



MONASH University

**Trajectories and transitions:
Exploring declining public transit use following
parenthood**

Laura Elizabeth McCarthy

BA, MURP

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Public Transport Research Group
Institute of Transport Studies
Department of Civil Engineering

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Abstract

The transition to parenthood is a significant change in life stage. It disrupts habitual travel behaviour and provides a valuable opportunity to influence the adoption of sustainable transport practices. To effectively promote sustainable travel patterns, it is important to understand the factors that influence mobility choices during this transition. However, while much is known about how travel behaviour changes during this period, there is little research explaining the processes by which car orientated travel practices are adopted. This thesis aims to fill this gap.

Using a mixed-method approach, this research provides empirical evidence to explain why travel behaviour changes following parenthood, with an emphasis on public transit use. Methods include analysis of household travel survey data, qualitative interviews and an online survey.

Household travel survey data was used to understand the context of travel behaviour change following parenthood in the case study location. This showed that, consistent with international literature on this topic, a pattern of increased car use and ownership is evident following parenthood in Melbourne, Australia.

Qualitative interviews and an online survey were conducted in order to understand the factors which influence mobility changes, and specifically public transit use, following parenthood. The qualitative interviews demonstrated that travel behaviour changes during this period are prompted by both major life events and minor, often child-led, milestones. Moreover, while overall increases in car-use and ownership is evident following parenthood, a diverse range of mobility trajectories are apparent. These range from a minimal change in travel behaviour to a dramatic decline in public transit use.

Caregiving and employment status, as well as car ownership changes, are shown to be crucial in determining the extent to which travel mode use changes, and in particular public transit use declines, following parenthood. Pro-environmental attitudes are shown to mediate the extent to which car-based mobility is adopted following parenthood.

Analysis of the online survey highlighted that weaker car-use habits are associated with a range of household characteristics, including higher household incomes and low car ownership. Moreover, it shows that (in combination with becoming a parent) some life events are associated with strengthening car-use habits while others have a weakening effect.

The qualitative interviews highlighted a range of structural, psychosocial, household and child-related barriers which deter public transit use among households with children. While all factors were important, household and child-related characteristics were the two most important categories shaping new parents' choice to travel by public transit.

This thesis provides a number of theoretical and practical contributions to knowledge. Overall, it identifies and analyses the complex set of factors that prompt mobility changes and tend to encourage the adoption of car-based travel behaviour following parenthood. The findings can be used to understand how to better accommodate families with young children in the design of transport systems. This, in turn, will allow families transitioning to parenthood to adopt or retain sustainable travel behaviour, and will reduce car use among this group.

Declaration

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

This thesis includes four original papers published in peer reviewed journals. The core theme of the thesis is exploring declining public transit use following parenthood. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the Public Transport Research Group under the supervision of Dr Alexa Delbosc and Professor Graham Currie. The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

In the case of Chapters 2, 4 and 5 my contribution to the work involved the following:

Thesis Chapter	Publication Title	Status	Nature and % of student contribution	Co-author name(s) Nature and % of Co-author's contribution*	Co-author(s), Monash student Y/N*
2	Factors influencing travel mode choice among families with young children (aged 0–4): a review of the literature (Transport Reviews)	Published	65%. Initiation, ideas, systematic review of literature, manuscript writing	1) Alexa Delbosc: manuscript review, interpretation 20%; 2) Graham Currie: manuscript review 10%; 3) Andrew Molloy: manuscript review, ideas 5%	No
4	Parenthood and cars: A weakening relationship? (Transportation)	Accepted	75%. Initiation, ideas, data analysis and interpretation, manuscript writing	1) Alexa Delbosc: manuscript review, ideas, data interpretation 15%; 2) Graham Currie: manuscript review, ideas, 5%; 3) Andrew Molloy: manuscript review, ideas 5%	No
5	Trajectories and Transitions – mobility after parenthood (Transportation)	Accepted	75% Initiation, ideas, data collection, data analysis and interpretation, manuscript writing	1) Alexa Delbosc: manuscript review, ideas, data interpretation, 15%; 2) Graham Currie, manuscript review, 5%; 3) Andrew Molloy, manuscript review 5%	No

5	'Transit Faithfuls' or 'Transit Leavers'? Understanding mobility trajectories of new parents (Transport Policy)	Published	75% Initiation, ideas, data collection, data analysis and interpretation, manuscript writing	1) Alexa Delbosc: manuscript review, ideas, data interpretation, 15%; 2) Graham Currie, manuscript review, 5%; 3) Andrew Molloy, manuscript review 5%	No
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I have not renumbered sections of submitted or published papers in order to generate a consistent presentation within the thesis.

Student signature:

Date: 30/09/2019

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student's and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

Main Supervisor signature:

Date: 30/09/2019

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List of publications

Refereed papers:

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McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2019). "Transit Faithfuls' or 'Transit Leavers'? Understanding mobility trajectories of new parents". Transport Policy. 78: 105-112. <https://doi.org/10.1016/j.tranpol.2019.04.007>

McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2018). "Parenthood and cars: A weakening relationship?". Transportation (In press). <https://doi.org/10.1007/s11116-018-9963-7>

McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2017). "Factors influencing travel mode choice among families with young children (aged 0–4): a review of the literature". Transport Reviews 37(6): 767-781. <https://doi.org/10.1080/01441647.2017.1354942>

Referred conference papers

McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2018). "Are changes afoot? Early signs of declining car orientation among families with children". Transportation Research Board, Washington DC.

McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2017). "Is car orientation among families with children on the wane? Evidence from Melbourne, Australia". Australasia Transport Research Forum, Auckland, New Zealand.

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PART ONE:

Research context

Chapter 1

Introduction

1.1 Overview

This thesis aims to better understand why travel behaviour changes following parenthood, with an emphasis on public transit use. After briefly describing the background and motivations for conducting this research, the research aim, research questions and contributions are outlined. The chapter concludes with a description of the thesis structure.

1.2 Background and motivations

Private cars provide an important means of transport. However, there are many problems to which high levels of car use contribute, such as traffic congestion and air pollution; these problems have prompted a wide body of research seeking to better understand travel behaviour in order to reduce car use (Stradling et al. 2000, van Acker et al. 2010, Graham-Rowe et al. 2011, Buehler et al. 2016). Recent travel behaviour research has identified opportunities to change travel behaviour following a disruption to travel routines, such as due to housing or employment changes (for a summary, see Muggenburg et al. 2015). Importantly, people are more likely to change their travel behaviour following a change in circumstance than during stable periods (Clark et al. 2016). As such, it is in these periods during which habits are disrupted that individuals may be especially open to changing their travel behaviour.

The birth of a first child is a major life event, often prompting significant lifestyle changes. In terms of the effect on mobility, previous research has demonstrated that this is a crucial period in which travel behaviour undergoes extensive change. Changes in mobility, such as car ownership levels and public transit use, occur before the birth of a child and continue to evolve as children age (Lanzendorf 2010, Oakil 2016). Walking as a mode of transport increases in the first year following the birth of a child, while cycling and public transit use decrease. Overall, research suggests that travel behaviour becomes considerably more car-dependent following parenthood (Ryley 2006, Scheiner and Holz-Rau 2007).

As the literature above suggests, parenthood is a catalyst for significant changes to mobility patterns and travel mode use. However, for such an important group of transport users, the travel practices of those transitioning to parenthood are significantly under-researched. While much research has sought to understand *how* travel behaviour changes following parenthood,

limited research has sought to explain *why* it changes. Understanding why it changes is all the more urgent as the Millennial generation, comprising nearly a third of the global population, are entering this life stage. If this cohort adopts car-based mobility behaviour, it will have a significant impact on the sustainability of the transport system (McDonald 2015, Delbosc 2016).

Given this context, the focus of this research is to examine why travel behaviour changes, and specifically why public transit use declines, following parenthood. Findings from this research can be used to encourage the adoption of more sustainable travel choices behaviour among this group. Further, through comprehensively examining the processes of habit disruption and formation during this transition, this research will contribute to research regarding the role of habit during periods of frequent disruptions to routine behaviour.

1.3 Research aim and questions

The main aim of the thesis is to:

Explore why public transit use declines following parenthood

In order to achieve the primary research aim, three sub-questions and three research objectives have been developed:

- **RQ1:** What is the **context** of travel behaviour change following parenthood in Melbourne, Australia?
- **RQ2:** What factors influence **mobility changes** following parenthood?
 - Research objective 2a: To understand different mobility trajectories following parenthood
 - Research objective 2b: To quantify each mobility trajectory and identify differences in the attitudes and socio-demographic characteristics between each mobility trajectory
 - Research objective 2c: To understand factors influencing new parents' car-use habits
- **RQ3:** What factors influence **public transit use** following parenthood?

Research question 1 aims to provide context regarding the travel behaviour of families following parenthood in the case study location: Melbourne, Australia.

Research question 2 focuses on the broad processes facilitating change in travel behaviour following parenthood. It comprises three research objectives, exploring different aspects of the factors prompting travel behaviour change. As a group, new parents are not homogenous and not all will adopt more car-based mobility behaviour. We identified different “mobility trajectories” to illustrate the variety of changes in mobility patterns following parenthood. RO2a identifies the various mobility trajectories apparent following parenthood while RO2b examines the attitudes and socio-demographics associated with each trajectory. Habit is a powerful factor in determining travel mode choice. However, life events can act to disrupt habitual travel behaviour. RO2c examines the determinants, including life events, influencing new parents’ car use habits.

Research question 3 focuses more specifically on the factors influencing public transit use following the transition to parenthood. It seeks to understand the structural (built environment, transport infrastructure, transport operations and policy) and psychosocial (attitudes, social norms, intentions and perceptions) factors which influence public transit use among families with young children.

1.4 Research contributions

This research provides several theoretical and practical contributions to knowledge. It contributes to the expanding body of literature regarding the mobility biographies, or life course, approach to studying travel behaviour. It tests the association between the frequency of life events and car-use habit strength; highlights the importance of micro-transitions prompting travel behaviour changes; builds an understanding of the heterogeneity of travel behaviour changes following parenthood; and, examines the effects of the life event of childbirth on travel behaviour in a car-dominated location.

In terms of practical contributions it:

- provides a synthesis of literature regarding factors influencing travel mode choice among families with young children
- provides empirical evidence to explain why public transit use declines during the transition to parenthood

- introduces a framework of factors influencing public transit among families with young children
- identifies attitudes and characteristics associated with new parents who adopt or retain more sustainable travel behaviour
- identifies that a shift towards more sustainable travel behaviour is apparent among families with young and school-age children in Melbourne, Australia.

These practical contributions will enable transport practitioners and policymakers to better accommodate families with young children in the design of transport systems. This, in turn, can facilitate families transitioning to parenthood to adopt or retain sustainable travel behaviour, and reduce car use among this group.

1.5 Thesis structure

This thesis comprises three parts and includes four journal papers, as noted in Figure 1.1 below.

Part One, *Research context*, provides relevant contextual information material. This introduces the topic motivation, research gaps, relevant literature and approach to undertaking the research. Part One includes the following three chapters:

Chapter One – *Introduction* – this Chapter.

