full set of age dummies, dummies for male, religion, caste, control for household size, and fixed effects for district and primary sampling unit.
†: Parental controls(PC), this refers to Specification (ii). Controls include all variables of Specification (i) and additional controls for father's age, mother's age, father's education, mother's education, father's employment and mother's employment (all conditional on them being present in the household at the time of survey).
‡: Transmission channels (TC), this refers to Specification (iii). Controls include all variables of Specification (i), Specification (ii) and additional controls for maternal health, household quality, sanitation, non-infectious environment, media exposure to women and a safe neighbourhood.
Robust Huber-White standard errors in parentheses.

4.8.3 Variation of gradient across the income distribution

Concerns about whether channels like maternal health and sanitation influence child health directly or not have been raised in earlier work done by Kuehnle (2014). Since there is still some ambiguity surrounding the direct and indirect determinants of child health, we investigate the results from the spline regression framework for Specification (ii) only, which controls for parental characteristics and other variables (all controls of Specification (i)). The reason to do so is that, this method divides the income distribution into intervals and we seek to explore the differential effects of a rise in income (controlling for only direct determinants) on child health at various parts of the distribution.

Table 4.6 presents results from the linear spline specification for five equally spaced intervals in Panel A. First, we discuss the results shown in Panel A. It is evident that children belonging to different income groups are likely to respond to an increase in household income differently. We find that for households in the first quintile, the influence of a rise in income can have negative effects on health of children between age 0-5 years. It is quite possible that if an income support is provided to the very poor households, the budgetary allocation towards health seeking behaviour or nutrition promoting activities may decrease.[48]

In this case, we see children in households with incomes falling in the second quintile are likely to benefit with an increase of 0.645 S.D. (9.25 cm) in height for the whole sample, and that of 0.871 S.D. (9.36 cm) increment for children in the 0-2 years age category. It is this threshold income of 176.2 USD, beyond which an improvement in child health is observed. The other part of the income distribution as per the spline technique shows that the fourth quintile has the largest impact for a one log unit increase in income. For the whole sample, a 0.784 S.D. increment (11.24 cm) is predicted and specifically for the 3 to 5 year olds it is equal to 0.880 S.D. (7.97 cm). In no other part of the distribution is this change statistically significant.

Secondly, we look at some policy relevant income breaks without using splines. On bifurcating the data into two groups, viz. above and below the

[48]As a confirmation to the results obtained using splines from the income variable, we also estimate this using splines of annual household consumption and assets. The results (presented in Table 4.9) confirm the trends seen in the gradient of Panel A in Table 4.6

Table 4.6: Estimation results based on effect of linear splines of income on child health by age group.
Data source: IHDS-II (2011-12)

	Panel A				Panel B				Panel C		
Quintiles	0-5	0-2	3-5		0-5	0-2	3-5		0-5	0-2	3-5
First	-0.146	-0.232	-0.056	Below 50^{th} percentile	0.013	-0.01	0.045	Below poverty line	0.161*	-0.056	0.227*
	(0.090)	(0.149)	(0.120)		(0.066)	(0.111)	(0.089)		(0.073)	(0.128)	(0.090)
Second	0.645**	0.871*	0.463	N	5,177	2,035	3,142	N	3,039	1,199	1,840
	(0.231)	(0.432)	(0.259)								
Third	-0.350	-0.232	-0.301	Greater & equal to 50^{th} percentile	0.268***	0.271*	0.240**	Above poverty line	0.134***	0.186*	0.109*
	(0.287)	(0.541)	(0.315)		(0.071)	(0.122)	(0.088)		(0.039)	(0.076)	(0.046)
				N	5,205	2,113	3,092	N	7,343	2,949	4,394
Fourth	0.784***	0.633	0.880***	90^{th} percentile & above	-0.132	0.140	-0.330				
	(0.214)	(0.384)	(0.250)		(0.245)	(0.451)	(0.374)				
				N	1,040	428	612				
Fifth	0.084	0.172	-0.026								
	(0.116)	(0.174)	(0.147)								
N	10,382	4,148	6,234								

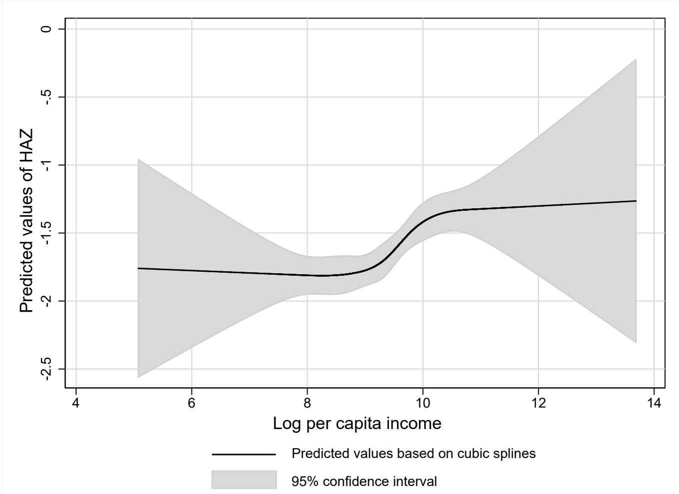
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Dependent variable in OLS regressions is height-for-age Z - score (HAZ) as defined by the WHO.
Full set of age dummies, dummies for male, religion, caste, control for household size, urban/rural have been included. Father's age, mother's age, father's education, mother's education, father's employment, mother's employment (conditional on them present in the household at the time of survey) and fixed effects for district and primary sampling unit have been included in all estimations. Robust Huber-White standard errors in parentheses.

median of annual income per capita, as shown in Panel B of table 4.6, we find that only the households that are above the 50^{th} percentile show a response of improvement in child health by 0.268 S.D. (3.84 cm). Once again, for households above the 90^{th} percentile (top-most part of the income distribution), although the proportion of such households is small, results are consistent with the fact that positive effects of income are not similar for all intervals. We find this once again, for households below and above the poverty line.[49] Children aged 3-5 years in households below the poverty line show an increase of 0.227 S.D.(2.06 cm) in height while for those who are in households above the poverty line a 0.109 S.D. (0.99 cm) increment is predicted. It is noteworthy to see that for the richer households an increase in height in predicted suggesting that positive impact is possible only if the household's income is above a certain threshold. It is also indicative that quality of health care provided by the rich is independent of income raise and more grounded in their ability to sustain or respond to health shocks in a better way.

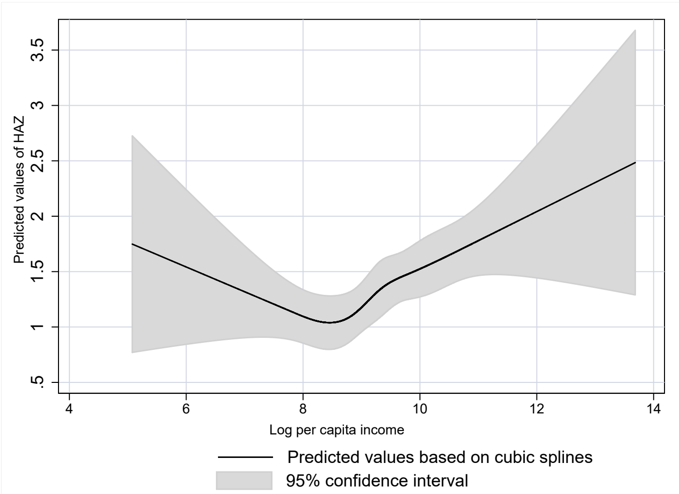
We go a step further to see if the relationship exhibits a similar pattern on estimating the association using cubic splines (the polynomials have a degree 3). We divide the income distribution into six intervals and predict the value for HAZ controlling for all variables of Specification(ii). Figure 4.3 illustrates that cubic splines smoothed the association at the threshold, and the gradient still exists for each age group. Predicted values of HAZ show that richer households are likely to have healthier children with the effect most prominent for children in households in the second sextile (per capita

[49]The poverty line has been calculated using the Tendulkar method (2012), adjusted for the interview date. Households that have an expenditure/capita less that the poverty line have been categorised as poor and non-poor, otherwise.

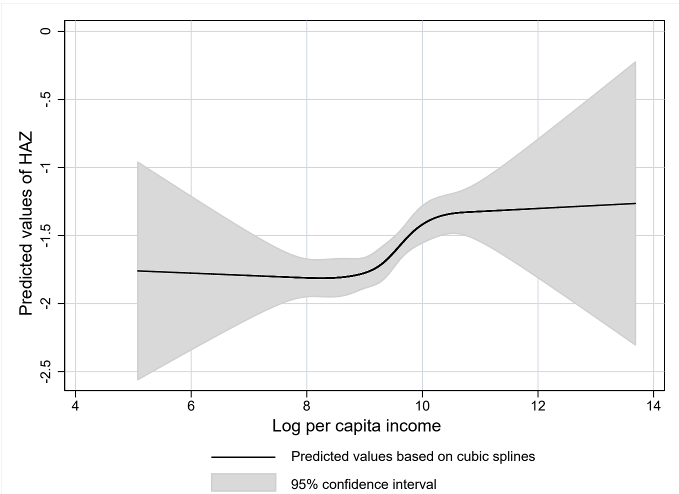
income between 129 USD to 210 USD).



(a) Age 0-5



(b) Age 0-2



(c) Age 3-5

Figure 4.3: Cubic splines of income and child health by age group.

Figure 4.3a is for ages 0-5, figure 4.3b is for ages 0-2, and figure 4.3c is for ages 3-5. Solid black line shows predicted values of HAZ (y-axis), grey region is for the 95 per cent C.I., and log per capita income is on the x-axis.

4.8.4 Simulating the effect of income rise on decrease in stunting

One of our primary contributions is simulating the expected decrease in stunting percentage at sample mean as a result of increase in income. We do not account for variables of TC to simulate the effect, as it may result in under estimating the income effect. We show these results in Table 4.7. On increasing income by 10 percentage points the average stunting reduces from 35.17 per cent to 35 per cent. However, a doubling of income may reduce stunting on an average by 1.89 percentage points. In India, income per capita rose by 119 per cent between 2005 (730 USD) and 2015 (1600 USD). We also show the expected average decrease across all quintiles for an income rise ranging between 10 per cent to 120 per cent. The realistic scenario is a rise of about 8.03 per cent in income over a year, which as per our analysis predicts a decrease of 0.16 percentage points in stunting.

Table 4.7: Predicted decreases in percentage of stunted children on increasing income.
Data source: IHDS-II (2011-12)

	Stunting percentage across quintiles					
	Mean	Q1	Q2	Q3	Q4	Q5
	35.17	**41.72**	**38.05**	**36.46**	**32.98**	**25.00**
Increase in income	Reduction (%)					
10%	-0.16	-0.18	-0.23	-0.19	-0.10	-0.11
20%	-0.35	-0.50	-0.37	-0.42	-0.15	-0.26
50%	-0.75	-1.22	-0.74	-0.89	-0.46	-0.37
100%	-1.89	-2.52	-1.53	-1.64	-2.33	-1.37
120%	-2.53	-2.97	-2.17	-2.39	-3.35	-1.74

Reduction in percentage points in stunting for each quintile on increasing income based on estimates from Specification (2) controlling for full set of age dummies, dummies for male, religion, caste, control for household size, urban/rural. Father's age, mother's age, father's education, mother's education, father's employment, mother's employment (conditional on them present in the household at the time of survey) and fixed effects for district and primary sampling unit have also been included.

4.8.5 Sensitive Analysis

Alternative measures of household resources

The results discussed thus far asses the association between child health and income. We consider two alternatives measures, per capita consumption and per capita assets owned, as proxies for income. The outcome variable is HAZ.

Table 4.8: Child health and income gradient with consumption and assets as proxies for income.
Data source: IHDS-II (2011-12)

	Panel A: Consumption				Panel B: Assets		
	0-5	0-2	3-5		0-5	0-2	3-5
Consumption	0.313***	0.215*	0.372***	Assets	0.552***	0.649***	0.493***
	(0.052)	(0.096)	(0.061)		(0.058)	(0.093)	(0.071)
Consumption+PC†	0.171***	0.040	0.372***	Assets+PC†	0.426***	0.535***	0.493***
	(0.055)	(0.102)	(0.061)		(0.066)	(0.108)	(0.071)
Consumption+PC+TC‡	0.032	-0.128	0.157*	Assets+PC+TC‡	0.228**	0.336**	0.239*
	(0.056)	(0.105)	(0.062)		(0.091)	(0.150)	(0.104)
N	10,382	4,148	6,234	N	10,382	4,148	6,234

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Dependent variable in OLS regressions is height-for-age Z - score (HAZ) as defined by the WHO.
In Panel A the coefficients are of log per capita consumption and in Panel B, the coefficients are on log per capita assets.
Consumption and Assets refer to Specification (i) and control for full set of age dummies, dummies for male, religion, caste, control for household size, urban/rural, and fixed effects for district and primary sampling unit.
†: Parental controls(PC), this refers to Specification (ii). Controls include all variables of Specification (i) and additional controls for father's age, mother's age, father's education, mother's education, father's employment and mother's employment (all conditional on them being present in the household at the time of survey).
‡: Transmission channels (TC), this refers to Specification (iii). Controls include all variables of Specification (i), Specification (ii) and additional controls for maternal health, household quality, sanitation, non-infectious environment, media exposure to women and a safe neighbourhood.
Robust Huber-White standard errors in parentheses.
Full set of age dummies, dummies for religion, caste, controls for household size, urban/rural, and fixed effects for district and primary sampling unit have been included in all estimations. Robust Huber-White standard errors in parentheses.

Table 4.8 presents results from these two regressions. Panel A shows coefficients on log per capita consumption for all three model specifications. As expected, the association continues to remain positive and significant for all ages, with a decrease in magnitude as more controls are included. Panel B shows coefficients on log assets per capita. For every one log point increase in consumption, on controlling for all regressors a 0.157 S.D.(1.42 cm) increase in child height is predicted for children aged 3-5. For every one log point increase in the assets based index, child height can increase by 0.228

S.D. (3.27 cm) from median of reference population when all regressors are a part of the model.

Table 4.9: Estimation results based on effect of linear splines of consumption and assets on child health by age group.
Data source: IHDS-II (2011-12)

Consumption splines				Assets splines			
Quintiles	0-5	0-2	3-5	Quintiles	0-5	0-2	3-5
First	-0.355	-0.410	-0.505	First	0.067	0.465	-0.140
	(0.244)	(0.374)	(0.299)		(0.152)	(0.245)	(0.182)
Second	1.180**	0.797	1.388**	Second	0.890***	0.478	1.169***
	(0.418)	(0.672)	(0.494)		(0.254)	(0.438)	(0.298)
Third	-0.306	0.667	-0.525	Third	0.454	0.997	0.067
	(0.283)	(0.525)	(0.338)		(0.332)	(0.614)	(0.383)
Fourth	0.714*	-0.092	1.025**	Fourth	0.334	0.042	0.469
	(0.283)	(0.525)	(0.338)		(0.351)	(0.674)	(0.401)
Fifth	-0.153	-0.417	0.007	Fifth	0.773**	1.066*	0.595
	(0.136)	(0.251)	(0.164)		(0.287)	(0.499)	(0.339)
N	10,382	4,148	6,234	N	10,382	4,148	6,234

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Dependent variable in OLS regressions is height-for-age Z - score (HAZ) as defined by the WHO.
Full set of age dummies, dummies for male, religion, caste, control for household size, urban/rural have been included. Father's age, mother's age, father's education, mother's education, father's employment, mother's employment (conditional on them present in the household at the time of survey) and fixed effects for district and primary sampling unit have been included in all estimations. Robust Huber-White standard errors in parentheses.

Alternative measures of child health

As a substitute to HAZ, we include WHZ in our study and run similar regressions using income as the main explanatory variable. Table 4.10 shows the results for all three specifications. In terms of the magnitude of the coefficients, they are much smaller, however, the direction is similar and after controlling for all regressors, a 0.071 S.D. increase in the WHZ is predicted for children aged 3 to 5 years.

Table 4.10: Association between wasting and income by age group.
Data source: IHDS-II (2011-12)

	0-5	0-2	3-5
Income	0.118***	0.124**	0.113***
	(0.026)	(0.042)	(0.032)
Income+PC†	0.090***	0.100*	0.080*
	(0.027)	(0.044)	(0.034)
Income+PC+TC‡	0.077	0.081	0.071*
	(0.028)	(0.045)	(0.035)
N	10,382	4,148	6,234

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Dependent variable in OLS regressions is Weight-for-length/height Z score as defined by the WHO.
Coefficients are marginal effects of log per capita income.
Income refers to Specification (i) and controls for full set of age dummies, dummies for male, religion, caste, control for household size, urban/rural, and fixed effects for district and primary sampling unit.
†: Parental controls(PC), this refers to Specification (ii). Controls include all variables of Specification (i) and additional controls for father's age, mother's age, father's education, mother's education, father's employment and mother's employment (all conditional on them being present in the household at the time of survey).
‡: Transmission channels (TC), this refers to Specification (iii). Controls include all variables of Specification (i), Specification (ii) and additional controls for maternal health, household quality, sanitation, non-infectious environment, media exposure to women and a safe neighbourhood.
Robust Huber-White standard errors in parentheses.

We also choose a binary variable, CIAF as a proxy for combined anthropometric failure. Table 4.11 reports the marginal effects of log per capita income from weighted probit regressions for all ages. Our results show that a one log point increase in per capita income (~387 USD) can reduce the probability of a combined anthropometric failure in children aged 0-5 by 9.1 percentage points. On controlling for PC variables a one log point increase in income reduces the likelihood of the child (aged 0-5) suffering from a combined anthropometric failure by 5.8 percentage points. The association turns insignificant after controlling for all regressors but the negative signs reinforce the expected trend.

Table 4.11: Association between CIAF and income by age group.
Data source: IHDS-II (2011-12)

	0-5	0-2	3-5
Income	-0.091***	-0.083*	-0.100***
	(0.021)	(0.035)	(0.027)
Income+PC†	-0.058**	-0.056	-0.056
	(0.022)	(0.037)	(0.029)
Income+PC+TC‡	-0.019	-0.016	-0.015
	(0.023)	(0.038)	(0.030)
N	10,382	4,148	6,234

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Dependent variable in probit regressions is Composite Index for Anthropometric Failure (CIAF).
Coefficients are marginal effects of log per capita income.
Income refers to Specification (i) and controls for full set of age dummies, dummies for male, religion, caste, control for household size, urban/rural, and fixed effects for district and primary sampling unit.
†: Parental controls(PC), this refers to Specification (ii). Controls include all variables of Specification (i) and additional controls for father's age, mother's age, father's education, mother's education, father's employment and mother's employment (all conditional on them being present in the household at the time of survey).
‡: Transmission channels (TC), this refers to Specification (iii). Controls include all variables of Specification (i), Specification (ii) and additional controls for maternal health, household quality, sanitation, non-infectious environment, media exposure to women and a safe neighbourhood.
Robust Huber-White standard errors in parentheses.

4.8.6 Potential effect of various transmission channels

Table 4.12 presents results after we control for TC separately and jointly, to examine the impact each set of channels has in addition to the Specification (2) variables. Overall we notice a reduction in the income coefficients for each channel, affirming that these channels partially explain the gradient. Maternal health decreases the income coefficient from 0.150 to 0.141, housing quality and sanitation to 0.122, while non-infectious environment, media exposure, and safe neighbourhood channels reduce it to 0.149, 0.135 and 0.149, respectively.

A child not defecating in the open is likely to experience a 0.166 S.D. (2.38 cm) increase in height when compared to those not having access to a toilet. The importance of practising hand hygiene is evident as usage of soap is likely to increase child height by 0.195 S.D. (2.79 cm). We also find that in households where women are exposed to media, a 0.170 S.D. (2.44 cm) increase in height is predicted, ascertaining that awareness among women is key to promoting child health.

Table 4.12: Transmission channels explaining the income effect for entire sample.
Data source: IHDS-II (2011-12)

Transmission channels							
Log per capita income	0.141***	0.122***	0.122***	0.149***	0.135***	0.149***	0.092**
	(0.033)	(0.033)	(0.034)	(0.033)	(0.034)	(0.0343)	(0.034)
Maternal health	0.017**						0.016**
	(0.006)						(0.006)
Housing quality							
Electricity supply		0.228***					0.159
		(0.077)					(0.082)
Concrete roof		0.214***					0.173**
		(0.059)					(0.060)
Sanitation							
No open defecation			0.166**				0.114
			(0.067)				(0.068)
Piped water			0.012				-0.038
			(0.061)				(0.062)
Hand hygiene			0.195**				0.160*
			(0.065)				(0.064)
Non-infectious environment				0.111			0.078
				(0.072)			(0.072)
Media exposure women					0.170**		0.083
					(0.067)		(0.072)
Safe neighbourhood						0.065	0.071
						(0.055)	(0.055)
N	10,382	10,382	10,382	10,382	10,382	10,382	10,382

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
The dependent variable is height-for-age Z - score (HAZ) as defined by the WHO. All controls used in Specification (ii) have been included. These are full set of age dummies, control for household size, dummies for male, urban residency, if belonging to backward caste, and if a Hindu. Additionally, fixed effects for district and primary sampling unit are included in all estimations. Father's age, mother's age, father's education, mother's education, father's employment, mother's employment (all conditional on them being present in the household at the time of survey) have also been included. The entire sample has been used for estimation. Robust Huber-White standard errors are in parenthesis.

In the specification that includes all the variables related to TC's simultaneously the coefficient on income reduces by 0.093. In summary, the maternal health channel accounts for 6 per cent ($= \frac{0.141-0.150}{0.150}$) of the variation in income and housing quality and sanitation account for 18.67 per cent ($= \frac{0.122-0.150}{0.150}$). Exposure to media for women explains 10 per cent ($= \frac{0.135-0.150}{0.150}$) of the income effect. Living in a non-infectious environment with safety in surroundings explain only 0.67 per cent ($= \frac{0.149-0.150}{0.150}$) of the overall income effect. All channels together explain 38.67 per cent ($= \frac{0.092-0.150}{0.150}$) of the overall income effect on child health. To reinforce the impact of these channels, we use interaction terms to determine the change in HAZ for children who belong to households with high income and the availability of these household characteristics. Table 4.13 shows that if sanitation conditions are practised in high income households, a child's HAZ will improve by 0.031 SD (0.45 cm).

It should be noted that although our analysis highlights the importance of transmission mechanisms contributing to the health and income gradient, it also demonstrates that ceteris paribus there is still a residual gradient (across our estimation sample) indicating income's potentially "independent" effect on child health.

Table 4.13: Transmission channels and income interaction terms effect for entire sample.
Data source: IHDS-II (2011-12)

Transmission channels						
Log per capita income	-0.184	0.121***	0.117***	0.195***	0.163***	0.209***
	(0.095)	(0.035)	(0.035)	(0.033)	(0.035)	(0.032)
*Maternal health*Income*	0.002***					
	(0.001)					
Housing quality						
Electricity*Income		0.032***				
		(0.008)				
Roof*Income		0.031***				
		(0.006)				
Sanitation						
No open defecation*Income			0.031***			
			(0.007)			
Piped water*Income			0.005			
			(0.006)			
Soap use*Income			0.025***			
			(0.007)			
*Non-infectious*Income*				0.018*		
				(0.008)		
*Media*Income*					0.029***	
					(0.007)	
*Safe neighbourhood*Income*						0.006
						(0.006)
N	10,382	10,382	10,382	10,382	10,382	10,382

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Note: The dependent variable is height-for-age Z - score (HAZ) as defined by the WHO. All controls used in Specification (ii) have been included. These are full set of age dummies, control for household size, dummies for male, urban residency, if belonging to backward caste, and if a Hindu. Additionally, fixed effects for district and primary sampling unit are included in all estimations. Father's age, mother's age, father's education, mother's education, father's employment, mother's employment (all conditional on them being present in the household at the time of survey) have also been included. The entire sample has been used for estimation. Robust Huber-White standard errors are in parenthesis.

4.9 Discussion

This study adopts a new methodological approach to explore the income health gradient by allowing the gradient to vary across income distribution. This is critical in a developing country setting like India (characterised by significant income inequality) where household's allocation of resources towards health can vary based on economic status of households - for example below poverty line households can react differently to an incremental increase in income compared to relatively richer households. We use various specifications of spline regressions to estimate the gradient across different income intervals. One of the key finding of our analysis is that not only gradient varies across different intervals of income (i.e. households respond differently to change in income depending on how much they earn), for some age groups the positive relationship between income and health is observed only after a certain minimum threshold of income. There are two other major findings from our analysis. The first finding is that an increase in income, on an average, is associated with a decrease in prevalence of stunting and reduced probability of anthropometric failure in Indian children. The second finding is that maternal health, housing quality, sanitation, non-infectious environment, media exposure to women, and safe neighbourhood are critical factors underlying this positive income effect and explain almost 40 per cent of the overall income effect in our sample.

One of the major implications of our findings is that any policy to increase income in poor should be complemented with a health policy designed specifically towards children from this poor cohort as poor households are less likely to allocate additional income to child health. Another implication is that any government policy designed at improving sanitation, safe housing or maternal health has potential to improve child health.

To explore one such pathway, we conducted a trial with a study population where high burden of undernourishment has been reported. Details of the study are reported in the following chapter.