Chapter Two – *Literature review* – introduces the relevant theory underpinning the work, the mobility biography approach. It reviews current knowledge in the field and discusses the identified research gaps. This chapter includes the following journal paper:

- McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2017). "Factors influencing travel mode choice among families with young children (aged 0–4): a review of the literature". *Transport Reviews* 37(6): 767–781.
<https://doi.org/10.1080/01441647.2017.1354942>

Chapter Three – *Research approach* – outlines the approach and methods used to answer the research questions.

Part Two, *Results and discussion*, presents and discusses the research results. These chapters are presented by research question rather than research method. The findings from both the qualitative interviews and online survey are synthesised and spread across Chapters 5 and 6. Part Two includes the following three chapters:

Chapter Four – *Travel behaviour of families with young children* – presents the results relating to Research Question 1: What is the context of travel behaviour change following parenthood in Melbourne, Australia? This Chapter comprises a journal paper:

- McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2018). "Parenthood and cars: A weakening relationship?". *Transportation* (In press). <https://doi.org/10.1007/s1116-018-9963-7>

Chapter Five – *Factors influencing mobility changes following parenthood* – outlines the research findings relating to Research Question 2: What factors influence mobility changes following parenthood? This Chapter includes the following two journal papers:

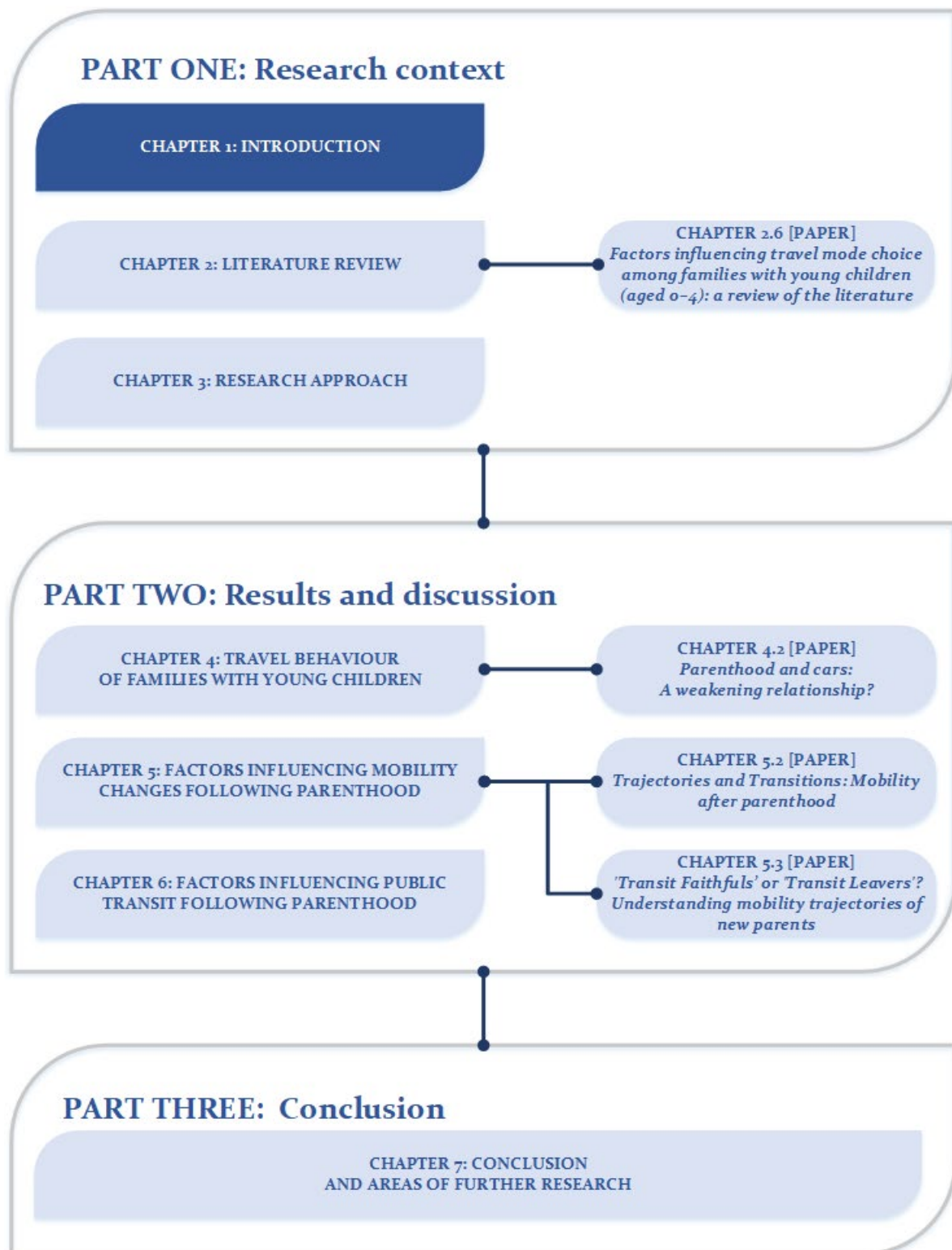
- McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2019). "Trajectories and Transitions – mobility after parenthood". *Transportation*. (In press). <https://doi.org/10.1007/s1116-019-10051-5>
- McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2019). "Transit Faithfuls' or 'Transit Leavers'? Understanding mobility trajectories of new parents". *Transport Policy*. 78: 105-112. <https://doi.org/10.1016/j.tranpol.2019.04.007>

Chapter Six – *Factors influencing public transit use among families with young children* – discusses the qualitative and quantitative research findings relating to Research Question 3: What factors influence public transit use following parenthood?

Part Three, Conclusion, includes the following chapter:

Chapter Seven – *Conclusion and areas of further research* – summarises the most significant findings from this work and discusses whether the aims and objectives of this research have been achieved. It concludes with suggestions for further research, policy implications and limitations.

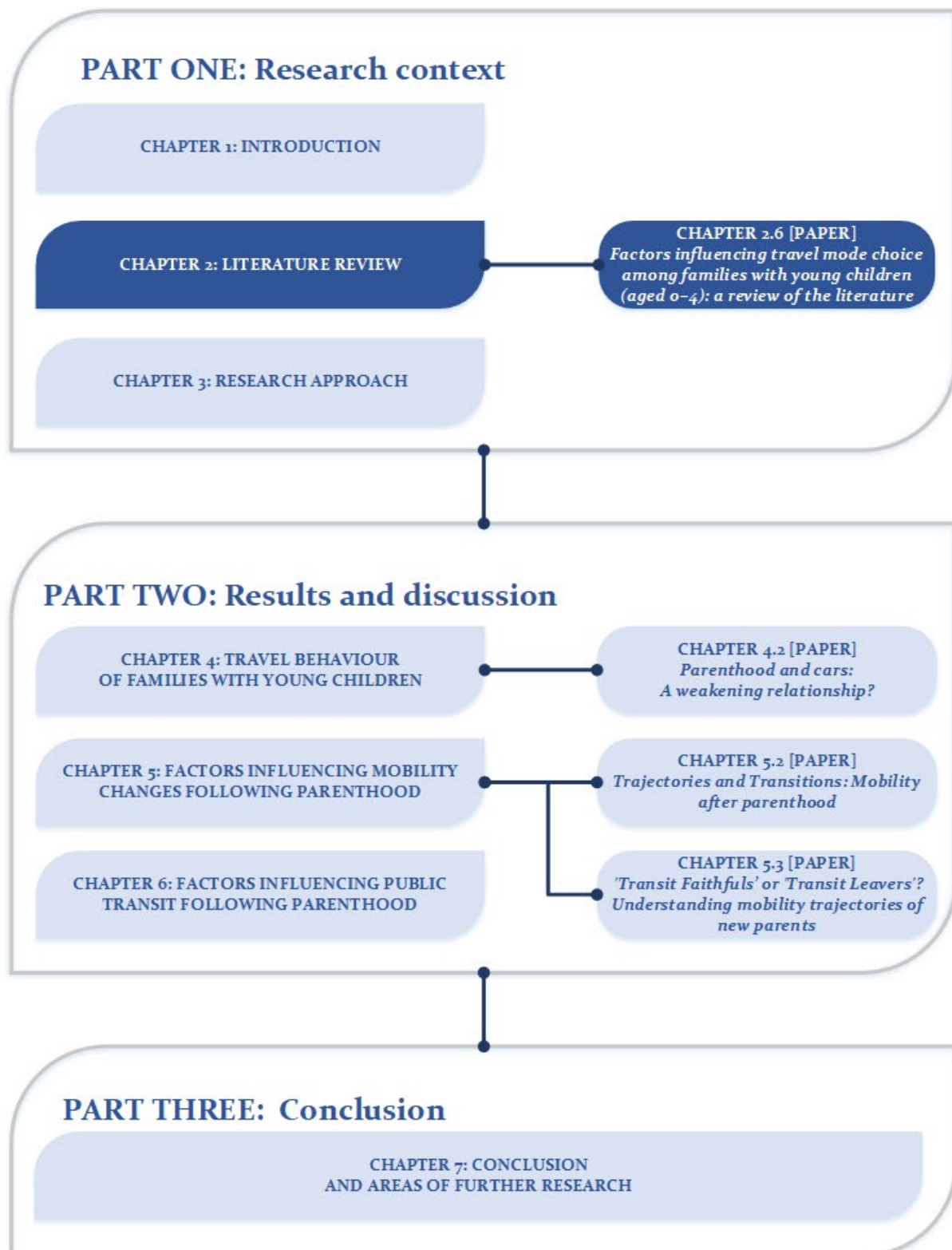
Figure 1.1: Thesis structure



Chapter 2

Literature review

Figure 2.1: Chapter 2, thesis structure



2.1 Introduction

This literature review aims to provide an overview of existing research into travel behaviour change following the transition to parenthood. After briefly discussing the literature regarding travel behaviour change more generally, it discusses relevant studies within the mobility biographies approach. It then reviews the existing literature regarding travel behaviour changes following parenthood in order to identify relevant research gaps. This draws together three disparate bodies of literature: life events and travel behaviour change, school-age children's travel and parental mobilities. Following this, it discusses the literature regarding factors influencing travel mode choice among families with young children, included as a journal paper. It concludes with an outline of the identified research gaps and a summary of this literature review.

2.2 Travel behaviour change

Private cars have enabled great advances in personal mobility. However, the growth in private vehicle use has brought with it a multitude of major societal problems. These problems range from well-established economic and environmental concerns, such as air pollution and the economic impacts associated with growing traffic congestion, to exacerbating social inequities (Fenger 1999, Currie et al. 2010, Banister et al. 2011, Mackett 2014). More recently, car-dependent lifestyles are increasingly viewed as a public health issue contributing to rises in obesity and associated with a range of negative health outcomes (Douglas et al. 2011, Cohen et al. 2014).

These problems have prompted an extensive body of literature seeking to understand travel behaviour in order to reduce private car use. The extensiveness of this work reflects the complexity of peoples' travel choices. Travel behaviour is influenced by a breadth of environmental, demographic and psychosocial factors. Research has begun to quantify the extent to which urban form and the built environment, specifically density and transport accessibility, can explain differences in travel behaviour (Cervero and Kockelman 1997, Cervero 2002). Demographic characteristics, particularly income, life stage and vehicle ownership, play a vital role in determining the extent to which car-based mobility behaviour is adopted (Dargay 2001, Kitamura 2009, Van Acker and Witlox 2010). Psychosocial factors, such as travel attitudes and preferences towards different travel modes, also perform a pivotal role (Sheller 2004, Anable 2005, Steg 2005).

In recent years, transportation research has begun to emphasise the importance of routines in travel behaviour (Gärling and Axhausen 2003, Verplanken and Wood 2006, Beige and Axhausen 2012). Recent research, discussed below, has begun to emphasise the importance of identifying opportunities during an individual's life course in which travel routines are disrupted. It is these periods when individuals may be especially susceptible to changing their behaviour.

2.3 Habitual travel behaviour

Habit is a principal factor influencing travel mode choice (Aarts and Dijksterhuis 2000, Bamberg and Schmidt 2003, Gärling and Axhausen 2003, Verplanken et al. 2008). Habitual travel behaviour is characterised by an absence of deliberative decision-making and is particularly resistant to travel behaviour change interventions (Verplanken and Roy 2016). As the behaviour is script-based, the decision-making processes by which people choose to drive to their daily activities are typically undertaken without consciously weighing up the costs and benefits of travelling by alternative modes (Gärling and Axhausen 2003). As such, measuring and understanding differences in habit strength, particularly for car-use habits, has received much research interest (Bamberg and Schmidt 2003, Verplanken and Wood 2006, Walker et al. 2014). It is reasoned that an improved understanding of which characteristics are associated with weaker car-use habits will enable better targeting of travel behaviour interventions to those groups within the population who will be more susceptible to changing their travel behaviour.

Studies measuring habit have tended to focus on the extent to which habit predicts mode choice (see, for examples, Aarts et al. 1997, Bamberg and Schmidt 2003). Gardner and Abraham (2008), in a meta-review of studies examining psychological predictors of mode use, included five studies testing habit and car use (Gardner and Abraham 2008). This showed that habit has a large effect on the decision to drive (Gardner and Abraham 2008).

In response to the limited studies examining variations in habit strength by individual characteristics, Şimşekoğlu et al. (2015) examined car-use habit strength, among urban Norwegians. This showed car-use habits tend to be stronger among males than females, and weaker among those with strong pro-environmental attitudes or on a low-income. Moreover, the findings underscored the importance of other spatial factors in influencing car-use habit

strength. For example, respondents with a longer commuting distance had stronger car-use habits than those with a shorter commuting distance (Şimşekoğlu et al. 2015).

While studies have examined the role of habit in influencing car-use, few studies have examined the factors influencing car-use habit (Şimşekoğlu et al. 2015). As such, we seek to contribute to this literature by exploring the determinants of car-use habits among new parents.

2.4 The mobility biographies approach

The mobility biographies approach, alternatively called the ‘life course perspective’, provides a framework for understanding travel behaviour changes throughout an individual’s life. The approach recognises that the current travel choices made by an individual are influenced by a broad range of events, attitudes and other characteristics developed over an individual’s lifetime (Lanzendorf 2003).

Drawing on the role of habit as an important determinant of travel behaviour, a key concept emerging from the mobility biographies literature relates to the notions of stability and change inherent in travel behaviour. Life events, such as the birth of the child or residential move, can prompt changes to travel routines in the period of time before or after that event. Changes to travel routines require a shift from automatic to reflective consideration of travel choices. This, in turn, requires individuals to actively reflect on the costs and benefits of travel by different modes, on new routes or under new circumstances. It is these periods of change that offer a greater opportunity to influence travel choices.

Events that can prompt changes in travel behaviour have been variously described as ‘life events’ (Clark et al. 2016), ‘key events’ (Busch-Geertsema and Lanzendorf 2017), ‘turning points’ (Beige and Axhausen 2012) and ‘disruptions’ (Marsden and Docherty 2013), amongst other terms. Reflecting the breadth of terminology a range of definitions exists as to what constitutes an ‘event’ in the relevant sense.

Müggenburg et al. (2015), in a review of the mobility biographies approach, identified several definitions of an event put forward by researchers in this field. Müggenburg et al. (2015) note

that definitions of a 'life event' can be derived from the field of psychology. Such events are marked by the fact they trigger behavioural change, are subjectively significant for the individual and cause initial stress which requires some degree of adaptation. In this sense, life events can be anticipated (such as a marriage or, usually, childbirth) or unexpected (such as a natural disaster).

Drawing on the definition of a key event put forward by van der Waerden et al. (2003) Müggenburg et al. (2015) also refer to 'key events'. This is intended to be a broader category of an event than 'life events' as understood in psychology. Life events are a sub-set of key events, on this account, and turn into key events "if (the life event) has significant meaning for the individual and activates a re-evaluation of mobility behaviour, which might result in a behavioural change" (153).

'Key event' is a broader category insofar as it is not limited to life events as these are understood in psychology. It can also include exogenous interventions (such as free public transport tickets or the closure of a road) and adaptations of long-term mobility decisions (such as car ownership changes) (157). Our present study follows Müggenburg et al. (2015) in this usage but focuses only on life events rather than the broader category of key events. The exception to this relates to residential relocations which Müggenburg et al. (2015) categorise as long-term mobility decisions. However, as Müggenburg et al. (2015) note, most researchers in this field categorise residential relocations as 'life events' rather than as long-term mobility decisions, and we do likewise (Müggenburg et al. 2015).

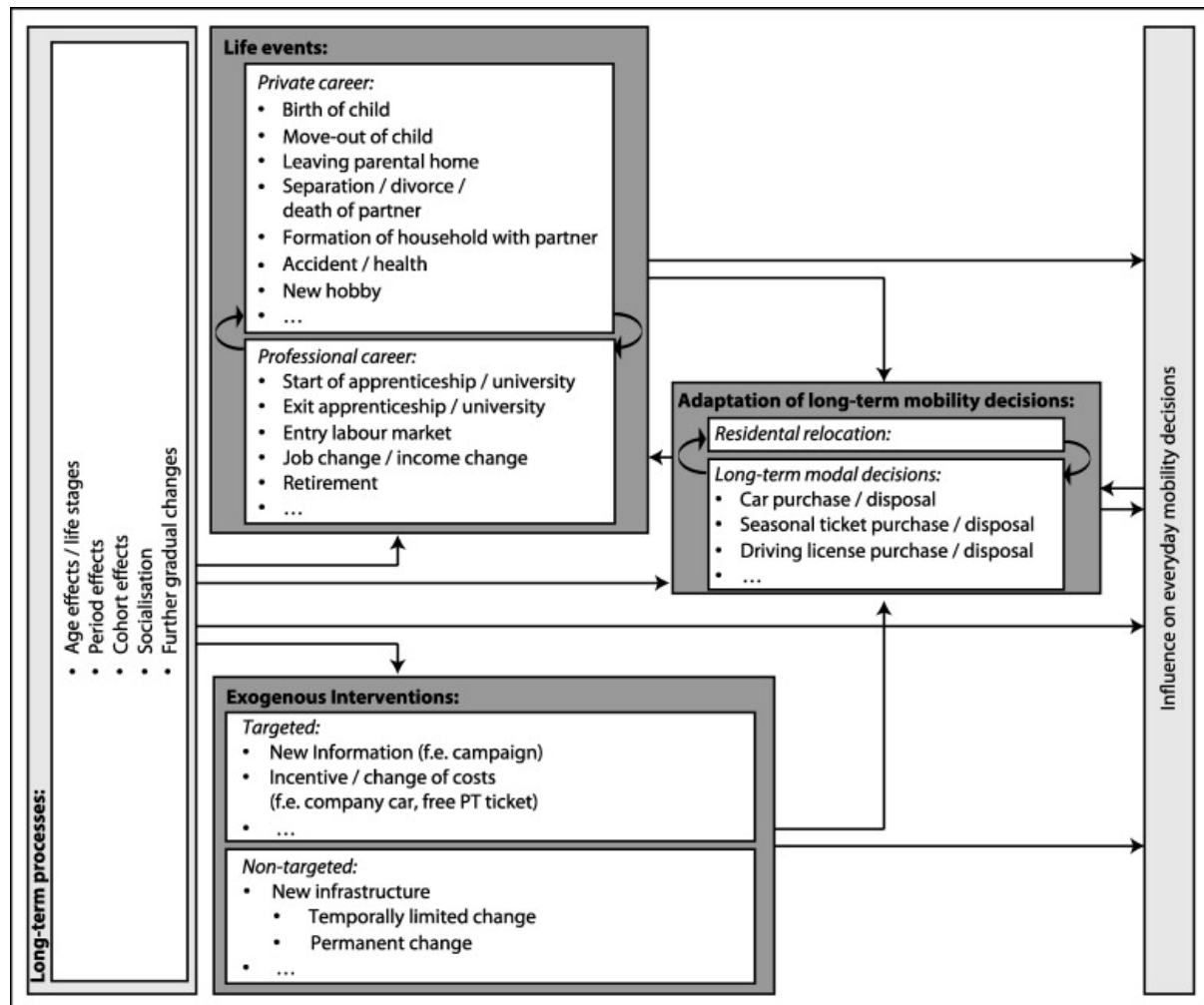
Studies examining life events have shown that people are indeed more likely to change travel modes following a life event than during stable periods (Verplanken et al. 2008, Scheiner and Holz-Rau 2013, Clark et al. 2014). For instance, de Haas et al. (2018), using data from a Dutch travel study, conducted a latent class and a transition analysis to examine the effect of life events on movements between classes of travellers. This showed not only that experiencing life events was associated with a greater likelihood of movement between mobility classes but that strict car users were less likely to change travel modes following a life event than multimodal travellers (de Haas et al. 2018).

Life events typically associated with increases in car-based mobility include childbirth (Oakil et al. 2016, de Haas et al. 2018) and entering the workforce (Busch-Geertsema and Lanzendorf 2017) whereas life events associated with a decrease in car ownership are often associated with worsening financial circumstances, such as unemployment (Clark et al. 2016). Invariably, life events associated with spatial changes, such as residential or employment changes, can prompt travel mode changes in both directions. For instance, Clark et al. (2016), show changes in commute mode are primarily prompted by changes in the distance to work (Clark et al. 2016).

The mobility biographies approach has undergone significant development since it was first introduced. Recognising the efficacy of life course approaches to studying long-term behaviour changes in other research fields, Lanzendorf (2003) introduced a framework that applied this approach to travel behaviour. The framework, based on the lifestyle concept introduced by Salomon (1983), shows the interrelationship between travel behaviour changes and events in the mobility, accessibility and lifestyle domains. Muggenburg et al. (2015) put forward an updated theoretical framework to consider the relationship between travel behaviour changes and life events (Figure 2.2). Building on the mobility biographies framework introduced by Lanzendorf (2003), Muggenburg et al.'s framework recognises that a change in one area of an individual's life will have ramifications in other areas. For instance, the birth of a child may also coincide with a break in the professional career and a residential relocation, with all events possibly contributing to changes in travel behaviour. A holistic examination of an individual or household's travel behaviour allows for a richer understanding of the interaction between these multiple life events and the subsequent changes in travel behaviour.