Chapter 5

Impact of nutritious supplement on child health: Evidence from a randomised controlled trial

~ Cluster randomised control trial

5.1 Introduction

In this chapter, we discuss a Cluster Randomised Trial (CRT) based on the second theme identified in section 1.5.2. MCGM (2009) in an exclusive human development report studied the visible economic disparities of the city of Mumbai. Thus, making it an ideal ground for understanding the interplay of governance, poverty, nutrition abatement initiatives, and working with sections of the society that are on the periphery of development. We focused on providing an alternative to THR that was localised and suited the dietary preferences of the population we worked with in Dharavi, Mumbai.

Our aim was to study the efficacy of micronutrient fortified supplementary food by analysing the improvement in standardised z-scores. These supplements were made specifically for moderately wasted children as an alternative to the existing THR. We collected data over a period of one year starting from enrolment of children in each phase of the study to the end of follow up period for respective phases.

The main highlights of this trial are as follows. First, we collaborated with the ICDS, a municipal hospital, and an NGO. The partnership intentioned to propose a community based model for management of moderate acute malnourishment in children upto the age of 5 years. Consultation with the government helped identify the target group; if MAM children are neglected due to the absence of apparent symptoms the likelihood of growth slippage into SAM category also increases.

Secondly, the food supplements were developed adhering to the prescribed RNI and RDA (discussed in sections 1.2.1.2 and 2.4), carefully including the micronutrients in appropriate amount, while customising it to the needs of children below the age of 5 years. All the supplements were localised and nutrient dense such that smaller portions would suffice the dietary requirement per day as per WHO and FAO norms (WHO-FAO, 2006).

Thirdly, we once again choose an objective measure, WHZ, as the primary outcome measure. Other than anthropometry data, socioeconomic data was collected through a paper based interview at the time of enrolment into the study.

Lastly, the analysis conducted as a part of this thesis follows the person centred treatment (PeT) effects estimation outlined in a paper by Basu (2014).

This chapter proceeds as follows. A review of similar studies done in India and other developing countries has been presented in section 5.2, also briefly considering the controversies surrounding Ready To Use Therapeutic Food (RuTF) supplementation. Section 5.3 informs about the advantages of a CMAM approach. Section 5.4 reports the methods followed as per consolidated statements for reporting trials (CONSORT) guidelines. In section 5.5, baseline characteristics, econometric specification, and the advantages of estimating PeT has been presented. Section 5.6 discusses the results and section 5.7 concludes this chapter.

5.2 Urban malnutrition

Urban malnutrition—largely unnoticed—is on a steady rise, stemming from rapid urbanisation, increasing urban poverty, and inadequate availability of high quality health care. Specific sections of marginalised communities, such as slum dwellers, not necessarily in the low-income category, record a high rate of malnutrition, mostly due to low standards of living and an improper diet. Affordable housing is among the prime drivers for rising urban settlements (Planning Commission, 2011). According to the Census (2011) these are defined as residential areas typified by over crowding, narrow streets, dilapidation, poor arrangement and building design, lack of light and ventilation, and below par sanitation.

Latest estimates for proportion of households in urban settlements is 17 per cent across India and that for Mumbai alone is 41 per cent (Chandramouli, 2011). There is an emerging human development crisis in these informal settlements as well, where continuous inter city/town migration in search of livelihood has debilitating effects on the nutritional status, especially of neonates, children, and women.

A study by Bentley *et al.* (2015) recorded data for 7,450 children from 40 informal settlements of Mumbai. Out of all the children, 45 per cent were stunted and stunting rose steadily from 15 per cent in 1 year olds to 56 per cent for children aged 5 years. Overall, 16 per cent were wasted and 4 per cent were overweight.

5.2.1 Nutrition supplementation and child feeding

Mitigation of poor nutrition has been reported in studies from countries in Africa, South Asia, South East Asia, and Latin America (some from the Carribean islands too). Review by (Rivera *et al.*, 2003) furnishes results from randomised and placebo control trials of single micronutrient and multiple-micronutrient supplementation on child growth. Fortification of food from animal/plant sources were also among lines of treatment followed in experimental trials.

In most studies supplementation of a minimum of 8 weeks is mandated to observe a change in standardised measures like z-scores and be statistically detectable as well. Since the outcomes are dependent on prior health burden, sample sizes, study design, and other pragmatic community specific considerations, varied results emerge from such trials. Most studies report increased rate of weight gain (for example, effect size for WAZ~ 0.36), reduction in risk of stunting (mean change in height was 0.7 cm for treated children), and changes in arm circumference. A few studies from Kenya, Indonesia, and Benin observed no change in children who were already anaemic (Rivera *et al.*, 2003).

Within the framework of a food distribution programme, Ready to Use Supplementary Food (RuSF) was employed for prevention of wasting in 6-36 months old children in Chad (Huybregts *et al.*, 2012). Haemoglobin concentration improved by +3.8g/l ($p<0.001$) and a modestly higher gain in height-for-age (+0.03 z-score/month; $p<0.001$) in children assigned to the treatment group. However, Huybregts *et al.* (2012) found no statistically significant reduction in cumulative incidence of wasting (incidence risk ratio: 0.86; $p= 0.25$).

Specifically aimed at MAM children, Lagrone *et al.* (2010) proved that locally produced soy/peanut RuSF was more effective than the standard Corn/soya blend (CSB) in rural southern Malawi. Measured in terms of recovery rates of the 2,417 children enrolled, 80 per cent recovered, 4 per cent defaulted, 14 per cent remained moderately wasted, while 3 per cent developed SAM. Intervention in the Lagrone *et al.* (2010) study cost USD 5.39 per child.

In Chandigarh, a union territory of India, apart from the supplementary nutrition received by children from AWCs, Shewade *et al.* (2013) also provided indigenous RuTF in a CMAM programme for uncomplicated SAM children between 6 months-5 years of age. The WHO-UNICEF guidelines based RuTF (blend of oils, sugar, skimmed milk power, roasted peanuts, and micronutrients) resulted in an average additional increase in weight by 13g/kg of baseline weight/week/child for the intervention group.

Among all feeding protocols, the IYCF indicators (WHO, 2008) capture the unawareness amongst mothers from a low socioeconomic status. In a study by Bentley *et al.* (2015) referred to earlier as well, early initiation of breast feeding was for only 43 per cent babies in informal settlements of Mumbai. As also impressed upon in section 2.3, breastfeeding and appropriate complementary feeding are the mainstay of good practices for child feeding. In informal urban settlements, ignorance, maternal illiteracy are prime influencers of poor feeding (Kuriyan and Kurpad, 2012). A community based, cross-sectional study from Bankura, in West Bengal assessed the IYCF practices and found that close to 20 per cent deaths of under 5 year olds could be prevented if all IYCF indicators were achieved (Sinhababu *et al.*, 2010). In our study as well, as will be shown later, certain aspects of the IYCF have been captured through the socioeconomic survey.

5.2.2 Debates around type and need for supplementation

The intensity of contradictions around the type of supplementation that must be promoted around the world has magnified over the past one decade. Whilst effort to control malnutrition levels invites solutions from many scientific quarters, there is also a widening debate over medicalisation and marketisation of products meant for treating malnourished children. Evidence from Black *et al.* (2013) has already indicated that 45 per cent deaths in children under 5 years of age is due to undernutrition, thus, this emergent development policy debate needs a framework that promotes indigenisation of products suited for the needs of the target group (Robinson, 2016).

In a position paper by a Working group for children under six (2009), primarily comprising Indian paediatricians, there is widespread opposition against import of products to feed children (especially for SAM). Recommendations include localisation of regionally available products for preparing formulations for the already medically weak children. These suggestions make way for better nutrition security, encourage local agricultural practices, and use of millets (*ragi*). Moreso, there is decentralisation and allows control by community.

For the Indian scenario, cost effectiveness, affordability, and sustainability of such products determine the success rates of programmes based on supplementation. Discussions in section 2.4 detailed the onus on THR and meals at AWCs through ICDS as a sought after mechanism for benefitting vulnerable target groups like children, adolescents, and pregnant and nursing mothers. Our study in this light possesses salient features of promoting indigenisation of products while also adhering to RNI and RDA (section 2.4, Golden (2009), and (WHO-FAO, 2006)).

5.3 CMAM for moderate acute malnutrition

Most CMAM programs focus on treating SAM and include only provision of supplementary food for MAM children, partly due to the absence of normative global guidance for the MAM management instrumented by the community only. MAM children have a 3 times higher risk of dying than a well nourished child, compared to SAM, where the risk of dying is 9 times higher (Olofin *et al.*, 2013).

In this project, on consultation with the Government of Maharashtra, Micronutrient Fortified Food (MFF) was provided to children in the MAM category. The aim to do so is incorporating MAM management and prevention a priority area either through a dedicated CMAM approach itself or through forward linkages with complementary programs. We have focussed on treating children diagnosed with MAM to reduce the burden of severe malnutrition on the community. All guidelines enshrined in the CMAM (UNICEF Evaluation office, 2013) encompass the following:

- Community outreach and mobilisation;
- Outpatient management of SAM without medical complications;
- Inpatient management of SAM with medical complications; and
- Services or programmes to manage MAM such as supplementary feeding program

Burza *et al.* (2015) in a first conventional CMAM project in India, achieved low mortality and high cure rates in non-defaulting children from Bihar admitted to the study for the treatment of SAM. This study focussed on children from SC/ST and OBC families. In principle, CMAM acknowledges prolonged treatment and ambulatory care. More than 50 countries use this model for first line treatment of SAM, while other than Odisha and Rajasthan, all states have only approved the in-patient care model for SAM (Emergency Nutrition Network, 2012).

In this study, as the focus was on MAM management, all SAM children were referred for in-patient care, while some novel aspects were:

- Training of AWWs and helpers of AWCs on using all scales and balances, measurement tapes, and recording data (apart from training by ICDS);
- nutrition counselling during all follow-up visits;
- demonstration on handwashing and boiling water;
- usage of only locally available ingredients for development of formulations followed by sensory evaluation by children
- variety in products (consistency and taste); and

- home visits

5.4 Methods

The reporting of methods adopted follows the CONSORT guidelines (Campbell *et al.*, 2012) and (Schulz *et al.*, 2010).

5.4.1 Study setting

The study was set in Dharavi. Located in Mumbai, it is Asia's largest slum, originally inhabited by fishermen since the 18th century. Presently, it spreads across 2.165 km^2 with an estimated population between 6,00,000 to 10,00,000. Historically, Dharavi's development is closely entwined with migratory pattern; making it one of the most multi-religious, multi-lingual, and multi-ethnic communities. In a setup such as this, socioeconomic development has consistently posed challenges, thus drawing attention to the pressing need to solve some of Dharavi's daunting problems.

In Mumbai, as per the latest predictions of the NFHS-IV, the prevalence of malnutrition in children below the age of 5 years is 26 per cent NFHS 4 (2017). It has been recognised that urban malnutrition is turning into a serious concern, with high under five mortality rate being recorded in urban areas. Table 5.1 shows the various indicators that provide an insight into current standards of child health in Mumbai. In 2015-2016, of the children being breastfed between 6-23 months of age 49.8 per cent of children received an adequate diet. Lack of diet diversity and deficient awareness about child feeding practices is reflected, as only 3.5 per cent of all children in the 6-23 months category receive an adequate diet.

Table 5.1: NFHS-IV (2015-16) child health and nutritional status indicators for Mumbai.

Indicators	Percentage
Breastfeeding children age 6-23 months receiving an adequate diet	49.8
Total children age 6-23 months receiving an adequate diet	3.5
Stunted (height-for-age)*	25.5
Wasted (weight-for-height)*	25.8
Severely wasted (weight-for-height)*	7.0
Underweight (weight-for-age)*	22.7
Institutional births in public facility	56.3
Children age 12-23 months fully immunized (BCG, measles, and 3 doses each of polio and DPT)	45.6
Children age 12-23 months who have received 3 doses of Hepatitis B vaccine	45.9

* indicates children under 5 years of age
Inputs from NFHS 4 (2017)

5.4.2 Study design

The study has been reviewed by Institutional Ethics Committee of Lokmanya Tilak Municipal Medical College and Lokmanya Tilak Municipal General Hospital (LTMGH). The trial was registered at `ctri.nic.in` (registration number CTRI/2017/08/009260). The project was undertaken by four partners, Indian Institute of Technology Bombay (IITB), LTMGH, ICDS Dharavi, and Society for Nutrition, Education and Health Action (SNEHA). A cluster randomised controlled trial comparing MFF with THR, to understand its effectiveness on MAM children on parallel assignment was conducted. The unit of randomisation was a cluster comprising AWCs.

The study began in April 2016 (planning and ethics clearance onwards) and ended in July 2017 (end of follow-up for third phase). Each phase was 6 months long, involving 3 months of food-product based intervention followed by 3 months of follow-up. For ease of implementation and production feasibility of MFF, the phases overlapped, however, each phase had different clusters, thus at any given point in the study, only clusters from the same phase were at a similar stage. For example; if in phase 1 intervention was rolled out, children from clusters of phase 2 were being enrolled into the study. A total of three such identical phases were spread over one year. In this collaborative effort, children in the age group of 6-60 months were enrolled into treatment (T) and control (C) groups. They were divided into two age categories; a.) 6-24 months (6m to 2 years) and b.) 24-60 months (2 years to 5 years). We decided to make two age categories as all the MFF were developed according to age group. Details are discussed in section 5.4.6.

The four main reasons for choosing this design were two fold. First, in each phase due to the nature of intervention, all T clusters were geographically closer and all C clusters were in a separate location. Secondly, if there was a T cluster near a C cluster, they would have been assigned to separate phases. As explained earlier, no two phases were at the same stage in the study. Therefore, each phase was a parallel assignment. Thirdly, our field partners suggested that implementing in parallel in each phase is more viable on ground. Lastly, results from parallel design are easier to interpret compared to other designs like step-wedge trials which also need a larger sample size (Moulton *et al.*, 2007). Moreover, community intervention trials must be tailored according to practical issues that arise on the field (Gail *et al.*, 1996). We specified WHZ as the primary outcome for this study. As per definition, WHZ is an acute measure and is used to classify children as MAM/SAM.

5.4.3 Sample size calculation

Extensive use of CRT for assessing impact of interventions has led to various possibilities for analysis and design of these trials. We draw on the methodologies reviewed in Rutterford *et al.* (2015) which comprehensively describes the options available for sample size calculations.

In a CRT, a group, instead of individuals are randomly allocated to treatment and control arms. The rationale behind cluster randomisation is structured around their ability to introduce an intervention to a group that either resides in a specific area or receives healthcare services from the same clinic/centre (Eldridge and Kerry, 2012). In the case of this study children from a cluster visit different AWCs that are only about 50-100 m apart. Therefore, each cluster represents a group exposed to similar external conditions. As suggested by Donner *et al.* (1981), sample size for a CRT can be calculated as per individual randomisation while inflating it by a Design Effect (DE) to reach the required statistical power under cluster randomisation. DE is given by:

$$DE = 1 + (n-1)\rho \tag{5.1}$$

where, ρ is the Intra-cluster Correlation (ICC) and n is the number of individuals per cluster. The final sample size was calculated as per the equation 5.2:

$$n = \frac{t^2(p)(1-p)(DE)}{d^2} \tag{5.2}$$

where; n is sample size in each arm of the study, t is $(Z_{1-\frac{\alpha}{2}} + Z_{1-\frac{\beta}{2}})$ equal to 2.045 at 0.05 level of significance and 80 per cent power, p is expected prevalence (fraction of 1), d is relative desired precision (fraction of 1), and DE is design effect for cluster surveys. In our study, we aimed to recruit a total of 150 children in each group, considering drop-out rate of 25 per cent. Thus, the final sample size was calculated as:

$$n = \frac{2.045^2 * 0.09 * 1.5}{0.075^2} \tag{5.3}$$

Given an expected prevalence of MAM to be 10 per cent (as per data from municipal hospital), DE of 1.5, ICC equal to 0.05, assuming 10 children per cluster, and the relative desired precision of 7.5 per cent as showed in equation 5.3, n was equal to 100 in each arm of the study.

5.4.4 Eligibility criteria and enrolment

Fo recruiting children in the field, a screening was conducted before the beginning of the study. The field level inclusion criteria was being registered in the AWCs and being aged between 6-60 months. Information pertaining to the age, sex, weight, height, and MUAC was collected in screening forms. Children identified as MAM by AWWs and field workers were referred to the enrolment centre, the Nutrition Rehabilitation Research and Training Centre (NRRTC), LTMGH. The children identified as SAM were referred for in-patient treatment, while those who were normal, were excluded. The screening phase assessed a total of 9,166 children. 3,000 children did not meet the field level inclusion criteria. 575 children from the T clusters were referred to the enrolment centre, while 251 were referred from the C clusters at the time of screening.

At the beginning of each phase, an informed consent was taken from parent(s)/guardian of each child. The enrolment inclusion/exclusion criteria is presented in table 5.2.

Table 5.2: Inclusion/exclusion criteria for enrolment into the study.

Inclusion criteria	**Exclusion criteria**
Registered at an AWC	Not registered at an AWC
WHZ between -2 and -3 SD and/or MUAC between 115-125 mm	WHZ <-3 SD and/ or MUAC <115 mm (SAM) or Normal (WHZ >-2 SD) or MUAC >125 mm
Age at enrolment between 6-60 months	Age at enrolment below 6 months or above 60 months
No chronic disease/syndrome/ major illness as certified by physician	Presence of chronic disease/syndrome/ major illness as certified by physician

WHZ and MUAC as per WHO standards

At the time of enrolment at NRRTC, a dietitian, a public health nurse, and a medical physician were responsible for taking anthorpometry measurements, assessing for any medical condition, and interviewing the parent(s)/guardian. At this point a socioeconomic questionnaire with information related to household and parental characteristics, medical history of child, breast feeding, and immunisation history of the children was obtained. A total of 186 children were assigned to the T group and 138 to the C group. During the follow-up phase, 38 children and 27 in the T and C group, respectively, were considered drop-outs since they were not available for weekly anthropometry for a period of 4 weeks continuously. Finally, a total of 259 observations were considered for analysis. During the analysis, 6 more observations, 3 each from each group were further dropped due to error in measurement of the height and weight values. Final sample size attained is 145 in T group and 108 in C group (Figure 5.1).

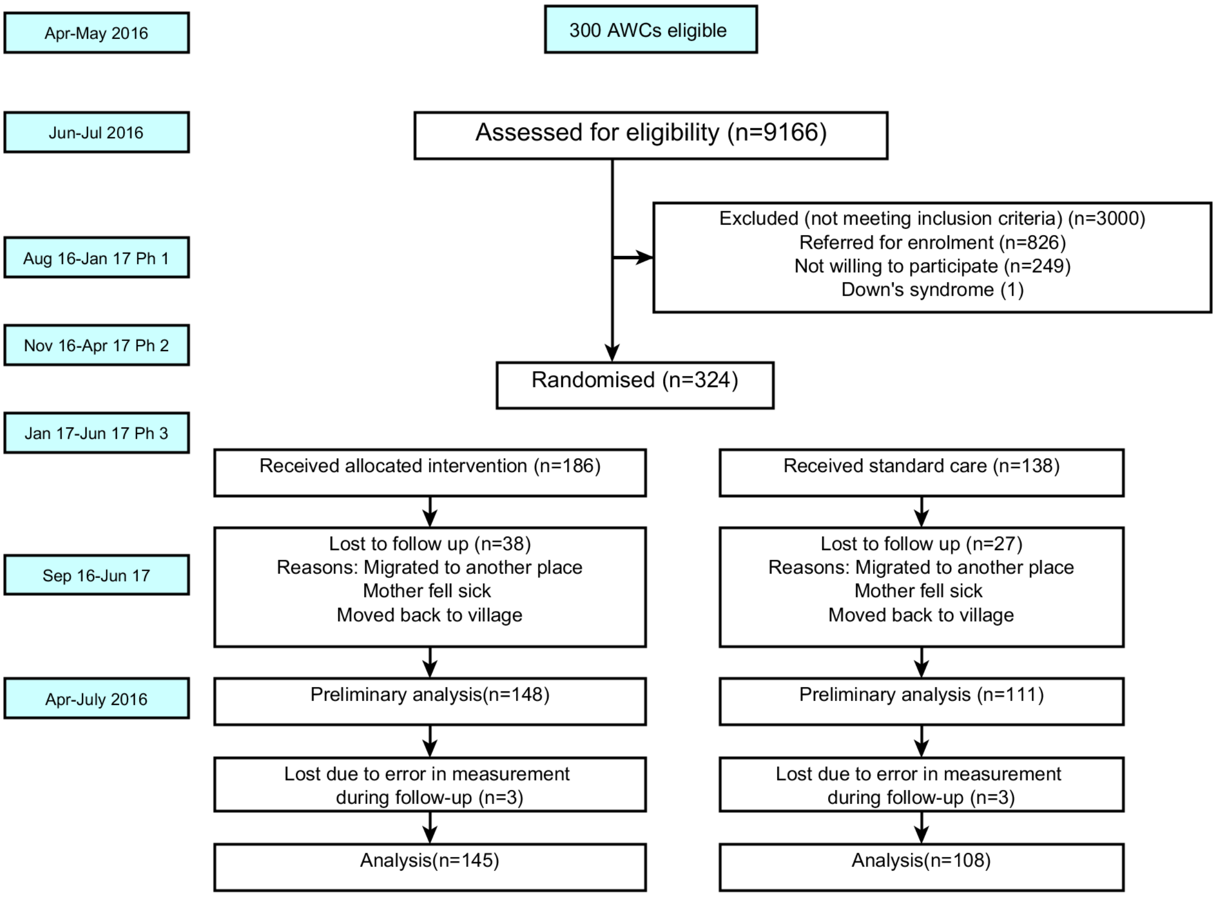


Figure 5.1: Flow diagram of the progress through the cluster randomised trial of two groups.

5.4.5 Procedures for randomisation

From a total of 300 AWCs, all the 121 AWCs chosen for the study were grouped into 19 clusters. For convenience in implementation, the entire study was carried out in three phases. The allocation ratio was 1:1 in the first two phases of the study, i.e., 3 clusters in the treatment group and 3 clusters in the control group. In the third and final phase, 4 clusters were assigned to the T group, while 3 were assigned to the C group. Totally, 64 AWCs were in T group, while 57 in the C group. A team of two persons not involved in the data collection process assigned computer generated random numbers to all 300 AWCs. AWCs corresponding to the first 121 random numbers were chosen. AWCs that were geographically closer to one another were then grouped into clusters. Each cluster on an average had 10 AWCs. Each cluster was then assigned to either a treatment group or control group. For this purpose, once again random numbers were assigned and alternatively clusters were allocated to the T/C group. Each child's AWC number would be known at the time of enrolment, which would categorise them either as a part of the T or C group. To enable effective visualisation of the location of all AWCs enrolled in the project, a mapping exercise was carried out. All 121 AWCs were visited to record the coordinates and a map was created using a Geographical Information System (GIS) platform.[50]

5.4.6 Intervention

Intervention involved the provision of food supplementation, MFF (food developed for the project) for a period of 13 weeks (approx. 3 months) in place of THR (regular soya based and green gram based) to T group children, succeeded by a follow-up phase of 12 weeks (approx. 3 months). This was done by coordinating with the ICDS functionaries, while all the ICDS's services listed in section 2.4 continued.

Large scale production of food products was done by a third party food manufacturer. The food products were packed in a thick, metallised, and sealed aluminium pouch. Since each child was to be given 1 product per day, 7 of such sealed food packets were packed in a larger 7-in-1 sealed plastic bag. This ensured ease of transportation and distribution.

Each 7-in-1 pack for a 6m-2y old child was marked with a pink sticker and contained the following products inside; one packet each of *Upma* premix, *Ladoo* premix, wheat *payasam* premix, *kheer* premix, *ragi* porridge pre-

[50]This map is available in Figure 4 in Annexure 1.

mix (Ready to Cook (RTC)) and two packets of Multi grain flour paste (Ready to Eat (RTE)). For the younger age group, products were mostly pasty and semi-solid in consistency.

Each 7-in-1 pack for a 2y-5y old child was marked with a yellow sticker and contained the following products inside; one packet each of *Upma* premix, *Ladoo* premix, *zunka* premix (RTC); Multi grain flour paste, *mathri*, *shakarpara* and *nankhatai* (RTE). For the older age group, a combination of semi-solid and finger foods were chosen.

These variations were introduced after recommendations made by paediatricians and nutritionists. As discussed in chapter 3, palatability of THR was reported as an issue, which led to the formulation of multiple variations based on RNI. In the ICDS office, these packs were transferred into steel trunks, under the supervision of ICDS supervisors/LTMGH staff/IITB staff. Two steel trunks were placed for storing the food packets (one marked pink for storing packets of 6m-2y old children and the other yellow for storing packets of 2y-5y old children). Every week, each AWW was asked to collect the packets from the ICDS office for MAM children enrolled in the project. Local field coordinators from the partnering NGO were responsible for community mobilisation and encouraging mothers/parents/guardians to comply with the feeding norms.

In each phase, C group children were being fed THR as per standard protocol of the ICDS. After the end of treatment period, T group children reverted to the standard procedures as well.

5.4.7 Documentation of intervention delivery

A team of ICDS supervisors separate from the data collection team or the field NGO recorded the distribution of MFF packets to the AWWs each week. Weekly documentation was supervised by project team from IITB. Only the required number of sealed packets (after considering drop outs) were given to each AWW to prevent excess consumption or leakage into C clusters.

To monitor compliance, feedback forms (designed pictorially) were distributed to both the study arms. Mothers/guardians/parents were asked to provide information on amounts and frequency of consumption of both the MFF and the THR, as well.

5.4.8 Hurdles crossed and course correction

During the implementation several community level challenges were posed. At the beginning, mothers reported that cooking demonstrations of the RTC products would assist them in complying with the feeding protocol. The nutritionist in our team conducted demonstrations for each cluster and counselled mothers about hand washing, boiling water, and hygienic storage practices. Course correction also involved reducing quantities of certain condiments from a few products like *zunka* and *upma* premixes. Despite an extensive sensory evaluation exercise, MFFs needed to be customised after the start of the trial.

We received complaints from AWWs regarding unwillingness of fathers and older men to allow their children to consume MFF. This was handled by organising special community level counselling sessions with all the parents. Additionally, our field NGO team, IITB team, and the ICDS conducted regular monthly meetings to track progress and receive feedback from AWWs.

5.4.9 Anthropometrics

Standard procedures for anthropometric measurements were followed. All WHO standards were used to calculate z-scores. We took weekly measurements of height, weight, and MUAC during the six month period of each phase. During the follow up period, anthropometry was also done once every month at the enrolment centre. If a child was found to be absent on the day of measurement, her/his data was collected within a window of 2-3 days. Even so there were instances when children were not available each week. Only if data was not collected for a child for 4 weeks continuously, we considered them as drop outs. Weight was measured using the NBY-30 baby weighing scale for smaller children (6m to 2y) having a maximum capacity of 30 kg. For the older children (2y to 5y), a standard digital weighting scale was used. Recumbent length of children younger than 2 years was measured by an infantometer with 1mm increments. Height for children aged more than 2 years and more was measured by a BioPLus stadiometer. MUAC tapes (S0145620) were used for measuring arm circumference. All equipments were maintained and calibrated by the study team each month.

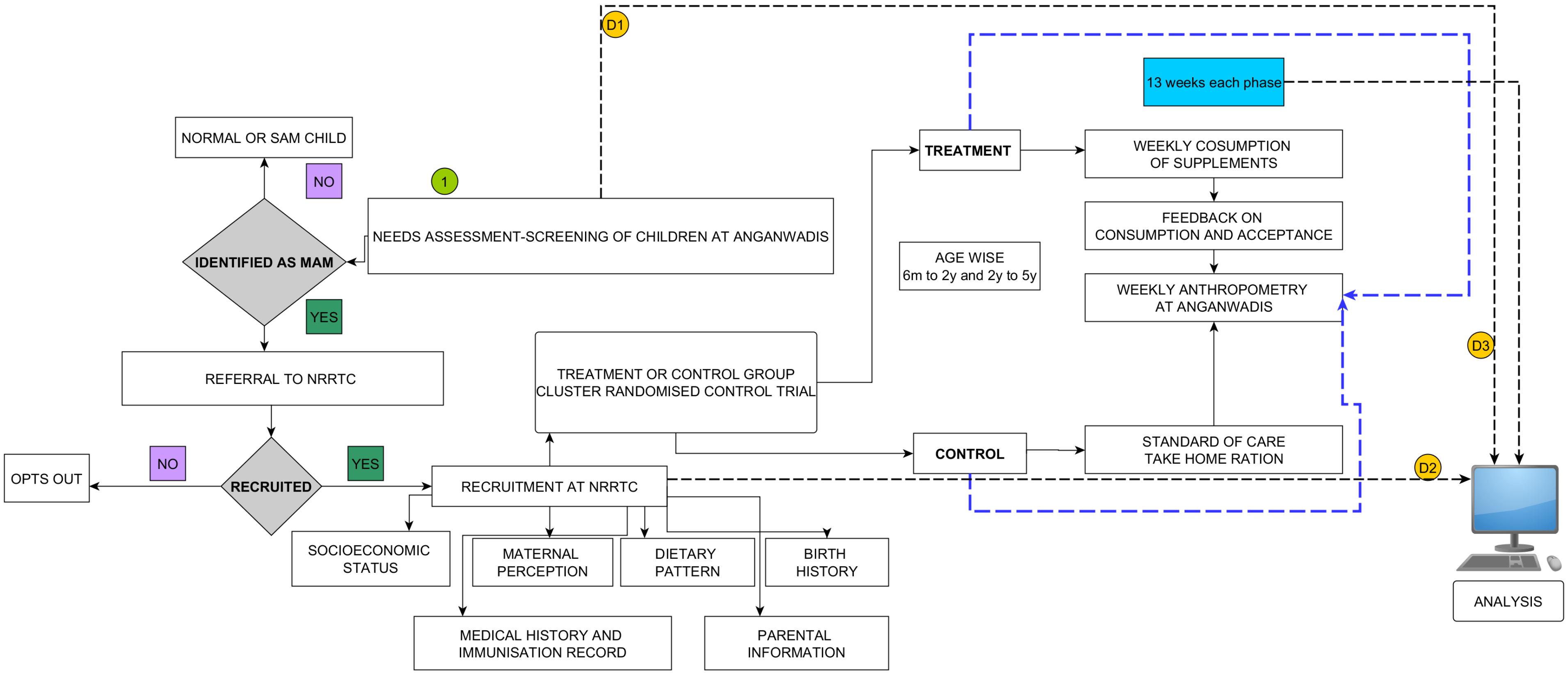


Figure 5.2: Process flow of intervention indicating an overview of the methodology. 1 is the starting point. Dashed blue lines indicate iterations over 13 weeks. Dashed black lines indicate data, D1, D2, and D3.

5.5 Empirical analysis

5.5.1 Identifying individual treatment effects

In this MFF supplementation study, we obtained data for children with highly diverse characteristics, thus making the sample heterogeneous. The aim of our analysis is to estimate individual level response to treatment provided during the intervention. Usually, intention to treat analysis fails to capture individual level behaviour (Basu, 2014). We hypothesise that, at the end of treatment (nutritious supplement in this study), there would be an impact on the child's nutritional status (based on anthropometry) which will vary as per individual level characteristics, observed variables, and unobserved factors. Therefore, the mean value may be misleading and heterogeneity in treatment effects cannot be determined. In order to capture the extent to which an alternative for THR is correlated with reduction in MAM incidence rate, we employ a new method to improve upon the existing post hoc methods.

In most randomised settings, Conditional Average Treatment Effect (CATE) or the mean effects of the treatment is conditioned on observed characteristics. Estimating individual level treatment effects is possible by employing a local instrumental variables (LIV) approach developed by Heckman and Vytlacil (1999), Heckman and Vytlacil (2001), and (Heckman and Vytlacil, 2005). LIV methods explore treatment level heterogeneity across both observable characteristics and unobserved factors (Basu, 2014). Additionally, all mean level treatment effect parameters such as average treatment can be computed from PeT effects without using weights. We leverage the advantages of the LIV method to also account for unobserved factors. The next section describes the data, the variables chosen for analysis, and the econometric technique in detail.

5.5.2 Data

5.5.2.1 Outcome variable (Y)

The primary outcome was WHZ at the end of each month from enrolment. We obtained data for 7 time periods for each child.[51] Each month's data in the treatment period (first three months) and follow-up period (next three months) was an average of the four weeks the child was monitored by field NGO coordinators and the AWWs. The WHZ calculated and adjusted for age in months was bounded at -5 to +5 (de Onis *et al.*, 2006).

5.5.2.2 Treatment indicator (D)

In our study we compare two different types of food supplements, one developed specifically for the study (MFF) and the other, THR, supplied by the government. The treatment group children were given MFF and the control group children were provided THR. The treatment indicator takes a value of 1 and 0, otherwise. The treatment indicator is likely to be endogenous for two reasons: the severity of the MAM condition is not completely observed as we have data on cross sectional characteristics. Thus, we do not observe the manner in which the nutritional status is changing. Second, general food preferences (dietary changes), hygiene, variation in living conditions are also unobserved, which again are correlated to the change in the

[51] Seven time periods include; a.) enrolment, b.) end of first month, c.) end of second month, d.) end of third month, e.) end of fourth month, f.) end of fifth month, and g.) end of sixth month. As the time between enrolment and beginning of treatment is approximately one month, we have seven data points for each child

outcome, WHZ.

5.5.2.3 *Covariates* (X_o)

Table 5.3 shows the covariates in the analysis. These include the age of child in months, a dummy for male, and an indicator that takes a value of 1 if the monthly household income is equal to or more than INR 10,000 (~USD 150). We also include controls for the parents' education level which takes a value for 1 if the father has completed 10 or more years of schooling and another indicator for mother's education, which takes a value of 1 if she has completed 5 or more years of schooling. We control for the presence of a toilet within the household, as well. We also control for time fixed effects.

Table 5.3: Definitions of covariates.

Variable	Definition
Age	Age in months for each child
Male	Dummy variable=1 if child is male; 0 otherwise
Income	1 if monthly household income>= INR 10,000; 0 otherwise
Father's education	1 if father has completed >=10 years of schooling; 0 otherwise
Mother's education	1 if mother has completed >=5 years of schooling; 0 otherwise
Toilet	1 if toilet is within the house; 0 otherwise
Time effects	Dummy for each time period

WHZ and MUAC as per WHO standards

5.5.2.4 *Instrumental Variable (IV)* (Z)

The main purpose of using an instrument is to address endogeneity. We use the 'number of adults' in the household as the instrument. The reasons for choosing this as an IV are the following: the adults do not consume the supplement but are responsible for feeding the children, second, the number of adults is a proxy for care given to the child at any point during the treatment. Thus, it is directly correlated with the treatment. An important property of the instrument is to satisfy the exclusion restriction. Therefore, the instrument must not be correlated with the outcome directly or be only partially correlated.

Concerns regarding contamination in the IV have been addressed by including levels of education of parents and household income as controls. Additionally, we account for the time fixed effects, as well. We study all properties of the instruments after conducting the tests as recommended by Stock and Yogo (2002) and find that it meets the criteria for a fairly strong instrument in this context.

5.5.3 Econometric technique

We follow Basu (2014) and begin by denoting two treatment states—the treated state shown by $j = 1$ and the control state by $j = 0$. The potential individual outcomes will be Y_1 for treated and Y_0 for untreated. The assumptions are as follows:

$$Y_1 = \mu_1(X_o, X_u, v) \tag{5.4}$$

where, X_0 is a vector of observed random variables; X_u is a vector of unobserved random variables, which are also believed to influence treatment selection (unobserved confounders); and v is an unobserved random variable which captures remainder of the unobserved random variables. $(X_o, X_u) \amalg v$ and $X_o \amalg X_u$, where $\amalg$ stands for statistical independence. We also assume that individuals will be in a state 1 or 0 before realising the outcome according to

$$D = 1 \text{ if } \mu_D(X_o, Z) - U_0 > 0 \tag{5.5}$$

where Z is a nondegenerate vector of observed random variables (instruments) influencing the decision (assignment) equation but not the potential outcome equations, μ_D is an unknown function of X_o and Z, and U_D is a random variable that captures X_U and all the other remaining unobserved random variables influencing assignment. Under assumptions of independence and monotonicity needed to interpret IV estimates, as mentioned in Heckman and Vytlacil (1999), equation 5.4 can also be written as:

$$D = 1 \text{ if } P(X_o = x_o, Z = z) > V \tag{5.6}$$

where $V = F_{U_D}\big(U_D|X_o = x_o, Z = z\big)$, $P(x_o, z) = F_{U_D|x_o}\{\mu_D(x_o, z)\}$, and F represents a cumulative distribution function. Thus, for any arbitrary distribution of U_D conditional on X_o and Z, by definition itself, $V \sim$ Unif[0,1] conditional on X_o and Z. Under IV assumption Mean Treatment Effects (MTE), can be identified by

$$\frac{\partial(Y|X_o = xo, Z = z)}{\partial p} = E_v\Big\{\big(Y_1 - Y_0|X_o, V = v\big)\Big\} = \mathrm{MTE}(x_o, v) \tag{5.7}$$

where $Y = D \times Y_1 + \big(1 - D\big) \times Y_o$ is the observed outcome and $v = P(x_0, z)$.

Basu (2014) explains further the extension of the LIV methods to identify PeT effects, which, for persons who are in treatment follows,

$$\begin{aligned} E_{X_U|X_o,P(Z),D}E_v\Big\{Y_1 - Y_0|x_o, P(Z), D = 1\Big\} &= E\Big\{Y_1 - Y0|x_o, V < P(z)\Big\} \\ &= P(z)^{-1}\int_0^{P(z)} MTE(x_o, v)dv \end{aligned} \tag{5.8}$$

For the untreated individuals the conditional effect is obtained by integrating MTEs over values of V greater than P(z).

We estimate the PeT effects by first, running a first stage regression of D against X (covariates) and instrument (Z) by using a logit model. We predict the propensity score $\widehat{p}(x,z)$ for every individual, and select only those observations that have mass rounded at a particular value. We specify a linear regression model $g(Y) = \alpha_o + \alpha_1 X + \alpha_3 \times \widehat{p} \times X + K(\alpha;\widehat{p})$. The link function is linear and polynomial function of $\widehat{p}(x,z)$, $K()$ were determined using goodness-of-fit tests. We run the second stage LIV for the outcome Y. Following numerical integration for each observation PeT effects are calculated. We average the PeT effects over all observations to get an empirical estimate of the Average Treatment Effect (ATE). Upon averaging PeT over $D = 0$ and $D = 1$, we obtained the effect on the treated (TT) and the effect on the untreated (TUT), as well. To calculate the standard errors for individual PeT effects, we bootstrapped over 1,000 replicates for each observation [52]

5.6 Results

Summary statistics of our sample is shown in table 5.4. There were 48 per cent boys in the T group and 46 per cent in the C group. Approximately 68 per cent fathers had completed at least 10 years of schooling, while about 80 per cent of the mothers had attained primary level education, in both the groups. 62 per cent households reported having stayed in the same city for a minimum of six years in the treatment group. Both groups have close to 70 per cent households above the poverty line while about 25 per cent had

[52] The *petiv* command is a available in the STATA package for running the final PeT effects estimation.

toilets within their homes. In both groups, more than 90 per cent of the households reported the average monthly income to be greater or equal to INR 10,000.

Considering child specific indicators, average birth weight was reported to be around 2.5 kg in both, treatment and control group, 95 per cent of them were given colostrum and 99 per cent were breastfed (at least for a month). For the children aged 6m to 2y, for 75 per cent of our sample, breast feeding was ongoing. For children over 2 years of age, only 26 per cent of the T group children were breast fed for a full 2 years, while in the C group complete breast feeding for a full two years was done for 21 per cent of the children. In this study, on an average, we observed that enrolled children were second born. Moreover, all the mean z-scores indicated wasting in both groups.

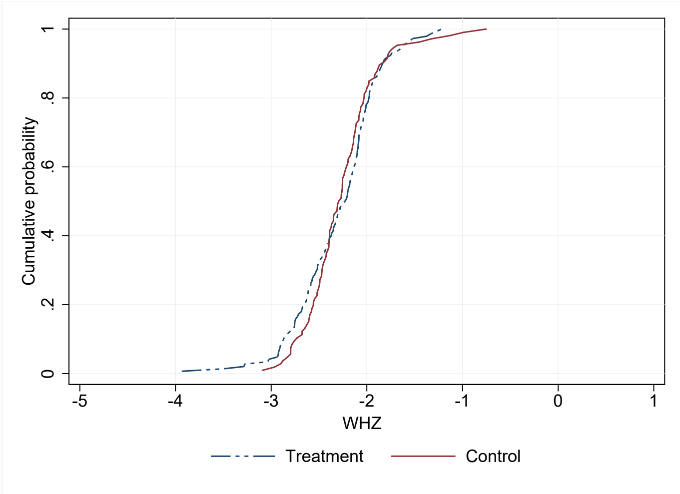
Figure 5.3 plots cumulative probability of WHZ and shows the variations in WHZ over three time points in the study, namely; enrolment, end of treatment, and end of follow-up. We begin by discussing results from the treatment group. First, at enrolment (figure 5.3a) all children were in the MAM category either by WHZ classification or by the MUAC criterion. After 13 weeks (treatment period) we see an improvement in z-scores with 60 per cent of the population moving into the normal category (z -score greater than -2 S.D.) in the treatment group (figure 5.3b). At the end of follow-up (figure 5.3c), about 40 per cent of the children have z-scores less than -2 S.D., while about 50 per cent of the children remain in the normal category.

Observing the cumulative plots for the control group children, we found that after end of the 13 weeks, i.e., feeding of THR, 40 per cent of the children moved into the normal category. While, after follow-up period, the children in MAM category remained close to 62 per cent.

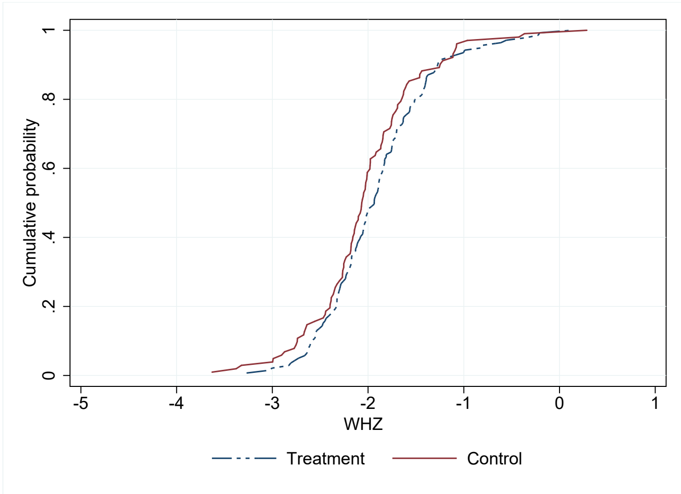
Table 5.4: Summary statistics of study sample of children enrolled in CRT at Dharavi.

Variable	Mean	Std. Dev.	Mean	Std. Dev.
	Treatment		Control	
Demographics				
Male child	0.48	0.50	0.46	0.50
Age in months	29.97	14.75	35.93	14.78
6 m to 2 y	0.41	0.49	0.28	0.45
2 y to 5 y	0.59	0.49	0.72	0.45
No. of adults	3.80	2.69	3.40	2.13
No. of male children	1.31	1.12	1.14	0.87
No. of female children	1.29	1.24	1.19	0.97
Monthly income>=10,000 (INR)	0.90	0.30	0.94	0.23
Father: Seconday education	0.69	0.46	0.67	0.47
Mother: Primary education	0.79	0.41	0.83	0.37
Father: Daily wage worker	0.34	0.47	0.32	0.47
Mother: Homemaker	0.86	0.35	0.88	0.33
In city for at least 6 years	0.62	0.49	0.70	0.46
Above poverty line	0.73	0.44	0.71	0.45
In house water tap	0.95	0.22	0.96	0.19
In house toilet	0.26	0.44	0.27	0.45
Rented house	0.42	0.50	0.35	0.48
Child specific				
Birthweight (kg)	2.51	0.45	2.56	0.53
Colostrum given	0.95	0.22	0.95	0.21
If breastfed	0.99	0.12	0.99	0.10
Currently breastfeeding: 6m to 2y	0.76	0.43	0.73	0.45
Breastfed for 2 years: 2y to 5y	0.26	0.44	0.21	0.41
Birth order	2.06	1.02	1.91	0.93
Anthropometry				
WAZ	-2.86	0.68	-2.79	0.65
WHZ	-2.30	0.43	-2.26	0.39
HAZ	-2.28	1.19	-2.20	1.13
Weight (kg)	9.04	1.82	9.88	2.08
Height (cm)	82.04	9.84	86.36	10.77
MUAC (cm)	12.92	0.70	13.13	0.70
No. of children	145		108	

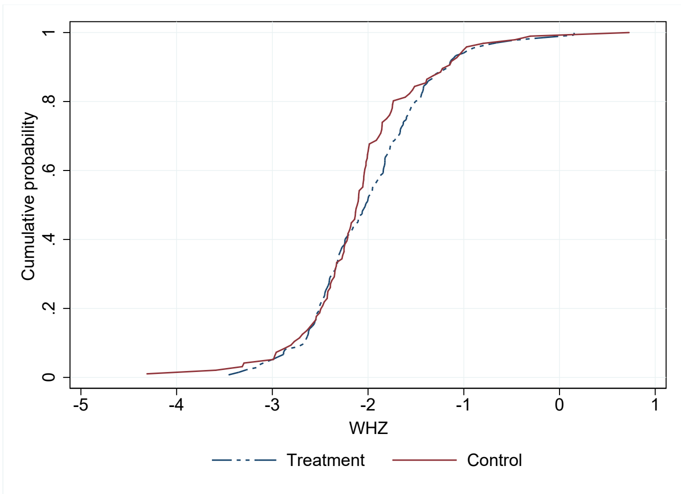
HAZ, WAZ, WHZ are standardised z-scores as per WHO standards (de Onis *et al.* (2007)).



(a) At enrolment



(b) After treatment period



(c) At the end of follow-up

Figure 5.3: Cumulative probability plots of WHZ for treatment and control groups. Figure 5.3a is at enrolment, figure 5.3b is at the end of treatment period, and figure 5.3c is at the end of follow-up.

Table 5.5: First stage results form logistic regression on treatment indicator.

Covariate	Logit coefficient
IV	
Adults	0.095***
	(0.021)
DEMOGRAPHICS	
Male	0.011
	(0.099)
Age in months	-0.043*
	(0.018)
Age in months^2	0.000
	(0.000)
Monthly income>10,000	-0.581**
	(0.216)
Father: Secondary education	0.361**
	(0.116)
Mother: Primary education	-0.470**
	(0.145)
Toilet inside the house	-0.257*
	(0.113)
Time effects	Yes

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Standard errors are in parenthesis
Monthly income is self reported in INR, secondary education indicates completion of 10 years of formal schooling, and primary education indicates completion of 5 years of formal schooling

Our final analytic sample consisted 1,771 observations.[53] 57.31 per cent children were in the treatment group. The results from the logit model are presented in table 5.5. The indicator for treatment was regressed on X_o (section 5.5.2.3). The IV was found to be strongly predictive of treatment conditional on other factors (F stat: 15.4131, p<0.0001). The propensity score

[53] In the treatment group the observations were 1015 (145*7) and the control group they were 756 (108*7)

computed based on the identified support ranged between 0.25 to 0.87 in both the groups of the study. 94 observations had to be dropped because of lack of overlap. The sample size was then 1,677. For the estimation of the PeT effects, interactions of covariates and propensity score were also included. The first degree polynomial was found to be most appropriate for the data.

Table 5.6: Mean treatment effects based on PeT effects (WHZ).

Effect	WHZ	Bootstrap S.E.‡
Average treatment effect (ATE)	0.063*** (0.039, 0.086)†	0.012
Effect on the treated (TT)	0.099*** (0.070, 0.127)	0.015
Effect on the untreated (TUT)	0.013 (-0.027, 0.052)	0.020
TT-TUT	0.079** (0.027, 0.131)	0.027

** $p < 0.01$, *** $p < 0.001$
‡ Standard errors based on 1,000 bootstrap replicates
† 95% confidence interval based on 1,000 bootstrap replicates

Table 5.6 shows the ATE, which is the mean of all the PeT effects across the entire duration of the study, i.e, from enrolment to end of follow-up period. The ATE was estimated to be an increase of 0.063 units of WHZ. An increase of 0.063 units may be due to change in height, a change in weight or change in both. This is interpreted as following. Considering an average constant height of 83.86 cm for all children at the time of enrolment, 0.063 units increase z-score translates into an increase of 0.215 kg of weight per month.[54] We now look at the effect on the children of the treatment group (TT). We found that, on an average, the treatment effect was 0.099

[54]Using our data we calculate the change in weight and height for a 1 unit change in WHZ and correspondingly calculate the increment for the predicted treatment effect.

units of WHZ. On considering the average constant height of 82.03 cm of a child in the treatment group, the effect on the treated may result in an increase in weight by 0.241 kg per month. The effect on the untreated (TUT), though not significant is 0.013 units which translates into 0.058 kg of weight increase per month at constant height of 86.35 cm. Children in the treatment arm benefited more on an average that those in the control group, as both, TT and TUT are identical to ATE and only effect on the treated reached statistical significance. Therefore, although assignment to treatment group varies across child specific characteristics, children receiving treatment gained more relative to the control group. The difference between TT and TUT, 0.079, is also statistically significant, indicating that the treatment group children had a 7.9 per cent higher change in WHZ than the control group children over the entire study duration. This highlights the potential for substantial benefits of using the MFF as an alternative over THR.

Since the aim of our analysis is to estimate the heterogeneity in the impact of such community based programs, the distribution of the individual PeT effects are shown in figure 5.4. These PeT effects (on the y-axis) against each observation number (x-axis) are for all the children (treatment and control group). Further, to emphasise on the incremental impact of the nutritious supplement, we study the PeT for the three months (13 weeks) of intervention period only. The values of PeT vary from -0.6 to 0.6, with a majority of individual level effects of the treatment group lying in the positive territory. Moreover, the variation in values specifies the heterogeneity of the effects, an advantage of individualised estimation over post hoc analysis. The overall mean value is equal to 0.145, higher by 0.082 units than the effect during the entire study duration. Clearly, the supplementation impact has been more pronounced in the 13 week period compared to the entire study duration. [55]

The heterogeneity in effects reveals the scope for improvement in designing the intervention. Though nutrition supplementation improved the outcome, the incremental change is child specific. These effects can be used to establish the necessity and value for a more targeted approach to the kind of treatment required (intervention specific) in terms of improving child health.