Moreover, the framework recognises that so-called 'long-term processes' such as life stage, cohort effects and other gradual processes can also contribute to travel behaviour changes (Muggenburg et al. 2015). These processes are often overlooked in mobility biographies studies in favour of 'major' events or milestones (Plyushteva and Schwanen 2018). Among families with young children, 'micro' transitions, such as a child's ability to walk, may also shape household travel choices, and are likely to occur with greater frequency than 'major' life events. However, to date, their influence on household travel behaviour is relatively unknown. This research gap will be explored in this thesis.

Figure 2.2: The interaction of long-term processes, life events, interventions and long-term decisions with daily mobility decision



Source: Muggenburg et al. (2015)

Research within the mobility biographies approach has revealed many important findings regarding opportunities to change travel behaviour. While extensive, there continue to be gaps within the field of the mobility biographies approach to studying travel behaviour (Muggenburg et al. 2015, Scheiner 2018). In a recent review paper of the state of the field, Scheiner (2018) notes studies within this field have, to date, tended to be quantitative in nature and focus on *how* rather than *why* travel behaviour changes following (or in anticipation) of a life event. Scheiner (2018) suggests a number of broader research gaps including: a need for more qualitative studies and studies linking both qualitative and quantitative approaches; a need for more studies testing theories; and a need for studies examining the interactions between events in multiple life

domains, and the ramifications of these interactions on travel behaviour. The gaps outlined in Scheiner (2018) form a significant justification for the research questions explored in this thesis.

2.5 Travel behaviour changes following parenthood

2.5.1 Parenthood and travel mode changes

One of the most significant life events and the focus of this thesis is the transition to parenthood. The transition to parenthood impacts all areas of an individual's life (Buhr and Huinink 2014) and can create changes to work, education, income, partnership and leisure routines for both parents. Given the many changes occurring during the transition period, it is unsurprising that a number of studies examining the life event of childbirth demonstrate significant changes in household travel behaviour.

Table 2.1 presents chronologically the key studies that have examined the effect of childbirth on travel behaviour. Overall it is clear that car use and ownership tends to increase during the transition to parenthood, while public transit use declines. Walking as a mode of transport increases in the first year following the birth of a child, while cycling decreases. Changes in mobility, such as car ownership levels and public transit use, occur before the birth of a child and continue to evolve as children age (Lanzendorf 2010, Oakil et al. 2016).

Table 2.1: Studies examining the effect of childbirth on travel behaviour

Author/s (Year)	Multiple events	Childbirth only	Findings	Quantitative	Qualitative	Panel	Cross-sectional	Country
Prillwitz et al. (2006)	X		Increase in car ownership	X		X		Germany
Zwerts et al. (2007)		X	Women adopt 'taxi driver' like behaviour soon after childbirth	X	X			Belgium
Beige and Axhausen (2012) Beige and Axhausen (2008)	X		Childbirth increases the propensity to move house, affecting travel behaviour	X			X	Switzerland
Lanzendorf (2010)		X	Car use and ownership increases for some families and decreases for others		X		X	Germany
Ottmann (2010)	X		Reduction in overall travel demands for women	X		X		Germany
Oakil et al. (2011) Oakil et al. (2016)	X		Increase in car use and ownership	X			X	Netherlands
Scheiner and Holz-Rau (2013)	X		Decline in use of public transit and cycling, particularly for women	X		X		Germany
Schoenduwe et al. (2015)	X		First-child has a greater impact on travel behaviour changes than subsequent children	X			X	Switzerland
Clark et al. (2016)	X		Car ownership increases for no-car households and decreases for two car households	X		X		UK
Lavieri et al. (2017)	-	-	Young millennial parents possess similar travel behaviour to young millennials generally	X			X	US
de Haas et al. (2018)	X		Increase in car dependency	X		X		Netherlands
Janke and Handy (2019)	X		Parents' cycling varied overtime in response to child's developmental stage		X			US
Klein and Smart (2019)	X		Increase in car ownership but less likely among low-income households	X		X		US

Source: Adapted by the author from Muggenburg et al. (2015)

As Table 2.1 demonstrates, the majority of studies in this field are quantitative and tend to utilise national datasets collected for other purposes. This is unsurprising given the significant expense involved in data collection processes. However, this inevitably introduces limitations, such as the type of life events captured and the type of travel mode changes examined. Moreover, they have typically studied multiple life events rather than focusing singularly on the event of childbirth. Furthermore, the vast majority have been undertaken in Europe with a very different mobility context to our present study.

In addition, the studies tend to focus on *how* rather than *why* travel behaviour changes and do not specifically examine changes regarding public transit use. Moreover, only two studies were qualitative, yet these type of studies are better placed to unpick the complexities surrounding changes in life events (Müggenburg et al. 2015). While both of these studies focused on the event of childbirth, they were both conducted in Europe. Our present study addresses these research gaps through examining the life event of childbirth in a car dependent context, using both qualitative and quantitative approaches. Further, it focuses on exploring *why* travel behaviour and, in particular, public transit use changes.

In addition to the studies outlined in Table 2.1, research adopting the life stage approach to understanding travel behaviour demonstrates the many ways in which travel among families with children differs from other household groups (Kitamura 2009). Households with children are generally less multimodal (Scheiner 2014), have lower levels of public and active transit use (Zwerts et al. 2007, Chakrabarti and Joh 2019), have higher rates of car ownership (Ryley 2006, Nolan 2010, Oakil et al. 2014) and display car-dependent travel behaviour (Ryley 2006, Scheiner and Holz-Rau 2007).

Myriad factors explain the propensity for higher levels of car dependency among households with children. In auto-orientated contexts, households with young children face many spatial and time constraints in meeting their travel needs (Schwanen 2011, Wheatley 2014, Dowling 2015). Parents' travel behaviour increases in complexity as they accommodate both their own and their child's travel demands (Dowling 2015). This results in trip chaining and complicated schedules being a common feature of travel in households with children (Dowling 2015) and make it difficult for parents to use some alternatives to travel by private car. Moreover, family-

style housing tends to be located in outer urban areas where activities and workplaces are dispersed over greater distances.

2.5.2 *Gender, parenthood and travel behaviour changes*

Given traditional divisions of domestic and caregiving activities, several mobility biography studies have adopted a gender lens to explore differences in travel behaviour changes following the birth of a child (Zwerts et al. 2007, Scheiner 2014, Oakil 2016). These studies have revealed that women's travel behaviour tends to change more dramatically following the birth of a child than their male partner's. For instance, Scheiner (2014) shows that walking increases for women following the birth of a child but not for men, while Zwerts et al. (2007) show women adopt 'taxi driver' like behaviour soon after the birth of their child but the same change is not observed among their partners.

Moreover, studies exploring gendered differences in travel more generally, have shown that while modest signs of change are evident, women continue to perform the majority of domestic responsibilities and child-serving transportation (Schwanen 2011, Fan 2015, Taylor et al. 2015, Craig and van Tienoven 2019). These studies show the additional childcare responsibilities invariably affect how women travel and can, in part, explain differences in women's travel, such as more complex travel schedules (Rosenbloom 2006) and undertaking more trips but of shorter distance (Crane 2007).

2.5.3 *School-age children's travel*

An extensive body of literature has examined school-age children's travel (Mackett 2002, Anderson and Butcher 2006, Buliung et al. 2009, Faulkner et al. 2009, Lubans et al. 2011). This work has been prompted by two prominent trends: an increase in the typical age at which children travel without parental or adult supervision and a decline in the number of children walking and cycling to school (Buliung et al. 2009, Fyhri et al. 2011). These trends are evident across multiple Western nations (Fyhri et al. 2011).

The reasons for the growth in car dependency among school-age children and their families are nuanced and complex. Fyhri et al. (2011), identify multiple childhood trends that have

contributed to declining walking and cycling and increasing car use among this group. An increase in dual-earner families leads to both higher household incomes and less time available for travel. This, in turn, has contributed to higher rates of car use and ownership. Running alongside these trends are parents' increased perception of risk and growth in school travel distances which have contributed to fewer school-age children walking and cycling (Fyhri et al. 2011).

The implications of these trends for school-children and their families are wide-ranging. Most notably, research has focused on the health implications resulting from a loss of physical activity and the implications of delayed independence on a child's social well-being and development (Mackett 2002, Faulkner et al. 2009, Lubans et al. 2011) as well as the increased stress on parents to accommodate these travel demands (Wheatley 2014).

Despite the immense literature examining school-age children's travel very little research attention has been directed to travel among families with young children. Early research in this field suggests that many of the trends shaping contemporary school-age children's travel are likely to hold relevance for families with young children. For instance, acknowledging the importance of physical activity from a young age, a nascent body of work has begun to examine children's travel mode use to preschool drawing many of the same conclusions regarding the causes of the decline in active mode use among school-age children (Oxford and Pollock 2015, Rothman et al. 2016). Nonetheless, travel with, and for, young children is likely to also differ in important respects to school-age children's travel. The highly dependent nature of young children's travel, for example, necessitates that all travel among this group is accompanied. As a preliminary step to understand why public transit use declines following parenthood, and to address this research gap, section 2.6, presents the results of a comprehensive literature examining factors influencing travel mode choice among this group.

2.5.4 Parental mobilities

A further distinct but relevant body of work has focused on parental mobility. This, entirely qualitative literature, provides rich and detailed accounts of parents' experiences travelling with, and for, their young children. Recent literature has explored the role of the family car (Waitt and Harada 2016), voluntarily carless families (Lagrell et al. 2018) as well as mothers' experiences

walking with their children (Clement and Waitt 2017), and using different mobility devices for transporting their children, such as prams (Clement and Waitt 2018) and slings (Whittle 2018). Given typically gendered divisions of household labour, much of this work takes a feminist perspective and aims to explore mothers' experiences of caring for their children while 'on the go'. Further, while much of this literature derives from a sociological perspective and, as such, attempts to answer different types of questions to our transportation focussed study, it provides several pertinent findings, discussed below.

Building on other work illuminating the symbolic and affective value of cars (for examples, see, Sheller and Urry 2000, Sheller 2004), researchers have examined the role of the car in family life. This work has demonstrated that for some families the car is more than simply a convenient means of transportation but provides an important space for family interaction (Waitt and Harada 2016). Dowling and Maalsen (2019) succinctly capture the advantages afforded by the private car for families into three elements: 'convenience and flexibility, carrying objects and people, and familial interaction' Dowling and Maalsen (2019, 3). The latter, alternately referred to as 'cocooning', highlights the important role of the family car in providing a safe, separate and private space for social exchanges (Dowling and Maalsen 2019).

A common theme emerging from this literature is the notion of 'good parenting' practices and how these are often manifested through car use (Dowling 2000, Waitt and Harada 2016, McLaren 2018). For instance, Dowling (2000), in her work examining parenting practices of suburban mothers in Sydney, Australia, demonstrates that perceptions of 'good mothering' practices are displayed through parents driving their child to activities that best meet their needs and interests, rather than those that are in the closest proximity. These practices were evident among parents with children of all ages, shaping decisions from childcare facilities and playgroups through to schooling and out-of-home activities (Dowling 2000).