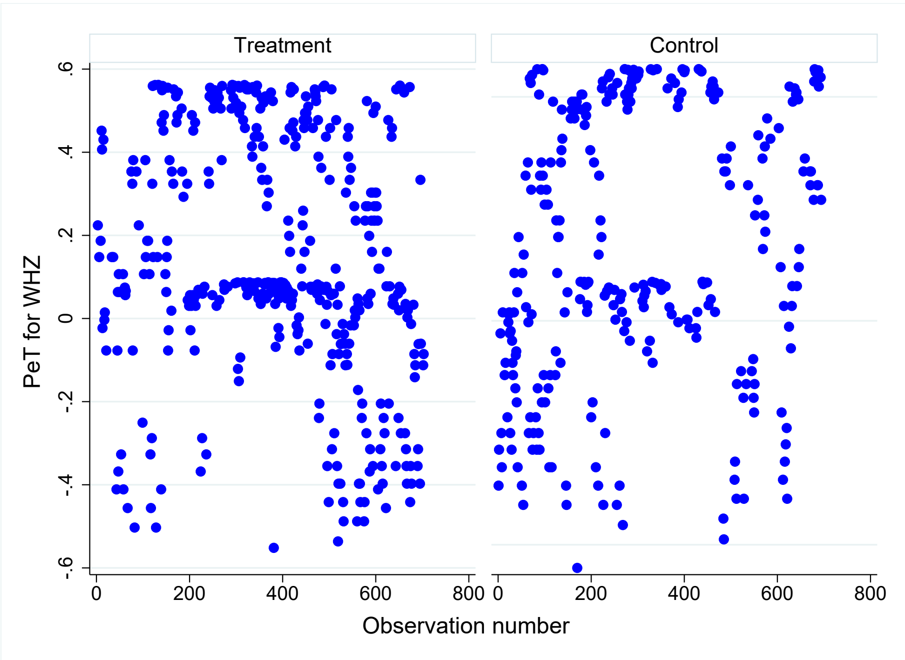


Figure 5.4: Distribution of PeT for WHZ for the 13 week intervention period for treatment and control group.

5.7 Discussion

In this chapter, the second area of focus in this thesis—providing an alternative to THR, which occupies a notable fraction of all the malnutrition abatement schemes in India, has been specified. We conducted a CRT in a slum

[55] See table 5.6 for treatment effects.

population, also considering the burden of urban undernourishment in informal settlements. The study was conducted as a multi-sectoral partnership with the chief purpose to establish a CMAM strategy for MAM management in children aged between 6 months-5 years.

The CONSORT guidelines (Campbell *et al.*, 2012) and (Schulz *et al.*, 2010) were followed for reporting of the trial. We analysed a sample of 145 children in the treatment group and 108 children in the control group. All the anthropometrics were carried out using standard procedures. Randomisation was carried out at cluster level and a field NGO was responsible for the implementation in parallel design. The MFF provided in this study were localised as per the needs of the study population supported by a sensory evaluation by a group not enrolled in the study. Continuous monitoring of feeding protocol in both the study arms and regular home visits were strengths of our community approach. Course correction involved demonstrations, improvising the MFF formulation, and counselling for parents.

The key findings showed that at the end of follow-up period, 50 per cent of the children in the treatment group were in normal category, while 62 per cent of children from the control group were still in MAM category. Clearly, the impact of micronutrient fortified food along with counselling was among the factors for improvement of child health. The PeT (Basu, 2014) based methodology for identifying treatment effect heterogeneity was found to be appropriate for evaluation at individualised level. Since all evaluation studies estimate average treatment effects, PeT has additional advantages of being able to estimate effects conditional on unobserved characteristics too. We find that the average effect of treatment on all the children over the entire study duration was equal to 0.099 units of WHZ, equivalent to 0.241 kg increase in weight per month at a constant mean height. We found that the effect on the untreated (control) group did not attain statistical significance.

In this thesis, this study emphasises the necessity for multi-sectoral coordination and targeted intervention towards reducing the burden of malnutrition. It centres on the requirement of community involvement and localisation of solutions. The method of evaluating individual effects is effective at policy level while catering to unobserved confounders.

In the following chapter, we address the variation in household level differences to include a nutrition index and construct the HDI.

Chapter 6

Human Development Index: Incorporating nutrition using household level data

~ ***State wise comparisons based on household data***

6.1 Introduction

The previous three chapters discussed how poor nutrition is detrimental to human development outcomes and explained the pathways through which this linkage has been explored for the Indian case.

This chapter attempts to bring together the three dimensions of human development as discussed in chapter 1 based on the core argument that enhancement in the HDI is reflected when contributing social and economic indicators improve (see figure 1.1 for the framework).

The HDI has become among the most widely used indicator for comparisons of welfare. This is linked to its foundations lying in the ability to summarise multi-dimensional well-being in a very easily interpretable and transparent manner. In the Indian context, while some states have outshone the others on aspects related to employment, health, and economic productivity, many states and pockets of regions within states continue to languish under mass deprivation (Drèze and Khera, 2012). Studies by Chakrabarti and Cullenberg (2013) and Ghosh (2006) note that lop-sided development and ineffective outreach of social schemes are among the foremost reasons driving such patterns.

Given the above, the first HDR commissioned in 1990 by the United Nation's Development Programme (UNDP) also argued that, "averages of progress in human development conceal large disparities within developing countries — between urban and rural areas, between men and women, between rich and poor" (UNDP, 1990). Thus, neglect of variation and distributional differences within a country, specifically that classified as a developing economy, underpins the necessity to construct an index that reflects achievement/underachievement across various groups within a country.

The central objective of this study is to demonstrate the possibility of calculating an index at the household level for better target group identification, drawing attention towards zones of under-development and to guide policy concretely and specifically. We present our analysis for all states of India after combining the seven North Eastern states (Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, and Meghalaya) into one. We combine data from Chandigarh with Punjab, Daman& Diu and Dadra& Nagar Haveli with Gujarat, Goa with Maharashtra, and Puducherry with Tamil

Nadu. Thus, a total of 21 highly diverse regions are analysed.

This study contributes in several ways. First, we include nutrition as a sub-component to the HDI by constructing a household level human development index. Unlike previous studies we calculate three components of HDI (standard of living, knowledge, and health) using household data. Second, we replace the life expectancy indicator of the health component with nutrition component to highlight the role of nutrition (especially among children and adolescents) on HDI. This renders a unique advantage as many developing economies, including India do not report data on life expectancy by population sub-groups. Thirdly, we analyse the variation in HDI based on caste status, gender, education levels, and income. This sub-group analysis enables us to highlight the potential correlation between key demographic indicators and HDI. One of the principal objectives of this is a direct assessment of inequality in the HDI, along with decompositions of inequality by sub-groups. For example, we find that index based on nutrition sub-component of HDI (nutrition index) is relatively higher among households with female household heads. Lastly, we decompose the inequality in HDI to quantify the contributions of income and education. The main findings of our analysis is that the household level data contributes to the variation in the relative standing of states. Nutrition index based scores show the disparities in achievements across states, highlighting the importance of their correlation with other indicators of development. The inequality in the education index is the highest and the impact of caste reduces with increasing scores of the HDI.

The chapter is organised as follows. Section 6.2 discusses the background and section 6.3 the institutional setting. Analytical framework is discussed in section 6.4 where the construction of HDI and its sub-components is discussed in detail. Section 6.5 elaborates the results and section 6.6 concludes.

6.2 Background

The HDI has served as a widely used indicator for comparing the human development progress among nations. It received attention for being an improvement over using income as a measure of well-being and quality of life. Since its inception in 1990 (discussed in section 1.1.1) due to its simple interpretation, it has been continuously used to set a country's development goals and design policy for economic measurement as well. It also plays a major role in advocacy, seeking to re-establish the fundamental premise of growth-centric approaches (Klugman *et al.*, 2011). Despite being widely accepted it has also been criticised on the following fronts. It chooses three sub-components (income, education, and life expectancy) arbitrarily and assigns them equal weights (Desai, 1991), (Kelley, 1991), and (Srinivasan, 1994). Further, HDI combines both, stock (time invariant) and flow (time variant) variables, which does not capture the dynamics of of policy changes (Hopkins, 1991) and (Hou *et al.*, 2015). Recently, there has also been a criticism on the type of dimensions included in the index. Ranis *et al.* (2006) recommend the use of indicators that address issues like mental well-being, peace, security, cultural freedom, and access to social services.

Among its functions as serving as a composite indicator, the HDI has also been used to measure inequality. In the (UNDP, 2010) report, for the first time an "Inequality-adjusted HDI (IHDI) " for all nations was presented. It used a modified version of the methodology used by Foster *et al.* (2005) to adjust for inequality in the distribution of each dimension across populations. [56]

The latest improvement in the HDI has been proposed by Mishra and Nathan (2018). They suggest a new aggregation method instead of the current Geometric Mean (GM) approach. The new method is termed the Displaced ideal (DI) method—defined as the additive inverse of the distance from the ideal.[57] Their findings elaborate on the necessity to use aggregation methods that capture shortfalls in the achievement in various components of the HDI.

6.3 HDI: Indian context

Many variants of the HDI devised over time reported it for assessing the relative achievements for Indian states. Suryanarayana *et al.* (2011) present the estimates for IHDI and HDI for Indian states. In their work, they use aggregated measures from national accounts' data using the international goalposts to examine the relative standing of Indian states. Recognising the rising inequalities and uneven distribution of wealth, the IHDI applied to Indian states enables in determining the HDI achievements across states in India. For example, Kerala ranked highest at 0.625 followed by Punjab (0.569), while Odisha (0.442), Bihar (0.447), and Chattisgarh (0.449) are states with the lowest HDI. Drèze and Khera (2012) have proposed yet another variant of the HDI called the ABC index with the main focus on regional deprivation

[56] For specific details, refer to UNDP (2010) and Foster *et al.* (2005). 'Discounting' is achieved by taking the geometric mean of achievements in a dimension which is lower than the arithmetic mean if there is inequality (and the difference grows with the amount of inequality). If there is no inequality, the two are the same.

[57] A detailed explanation of this is presented in section 7.5.

of children's health. Their findings show the emergence of a resilient north-south contrast in matters of human and child development. It also documents the clumping of "poor achieving" northern states that perform very poorly on child health related indicators. Indices like these serve a useful purpose and contribute to a deeper understanding of disparities in human development.

All above studies use aggregated data and it has been argued in literature by Harttgen and Klasen (2012) that using household data allows immediate comparison across demographic groups, e.g., urban/rural, educational attainment, and gender of household heads. They use data from DHS of 15 middle-low income countries to construct an HDI. Also, once an HDI is available for each household it is fairly straightforward to calculate an inequality measure, compare across regions differing in socio-economic status, and decompose inequality within and between groups. Drèze and Sen (2002) note that India's rapid economic expansion in specific fields like science and technology do not correspond to the sluggish progress in areas like elementary education, health care, child nutrition, and women's literacy. Therefore, there is a necessity to construct a household level HDI that focuses largely on using disaggregated data for measuring and elaborating on distributional differences.

6.4 Analytical framework

National Human Development Reports have carried out analyses for various regions to delineate differences by ethnic groups, racial classes, and most recently by income quintiles. Thus far, no HDI exists based on household level information pertaining to the three sub-component indices of Gross National Income (GNI), life expectancy, and education.

We use the IHDS-II data which collects data related to health, education, employment, economic status, marriage, social capital, and anthropometric measurements. Both, rural and urban areas have been taken into account in our estimation sample. With the exception of the Andaman/Nicobar islands and Lakshadweep, all states and Union territories have been included.

Informed by the lack of an index constructed using household data, this study explores how measurement of alternative dimensions may be reinforced and made more policy relevant. We construct a household based standard HDI (HDI_s) using the methodology employed in HDR 2011 and an an alternative HDI that replaces the life expectancy sub-component by the nutrition sub-component. Nutrition is proxied by using growth failure and thinness, discussed in detail in section 6.4.6. We term this alternative index HDI_n (n here stands for nutrition). We use both the indices mentioned above to compare the difference in achievements at the state level. Subsequently, the HDI_n is used to carry out further analysis involving measuring inequalities and distributional differences as per demographic characteristics (sub-group analysis).

6.4.1 Nutritional status and HDI

After the major revision in 2010 pertaining to construction of the HDI, a key contention remains broadening the scope of measuring human development beyond the core dimensions. Antony and Laxmaiah (2008) study the variations is socio-economic, demographic, and dietary indicators by grades of HDI and summarise that proper nutrition and health awareness are important to tackle the health hazards of developmental transition.

Tackling malnutrition, closely linked to poverty, remains a serious challenge for India, therefore, including indicators that reflect nutritional status becomes imperative (Desai and Vanneman, 2015a).

In a first time attempt to construct a widely accepted single, comprehensive measure for a country's or region's nutritional status, Wiesmann *et al.* (2002) provide a Nutrition Index (NI) that is based on factors which influence underlying determinants of malnutrition at the household and community level. Further, HDR 2002 states that under five mortality rate is among the most sensitive indicators of human welfare across nations and the effectiveness of public policy is more accurate, especially over time (UNDP, 2002). Hou *et al.* (2015) also use under five mortality rate as a replacement of life expectancy. Thus, Currie and Almond (2011) study how early life influences are directly associated to human capital development. A key aim of taking into account nutritional status helps in better assessing 'human development'. Since there are very few studies that use household data, we fill this gap, and additionally also suggest an alternative nutrition sub-component index.

6.4.2 Constructing the index

Since our analysis includes nutritional indicators such as stunting and thinness based on child level and adolescent information, respectively, we choose households that have at least one child in the age group of 0-20 years. The HDI_s comprises the GNI index, education index, and health index. While HDI_n comprises GNI index, education index, and the NI index.

6.4.3 Gross National Income index

GNI per capita component, which reflects the 'standard of living' dimension of the HDI is calculated using data on household income. IHDS-II reports information on each household's annual income constructed as the sum of wages (agricultural/non-agricultural), salaries, remittances, income from property, pension, and government benefits. Previously, alternative studies use an asset based index instead of income. However, income — defined as the increase in a person's command over resources during a given period — has merits in the sense that it is easily interpretable than wealth or lifetime income.

First, we use the income per capita variable provided in the IHDS-II data set and convert it to PPP USD by using the World Bank International Comparison Program database.[58] Second, we take log values of this income component. Finally, we use the international goal posts from the HDR 2011, the same period as IHDS-II (see equation 6.1 below). The minimum value is set to \$100 PPP (4.605 in ln terms) and the maximum is set to \$107,721 PPP (11.587 in ln terms). GNI per capita index is then calculated for each household using the following equation.

$$HH_{zi} = \frac{ln(gni_{hh}) - ln(gni_{min})}{ln(gni_{max}) - ln(gni_{min})} \tag{6.1}$$

where, HH_{zi} is the GNI index for household i, $ln(gni_{hh})$ is the \$ GNI per capita for each household, $ln(gni_{min})$ is the minimum value of \$ GNI PPP

[58]The goal posts are reported in USD and thus, the income values have to be converted into PPP USD terms

and $ln(gni_{max})$ is maximum value of \$ GNI PPP.

6.4.4 Education index

In the next step, we calculate the second sub-component; education index of the HDI. Since 2010, the education index consists of two sub-indices. These are the 'expected years of schooling for children' and 'mean years of schooling for adults'. HDI's education index uses the mean years of schooling for adults aged 25+ years and the average number of years of education for a child born today, could be expected to attain if enrolment rates remain at the current levels. Thus, expected years of schooling in a year t is written as;

$$eys^t = \sum_{i=0}^{n} \frac{E_i^t}{P_i^t} \tag{6.2}$$

where, E_i^t is the enrolment of children of age i, and P_i^t is the population of age i in that year. n is the theoretical maximum age of schooling (Klugman *et al.*, 2011). Using household level information about enrolment at each age of schooling and the number of school going (eligible) children, we calculate household specific expected years of schooling index. The formula is;

$$eys_{hh_i} = \frac{eys_{hh} - eys_{min}}{eys_{max} - eys_{min}} \tag{6.3}$$

where, eys_{hh_i} is the expected years of schooling index for each household i, eys_{hh} is the actual value of the age specific expected years of schooling for children of each household, eys_{min} is the minimum value set to 0, eys_{max} is the maximum for expected years of schooling set to 18 years, equivalent to achieving a master's degree in most countries, as well as in India.

In HDR 2011, individuals aged 25+ years are considered for calculating the adult mean years of schooling (mys) index. In the IHDS-II, children include individuals up to the age of 20 years, while the formal age for being counted as an adult is 21 years. For constructing this index for a household, we consider individuals aged 21+ years which is different from the HDR method.

$$mys_{hh_i} = \frac{mys_{hh} - mys_{min}}{mys_{max} - mys_{min}} \tag{6.4}$$

where mys_{hh_i} is the mean number of years of schooling index for household i, mys_{hh} is the actual value of the mean years of schooling for adults of each household, mys_{min} is the minimum value, set to 0 and mys_{max} is the maximum value set to 13.1 years as per HDR 2011 (UNDP, 2011). The reason for setting the minimum value for years of schooling to 0 is that societies can subsist without any formal education (UNDP, 2011).

The minimum and maximum values are set using the Barro and Lee (2013) data set on years of education between 1890 and 2010. Now, the two sub-indices have the same relevant outcome variable, which is, years of schooling. The new education index also gives equal weights to the education of current and future generations. After calculating these two sub-indices for each household in the data set, we derive the household specific education index. We calculate it as the geometric mean of the two education sub-indices and normalise it using minimum and maximum values as per the HDR 2011 (UNDP, 2011). We use the following equation.

$$HH_{ei} = \frac{(eys_{hhi} * mys_{hhi})^{1/2} - 0}{0.978 - 0} \tag{6.5}$$

where, 0.978 is the maximum value observed for the education index.[59]

6.4.5 Health index

To calculate the health index, we use of the life expectancy at birth given in the life tables. These India specific life tables give us the advantage of utilising information specific to urban/rural residency status of households in the survey. We assign a value to each member of the household depending upon the gender and location of the household.[60] These life tables apply the latest modified life table system based on the Brass logit model using a global standard (Murray *et al.*, 2003).[61] At the end, after calculating the household specific life expectancy for all households in the IHDS-II data set, we use the following formula to calculate the health index of the HDI. (UNDP, 2011).

$$HH_{hi} = \frac{le_{hh} - le_{min}}{le_{max} - le_{min}} \tag{6.6}$$

where, HH_{hi} is the health index for household i and le_{hh} is the life ex-

[59]Recently, in the HDR 2014, HDR 2015, the education index is calculated as the arithmetic mean of the educational sub-indices. In our method we use the HDR 2011 method and use the geometric mean.

[60]Abridged life tables are available for all states of India, based for both, males and females and also urban/rural status of residency

[61]This life table model is based on a Brass logit approach $Logit(l_x^i) = \alpha_i + \beta_i.Logit(l_x^s) + \gamma_x\left[1 - \frac{Logit(l_5^i)}{Logit(l_5^S)}\right] + \theta_x\left[1 - \frac{Logit(l_{60}^i)}{Logit(l_{60}^S)}\right]\ \forall i = 1, 2, ... I$ where x is the age, γ_x and θ_x are parameters of the age specific Standard Life Table, α_i and β_i are India specific parameters, and γ is the survival probability from 0 to x, 5, and 60. For any value of l_s, the corresponding value for the life expectancy, e_0 can be estimated through an iterative process

pectancy of the household. Using lower and upper limits as specified in HDR 2011, le_{min} is set to a value of 20 and le_{max} is set to 83.4.

6.4.6 Nutrition index

We calculate the NI in three. First, we choose measures capturing "growth failure" in children up to age 5 years (60 months) by estimating gender specific standardised z-scores. We define growth failure as— presence of at least any one poor anthropometric condition i.e., underweight, stunting or wasting.[62] For each household, we determine the total underweight children, total stunted children, and total wasted children in the relevant age group (0-5 years). We adopt a Principal Component Analysis (PCA) method to derive weights for these measures. We extract one factor that accounts for 65.35 per cent of variation and divide the obtained scores by their sum to normalise the sum of weights to one.[63] The formula for growth failure is given by;

$$gf_{hh_i} = \frac{(0.386 * TU_{hh} + 0.341 * TS_{hh} + 0.273 * TW_{hh})}{TC_5} \tag{6.7}$$

where gf_{hh_i} is the growth failure index for each household i, TU_{hh} is total children underweight, TS_{hh} is total children stunted, TW_{hh} is total children wasted, and TC_5 is total children up to age 5 in each household. The parameters in above equation have been derived from the PCA method.

[62]See WHO (2016) for a detailed explanation on child growth standards. All the definitions have been provided in section 1.2.2

[63]See Table 6.1 for statistics of PCA method

Table 6.1: Statistics of principal component analysis.
Data source: IHDS-II (2011-12)

Correlation coefficients			
	Underweight	Stunted	Wasted
Underweight	1		
Stunted	0.697	1.000	
Wasted	0.486	0.218	1
Factor Statistics			
	Eigen value	Per cent of variance	Cumulative percentage
Factor 1	1.96	65.35	65.35
Factor 2	0.80	26.56	91.92
Factor 3	0.24	8.08	100.0
Final statistics			
	Factor score	Derived weight	
Underweight	0.662	0.386	
Stunted	0.586	0.341	
Wasted	0.468	0.273	

Formula for derivation : weight of variable x = factor score of variable x / sum of all factor scores.

In the second step, we focus on calculating an index for children in the age group of 6 to 19 years. WHO growth standards for school going and adolescent children classifies children with a BMI-for-age z-score below -2 S.D. from the median of reference population as "thin" (de Onis *et al.*, 2007). We use this measure to calculate a thinness index for each household given by the following formula;

$$TI_{hh_i} = \frac{TT_{hh}}{TC_{6-19}} \tag{6.8}$$

where, TI_{hh_i} is the thinness index for each household i, TT_{hh} is the total thin children, TC_{6-19} is the total number of children in the age group 6-19 years.

In the final step, we calculate a nutrition index for each household by taking the arithmetic mean of the two aforementioned sub-indices and subtract it from 1 to make it comparable with other dimension indices (to maintain the unit restriction, i.e., lying between 0 and 1) of the HDI.

$$HH_{ni} = 1 - \left[\frac{gfi_{hh_i} + TI_{hh_i}}{2} \right] \tag{6.9}$$

where HH_{ni} is the nutrition index for each household i. The distribution of WAZ, WHZ, HAZ, and BMI-for-age-z score has been presented in figures 6.1, 6.2, 6.3, and 6.4, respectively. The density of children aged 0 to 5 years who are underweight and stunted is high, while many children (6 to 19 years) are in the low BMI category.

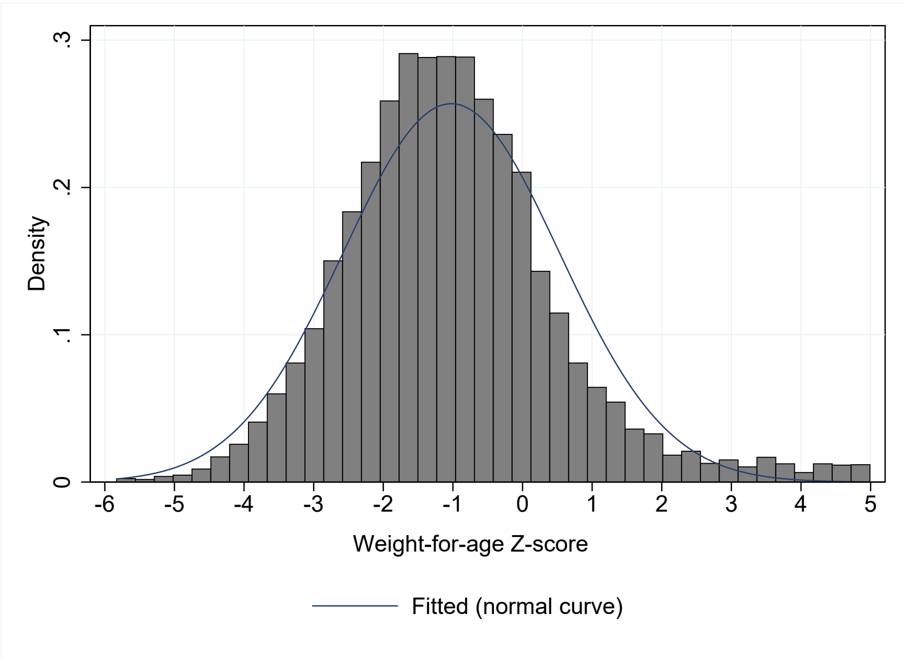


Figure 6.1: Distribution of weight-for-age Z-score of children in the age group of 0 to 5 years.