Moreover, strong social norms influencing family practices including mobility can make it immensely challenging to remain carless (Sattlegger and Rau 2016, Rau and Sattlegger 2017). In a qualitative study of carless households in Vienna, Sattlegger and Rau (2016) show how cars are purchased, in anticipation of parenthood, to meet social expectations regarding a safe and secure method for transporting young children (Sattlegger and Rau 2016). Rau and Sattlegger

(2017), in a second phase of the same study focussing on a smaller subset of the Vienna households, reveal the birth of a first child is a prompt for a fundamental change in the way in which parents travel. These changes result in a shift to more car-based mobility which is attributed to both new activities that are more accessible by car but also due to new norms and values introduced through parenthood which favour car ownership (Rau and Sattlegger 2017).

Despite the importance of cars in family life, and strong social narratives reinforcing the notion that 'if you have kids, you need a car' (Freudendal-Pedersen and Kesselring 2016, 580), there are signs that this relationship may be weakening. McLaren (2016), explores families' changing mode use in Vancouver, Canada. In this study, while some parents, often constrained by their location, continue to travel primarily by car, the majority of participants travelled multimodally or 'altermobility' (i.e. they rely on non-car transport modes) (McLaren 2016). Likewise, Dowling and Maalsen (2019), through qualitative interviews with parents in Sydney, demonstrate the opportunities for electric bikes and car sharing to replace conventional car use and ownership among families with children. They show that electric bikes and car sharing can provide a demonstrable replacement for the family car and, in particular, e-bikes can be more time efficient than using alternate modes (Dowling and Maalsen 2019).

In a similar exploration of a shift away from parental automobility, Lagrell et al. (2018) examine the experiences and motivations of families with young children choosing to remain carless in Gothenburg, Sweden. Among these families, their ability to remain carless was generally considered to be predicated on selecting housing near routinely visited destinations, such as work and preschools. This allowed participants to manage most of their daily mobility by means other than a car with relative ease. However, transportation difficulties were more likely to occur for 'non-routine' activities, such as attending children's sport or family holidays. These difficulties gave rise to certain tensions, such as compromising on the type of activity, forgoing the activity or feeling like they were 'being a free-rider' for relying on others to reach car dependent locations. It was these type of occasions for which car-based mobility was often sought and why most participants still deemed some level of car use necessary.

As these households are carless by choice, it highlights the precariousness of their mobility situations. Lagrell et al. (2018) describe participants' carless situation as a 'continual process of

refraining from a car purchase'. While their carlessness was driven by a range of *individual* ideals and preferences, such as the convenience of not having to maintain a car or a preference for living more sustainably, these were negotiated at a *household* level. Changes in family situations can prompt a renegotiation of such ideals and preferences. For instance, participants commonly mentioned residential moves (to accommodate a growing family) to be one such situation that would likely result in a car purchase (Lagrell et al. 2018).

This body of work also provides rich insights into the practical realities of travelling with young children. Through the experiences of participants, we can learn of the merits and challenges of travelling by different modes and how these can vary by location and family situation. For instance, Boyer and Spinney (2016) examining new mothers' mobility experiences living in urban London, illuminate several factors which can make journeying by public transport prohibitively challenging. Obstacles frequently mentioned by participants included stairs and the repercussions of policies restricting the number of prams on buses (which often result in waiting to board a bus with sufficient space, delaying the journey). The larger footprint taken up by prams can make parents feel burdensome to other commuters. Similarly, parents felt anxious about travelling with an unsettled baby in a confined public space. These feelings were exemplified by perceptions that parenting practices, and how parents respond to their fractious children, are open to public scrutiny (Boyer and Spinney 2016).

In general, navigating the city with a pram and attempting to negotiate obstacles, such as narrow doorways and stairs, was perceived by participants to be very difficult. In order to navigate public transport and the urban environment more easily, some parents would use slings rather than prams when travelling with their children, a coping strategy also observed by Whittle (2018). However, the many physical and social obstacles experienced by some parents relying on non-car modes would often prove too much, leading some participants to simply forgo trips (Boyer and Spinney 2016).

Clement and Waitt (2017) show the level of preparedness required for travelling with children and the additional equipment needed even for short-trips. They also illuminate how trips by slower modes, such as walking, can become enjoyable family activities, in and of themselves (Clement and Waitt 2017). However, echoing other literature (Bostock 2001) they also highlight

that such trips are highly location dependent. In high traffic environments, such walks can give rise to parental anxiety in response to the potential threats to their child's safety (McLaren and Parusel 2014). These recent findings illuminate some of the factors which can shape travel choices among new parents. Complementing these findings, the next section comprises the following paper: *Factors influencing mode choice among families with children: a review of the literature*.

2.6 Paper: *Factors influencing mode choice among families with young children (aged 0-4): a review of the literature*

The earlier part of this chapter outlines relevant literature regarding *how* travel behaviour changes following parenthood. In order to understand *why* travel behaviour changes following parenthood, a review of the literature regarding factors influencing mode choice among families with young children was conducted in August 2016. This aimed to identify relevant literature that could provide an explanation as to why car orientated travel behaviour is adopted following parenthood.

Factors influencing travel mode choice among families with young children (aged 0–4): a review of the literature

Laura McCarthy, Alexa Delbosc, Graham Currie & Andrew Molloy

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Factors influencing travel mode choice among families with young children (aged 0–4): a review of the literature

Laura McCarthy^a, Alexa Delbosc^a, Graham Currie^a and Andrew Molloy^b

^aDepartment of Civil Engineering, Institute of Transport Studies, Monash University, Clayton, Victoria, Australia; ^bPublic Transport Victoria, Melbourne, Victoria, Australia

ABSTRACT

Life events, such as the birth of a child, disrupt habitual travel behaviour and provide a valuable opportunity to influence the adoption of sustainable transport practices. However, in order for sustainable travel practices to be adopted, an understanding is required of the factors that influence travel mode choice among families with young children. Research in this field is particularly timely given many in the millennial generation, a comparably large cohort, are approaching this life stage. This comprehensive literature review develops a framework of factors influencing travel mode choice among families with young children. The findings reveal a multitude of factors influence decisions about mode choice, and, in particular, encourage travel by car, when travelling with young children. The paper concludes with an agenda for future research about travel among families with young children, a largely overlooked group of transport users.

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1. Introduction

While the private car has made great advances in personal mobility possible, high levels of car use have created a myriad of societal problems, ranging from rises in obesity (Anderson & Butcher, 2006; Frank, Andresen, & Schmid, 2004) and social inequities (Currie et al., 2010; Mackett, 2014) to increasing congestion (Hymel, 2009; Stradling, Meadows, & Beatty, 2000) and environmental degradation (Banister, Anderton, Bonilla, Givoni, & Schwanen, 2011; Fenger, 1999). To mitigate these problems, approaches to change travel behaviour to reduce car use are urgently sought (Chapman, 2007). Life events, such as a change in life stage, disrupt habitual behaviour and provide a valuable opportunity to influence the adoption of sustainable transport modes (Beige & Axhausen, 2012; Clark, Chatterjee, Melia, Knies, & Laurie, 2014; Verplanken & Wood, 2006). The life event of childbirth is one such occasion during which changes to habitual travel practices occur.

Although car dependency tends to increase among families with young children (Klößner, 2004; Prillwitz, Harms, & Lanzendorf, 2006; Ryley, 2006), there is increasing reason to

CONTACT Laura McCarthy  laura.mccarthy@monash.edu  Department of Civil Engineering, Institute of Transport Studies, Monash University, 23 College Walk, Clayton, Victoria 3800, Australia

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think that car use can be reduced among this group. Recent research highlights a diverse set of mobility practices among families with young children in more developed nations (Lanzendorf, 2010; McLaren, 2016; Schwanen, 2011). This indicates that, at least in certain environments, it is feasible for less car-orientated travel practices to be adopted by families with young children. Furthermore, while private cars provide an important means of accessing activities and services for families with young children, high levels of car use create significant ongoing financial burdens (Currie & Senbergs, 2007; Dodson & Sipe, 2007; Mattioli, Lucas, & Marsden, 2016) and can contribute to worsening health outcomes (Beavis & Moodie, 2014; Douglas, Watkins, Gorman, & Higgins, 2011; Mackett, 2002, 2014).

The detrimental health and economic consequences of high levels of car use, as well as a large cohort of millennials on the cusp of embedding new mobility practices (Delbosc, 2016; Delbosc & Nakanishi, 2017), provide good reasons to want to encourage sustainable travel habits among families with young children. While an extensive body of literature has examined travel habits of school-age children and their families (Buliung, Mitra, & Faulkner, 2009; Faulkner, Buliung, Flora, & Fusco, 2009; Fyhri, Hjorthol, Mackett, Fotel, & Kyttä, 2011; Larsen et al., 2009; McDonald, 2007; McMillan, 2007), this literature does not focus on the valuable opportunity presented by the disruption to household travel habits resulting from the birth of a child.

Young children (aged 0–4) have specific travel needs which can affect parental mode choices. In order to encourage the adoption of sustainable travel practices during the transition to parenthood, we need to understand what factors influence mode choice when young children are present. Furthermore, we need to understand the feasibility and implications of reducing car use among families with young children. This paper aims to consider these two matters and develops a framework of factors influencing mode choice among families with young children. It does this by synthesising the results of a comprehensive literature review on the travel behaviour of families with young children.

After setting out the literature search methodology, this paper goes on to discuss the implications of reducing car use among this household group. Next, the factors that influence mode choice for adults travelling with young children are outlined. This is followed by a discussion of how the factors that prove a barrier to travelling by alternative modes might be best addressed through policy or infrastructure changes. Finally, an agenda for future research regarding travel among families with young children is suggested.

2. Search methods

In August 2016,¹ a literature search was conducted to retrieve records that examine the travel patterns of young children or provide findings relating to the factors which influence mode choice among families with young children. Young children are defined in this paper as aged between 0 and 4. A search was conducted in Compendex, Scopus, TRID, Web of Science and World Transit Research databases, for records published within the previous two decades, using the following two search strings:

- (a) small child* OR young child OR preschool age OR preschool age OR preschooler OR toddler OR baby*

AND

- (b) active trans* OR walking OR cycling OR car OR public trans* OR train OR tram OR bus OR travel OR mobility.

A record was retrieved if at least one term from each of the two search strings appeared in either the title or abstract.

A large number of research papers were retrieved (6695). All duplicate records were removed (1123). A large number of records were excluded which related to: car seat practices and policies; children's traffic safety; school-age children's active travel; children's independent mobility; and the development of mobility aids for children with disabilities. The titles and abstracts of records were screened, and records were included if they met the following criteria:

- Published, in English, between September 1996 and April 2017;
- The study participants included children aged between 0 and 4, or, parents or guardians of children aged between 0 and 4 (studies that encompassed participants aged between 0 and 4 and older children were also included);
- The study explored either mode use of young children or provided some relevant findings relating to factors which influence mode choice among families with young children.

At the conclusion of the screening process, 28 records remained. Due to the low number of relevant records retrieved, a further search was undertaken, involving reviewing the citations and references of the selected 28 records. A further 10 records were retrieved. At the conclusion of these searches, 39 records were evaluated. After evaluating each of the 39 records, 28 records² were deemed to meet the inclusion criteria.³

Only two papers specifically examined the travel patterns of young children and no papers examine the factors which influence mode choice among families with young children. The limited number of relevant records examining young children's travel raises a number of questions. Given the vast body of literature on school-age children's travel, why is there so little research on young children's travel and, in particular, factors influencing mode choice? The next section explores the implications of reducing car use among families with young children. This is followed by the literature search findings regarding the factors influencing mode choice among families with young children.

3. Travel behaviour of young children and their families

3.1. Car use among families with young children

Households with young children face a number of spatial and time constraints in meeting their travel needs (Dowling, 2015; Schwanen, 2011; Wheatley, 2014). Accommodating childcare, employment and household responsibilities can restrict the time available for parents to meet their own and their child's travel demands (Dowling, 2015). Family style housing tends to be located in outer urban areas where activities and workplaces are dispersed over greater distances. These constraints to mobility practices of families with young children mean policies restricting car use, such as work-place parking constraints, can exacerbate levels of stress in dual-earner households, particularly for women (Wheatley, 2014).

Moreover, research examining the experience of parents on low-incomes, living in auto-orientated areas with no or limited access to cars, highlights the importance of cars to maintaining a child's health and well-being (Bostock, 2001; Fritze, 2007; McCray, 2000). Not only do children from low-income households have fewer trips for sports and recreation activities (McDonald, 2006), they also forgo trips to healthcare and social services (Fritze, 2007; McCray, 2000). Compared to adult's travel for work, children's trips, such as for recreation and sports, may be considered a lesser priority. In responding to car restriction measures, parents may well reduce car trips of this nature. If no alternative transport modes are available, the inability to partake in these activities will likely have a detrimental impact on a child's health and well-being.

Nevertheless, high levels of car use among households with young children can have detrimental health and economic consequences for families with young children. Purchasing a private car to manage the travel needs of an expanding household can create an ongoing financial burden (Dodson & Sipe, 2007; Mattioli, Lucas, et al., 2016). Car-dependent parents and children lose opportunities to gain incidental physical activity, otherwise gained through active travel contributing, to worsening health outcomes (Anderson & Butcher, 2006; Frank et al., 2004). Young children lose opportunities to cultivate independent travel habits with corresponding impacts on their overall health and well-being (Fyhri et al., 2011; Mackett, 2002; Mackett, Lucas, Paskins, & Turbin, 2005).

Furthermore, households with young children form a sizeable population group. In Australia, for instance, 13% of households are home to at least one dependent child aged 0–4 (ABS, 2013). If households are able to maintain sustainable travel behaviour during early child-rearing years, when constraints to using alternative modes with children are often the greatest, they are more likely to retain this behaviour as their children age. Changing travel behaviour among this group, then, could have a significant long-term impact on reducing the negative externalities associated with high levels of car use.

These considerations suggest that while cars provide important mobility benefits to families with young children, high levels of car use can also be seen as problematic. However, generalised approaches to restrain car use must be used cautiously as they may disproportionally burden this household group (Wheatley, 2014). Instead, removing barriers to using public and active transport for adults with young children will help make travel by these modes more attractive. In order to remove barriers to using alternative modes, an understanding of the factors that influence travel mode choice when young children are present is required. The next part of this section turns attention to this topic.

3.2. What factors influence mode choice among families with young children?

A range of literature has provided findings regarding factors which influence mode choice among families with young children. This reveals a multitude of factors that influence decisions about mode choice, and, in particular, encourage travel by car, when travelling with young children. A thematic analysis of the findings was conducted and the factors influencing mode choice were broadly grouped into four categories: (1) structural (built environment, transport infrastructure, transport operations and policy); (2) psychosocial (attitudes, social norms, intentions and perceptions); (3) household characteristics; and (4) features of young children's travel. The literature derives primarily from Europe, North America, and Australia. With the exception of several European countries that

have a strong cycling culture, the countries have a primarily auto-orientated transport system (Pucher & Buehler, 2008).

Table 1 helps create a preliminary view of factors that influence mode choice when travelling with young children. Determining the relative significance of each factor, and differences in how individuals may respond to each factor, is difficult and beyond the scope of this paper. For instance, extensive bodies of literature have examined differences in travel by characteristics such as gender (Hanson, 2010; Rosenbloom, 1993), immigration status (Blumenberg, 2009; Chatman & Klein, 2009) and income (Dargay, 2001; Pucher & Renne, 2003). These differences are likely to carry through to how individuals travel with young children. In

Table 1. Preliminary framework of factors influencing mode choice when travelling with young children.

Factors	Evidence	Hypothesised impact on mode choice			
		Active transport	Public transport	Ride source/ share car	Private car
<i>Structural</i>					
Inadequate or non-existent cycling infrastructure	[1, 14]	—	+	+	+
Poor quality or non-existent pedestrian infrastructure	[2, 3]	—	—	—/+	+
Physically inaccessible public transport	[4, 5]	+	—	+	+
Infrequent or indirect services	[6]	+	—	+	+
Requirement to collapse pram/pushchair	[7, 4]	+	—	+	+
Low density, single land-use	[5, 8]	—	—	—	+
Increasing travel distances	[9, 10]	—	—	?	+
High traffic speeds	[11]	—	—	+	+
Actual costs of transport	[3, 11]	+	—	—	—
Car share vehicle equipped with car seat	[13]	—	—	—/+	—
Car parking constraints	[14]	+	—/+	?	—
<i>Psychosocial</i>					
Perceptions of “good parenting”	[15]	—	—	?	+
Social norms of auto-ownership and parenthood	[16]	—	—	—	+
Perceived high costs of travel by public transport	[17]	+	—	?	+
Motivation to reduce car dependency	[5, 18]	+	+	?	—
Negative perceptions of walking	[19]	—	— / +	+	+
Perceptions of safety	[20]	—	—	?	+
<i>Household characteristics</i>					
Increasing car ownership	[21]	—	—	—	+
Increasing income	[21]	—	—	—	+
Dual-income households	[22]	—	—	—	+
Number of dependent children	[23, 24]	—	—	—	+
Recent immigrant	[25]	+	?	?	?
<i>Characteristics of travel with young children</i>					
Carrying child-related equipment	[17, 26]	—	— / ?	+	+
Ability for child to explore local environment	[11, 26]	+	+	—	—
Ability to attend to child while travelling	[17, 27]	+	+	—	—
Developing physical capability to walk or cycle long distances	[26, 28]	—	—	?	+

Note: 1 (Gaffga & Hagemester, 2016); 2 (Andrews et al., 2014); 3 (Bostock, 2001); 4 (Fritze, 2007); 5 (McLaren, 2016); 6 (McCray, 2000); 7 (Dols, Pons, Alcalá, Valles, & Martín, 2013); 8 (Guthrie & Fan, 2016); 9 (Caroli et al., 2011); 10 (Oxford & Pollock, 2015); 11 (Pooley et al., 2014); 12 (Rubin et al., 2014); 13 (Dowling, 2015); 14 (Thomas, 2016); 15 (Dowling, 2000); 16 (Sattlegger & Rau, 2016); 17 (Price & Matthews, 2013); 18 (Lanzendorf, 2010); 19 (Currie, Gray, Shepherd, & McInnes, 2016); 20 (Bean, Kearns, & Collins, 2008); 21 (McDonald, 2006); 22 (Wheatley, 2014); 23 (McQuaid & Chen, 2012); 24 (Scheiner, 2014); 25 (Rothman et al., 2016); 26 (Birken et al., 2015); 27 (Taubman-Ben-Ari & Noy, 2011); 28 (Zwerts, Janssens, & Wets, 2008).

Symbols: —, negative impact on mode; +, positive impact on mode; —/+, neutral impact on mode; ?, unknown.

Source: Author's synthesis.

particular, as women tend to carry out the majority of childcare in developed nations (OECD, 2016), features particular to women's travel are likely to exert a greater influence on young children's travel patterns. Moreover, many differences between the studies and the location in which they were undertaken make comparability difficult. Nevertheless, overall, it is clear that most factors favour private car and discourage public transport use.

3.2.1. *Structural factors*

Mixed-use, medium- and high-density built environments with good quality active and public transport infrastructure are widely acknowledged to encourage travel by sustainable transport modes (Buehler, Pucher, Gerike, & Götschi, 2017; Ewing & Cervero, 2010). Unsurprisingly then, several studies associated greater travel distances, low-density residential housing or poor quality pedestrian and cycling infrastructure with increasing car orientation of young children (Andrews, Rich, Stockdale, & Shelley, 2014; Caroli et al., 2011; Oxford & Pollock, 2015). Inadequacies of public transport infrastructure, such as lack of step-free access (Fritze, 2007; Lanzendorf, 2010), and operations, such as infrequent and indirect services (McCray, 2000), deter use when travelling with young children. Cycles and cycle equipment designed for travelling with children, such as adult tricycles and bike trailers, are often accommodated poorly in cycling infrastructure. Cycle ways that are too narrow, or include tight turns and bollards, are difficult to negotiate with the wider width characteristic of these types of cycles (Gaffga & Hagemester, 2016). Poorly kept or non-existent footpaths and pedestrian crossings, as well as levels of traffic noise and high traffic speeds, make walking with young children relatively unattractive and, often, unsafe (Andrews et al., 2014; Pooley et al., 2014).

Nonetheless, despite the inadequacies of cycling infrastructure, a recent qualitative study examining use of electric assisted bicycles by parents with young children emphasises the advantages this mode presents in densely populated urban environments (Thomas, 2016). The convenience provided by the e-bike, particularly in terms of ease of parking, was the main motivation for parents to choose this mode over available alternatives.

Although policies regarding child transit ticketing are not specifically discussed in the literature, several studies identified cost as a barrier to using public transport, particularly when travelling as a family group. The high cost can result in forgoing trips (Fritze, 2007; McCray, 2000) and make travel by private car more attractive, particularly when travelling as a family group (McLaren, 2016; Price & Matthews, 2013; Rubin, Mulder, & Bertolini, 2014).

A further factor not specifically discussed in the literature is the ability to use alternatives to conventional car ownership. Car-sharing and ride sourcing (for instance, Uber or Lyft) schemes tend to be located in dense inner-urban areas restricting access to them to those who live within close proximity of a car share. Furthermore, car seats are only included in some vehicles of car-sharing fleets (Dowling, 2015) and, in most jurisdictions, are not required in ride sourcing vehicles. Even when a car share or ride sourcing vehicle is in close proximity, the lack of a car seat may be a further barrier to use.

3.2.2. *Psychosocial factors*

While structural constraints influence parental mode choice, psychosocial factors also play an influential role (Andrews et al., 2014; Mattioli, Anable, & Vrotsou, 2016; Sattlegger & Rau, 2016). Sattlegger and Rau (2016), in a study examining the motivations of carless households in Europe, show that the parents of young children who choose to be carless in car dominant settings felt social norms associated with parental car use meant their decision

was viewed negatively by their peers (Sattlegger & Rau, 2016). Although psychosocial factors tend to influence mode choice in favour of the car, Lanzendorf (2010) in a qualitative retrospective survey of 20 parents of small children in Germany also shows some parents exerted a strong attachment to non-motorised transport, which they adapted to continue using with their young children (Lanzendorf, 2010).