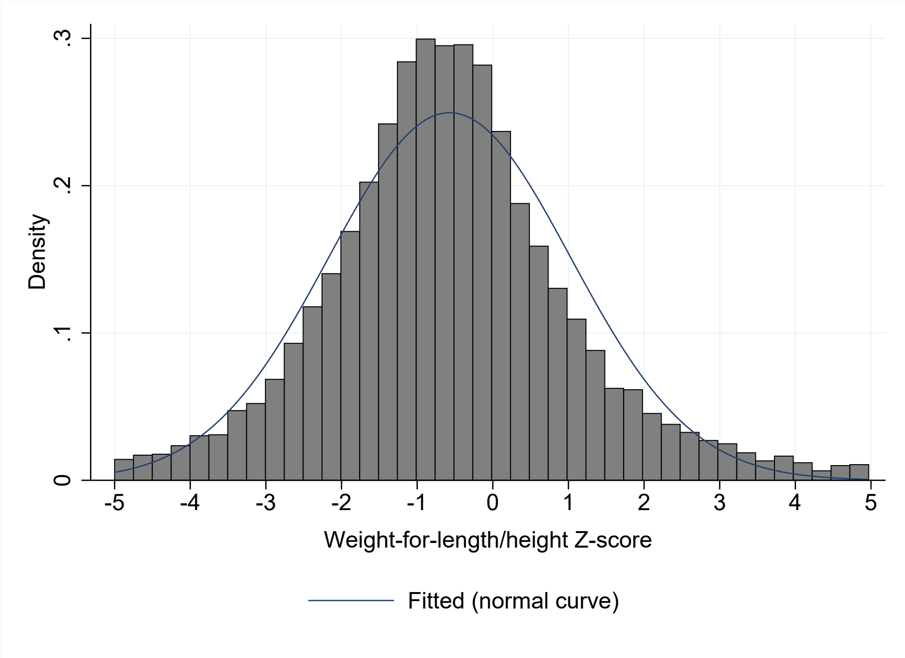


Figure 6.2: Distribution of weight-for-length/height Z-score of children in the age group of 0 to 5 years.

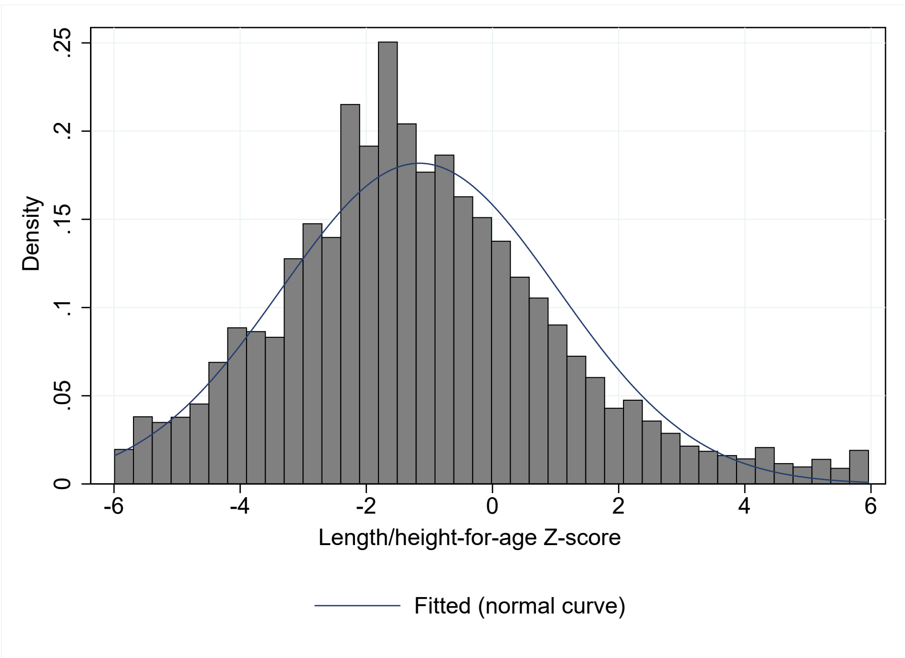


Figure 6.3: Distribution of Length /height-for-age Z-score of children in the age group of 0 to 5 years.

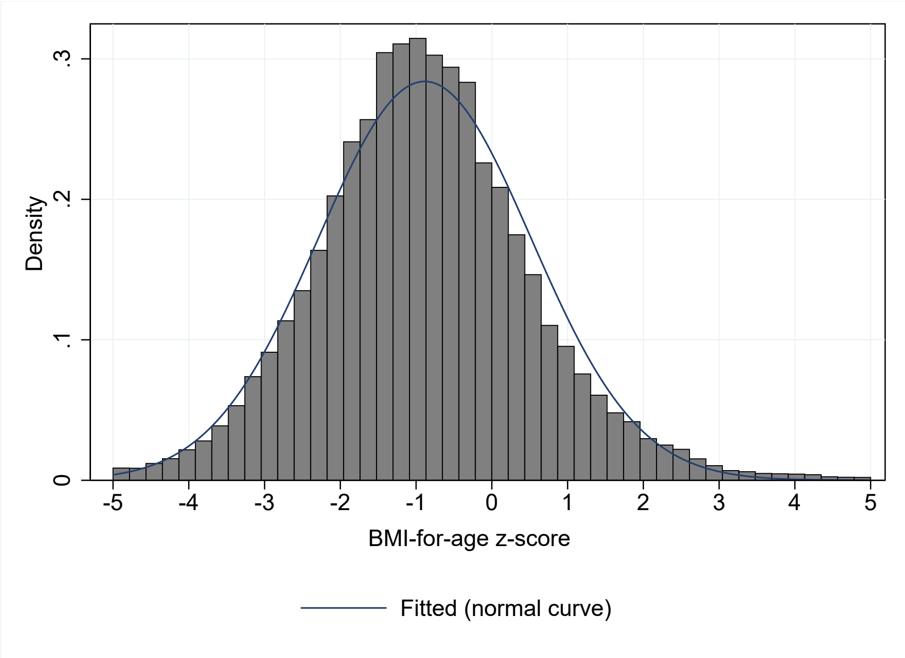


Figure 6.4: Distribution of BMI-for-age Z-score of individuals aged 6-19 years.

6.4.7 HDI calculation

We have a total of indices based on four sub-components, viz., decent standard of living (GNI index), knowledge (education index), long and healthy life (life expectancy based health index), and nutrition index. These are used to calculate the HDI for each household. We calculate two types of indices. The properties of the geometric mean are extremely favourable for calculating the HDI since it allows individuals with a more balanced achievement across components receive a higher score. This is, in principle, the main driving reason to change from arithmetic mean to geometric mean to aggregate dimensional indices (UNDP, 2010). It also helps address the issue of perfect substitutability, such that the level of priority to be given to a dimension is not invariant to the level of attainments. As for the issue of equal weights, Anand and Sen (1997) give an explanation saying—"any choice of weights should be open to questioning and debating in public discussions".

In the context of a development index, all choices are equally important, with no *a priori* rationale for giving a higher weight to one choice over the other.[64]

We denote geometric mean by g, μ denotes the arithmetic mean of a given distribution and z stands for household per capita income. We apply the same notation to education (e), health (h), and nutrition (n) components of the HDI. Three dimensions of $\mathrm{HDI_s}$ can now be seen in a three x, i, matrix S, where first row is the vector z, followed by e and h. Similarly, three dimensions of the $\mathrm{HDI_n}$ can be represented by a three x, i, matrix N. The household based HDI (where i refers to the total households in the data) can be defined as a function $F : D \to R$ from the set of matrices D and set of matrices N, separately, to the real numbers R and expressed as mean of the means by:

$$HDI_{\mathrm{s}}(S) = \mu\Big[g\Big((z),(e),(h)\Big)\Big] \tag{6.10}$$

$$HDI_{\mathrm{n}}(N) = \mu\Big[g\Big((z),(e),(n)\Big)\Big] \tag{6.11}$$

which corresponds to the mean achievement of the HDI which is then averaged across states of India. Each member of the household is assigned the same HDI, and we present analysis based on these person-based values. The key assumption we make here is that, there is no intra-household inequality in the attainment of human development, which is not possible. Apart from education and nutrition (only in case of children) which can be assessed at

[64]For a statistical explanation of equal weighting scheme refer to Nguefack-Tsague *et al.* (2011). Also see Klugman *et al.* (2011) for a detailed explanation on advantages of geometric mean's functional form.

individual level, there is no way to examine intra-household inequality in health and income due to data limitations.

6.5 Results

Figure 6.5 reports three types of HDI indices, first, HDI_s, which is the standard index with three sub-components as per HDR 2011 and second, HDI_n, which is the HDI calculated using the geometric mean of the GNI index, education index, and the new nutrition sub-indices. The third, "Aggregate national accounts' data HDI " refers to the HDI for Indian states calculated by Suryanarayana *et al.* (2011). [65]

In an ideal situation, the highest value for HDI is 1. The difference between the actual score and 1 signifies the gap in development achieved. Since HDI_n and aggregate data HDI have the same sub-components, we first use these two indices to compare the achievement for all states. The average value of aggregate HDI is significantly lower at the all India level than HDI_s (adjusting for household level data). The maximum difference is recorded for Bihar, followed by Andhra Pradesh, Uttar Pradesh, Rajasthan, and Madhya Pradesh. Jharkhand has the least difference while in Kerala, the score changes from 0.625 to 0.492 and in Tamil Nadu it is lowered from 0.544 to 0.438.[66]

Figure 6.5 shows the scores for all states in ascending order of HDI_n. Using household data makes a significant difference to the deviation from 1 for

[65]The aggregated HDI values are available for all states except Delhi, Jammu & Kashmir, and states of the North East of India.

[66]Difference here refers to the reduction in scores of HDI when calculated using aggregated data vis-à-vis household (disaggregated) data.

both, HDI_s and HDI_n, however, the rank of the states remain consistent with only few exceptions.

Due to the difference in one sub-component index between HDI_n and HDI_s, with two components (GNI index and education index) being the same, there are minute differences in the levels of the indices' values. The scores are marginally higher than those of HDI_s, due to substituting the health dimension with a new nutrition sub-component index. In principle, the relative standings of states do not differ much. In fact, states that have continuously progressed on the nutrition front are given higher scores of achievement, a pattern also seen in the study by Drèze and Khera (2012).

Once again, a closer look at the ranks also suggests that both these new indices constructed using household information consolidate evidence about the close relationship between various aspects of human development. This indicates that, the nutrition and life expectancy indices contribute lesser to the lowering of index values than the change to household data. Replacing the 'long and healthy life' dimension with nutrition index also determines the extent of human development attainment in the household index. While life expectancy at birth is a cumulative effect of years of changes in the policies that govern the health status of a country/state, nutrition indicators provide a better indication of current status of a household's calorie intake, access to food, health of children and adolescents, and enables measurement of multiple deprivations/attainments. Also, for developing economies, in the absence of life expectancy data by population groups, the HDI_n emerges as the only alternative. Further, life expectancy index is a stock variable, whereas the nutrition index (constructed in this study) is a flow variable. We show this in figures 6.8a and 6.8b and discuss the inference in more detail in section 6.5.1.

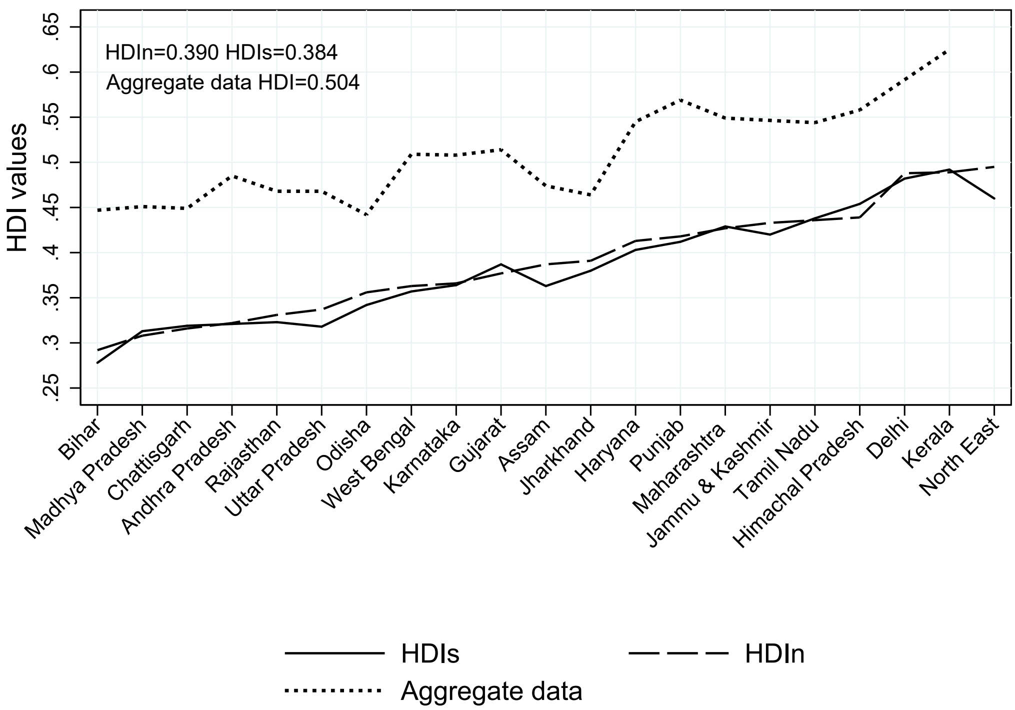


Figure 6.5: HDI_s and HDI_n for states of India. The states are ordered in ascending order of HDI_n.

Bihar, Madhya Pradesh, and Chattisgarh have the lowest scores, while Delhi, Kerala, and the North East have the highest scores. For clarity and simplicity in establishing robustness in relative variation in the values of the new HDI_n as an alternative to HDI_s and the subsequent ranks of the states, we calculated the Spearman's correlation coefficient between each pair of rankings. It was 0.98, clearly indicating that the measures are quite robust. As seen in Figure 6.6, the scatter plot shows the correlation between the values of both, HDI_s and HDI_n, for all states.

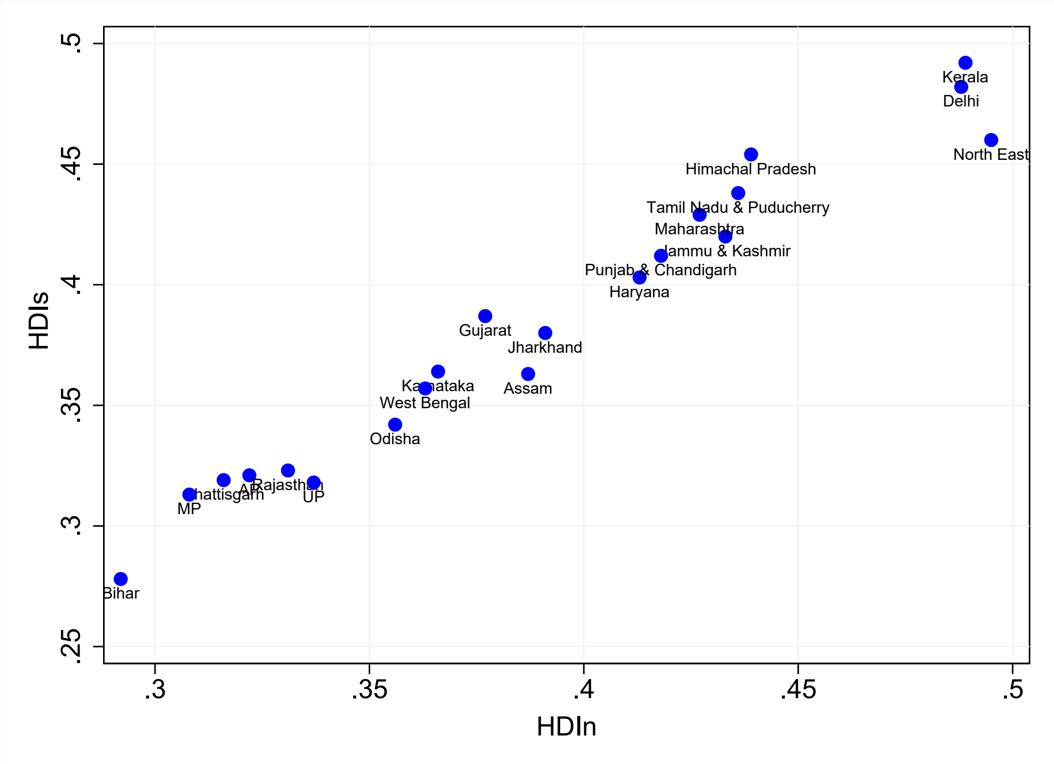


Figure 6.6: Rank correlation between HDI_s and HDI_n.

In the following sections we discuss inequality in HDI_n. We use income, education, gender, and caste status for sub-group analysis. For further analysis, HDI_n has been used unless specified otherwise.

6.5.1 Inequality in the HDI

We begin with a discussion on indicators of inequality in the HDI_n. First, we illustrate with the help of maps (see Figures 6.7, 6.8a, and 6.8b), the extent to which dimensions that reflect human development are intricately connected. It draws attention to some critical aspects of the geography of human deprivation in India. The first map (map 6.7) of India shows the HDI_n scores on a "dark to light" colour gradient. Darker the colour, lower is the level of human development. Compare this to map (6.8a) which depicts the relative attainment on the nutrition dimension alone. Almost the same states have similar patterns and clumping of low attainment is seen in the northern/central regions of India. Gujarat and Maharashtra have a light colour (shades of green) in the HDI_n map but turn into states with darker colours (shades of orange) on the nutrition map. This too indicates, though not very well understood, the tendency of high income, not always translating into better performance on child health indicators.[67]

Contrastingly, Bihar and Andhra Pradesh (including Telangana) show a reverse trend that despite having a low score on overall human development, on the nutrition parameter alone they show relatively better performance (darker colour gradient to lighter colour gradient). Additionally, the relevance of using the NI may also be seen by comparing map 6.8a to map 6.8b, whereby the stochastic measure of life expectancy at birth is used as an indicator for the health index. It is observed that states such as Madhya Pradesh, Chattisgarh, Rajasthan, Maharashtra, and Gujarat emerge as better performers on the 'health' dimension when life expectancy is used as the indicator. On the contrary, Uttar Pradesh (including Uttarakhand), Bihar, Odisha, Andhra Pradesh (including Telangana), and the North East show higher scores in health when nutrition is used as an indicator. This geography of under-development was also discussed in section 1.7 where two maps showing the loss in DALYs also depict similar trends across different states with respect to social indicators.

[67] See work done as a part of this thesis in Chapter 4 and study by Cameron and Williams (2009) on relationship between income and child health in developing countries

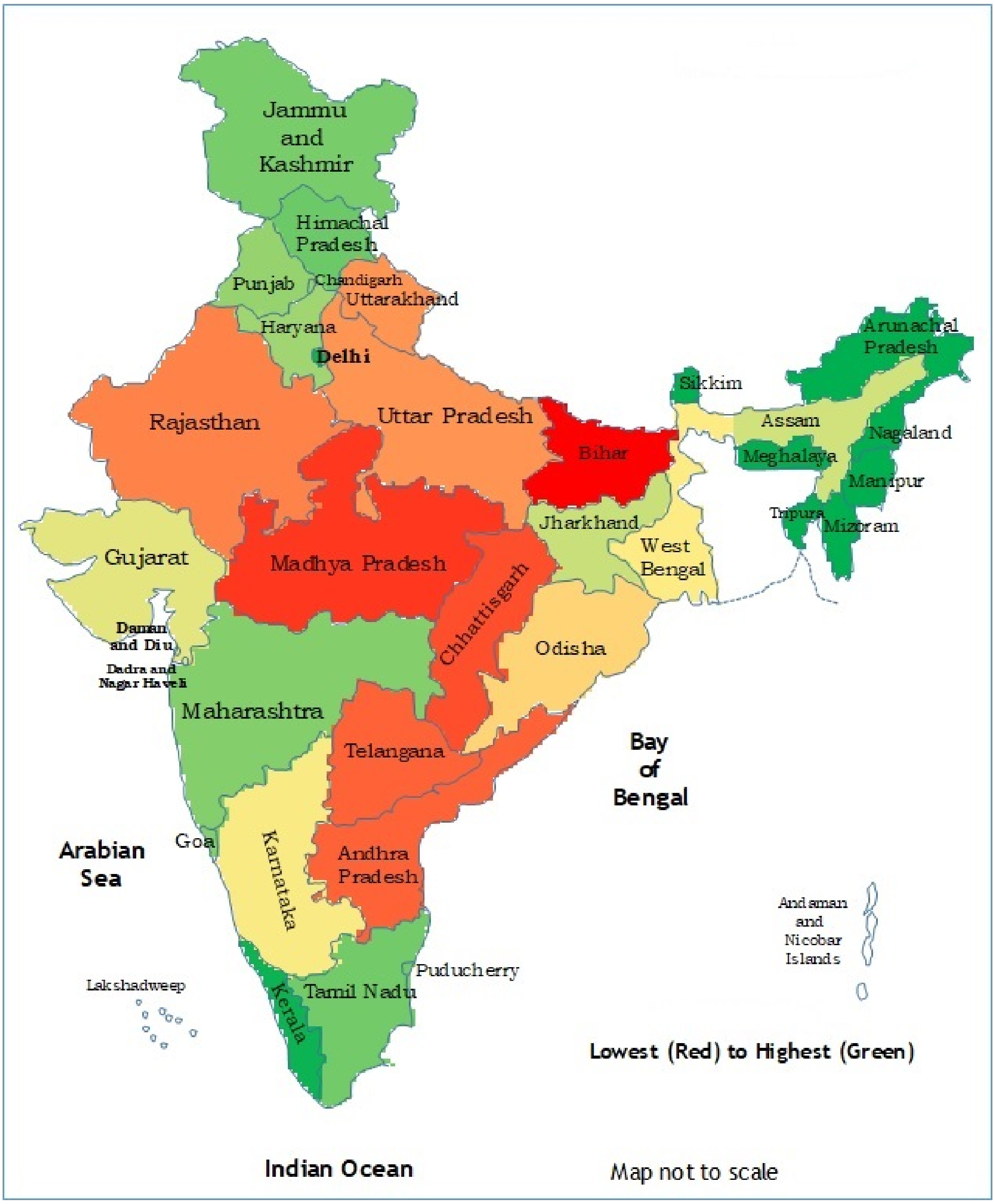
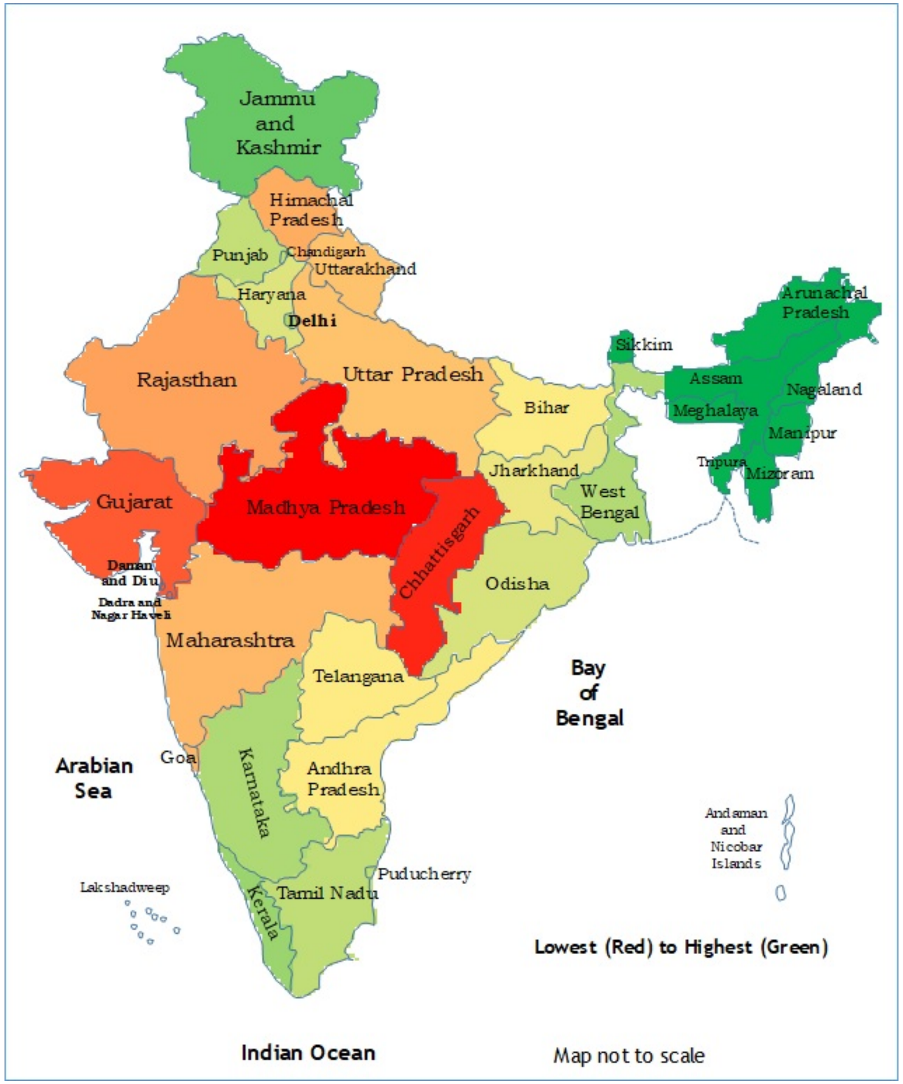
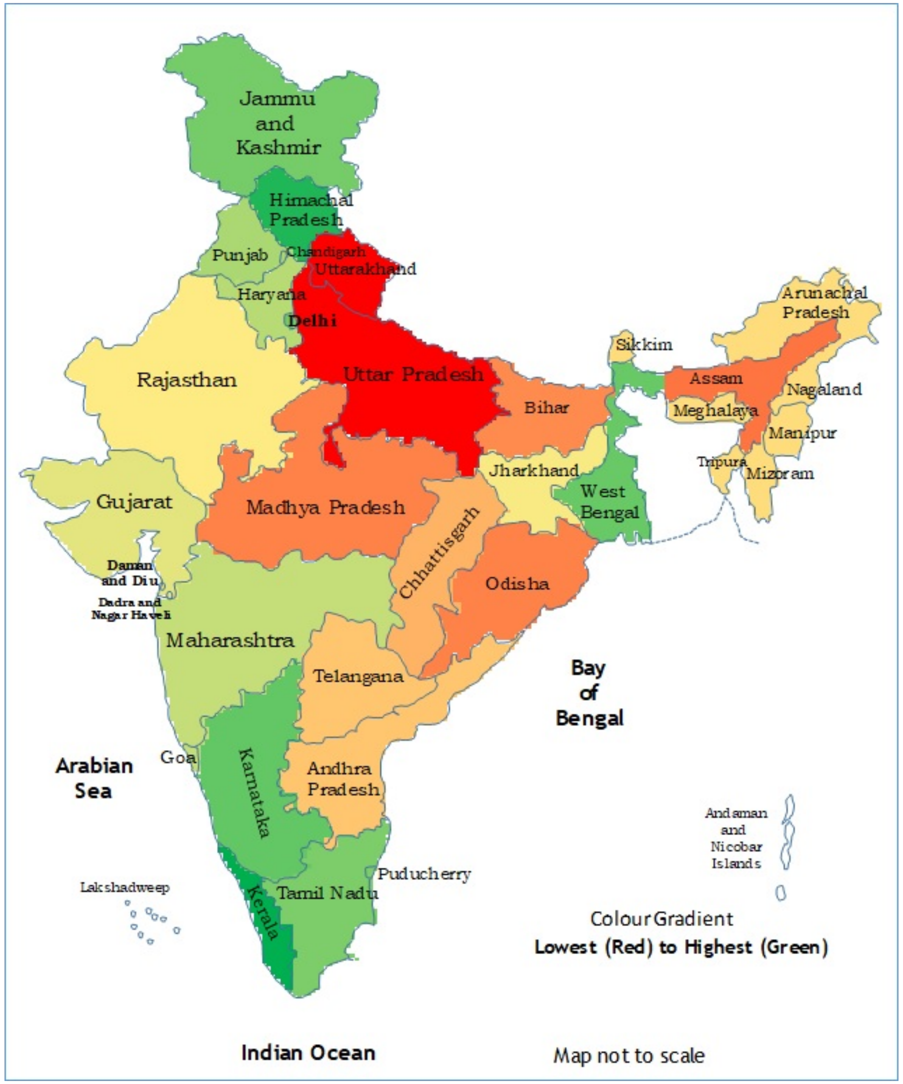


Figure 6.7: Map 1: Map based on HDI_n



(a) Map 2 : Nutrition index



(b) Map 3 : Life expectancy index

Figure 6.8: Maps based on nutrition index (map 6.8a) and life expectancy index (map 6.8b).