Dowling (2000) demonstrates that in auto-orientated cities, cultures of good parenting are manifested through car use. Parents use cars as a means of safely transporting their child to destinations that best meet their needs and interests (Dowling, 2000). Nevertheless, in the nearly two decades since Dowling's influential paper on parental mobility, the negative aspects of car use – in particular, health implications and environmental costs – have entered mainstream discourse. Parents are increasingly reflecting on these negative aspects (Andrews et al., 2014; McLaren, 2016). The negative aspects of car use are, in fact, prompting some families to move away from conventional car-dependent suburban lifestyles to mixed-use locations where active transport can be readily incorporated into daily travel (McLaren, 2016). Nonetheless, McLaren (2016) highlights the precariousness of this change. While the intention to reduce car use is present, it is often impeded by inadequacies in urban design and alternatives to car use (McLaren, 2016).

3.2.3. Household characteristics

The number of dependent children in a household is associated with higher levels of car orientation (Scheiner, 2014; Taubman-Ben-Ari & Noy, 2011). Similarly, McDonald (2006), in a study of US national household travel data, demonstrates increases in household income and car ownership are associated with higher levels of car use by children. Compared with children from low-income households, children from households with higher incomes make more trips by car, in particular for sport and recreation (McDonald, 2006). Studies examining the experience of parents on low-incomes highlight that household income constraints mean that it is not only cars that are an unattainable mode of transport but, often, public transport too. In these situations, walking becomes the dominant form of transport. This creates barriers to accessing health and social services that perpetuate cycles of social disadvantage (Bostock, 2001; Fritze, 2007; McLaren, 2016).

The growth in dual-earner households has resulted in more families with young children accommodating both childcare responsibilities and employment demands within a standard working day. Cars are often considered the preferred mode of transport in order to successfully juggle these demands within time and spatial constraints (Wheatley, 2014). Declining active travel of school-age children has, in part, been attributed to a rise in time-poor dual-earner households (Dowling, 2015; Fyhri et al., 2011). However, not only are both parents increasingly likely to work but parents, in particular women, are taking shorter periods of parental leave. In Australia, for instance, the proportion of mothers in employment with a child less than a year old increased from just over a quarter in 1991 to nearly one in two in 2011 (Baxter, 2013). This suggests the pressures of managing these competing demands are occurring earlier in a family life cycle with corresponding impacts on young children's mode use.

3.2.4. Characteristics of travel with young children

Carrying additional child-related equipment can pose a challenge when accompanying a young child, especially when combined with carrying additional luggage or shopping

(Price & Matthews, 2013). Some other unique features of travelling with young children, not discussed in the literature, are likely to be relevant here too. For instance, the unpredictable nature of young children is more readily constrained when they are strapped in a car seat. The perceived disruption that a fractious child may cause other passengers may further deter adults from travelling with young children on public transport. Parents often have a strong preference to have immediate access to transport in case of a child's sickness or accident. This preference is most often met by access to a private car. Other factors can be drawn from the literature on school-age children's travel. All travel with young children is accompanied, alleviating many of the safety concerns that contribute to increasing car orientation of school-age children. Nevertheless, factors such as weather, while not discussed in the literature, are likely to influence young children's travel.

4. Addressing barriers to sustainable transport modes

The many factors, outlined in Table 1, help explain why car use dominates travel with young children. Structural factors such as poor access to affordable and accessible public transport or a lack of good quality active transport infrastructure facilitate an auto-mobile lifestyle, particularly in auto-orientated cities. These structural factors then reinforce psychosocial factors, such as social norms that strengthen the association between good parenting and auto-ownership.

Nevertheless, alternatives to car use and ownership, such as car-sharing schemes, are increasingly being marketed to families with young children as an alternative to purchasing a second, or even a first car (Dowling, 2015). Less car-orientated travel behaviour, evident in some millennials, suggests that, as this cohort approaches parenthood, a life stage long associated with increased car use, they may be more open to using alternatives to car use and ownership when travelling with their children, than previous generations (Guthrie & Fan, 2016; McDonald, 2015). For instance, Guthrie and Fan (2016) examine the likelihood of using public transport by certain household characteristics in a medium-sized, auto-orientated city in the US between 2000 and 2010. The authors note that during this period many millennials transitioned into child-rearing age and also extensive improvements were made to the city's public transport network. In 2000, adults in a household with a child under 6 were less likely than other adults to use public transport. By 2010, this household characteristic was no longer associated with an adult being less likely to use public transport (Guthrie & Fan, 2016). This suggests that a transition away from car dependency may be possible for families with young children.

Moreover, recent research reveals the emergence of more varied travel patterns among families with young children (Lanzendorf, 2010; McLaren, 2016) than is often recognised in transportation research. This highlights that in some environments it is feasible for families with young children to use sustainable transport modes. For instance, Lanzendorf (2010), in a qualitative retrospective survey of 20 parents of small children in Germany, shows car use increased for some parents following the birth of their child but decreased for others (Lanzendorf, 2010). McLaren (2016), examining parents' travel behaviour in Vancouver, demonstrates a diverse spectrum of mobility practices among families with young children ranging from auto-dependency through

to multimodality and reliance on alternatives to conventional car ownership, both voluntarily and involuntarily.

Similarly, turning attention to nations with strong cycling cultures, such as the Netherlands and Denmark, provides an insight into what is possible in other localities. In Copenhagen, for example, approximately a quarter of families with at least two children have a cargo bike (Colville-Andersen, 2011 cited in Pucher & Buehler, 2012). This demonstrates that sustainable modes can be a mainstream transport options for families with young children, where the environment is favourable.

Evidence that parental mobility practices are not universally car orientated indicates that some factors, influencing mode choice when travelling with children, can be influenced. Some factors, particularly many household characteristics, are outside the influence of transport planners and policy-makers. Nonetheless, as outlined in Table 2, many factors that discourage travel by public or active transport can conceivably be influenced through policy formation or infrastructure changes. For instance, Ho and Mulley (2013) highlight the opportunity to grow patronage of public transport among families with young children through family fares that accommodate a variety of family compositions (Ho & Mulley, 2013). Psychosocial factors, such as perceived disruptions young children may present to other public transit riders, could be addressed through marketing campaigns making it clear families with young children are welcome on public transport services.

Table 2. Barriers to sustainable transport modes.

	Factors that <i>can</i> be influenced	Factors that <i>could</i> be influenced	Factors that <i>can not</i> be influenced
Structural	Inadequate or non-existent cycling infrastructure Poor quality or non-existent pedestrian infrastructure Physically inaccessible public transport Infrequent or indirect services Requirement to collapse pram / pushchair Low density, single land-use Increasing travel distances High traffic speeds	Car share/ride source vehicle equipped with car seat	
Psychosocial	Perceived high costs of travel by public transport Perceptions of safety Perceived disruption that a fractious child may cause other passengers	Perceptions of “good parenting” Social norms of auto-ownership and parenthood Negative perceptions of walking	
Household characteristics			Increasing car ownership Increasing income Dual-income households Number of dependent children
Characteristics of travel with young children		Carrying child-related equipment Preference to have immediate access to transport in case of a child’s sickness or accident	Developing physical capability to walk or cycle long distances

Source: Author’s synthesis.

Table 3. Research gaps – travel among families with young children.

Research questions	Background	Research
What trends are occurring in young children's travel?	Exploring the modes that young children use will help reveal trends and variations by different household characteristics. However, young children are an under-researched group of transport users and little is known about their travel patterns (McDonald, 2006; Oxford & Pollock, 2015).	• Establish whether broader societal changes, such as the rise of dual-income households or increasing expectations for young children to partake in extra-curricular activities, are influencing young children's mode use. • Explore if variations exist in young children's travel by household characteristics, such as income, location or number of dependent children.
What barriers exist to the uptake of alternatives to conventional car ownership by families with young children?	Over the past decade or so alternatives to car use and ownership have grown into mainstream transport options (Shaheen, Cohen et al., 2009; Kent, 2014). Some alternatives, such as car sharing or e-bikes, would seem to provide a suitable transport alternative to acquiring a second car (Dowling, 2015; Thomas, 2016)) yet little is known about how they are being utilised by families with young children.	• Understand families with young children's use of new and emerging alternative transport options. • Examine whether the increase in cycling equipment for carrying children (such as cargo-bikes or bakfiets) together with improvements in cycling infrastructure can increase mode choice among this group. • Determine the affect alternative transport solutions have on parent's long-term mobility decisions, such as car ownership.
What other factors influence mode choice when travelling with young children?	This review has demonstrated the many constraints faced by carers travelling with young children. However, other factors, such as the need for safety and privacy when travelling on public transport, are not discussed in the literature yet are likely to influence mode choice.	• A fuller account of the range of factors that may influence parental mode choice when travelling with young children.
How does the travel modes used as a young child influence travel attitudes, habits and choices as an adult?	Research examining the travel socialisation of school-age children suggests that attitudes, habits and beliefs regarding travel modes are embedded at a young age (Baslington, 2008). However, less is understood about travel socialisation of preschool age children and how this, in turn, affects travel attitudes and choices as the child ages.	• Examine whether the travel modes exposed to as a young child influence travel attitudes and choices as an adult.

Source: Author's synthesis.

5. Agenda for future research

This literature review has helped to construct an initial understanding of what influences travel mode choice among families with young children. While the majority of factors tend to discourage travel by alternative modes, this literature review demonstrates that some of these factors are within the influence of transport planners and policy-makers. Moreover, it has highlighted that it is both feasible and beneficial to encourage less car use among this group. However, to achieve a transition away from auto-dependency, a richer account of travel behaviour among families with young children is required. With this in mind, several important aspects of young

children's travel and factors influencing mode choice remain unanswered. These are outlined in [Table 3](#).

6. Conclusion

This literature review has demonstrated the majority of factors influencing mode choice among families with young children tend to facilitate car use. While cars provide an important means for families with young children to access activities and services, high levels of car use can be problematic. It has been suggested in this paper that to reduce car use among families with young children, it is more advantageous for policy-makers to focus on addressing the factors that discourage travel of alternative modes rather than introduce policies restricting car use. The framework setting out influences on mode choice when travelling with young children, and discussion of how factors discouraging travel by alternative modes might be best addressed through policy or infrastructure changes, provides a starting point for how less car-orientated travel behaviour may be adopted by parents of young children. However, further research examining parental preferences for mode choice when travelling with young children, and barriers and motivations to using sustainable travel modes, is required. This, in turn, will assist households with young children to adopt sustainable travel practices during a period when they are actively evaluating their mobility practices.

Notes

1. Two supplementary searches were conducted. In April 2017, the first supplementary search was conducted to retrieve any literature published since August 2016. One additional record was retrieved that met the inclusion and screening criteria. The second supplementary search, conducted in July 2017, aimed to retrieve relevant records published in the MEDLINE/ PubMed database. This retrieved two additional records that met the inclusion and screening criteria.
2. This includes the three records retrieved during supplementary searches.
3. The following records are included in the literature review findings: 1 (Gaffga & Hagemeister, 2016); 2 (Andrews et al., 2014); 3 (Bostock, 2001); 4 (Fritze, 2007); 5 (McLaren, 2016); 6 (McCray, 2000); 7 (Dols et al., 2013); 8 (Guthrie & Fan, 2016); 9 (Caroli et al., 2011); 10 (Oxford & Pollock, 2015); 11 (Pooley et al., 2014); 12 (Rubin et al., 2014); 13 (Dowling, 2015); 14 (Thomas, 2016); 15 (Dowling, 2000); 16 (Sattlegger & Rau, 2016); 17 (Price & Matthews, 2013); 18 (Lanzendorf, 2010); 19 (Currie et al., 2016); 20 (Bean et al., 2008); 21 (McDonald, 2006); 22 (Wheatley, 2014); 23 (McQuaid & Chen, 2012); 24 (Scheiner, 2014); 25 (Rothman et al., 2016); 26 (Birken et al., 2015); 27 (Taubman - Ben-Ari & Noy, 2011); 28 (Zwerts et al., 2008).