6.5.1.1 *Lorenz curves*

With the help of Lorenz curves, a comparison of inequality across HDI_n and HDI_s has been presented in Figure 6.9. Lorenz curves are useful to plot the cumulative percentage of an economic indicator or any other measure against the cumulative percentage of the corresponding population ordered in increasing size of share. The extent to which the curve falls below the line of equality (45°line) represents the degree of inequality in the distribution. For analysing the inequality in the human development scores, the curve for HDI_n captures greater deviation from the line of equality than HDI_s. This trend is more pronounced for the households in the middle of the distribution than for those in the top most part. On an average, only 10 per cent of the households represent human development attainment of greater than 0.8.[68]

We now look at the Lorenz curves for the three sub-component indices in figure 6.9. The curve for GNI index suggests that inequality in the HDI's standard of living dimension is minimised and much lower than the actual inequality in income. Evaluating the curve for Education sub-component index sheds light on the massive inequality in this component, one of the prime drivers of differentials in HDI_n across the population. About 30 per cent of households have an education index score near the zero mark, also indicating variation in mean years of schooling. Once again, the inequality in the nutrition index is the maximum for 40 per cent households in the distribution.[69]

[68]For statistical difference of lorenz curves for both development indices from line of equality; refer to figures 5a and 5b in Annexure 3.

[69]For statistical difference of lorenz curves for the three sub-component indices from line of equality; refer to figures 5c, 5d, and 5e in Annexure 3.

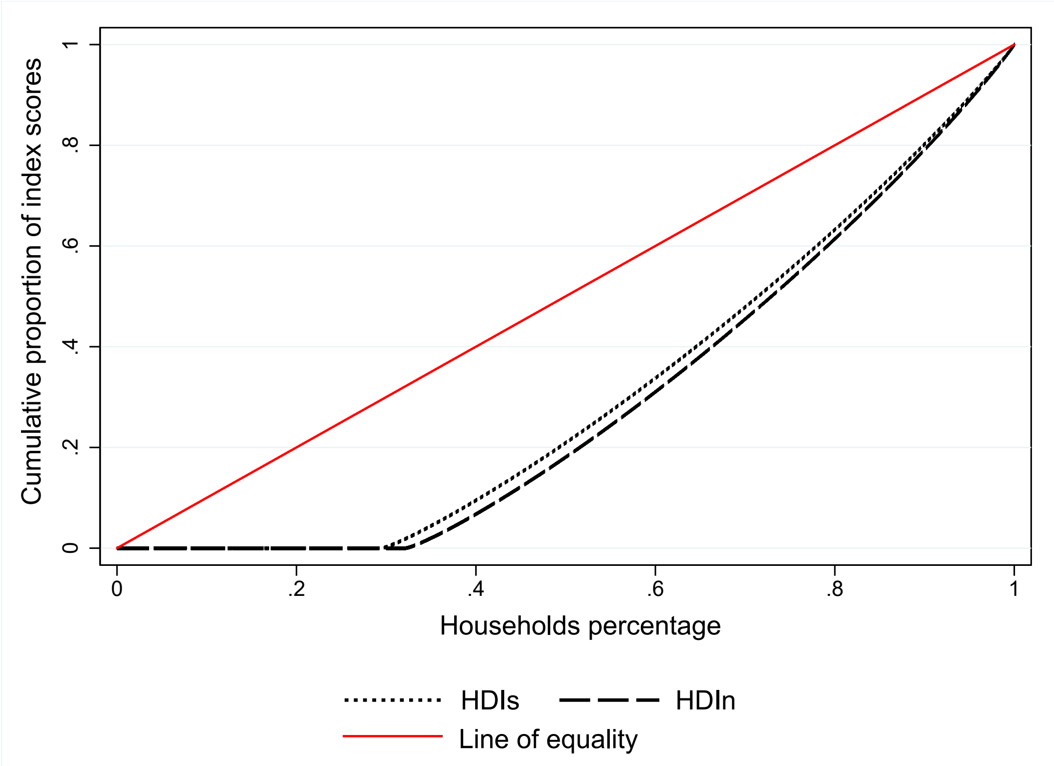


Figure 6.9: Lorenz curves for HDI_s and HDI_n for all households in the sample. Dotted black line is for HDI_s, dashed black line is for HDI_n, and 45°line of equality is shown in red solid line.

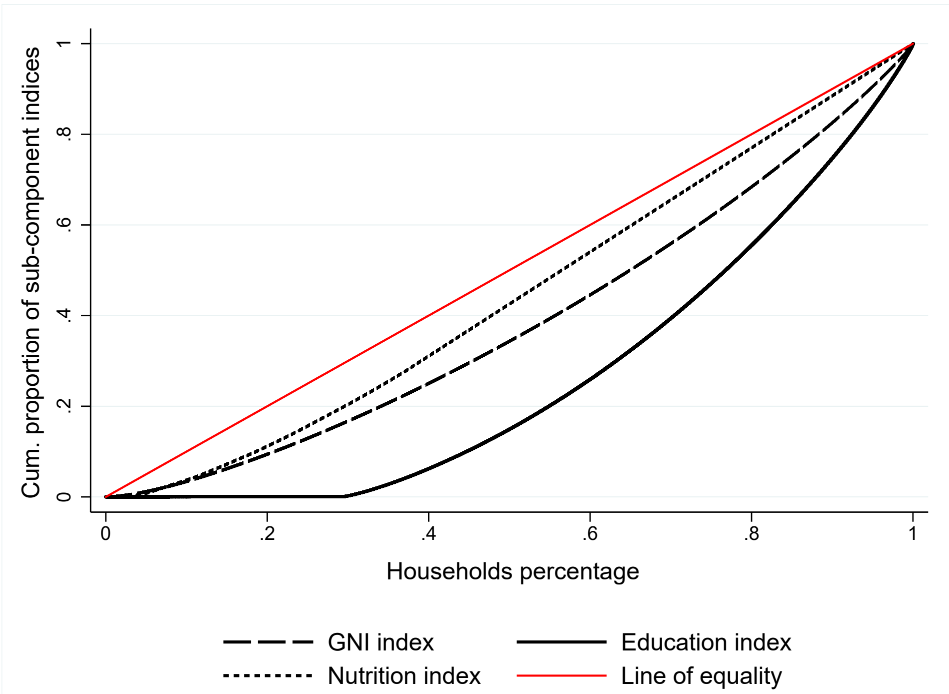


Figure 6.10: Lorenz curves for GNI index, Education index, and Nutrition index for all households in the sample. Dashed black line is for GNI index, Education index is shown by solid black line, and dotted black line is for nutrition index. 45°line of equality is shown in red solid line.

6.5.2 Sub-group analysis

Subsequent to looking at the levels, discrepancies, and drivers of inequality, we now inspect the trends in the HDI_n by income deciles and other demographic sub-groups, such as, gender, caste status, and education.

6.5.2.1 By income deciles

The first step to is dividing the households based on income deciles. Subsequently, we measure HDI_n value for households in the first decile and for those in the tenth decile. We then take a ratio of the scores between the tenth decile (top 10 per cent) and the first decile (bottom 10 per cent). As presented in figure 6.11, the states have been ordered is ascending order of the HDI_n values. A ratio of 1 (indicated by red solid line) indicates no disparity between the two income groups, while any value above 1 shows that the households in the tenth decile have higher HDI_n than those in the first decile.

Variation by income deciles is not high in regions with relatively low human development alone. It is high in regions that have done well on other parameters (e.g., Delhi, Tamil Nadu, and Himachal Pradesh), though having high HDI_n values also record high inequality based on income decile ratio. The highest variation based on ratio between tenth and first decile is seen in Bihar. Punjab, the North East, and Kerala have the least discrepancy between households in the bottom most decile and top most decile. In terms of the magnitude the ratio varies from 3.8 in Bihar to 2 in the North East, while in Kerala it is the least at 1.5. The ratio declines with increasing value of HDI_n, with it being lower with increasing HDI_n values. These results are not in any way a departure from an unexpected trend, as the income component is a part of the HDI_n. We further explore these distributional variations in the HDI_n by certain specific household characteristics, which is an advantage of using highly disaggregated information.

6.5.2.2 Impact of caste status

Among the tasks outlined at the beginning in section 1.4 was to investigate the extent to which caste underpins human development in India. The first characteristic we account for is caste status of the household. In an earlier discussion in section 3.3.1 the discrimination due to caste status, specifically in the context of access to nutrition related services alludes to differences that are likely to arise in the values of HDI_n. In figure 6.11, HDI_n has been divided into two categories. First, households that reported belonging to the non-SC/ST/OBC and secondly, those which reported belonging to the SC/ST or OBC community.

Figure 6.11 shows that, without an exception, all states show higher HDI_n values for non-SC/ST/OBC households. Delhi, Kerala, Assam, and the North East have the least discrepancy based on caste as the ratio is tending to 1. The states of Bihar, Uttar Pradesh, Odisha, West Bengal, and Gujarat are where in the case of non-SC/ST/OBC households, the attainment in human development is higher by about 1.3 to 1.7 times than the SC/ST/OBC counterparts within the same state. For the states with the highest HDI_n values, the ratio gradually declines, showing that with higher human development achievement, discrepancy based on caste may reduce.

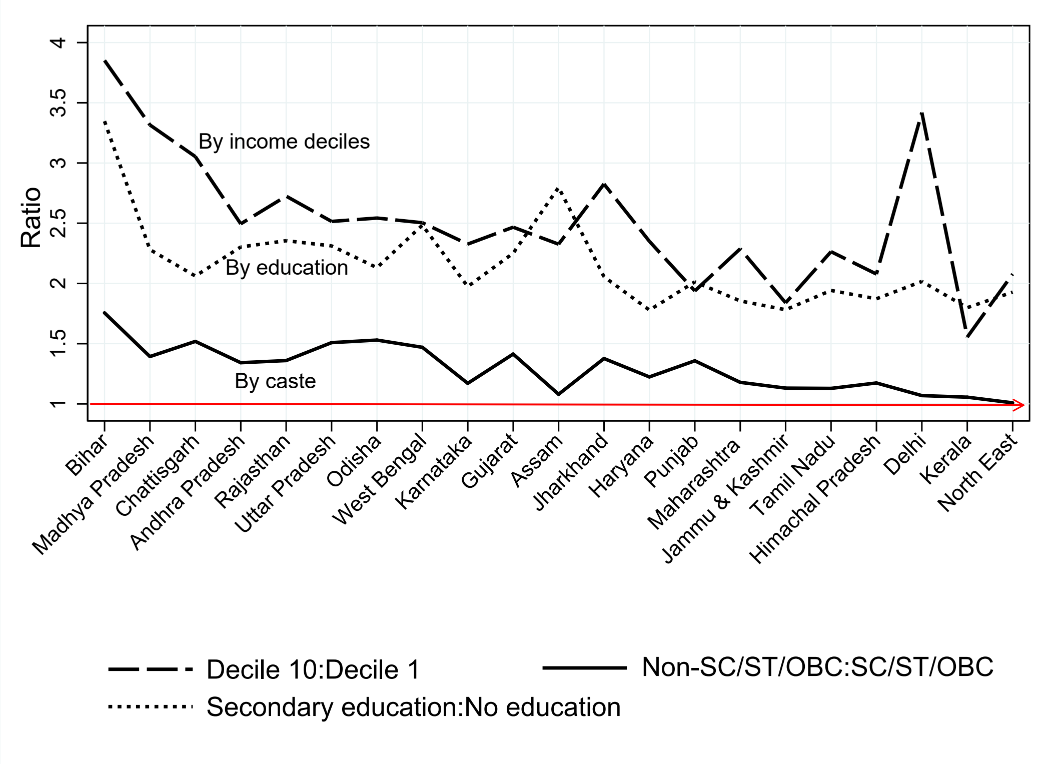


Figure 6.11: Inequality in HDI_n by income, caste, and education. Dashed black line is inequality by income deciles and solid black line shows by caste. Dotted black line is for education index. The states are ordered in ascending order of HDI_n.

6.5.2.3 Impact of household head's education level

Figure 6.11 also shows results of the changes in the HDI_n by the household head's education level. As expected, magnitude of average HDI_n is higher among households where the head has ten or more years of formal education (shown as sec.educ.). Bihar shows an HDI_n that is 3.5 times as high for households where the head has attained at least secondary level education compared to those households where the head has not received any form of formal education, while in West Bengal and Assam it is 2.5 to 2.8 times higher. In Assam, the inequality is higher on the basis of education level than that of the inequality due to income. While in West Bengal the inequality based on income deciles and education are equal at 2.5.

6.5.2.4 *Impact of household head's gender*

In figure 6.12, we show results of NI based on the gender of the household's head. Although, the share of households that report being headed by a woman is low, we confirm the impact women's status can have on health related matters. By estimating the nutrition index score for households headed by males and females, followed by taking a ratio of HDI_n of female headed households to HDI_n of male headed households, it was found that in 16 states the households headed by women had a higher NI score vis-à-vis male headed households. This can be seen in figure 6.12 where all the ratios that lie above 1 (solid red line) are the ones where nutrition index scores are higher for households with female heads. Jharkhand has the highest gender differential followed by Chattisgarh, Punjab, Maharashtra, and Tamil Nadu. Bihar, Andhra Pradesh, Jammu& Kashmir, and Himachal Pradesh are four states where the the male headed households have a higher NI score.

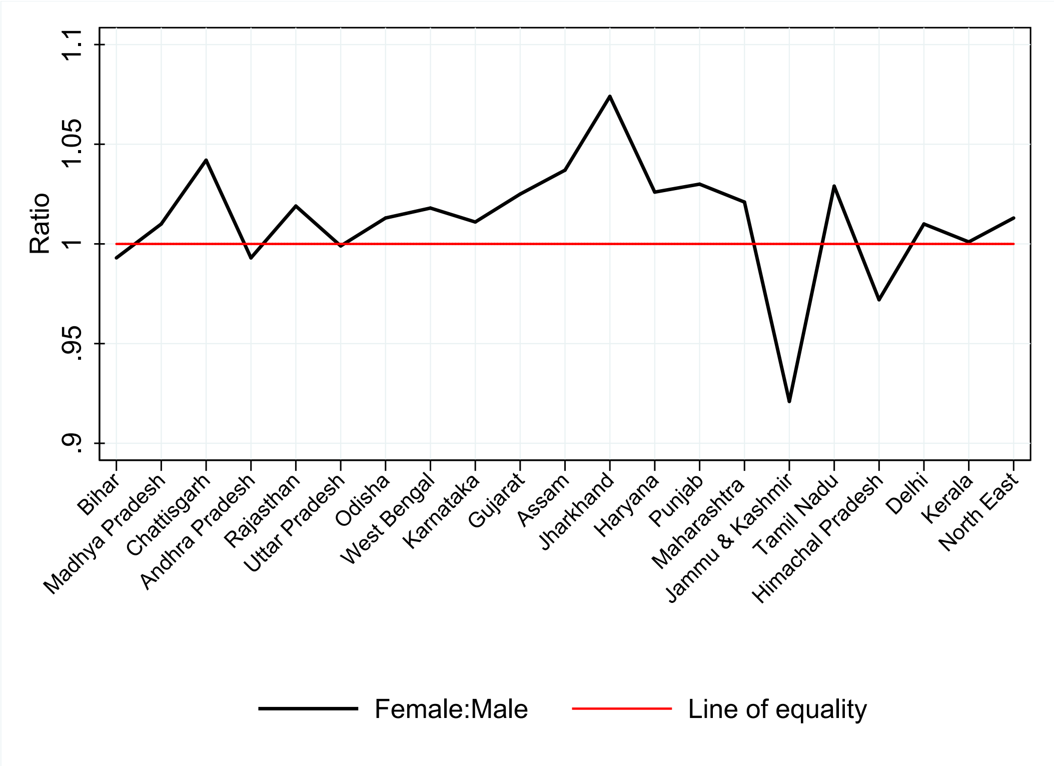


Figure 6.12: Difference in Nutrition index by gender of household head. Solid black line shows the ratio of female to male nutrition index. Solid red line shows equality. The states are ordered in ascending order of HDI_n.

In summary of the results presented thus far, we find a sizeable inequality in the HDI_n by income deciles, followed by education, and at last by caste. In the following section, we inspect these inter-group inequalities by utilising a decomposition method.

6.5.3 Decomposition analyses

Decomposition is a method by which inequality can be examined on the basis of income or population sub-groups like caste and gender. An inequality measure like the general entropy class index (Theil index) can be decomposed into components reflecting the size, mean and inequality value of each population sub-group (Heshmati, 2004).[70] The Theil index, by virtue

[70]General entropy measures are a class of inequality indices that are sensitive to changes at the lower and higher end of a distribution.

of being additively decomposable, can be used to further break down inequality into two groups; “within group” and “between group” inequality. A simplistic way of representing the additive property of the Theil index is given in equation 6.12.

$$T = \sum_{i=1}^{m} s_i T_i + \sum_{i=1}^{m} s_i \ln\left(\frac{\bar{x}_i}{\mu}\right) \text{ for } s_i = \frac{N_i}{N}\frac{\bar{x}_i}{\mu} \tag{6.12}$$

Here, s_i is the share of HDI_n of group i, N is the total number of households and N_i is the number of households of group i. T_i is the Theil index for that subgroup, $\bar{x}_i$ is the average HDI_n in group i, and μ is the average HDI_n of the population of households.

Table 6.2 shows values of the Theil index for HDI_n. It is a powerful instrument for analysing patterns of inequality (Conceição and Ferreira, 2000). The main idea here is to provide a measure of the deviances between the distribution of HDI_n and the distribution of population representing a share of this development measure. When all the population groups have a share of HDI_n equal to their population share, the Theil measure is zero. Higher values of the Theil index indicate the extent of sensitivity of transfer of income from the richer to the poor (Conceição and Ferreira, 2000). This means that the sensitivity increases as the gap between the rich and poor widens. States like Bihar (0.369), Chattisgarh (0.267), Madhya (0.272) Pradesh, Uttar Pradesh (0.274), and West Bengal (0.257) are among the regions with high inequalities and thus a large gap between the richest and the poorest (values in parenthesis are the Theil index scores). A transfer of income in these states will lead to fairer share of income for the households in the lowest part of the income distribution. As the Theil index approaches zero, it indicates that the distribution is moving towards equality faster. Examining such dramatic variation and linking them to policy strategies, while addressing some conceptual measurement issues can be carried out with results and indices of such kind.

Table 6.2: Inequality by general entropy class index for HDIn. Data source: IHDS-II (2011-12)

State	General entropy index
Bihar	0.369
Madhya Pradesh	0.272
Chattisgarh	0.267
Andhra Pradesh	0.301
Rajasthan	0.283
Uttar Pradesh	0.274
Odisha	0.223
West Bengal	0.257
Karnataka	0.233
Gujarat	0.218
Assam	0.243
Jharkhand	0.242
Haryana	0.218
Punjab	0.225
Maharashtra	0.194
Jammu & Kashmir	0.232
Tamil Nadu	0.202
Himachal Pradesh	0.186
Delhi	0.169
Kerala	0.150
North East	0.166

The states are ordered in ascending order of HDI_n.

Further, we carry out decomposition by the following groups; income deciles and head's education. Figure 6.13 shows that most of the inequality is attributed to inequality within the groups. Once again, in case of income deciles a group refers to one decile. In case of education, the three groups are; no education, primary (upto 5 years), and secondary (10 years or more). Between group inequality by income deciles, on an average account for 2-5 per cent of the total inequality for most states. Therefore, the inequality between households belonging to two separate deciles is much lesser. On the other hand, the within group inequality (belonging to the same decile) is ~28 per cent in Andhra Pradesh and Bihar. The lowest is the North east, equal to 13.6 per cent. Our results are similar to those reported by Harttgen and Klasen (2012), where they found heterogeneity within the groups are much larger than differences between groups.

By education of the head, in Bihar, within group inequality contributes to 27.4 per cent of the total inequality and in Madhya Pradesh it is equal to 25.1 per cent. The least is found to be in the North East. These results (seen in figure 6.13) show that, as the states's HDI_n scores improve, the contribution of income and education to inequality also decreases.

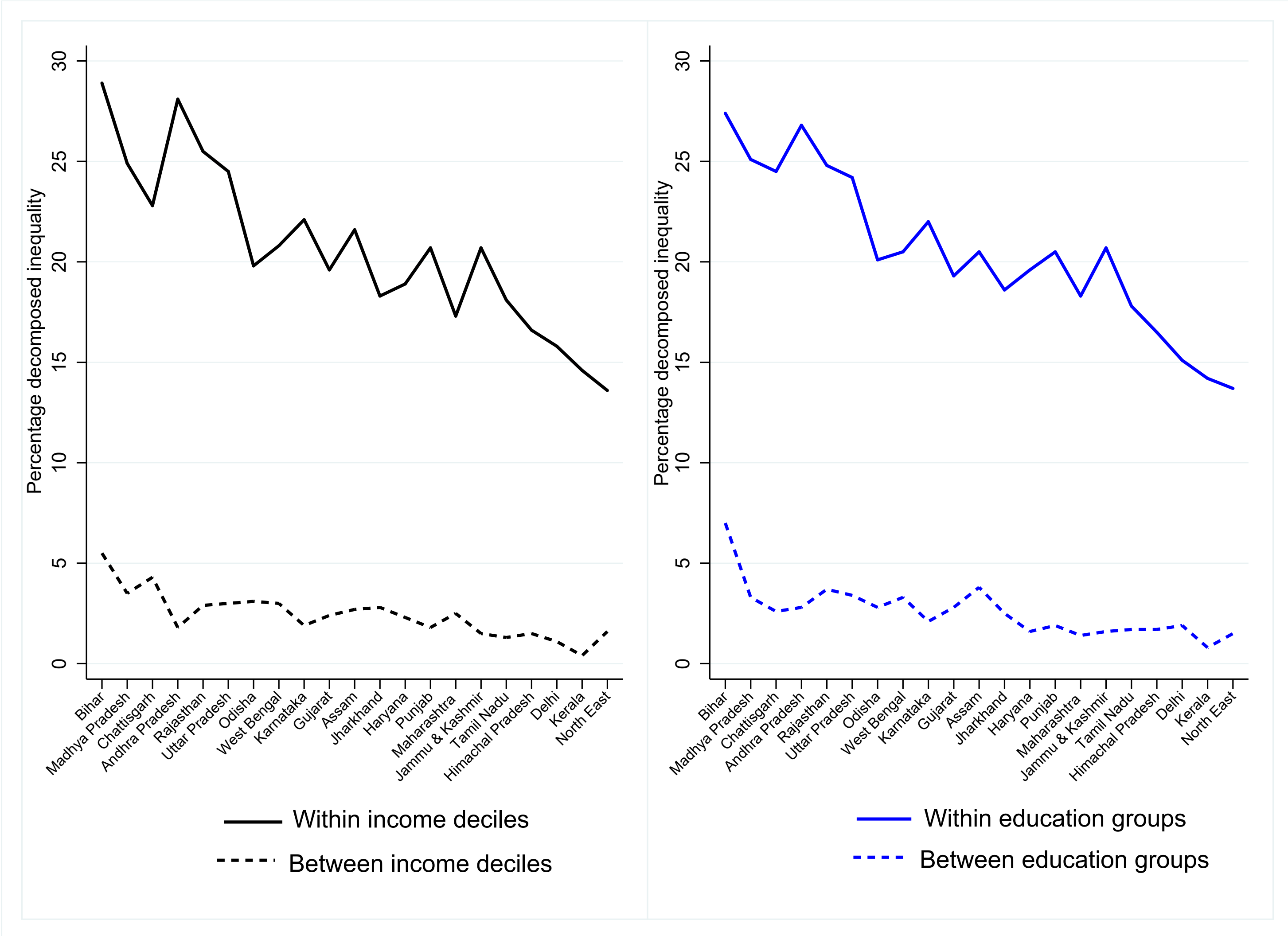


Figure 6.13: Inequality decomposition by income deciles and education levels. Solid black line shows the within group inequality by income and dashed black line shows between group inequality by income. Solid blue line shows the within group inequality by education and dashed blue line shows it for between group by education. The states are ordered in ascending order of HDI_n.

6.6 Discussion

In this chapter, we provide a method to calculate the HDI, both, HDI_s and HDI_n at the household level. We provide an alternative to the life expectancy index by constructing a nutrition index. A household based development index gives us an opportunity to implement analyses that is usually unavailable while using aggregated data. We analyse differences between states of India using a household based survey conducted by the IHDS-II.

The key findings of our study are that HDI_n is a robust alternative to the standard HDI. Upon using disaggregated data, unit of analysis being a household, we find that on an average, the HDI is lowered from 0.504 to 0.384 at all India level. We find that the contribution to reduction in the index value is due to the disaggregated data. Using the nutrition dimension, we show with the help of maps, a close association between indicators of social achievement and child health. We find that the nutrition subcomponent is a robust alternative to the life expectancy index and identify states that have under-performed based on nutritional status. Furthermore, the HDI_n is the only alternative in the absence of life expectancy data by population groups, which is the case for many developing economies.

The inequality analysis using Lorenz curves showed that massive disparities in the education component drives extremely high inequality. Also, HDI_n captures greater inequality than HDI_s.

We find that among population sub-groups; income deciles, caste status, and education of household head, inequality is substantially high by income and education status. Interestingly, we found that in 16 states, the nutrition index is higher for households that report being headed by a woman. General entropy class index calculation alluded to the largest gap in human development share in Bihar, Chattisgarh, Madhya Pradesh, Uttar Pradesh, and West Bengal. In all states, the within group inequality in the HDI_n dominates the share in total inequality. Differences in the household head's education attainment is largely pronounced in contributing to between group inequality in Madhya Pradesh, Rajasthan, Uttar Pradesh, and Bihar.

A major caveat in this study is that, this index underestimates inequality within the household/among individuals. We have not looked at the causes of such discrepancies in the levels and differences of the HDI_n, however, our approach helps us to identify those states that have the largest inequality in all dimensions. Among areas of interest for policy makers are, poor educational performance (measured as mean years of schooling and expected years of schooling) in Uttar Pradesh, Andhra Pradesh, Karnataka, Bihar, Chattisgarh, Madhya Pradesh, and West Bengal. Moreover, Maharashtra, Chattisgarh, Bihar, Gujarat, and Madhya Pradesh perform poorly on the nutrition dimension.

The final chapter of the thesis, revisits the key findings and concludes with future directives for research in this field.

Chapter 7

Conclusion

~ Applying what we learned

In this final chapter of the thesis, we look at a technology based solution that is concomitant with the recent goals established by the government of India (NITI aayog, 2017), revisit key findings and limitations of the research, suggest directives for future work, and then go on to discuss the implications on policy and conclude.

7.1 ICT for malnutrition abatement

In section 2.4 details of the abatement initiatives in India with the current problems related to convergence were elaborated. As part of a solution finding exercise, we propose more effective use of ICT focussing on the schemes/services listed in table 2.1. ICT based solutions provide a platform that are easily reproducible, modifiable, and replicable. Multiple schemes are administered by several ministries within the country with flexibility given to each state government to choose implementation methods. With this background, we identify three key challenges:

- 'first-mile' problems of penetration of all malnutrition abatement schemes to beneficiaries, for example; delivery of MDMS at schools in a timely, efficient, and transparent manner;
- 'last-mile' problems of real-time tracking of individuals (mothers, infants, children, and adolescent girls) irrespective of fragilities like migration; and
- 'beyond-the-last-mile' challenges of inclusion of the excluded (Mathew and Goswami, 2016)

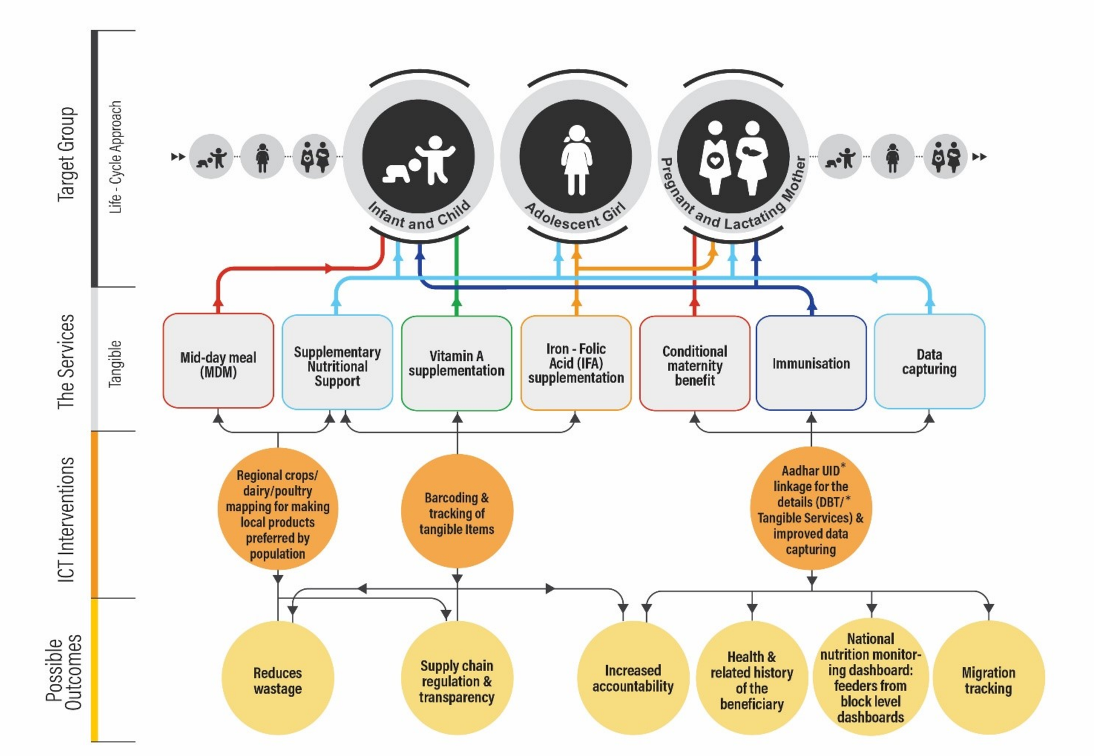


Figure 7.1: ICT interventions for all tangible services of various malnutrition abatement schemes with possible outcomes. * is the unique identification number for Indian citizens.

Figure 7.1 depicts the model overview of the tangible services that various target groups are eligible for as per respective schemes outlined in table 2.1.

Each service's delivery has then been associated to an appropriate ICT intervention (encircled in orange). Following which the possible outcomes expected have been mentioned (encircled in yellow). Similarly, figure 7.2 presents the intangible services along with the likely impact that corresponding ICT interventions may result in. Both the process architecture diagrams follow a life cycle approach of including the child, an adolescent girl, and mothers as target groups.

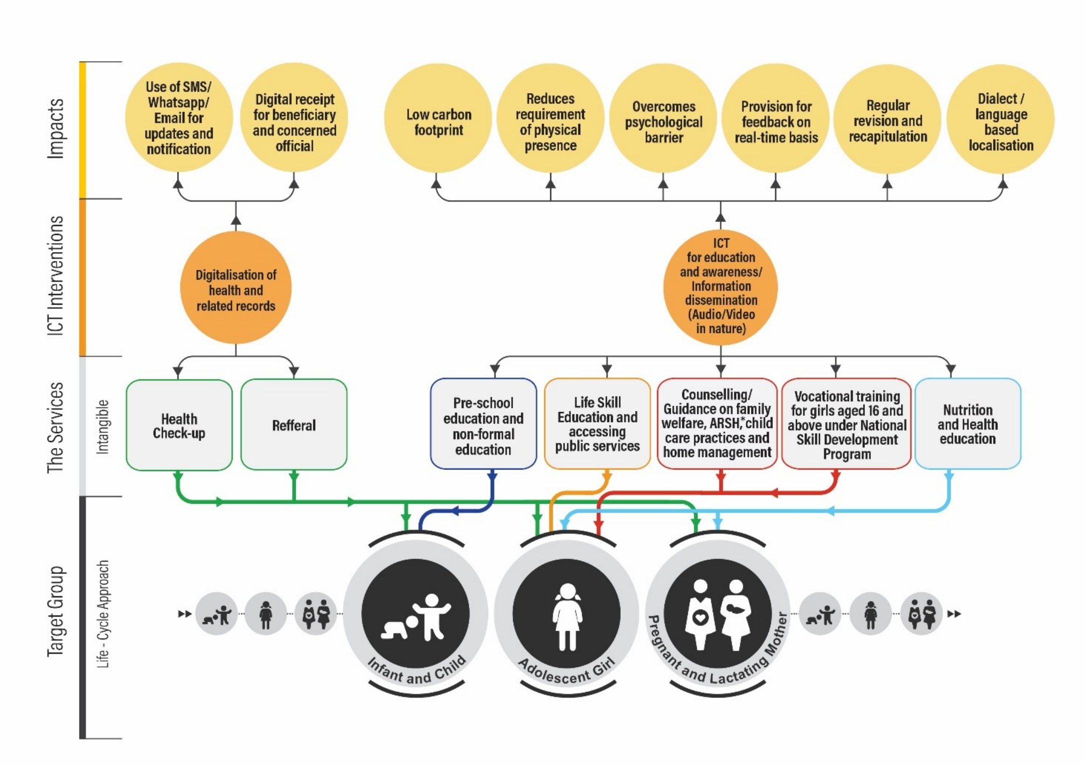


Figure 7.2: ICT interventions for all intangible services of various malnutrition abatement schemes with possible outcomes.

7.2 Key findings: the Indian case

The main concern of this thesis has been to study the association between malnutrition and human development in India. It is quite antithetical that, in India, where economic growth rate in the last two decades has been steady, mass deprivation resulting from malnutrition has curbed human development achievement.

The deconstruction exercise relates to the vast research and literature on how 'capabilities' defined as a basic set of 'functionings' and 'doings' are curbed when a minimum level of well-being is not attained. Malnutrition among other factors traps individuals in a cycle of inter-generational poverty and ill-health. Approaching development from a nutrition-centric approach with the 'child' as the foundation of human capital development is the cornerstone of the research conducted as part of this thesis.

The first task was to interact with people who live in remote areas and understand the less apparent factors leading to poor nutritional status. It was found that lack of social belonging, below par hygiene standards including open defecation, spurious outreach of abatement initiatives, and weak social status of women were prime drivers of malnutrition in the villages we visited. Empirically testing the association between child health (measured objectively) and income was possible by using the IHDS-II data–which is a nationally representative data set that provides a rich compendium of variables for studying human development. We used HAZ as the main dependent variable. Analyses in chapter 4 shows that, on an average when income doubles stunting rates reduce by 2.52 percentage points in households of the lowest income quintile. Results from regression show that for the smallest children this association is the strongest when the annual income is above 176.2 USD, or in other words if they are above the second quintile.

As the second challenge we chose to study the impact of community driven initiatives in recovering children from the MAM condition. Under the framework of the ICDS operational schemes and for leveraging the diversity of a multi-ethnic group a CRT study was conducted in Dharavi, Mumbai. The CMAM approach displayed tremendous potential for mobilising the AWWs and the mothers of enrolled children towards promotion of wholesome feeding options. Since the MFF catered to local dietary preferences of the study population, we observed a significant change in the nutritional status of the children. Comparison of both study arms reinforced the fact that nutrition counselling and consistent monitoring of growth are potent in increasing the weight of children within a certain time period.

Primary data from the field trial enabled the application of the PeT methodology which estimates individual level outcomes owing to the heterogeneity of treatment effects. Evaluation of this kind is highly relevant to policy as it caters to the unobserved confounders as well. We found a significant improvement in the child health status after the 13 week intervention period, thus, micronutrient fortified supplementation proved to be an effective alternative over the existing THR. Additionally, inadequacy of awareness related to IYCF guidelines amongst mothers and limited access to sanitation were also brought to the front.

Highly important to the line of enquiry is the construction of an alternative HDI based on household data for all states of India presented in chapter 6. Disaggregated data, unit of analysis being a household, showed that on an average, the HDI has lower values at all India level as compared to aggregate data. Therefore, the current standard HDI overestimates human development outcomes. The NI based on growth failure and severe thinness, as an alternative to the life expectancy index proved to be a reliable indicator of progress along the three core dimensions of standard of living, knowledge, and health.

The maps of states based on these indices show striking similarities with respect to the geography of underdevelopment across the country. The inequality between based on the the first and tenth decile of income is largest in Bihar and the least in North East. Poor education outcomes were the prime drivers of the large differences among households.

Conducting sub-group analyses based on income, education, caste status, and gender of the household heads are among the main advantages of using the IHDS-II data. All these demographic characteristics proved to be prime influencers of the performance levels seen on the three sub-components of human development. Households from the upper castes had higher achievement than SC/ST/OBC counterparts. The difference was about 1.1 to 1.7 times higher in the favour of non-SC/ST/OBC community. Inequality in the $\mathrm{HDI_n}$ attainment based on education was found to be the least in North East and Kerala. Head's gender emerged as a powerful predictor of relatively better nutrition outcomes. For 16 states, when the household head was a woman, the nutrition index scores were relatively higher. This is concurrent with our hypothesis that a woman's role in improving nutritional outcomes of the household remains pivotal, as also noted in our observations at Sheopur.

7.2.1 Limitations

There are several limitations in this study. These may have implications on the manner in which the findings and conclusions are interpreted. An even more rigorous conceptualisation of nutrition and human development would have been possible. The major limitations remain the lack of panel data analysis for investigating the child health and income gradient. An even more comprehensive analysis with panel data would assist in determining temporal trends. Also, we could not account for endogeneity, thereby the causal pathways cannot be confirmed.

In the CRT study, high attrition of enrolled children due to migration and illnesses reduced the sample size. Individualised estimations need high sample size which required the pooling of observations over all time periods. This could have been overcome if there were fewer drop outs in the study.

Owing to the diversity in governance, implementation methods, and varying development outcomes in India, further disaggregation of analysis to determine the contributors to high malnutrition rates and weak human development in different states is also lacking. Furthermore, a qualitative assessment of narratives from institutions and partners who deliver nutrition could have strengthened the overall empirical analysis.

7.3 Directives for further research

By tracing the pathways through which malnutrition and human development are connected—focussing on intrinsic and virtuous nature of the three core dimensions—the Indian case suggests that gains from the demographic advantage of a young population would be meagre if focus on programmatic changes are ignored. For a renewed focus on building capacity and moving towards real development outcomes, the following areas of research may be explored.

First, differentiating between access and usage of services is important to build sound evidence about what succeeds and what fails on ground. As seen in Coffey and Spears (2017c) availability of toilets did not guarantee their usage. This warrant better framing of questions in surveys to estimate actual outcome based improvement. Moreover, chapter 3 also shows that village level coordination among stakeholders focussed more on services rather than outcomes.

Secondly, developing collaborative models that when scaled up, also succeed in management of malnutrition requires much needed attention. Several challenges that are unique to various geographies prevent reproducibility of community models. Thus, identifying the nuances which can guide efficient implementation will be powerful in scaling up of initiatives.

Thirdly, analytical improvement building on methods elucidated by Basu (2014) which require larger and more reliable data sets will prove to be relevant in settings where newer schemes and programmes are rolled out. Fourthly, devising surveys for collecting disaggregated data catering to specific age groups like children below the age of 2 years and adolescents is yet another recommendation.

Lastly, studying human development for population groups that have similar eating/ feeding practices and live in analogous agro-climatic regions, rather than just as per states or districts will broaden the scope of measuring development outcomes. As an example, in Coffey and Spears (2017a) show how even though in Bangladesh people access toilets constructed at much lesser cost, Indians in West Bengal still refuse to use toilets. Studying enigmas like these may lead to solving the calorie reduction debate and also why malnutrition is so heavily concentrated in regions of India which otherwise have similar per capita income and education attainment.

7.3.1 Understanding as-is-processes

An example of an 'as-is-process' of the PMMVY, a conditional cash transfer scheme for pregnant women, has been presented (figure 7.3). This is another area of research that can attract many technology solutions for improving outreach, impact, and outcomes of schemes. There is both, an urgent need and ample scope for carrying out this exercise for all malnutrition abatement initiatives, education programmes, and other beneficiary oriented schemes.

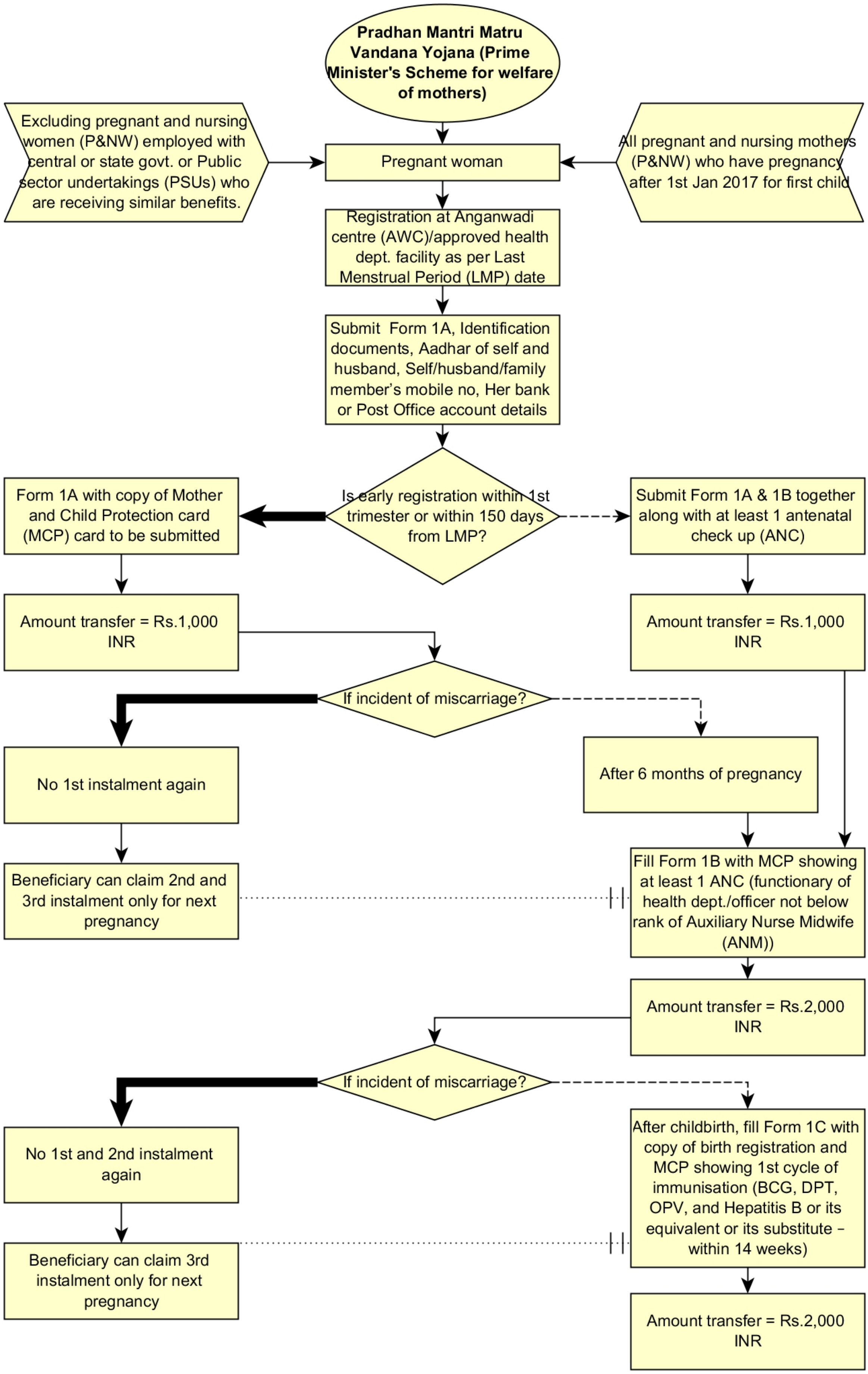


Figure 7.3: As-Is process for PMMVY. All bold black arrows indicate a 'Yes' scenario, all dashed lines arrows indicate a 'No' scenario, and all dotted lines with small parallel lines indicate a re-entry into the scheme.

7.4 Implications for policy

Policy implications from the perspective of this thesis are related to three aspects; political motivation, addressing health inequalities, and building multi-stakeholder partnerships for better nutrition.

The placement of power in a state, participation, and accountability are pillars for creating a nutrition sensitive ecosystem. While matters related to political patronage determine the process of accessing health care, as also noted in chapter 3, the attention given to tackling malnutrition remains a function of governance and commitment. Competing interests and difference in ideologies lead to ignoring the condition of the poor who are more likely to be undernourished. Vertical integration of policy making bodies, persuading an understanding among people about undernutrition, and the timing of interventions have been documented as key inter-related elements of policy processes. In India, local, district, national, and global co-ordination is necessary for addressing hidden hunger and malnutrition. A strict demarcation of roles for all players, starting from the frontline workers to the national directors requires consistent prioritisation of nutrition as a top development agenda.

As Deaton (2002) notes, effects of income on health or that of health on income result in 'inequalities in health'. Analyses and discussion in both chapters 4 and 6 indicate that, a gradient between child health and income can be addressed by a continuous redistribution of income and wealth, which is a remedy for population health. The upstream linkages, as detailed in this thesis, between malnutrition and human development need reform to harness benefits from improving the downstream influencers such as, the control of health behaviour or health delivery systems. Since 'within group inequalities' are higher than 'between group inequalities', wealth redistribution is not a long-term strategy. Policy needs to ensure that it does not improve health at the expense of income or vice versa. The only one policy that is doubly attractive, free from this conflict, and imbues earnings and health, is the quality and quantity of education. Chapter 6 showed that education attainment in terms of schooling and enrolment is dismal in several states, especially, in rural areas. Therefore, the reforms in education must be more cognizant of health benefits.

Multi-stakeholder partnerships make a ripe ground for giving a more productive life to millions of undernourished children. Accelerating nutrition specific interventions under this framework is a challenge that requires regulation and stewardship. In India, instead of promoting multiple smaller institutions acting locally, a district level consortium of must lead in channelising funds, resources, and identify only relevant scalable interventions. Gaps in reporting can be resolved by already available low-cost technology platforms that can act as feeders for data at national level (through missions like the new *Poshan abhiyan*).

Yet another area for mandatory reforms is making district planning budgets more child and mother sensitive. Encouraging research that develops user-friendly and locally customised training modules for AWW/ASHA is pivotal to the functioning of the entire machinery. Capacity building in high burden villages is a remedy for reducing the public health concerns of malnutrition. Overarching all these is creating a nutrition sensitive food system, to include, not promoting expensive micronutrients and inexpensive calories and concentrating on agriculture with a post-harvest value chain perspective. Chapter 5 showed how academia, government, and the civil society is an effective partnership in mobilising communities. More documented evidence even if not a trial is needed for Indian settings, which can lead the way in designing policy to this effect.

7.5 Concluding remarks

Our research shows that the correlation between income and child health is mediated by several socio-economic transmission channels. We found that on an average when income doubles stunting rates reduce by 2.52 percentage points in households of the lowest income quintile. While food based nutrition supplementation is necessary, the controlled trial proved that it needs to be accompanied by continuous monitoring and counselling. The children enrolled in the treatment group gained 7.9 per cent more on the WHZ than children of the control group. Nutrition index associated with child health developed in this work constituting anthropometric parameters can be a very useful and significant indicator of human development progress.

In closing, the opportunity that lies ahead of India and the world for tackling malnutrition is enormous. This thesis is an effort to redirect attention towards making the 'child' a priority. With much of the gradual reduction in malnutrition already accomplished, the response to changing environmental conditions, climate change, and increasing stress on agricultural systems, have to be sustainable and long-term.

A strong start to life is a need for every child, which must be independent of the economic strata, she/he is born into. In this era of Sustainable

Development Goals (SDGs), India's human development will depend largely on its maternal and child health care policies.

~ The health of a nation depends on the health of a child.

Appendices

Annexure 1

Figure 4 shows the map of Dharavi, Mumbai.

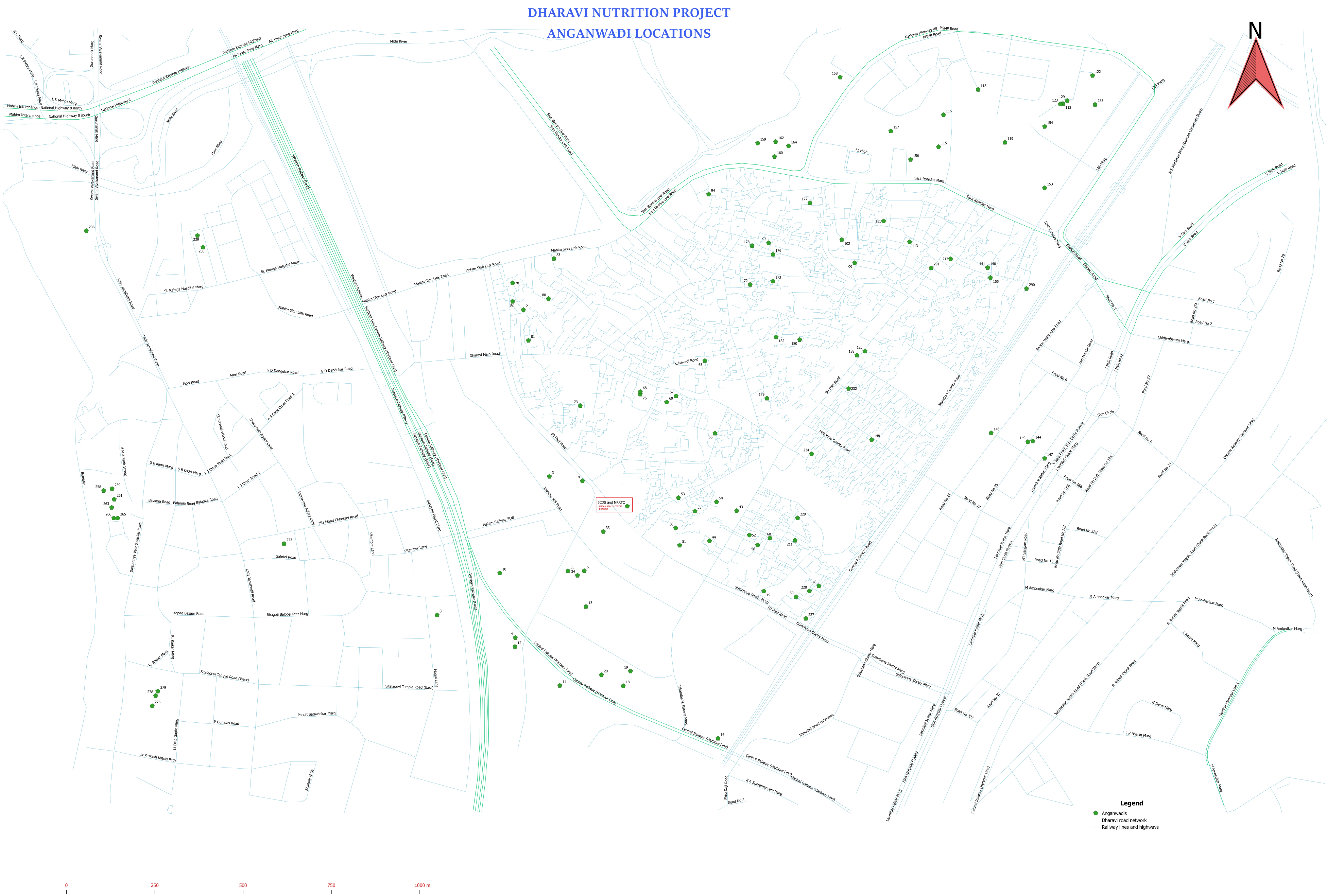


Figure 4: Map of all the project Anganwadis in Dharavi, Mumbai. Green dots indicate the location of the Anganwadi

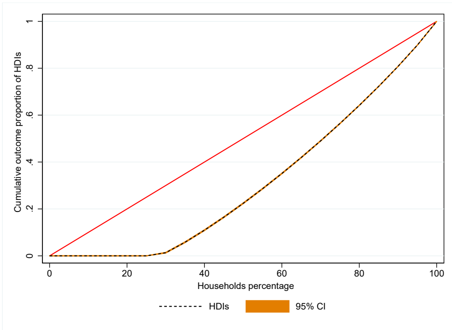
Annexure 2

Table 1: Nutritional value of all the Micronutrient fortified foods for the CRT study at Dharavi, Mumbai

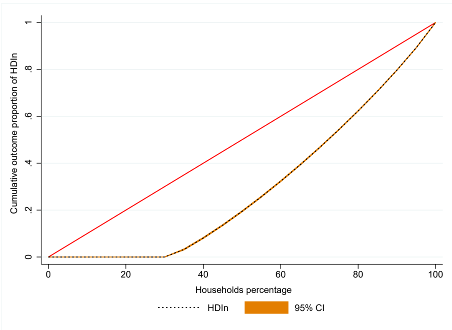
Products	Moisture (g)	CHO (g)	Energy (kcal)	Fat (g)	Protein (g)
Upma Premix	1.6	50.6	519	28.2	15.6
Zunka Premix	2.2	34.5	531	33.1	23.8
Ladoo Premix (LP)	1.8	53.1	522	15.8	27.7
Kheer Premix	2.5	66.0	423	9.3	18.9
Wheat Payasam Premix	1.6	49.3	513	27.6	16.9
Ragi Porridge Premix	1.7	65.0	452	14.1	16.4
Nankhatai	11.9	40.5	545	35.2	16.2
Ready to use multigrain flour paste	1.5	40.2	565	36.4	19.1
Mathri	4.1	41.7	512	29.2	20.6
Shakarpara	3.5	37.9	521	30.0	24.7

All values are per 100 g of the respective product

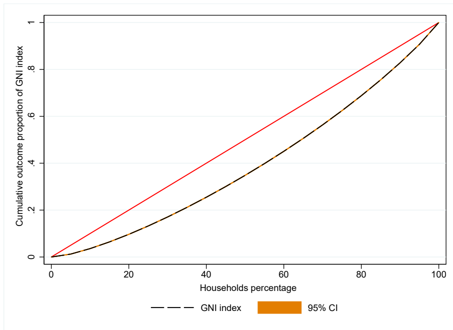
Annexure 3



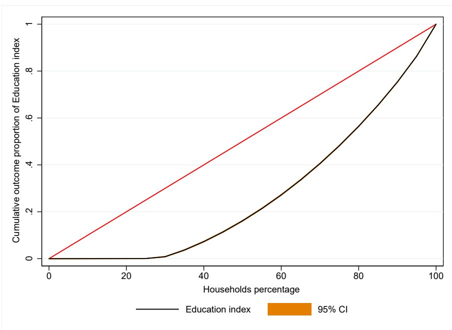
(a) HDIs



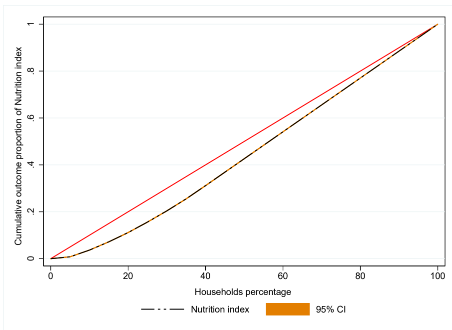
(b) HDIn



(c) GNI index



(d) Education index



(e) Nutriton index

Figure 5: Statistical difference of lorenz curves from the line of equality. Dark orange region shows the 95 per cent confidence interval.

Note: The test has been performed following the (Jann, 2016) paper. The commands are available in STATA.

Table 2: Sub-component indices of HDI_n.
Data source: IHDS-II (2011-12)

State	GNI index	Educ. index	Health index	Nutrition index
Andhra Pradesh	0.345	0.350	0.732	0.872
Assam	0.368	0.407	0.714	0.959
Bihar	0.279	0.344	0.719	0.872
Chattisgarh	0.279	0.363	0.728	0.819
Delhi	0.443	0.557	0.782	0.899
Gujarat [a]	0.351	0.425	0.748	0.833
Haryana	0.383	0.436	0.761	0.882
Himachal Pradesh	0.404	0.483	0.807	0.855
Jammu & Kashmir	0.420	0.465	0.781	0.923
Jharkhand	0.307	0.458	0.742	0.878
Karnataka	0.353	0.383	0.787	0.900
Kerala	0.436	0.530	0.816	0.906
Madhya Pradesh	0.289	0.356	0.717	0.809
Maharashtra [b]	0.370	0.490	0.757	0.858
North East [c]	0.428	0.514	0.737	0.957
Odisha	0.290	0.403	0.717	0.885
Punjab [d]	0.419	0.444	0.765	0.892
Rajasthan	0.344	0.345	0.740	0.852
Tamil Nadu [e]	0.401	0.474	0.779	0.893
Uttar Pradesh [f]	0.296	0.400	0.688	0.861
West Bengal	0.348	0.361	0.785	0.897
Average	0.360	0.428	0.752	0.881

a; includes Dadra& Nagar Haveli and Daman& Diu, b; includes Goa, c; includes Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalya, and Sikkim, d; includes Chandigarh, e; includes Puducherry, f; includes Uttarakhand

Table 3: HDI_n by education and gender of household's head.
Data source: IHDS-II (2011-12)

State	Head's education				Head's gender		
	No educ.	Prim. educ.	Sec. and above	Ratio (Sec. to No educ.)	Male headed	Female headed	Ratio (Female to Male)
Andhra Pradesh	0.173	0.343	0.399	2.303	0.316	0.241	0.765
Assam	0.178	0.403	0.497	2.798	0.399	0.318	0.797
Bihar	0.135	0.300	0.452	3.347	0.292	0.191	0.654
Chattisgarh	0.185	0.308	0.381	2.062	0.299	0.273	0.916
Delhi	0.277	0.484	0.558	2.017	0.485	0.441	0.909
Gujarat [a]	0.205	0.381	0.461	2.251	0.378	0.317	0.838
Haryana	0.267	0.398	0.476	1.779	0.401	0.364	0.908
Himachal Pradesh	0.268	0.450	0.502	1.873	0.436	0.441	1.012
Jammu & Kashmir	0.273	0.444	0.487	1.782	0.420	0.352	0.838
Jharkhand	0.232	0.352	0.477	2.056	0.383	0.284	0.742
Karnataka	0.213	0.398	0.421	1.974	0.353	0.339	0.961
Kerala	0.289	0.517	0.520	1.799	0.489	0.498	1.019
Madhya Pradesh	0.163	0.324	0.373	2.281	0.294	0.201	0.684
Maharashtra [b]	0.257	0.414	0.477	1.855	0.423	0.370	0.874
North East [c]	0.283	0.499	0.546	1.928	0.485	0.455	0.939
Odisha	0.200	0.372	0.425	2.131	0.344	0.297	0.864
Punjab [d]	0.242	0.420	0.488	2.013	0.406	0.395	0.973
Rajasthan	0.186	0.347	0.439	2.355	0.320	0.203	0.634
Tamil Nadu [e]	0.251	0.463	0.487	1.942	0.438	0.351	0.801
Uttar Pradesh [f]	0.186	0.348	0.430	2.312	0.325	0.252	0.778
West Bengal	0.185	0.349	0.460	2.484	0.358	0.305	0.850

HDI_n refers to the HDI with the nutrition index in place of the life expectancy index.
No educ. refers to no formal schooling, Prim. educ. refers to schooling up to standard five, and Sec. educ. and above refers to ten or more years of schooling.
a; includes Dadra& Nagar Haveli and Daman&Diu, b; includes Goa, c; includes Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, and Sikkim, d; includes Chandigarh, e; includes Puducherry, f; includes Uttarakhand

Table 4: Sub-component indices by household head's education level for states of India.
Data source: IHDS-II (2011-12)

State	GNI index				Education index				Nutrition index			
	No. educ.	Prim educ.	Sec. and above	Ratio (Sec. to No educ.)	No. educ.	Prim educ.	Sec. and above	Ratio (Sec. to No educ.)	No. educ.	Prim educ.	Sec. and above	Ratio (Sec. to No educ.)
Andhra Pradesh	0.326	0.337	0.365	1.117	0.187	0.339	0.487	2.604	0.896	0.823	0.872	0.973
Assam	0.331	0.325	0.400	1.211	0.214	0.340	0.545	2.551	0.957	0.961	0.959	1.002
Bihar	0.251	0.260	0.327	1.303	0.152	0.356	0.590	3.872	0.860	0.858	0.901	1.048
Chattisgarh	0.262	0.260	0.311	1.188	0.218	0.382	0.488	2.236	0.838	0.778	0.831	0.991
Delhi	0.398	0.413	0.466	1.172	0.311	0.515	0.662	2.130	0.877	0.867	0.916	1.045
Gujarat [a]	0.313	0.329	0.381	1.216	0.243	0.396	0.541	2.224	0.843	0.796	0.844	1.000
Haryana	0.356	0.366	0.408	1.145	0.277	0.415	0.551	1.988	0.872	0.880	0.890	1.021
Himachal Pradesh	0.376	0.395	0.418	1.113	0.289	0.474	0.566	1.957	0.866	0.853	0.852	0.984
Jammu & Kashmir	0.406	0.400	0.434	1.070	0.328	0.386	0.570	1.739	0.916	0.933	0.925	1.010
Jharkhand	0.279	0.286	0.335	1.202	0.254	0.431	0.608	2.394	0.857	0.844	0.909	1.060
Karnataka	0.329	0.335	0.376	1.144	0.231	0.387	0.490	2.127	0.915	0.872	0.901	0.986
Kerala	0.417	0.419	0.444	1.065	0.303	0.502	0.579	1.912	0.933	0.926	0.894	0.958
Madhya Pradesh	0.268	0.278	0.317	1.183	0.198	0.356	0.504	2.540	0.825	0.776	0.815	0.988
Maharashtra [b]	0.334	0.341	0.394	1.180	0.277	0.457	0.589	2.126	0.844	0.830	0.873	1.035
North East [c]	0.394	0.396	0.450	1.142	0.266	0.421	0.628	2.365	0.964	0.947	0.960	0.995
Odisha	0.259	0.264	0.323	1.251	0.209	0.401	0.537	2.576	0.886	0.843	0.906	1.023
Punjab [d]	0.393	0.385	0.444	1.131	0.239	0.443	0.566	2.367	0.903	0.839	0.907	1.005
Rajasthan	0.321	0.329	0.381	1.186	0.198	0.350	0.518	2.615	0.854	0.819	0.874	1.024
Tamil Nadu [e]	0.377	0.387	0.415	1.101	0.234	0.457	0.562	2.403	0.888	0.865	0.905	1.020
Uttar Pradesh [f]	0.276	0.277	0.329	1.194	0.232	0.386	0.597	2.573	0.848	0.854	0.880	1.038
West Bengal	0.303	0.308	0.397	1.309	0.192	0.339	0.489	2.540	0.888	0.861	0.926	1.043

No educ. refers to no formal schooling, Prim. educ. refers to schooling up to standard five, and Sec. educ. and above refers to ten or more years of schooling.

a; includes Dadra& Nagar Haveli and Daman& Diu, b; includes Goa, c; includes Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalya, and Sikkim, d; includes Chandigarh, e; includes Puducherry, f; includes Uttarakhand

Table 5: HDI_n and sub-components by location for states of India.
Data source: IHDS-II (2011-12)

State	HDI_n			GNI index			Education index			Nutrition index		
	Rural	Urban	Ratio rural to urban	Rural	Urban	Ratio rural to urban	Rural	Urban	Ratio rural to urban	Rural	Urban	Ratio rural to urban
Andhra Pradesh	0.252	0.391	0.644	0.321	0.373	0.860	0.263	0.441	0.596	0.860	0.882	0.975
Assam	0.351	0.508	0.690	0.337	0.436	0.773	0.363	0.537	0.676	0.962	0.949	1.014
Bihar	0.213	0.407	0.525	0.255	0.337	0.759	0.240	0.483	0.496	0.868	0.905	0.959
Chattisgarh	0.255	0.426	0.599	0.244	0.385	0.633	0.292	0.473	0.617	0.796	0.880	0.904
Delhi	0.450	0.481	0.935	0.403	0.438	0.918	0.502	0.542	0.926	0.940	0.901	1.044
Gujarat [a]	0.327	0.438	0.747	0.319	0.386	0.826	0.369	0.484	0.763	0.818	0.859	0.952
Haryana	0.385	0.463	0.832	0.366	0.445	0.823	0.402	0.515	0.779	0.878	0.890	0.986
Himachal Pradesh	0.419	0.506	0.829	0.383	0.455	0.842	0.464	0.536	0.866	0.848	0.876	0.968
Jammu & Kashmir	0.395	0.441	0.897	0.398	0.441	0.904	0.416	0.478	0.872	0.910	0.930	0.978
Jharkhand	0.301	0.467	0.645	0.266	0.364	0.733	0.334	0.545	0.614	0.875	0.890	0.983
Karnataka	0.319	0.426	0.748	0.330	0.384	0.861	0.328	0.459	0.714	0.881	0.922	0.956
Kerala	0.476	0.502	0.950	0.439	0.430	1.021	0.509	0.545	0.934	0.928	0.889	1.043
Madhya Pradesh	0.252	0.413	0.610	0.265	0.354	0.748	0.290	0.465	0.624	0.800	0.846	0.946
Maharashtra [b]	0.366	0.522	0.702	0.333	0.426	0.783	0.421	0.590	0.714	0.828	0.914	0.905
North East [c]	0.430	0.574	0.749	0.388	0.481	0.807	0.419	0.606	0.692	0.961	0.950	1.011
Odisha	0.301	0.448	0.671	0.251	0.389	0.647	0.332	0.488	0.680	0.875	0.910	0.962
Punjab [d]	0.383	0.455	0.842	0.400	0.432	0.927	0.397	0.505	0.785	0.890	0.897	0.992
Rajasthan	0.267	0.396	0.676	0.325	0.386	0.844	0.265	0.430	0.616	0.850	0.860	0.989
Tamil Nadu [e]	0.366	0.482	0.760	0.368	0.409	0.899	0.389	0.526	0.739	0.887	0.901	0.985
Uttar Pradesh [f]	0.285	0.378	0.752	0.271	0.356	0.761	0.329	0.441	0.746	0.856	0.884	0.968
West Bengal	0.279	0.447	0.624	0.287	0.402	0.713	0.274	0.434	0.630	0.882	0.923	0.955

HDI_n refers to the HDI with the nutrition index in place of the life expectancy index.
a; includes Dadra& Nagar Haveli and Daman& Diu, b; includes Goa, c; includes Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalya, and Sikkim, d; includes Chandigarh, e; includes Puducherry, f; includes Uttarakhand
Source: IHDS-II, authors' calculations

Annexure 4

Sensitivity analyses

The axiom MANUSH[71] has been presented which stands for Monotonicity, Anonymity, Normalisation, Uniformity, Sensitivity shortfall and Hiatus sensitivity to level. This axiomatic approach proved that while LA method satisfies MAN axiom and GM approach satisfies MANU, the DI satisfies the MANUSH axiom thereby setting a better platform for a more statistically and mathematically robust method of measuring the HDI. We return to this discussion on functional forms and the properties they render to the HDI in section 7.5. Also, a comparison of the indices when calculated using different aggregation methods will be detailed. In this section, we discuss the advantages of choosing functional forms that render desirable properties to the HDI. Conceiving the relationship between dimensions of capabilities is also determined by the method used to aggregate the dimension indices (Klugman *et al.*, 2011). In this regard, as discussed in section 6.2, major methodological changes in the HDI have involved shifting from the old arithmetic mean to the geometric mean. Insofar, the HDI_n too has been calculated using the GM which addresses the issue of perfect substitutability.

[71]An anagram of this axiom MANUSH is also Humans. Manush in several South Asian languages also means human beings.

It ensures that poor attainment in any one dimension cannot be compensated by improvement in other dimensions and penalises unbalanced development. This is in accordance with the definition of human development too, which states that each dimension is intrinsic (Sen, 1999). Moreover, the GM lends an attractive feature which makes the ranks produced invariant to scale (Klugman *et al.*, 2011).

As an extension to concerns related to the choice of aggregation method, Mishra and Nathan (2018) propose the DI, which follows the MANUSH axioms. They suggest the H_α measure where α is 'aversion to inequality' . The two additional properties, viz. shortfall sensitivity and Hiatus sensitivity to level, are also fulfilled when $\alpha = 2$ in H_α.[72] DI formula for calculating the HDI is

$$H_\alpha = 1 - \left[\left\{\sum (1 - x_j)^\alpha\right\}/n\right]^{1/\alpha} \tag{1}$$

where j is computed from attainments in several dimensions, $x_j; j = 1, ..., n$. Here, n is the number of dimensions. In our case, $n = 3$, as we have three dimensions in the $\mathrm{HDI_n}$, viz., decent standard of living (proxy measure income (z)), knowledge (education measures (e)), and nutrition attainment (n). For ease of comparison we calculate the DI with $\alpha = 2$ for $\mathrm{HDI_n}$ for all households in the sample and present it with the already calculated GM based $\mathrm{HDI_n}$ for all states of India in table 6.

[72]For details of the proof and theorems related to the DI method, see (Mishra and Nathan, 2018).

Table 6: Education index calculated as arithmetic mean and HDI_n calculated by different aggregation methods.
Data source: IHDS-II (2011-12)

State	Educ. index (old)	HDI_n (GM)	HDI_n (DI)
Andhra Pradesh	0.495	0.322	0.414
Assam	0.524	0.387	0.467
Bihar	0.491	0.292	0.388
Chattisgarh	0.504	0.316	0.386
Delhi	0.673	0.488	0.522
Gujarat [a]	0.539	0.377	0.442
Haryana	0.569	0.413	0.466
Himachal Pradesh	0.584	0.439	0.489
Jammu & Kashmir	0.603	0.433	0.489
Jharkhand	0.577	0.391	0.438
Karnataka	0.507	0.366	0.435
Kerala	0.615	0.489	0.529
Madhya Pradesh	0.502	0.308	0.383
Maharashtra [b]	0.601	0.427	0.471
North East [c]	0.601	0.495	0.516
Odisha	0.525	0.356	0.415
Punjab [d]	0.568	0.418	0.480
Rajasthan	0.485	0.331	0.412
Tamil Nadu [e]	0.582	0.436	0.486
Uttar Pradesh [f]	0.553	0.337	0.408
West Bengal	0.467	0.363	0.429

Educ. index (old) is calculated as arithmetic mean of two educational sub-components.
a; includes Dadra& Nagar Haveli and Daman& Diu, b; includes Goa, c; includes Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalya, and Sikkim, d; includes Chandigarh, e; includes Puducherry, f; includes Uttarakhand

Clearly, the values of HDI_n based on DI are comparatively higher, however, the performance of states relative to each other remains the same. We now look at each axiom individually to understand why the values differ when HDI is calculated using two separate aggregation methods.

The first four axioms apply to both GM and DI methods. Monotonicity means that if there is an increase or decrease in any one dimension (z, e, or n)

with the other two being constant, the value of HDI will also increase or decrease. Anonymity or a symmetry condition ensures that if values of attainments in any two dimensions get interchanged (say for two different states) while the value of one dimension index (say $z = 0.7$) remains the same, the HDI will be equal for both the states. For instance, if on one hand $e = 0.4$, $n = 0.6$ and on the other $e = 0.6$, $n = 0.4$, then for both the states HDI will take the same value. Normalisation or a boundary between 0 and 1, means that if all dimensions have a common value then HDI will be equal to this common value. Uniformity rewards balanced development across all dimensions (Mishra and Nathan, 2018). Thus, on keeping one dimension constant, if for any average attainment across dimensions, a greater deviation will lead to a lower HDI value. This axiom is critical to the need for uniform development across all these intrinsically related dimensions. (Sen, 1999).

The next two axioms are only applicable to the DI method. Shortfall sensitivity caters to the necessity for laying greater remedial emphases on those dimensions that are lagging behind from their respective ideal. This emphasis must also be in proportion to the extent of shortfall in the dimension which will ensure that all dimensions reach their ideal together. Hiatus sensitivity is related to the gap that exists across dimensions. For development with equity any gap that continues to persist between dimensions is not desirable for further development. Therefore, if education and nutrition continue to lag behind standard of living, this gap must be narrowed such that all three dimensions improve simultaneously.

With this as background, the values for $\mathrm{HDI_n}$ when calculated using the DI method, is a corollary to the articulation in this thesis that equitable development across dimensions is favourable.

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