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2.7 Research gaps

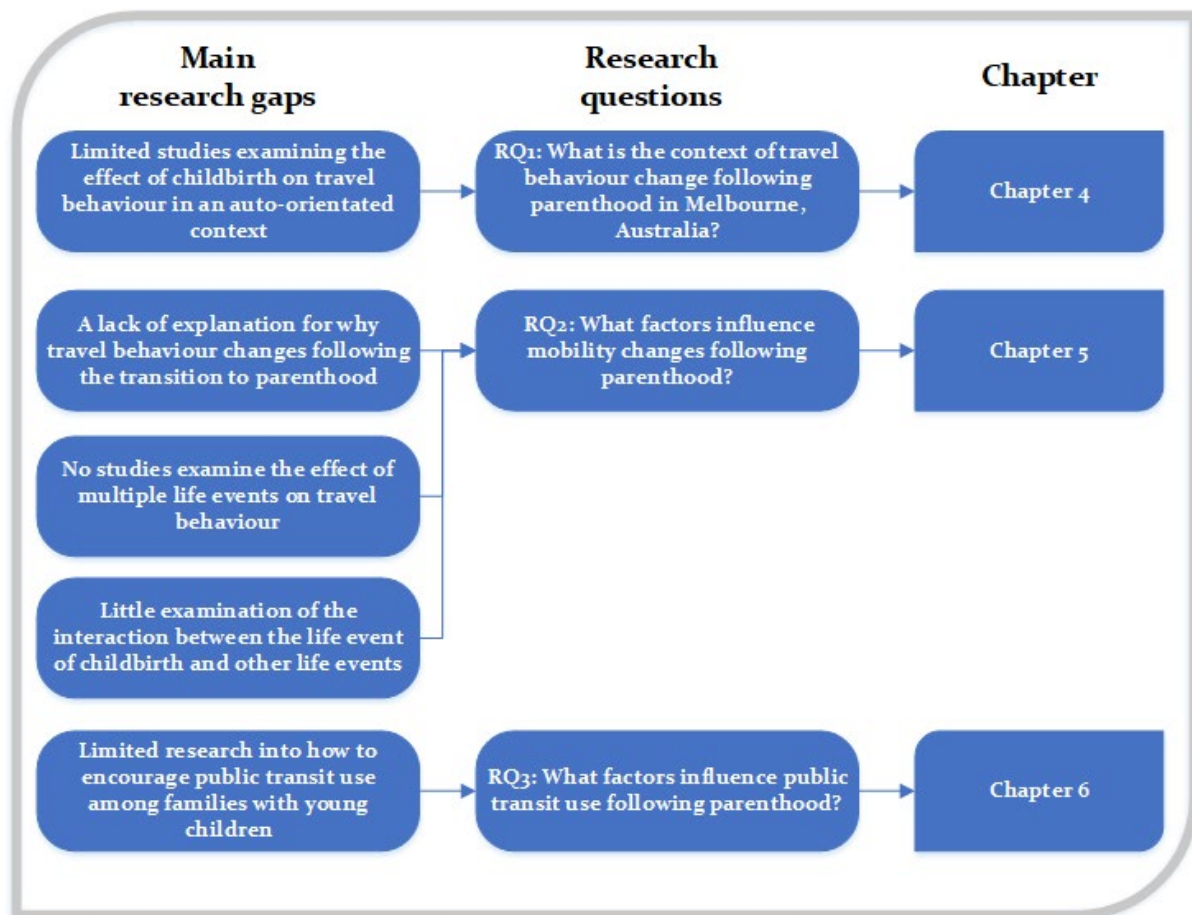
Overall, studies within the mobility biographies field have advanced our understanding of the dynamics of travel behaviour over the life course. However, while a number of quantitative studies have examined *how* travel behaviour changes following the birth of a child only two qualitative studies have, in part, examined *why* travel behaviour changes. Moreover, most studies have tended to focus on the association between mode use changes and life events at the aggregate level.

This suggests a number of research gaps:

- The barriers that hinder the adoption of **alternatives to car use and ownership** among families with young children are little understood
- Limited studies examine the effect of childbirth on travel behaviour in an **auto-orientated context**
- There is a lack of empirical research explaining **why travel behaviour changes** following the transition to parenthood
- No studies examine the **effect of multiple life events** on habitual travel behaviour
- Little examination of the **interaction** between the life event of childbirth and other life events
- Limited research into **how to encourage** public transit use among families with children
- Limited number of qualitative studies within the mobility biographies approach and few **link qualitative and quantitative** approaches.

These gaps form the justification for the research questions explored in this thesis, first introduced in Chapter 1. Figure 2.3, below, shows the linkages between the *main* research gaps, *major* contributions to knowledge and the chapter in which the relevant results are presented.

Figure 2.3: Linkage between main research gaps and research questions



2.8 Conclusion

This literature review, after briefly outlining factors influencing travel behaviour, discussed research within the mobility biographies approach. The approach emphasises the importance of habits in influencing daily travel behaviour. It highlights the important opportunity represented by life events, such as moving house or changing jobs, which disrupt habitual travel behaviour. Life events can prompt a change in travel routines that require individuals to actively evaluate their travel choices under new routes or circumstances. This, in turn, provides an opportunity to intervene and encourage the adoption of more sustainable travel choices during a period in which an individual is actively deliberating their travel options.

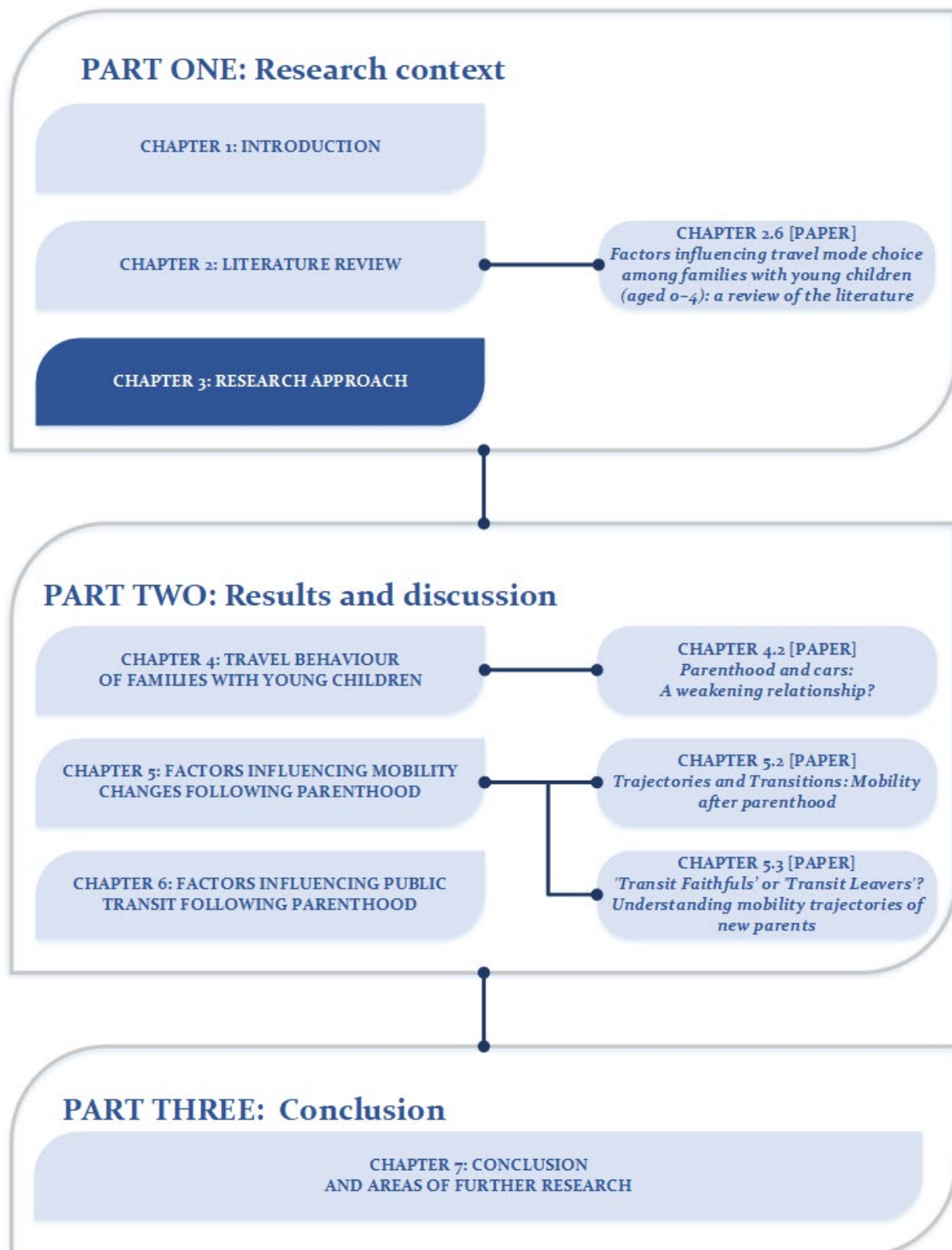
The Chapter then discussed the literature regarding travel behaviour changes following parenthood. An extensive body of work has shown that car use and ownership tends to increase following childbirth. The journal paper, turning attention to families with young children, examined the many factors that influence travel mode choice among this group. These factors were synthesised into a framework of factors influencing mode choice among families with young children, which grouped the factors into four categories (structural, psychosocial, household and child's characteristics). It revealed that the majority of factors tend to facilitate car use at the expense of alternative modes.

Although an extensive body of work has contributed to an improved understanding of travel behaviour changes throughout the life course, there still remains a number of gaps within the mobility biographies approach to studying travel behaviour. In particular, in terms of the life event of childbirth, while numerous quantitative studies have shown *how* travel behaviour changes, few studies, either qualitative or quantitative, have examined *why*. This notable research gap forms the focus of this thesis.

Chapter 3

Research approach

Figure 3.1: Thesis structure



3.1 Introduction

This Chapter provides an overview of the research methods used in this thesis. It begins by describing the study location: Melbourne, Australia. This is then followed by an overview of the research approach and a description of the three research instruments used to answer the research questions: analysis of household travel survey data, qualitative interviews with new and expectant parents and an online survey of new parents. It then describes the analysis methods used to answer the research questions. The Chapter concludes with a summary.

3.2 Study location

The research was conducted in Greater Melbourne, Australia. Greater Melbourne (referred to throughout simply as “Melbourne”) is the second most populous city in Australia, with a population in 2018 of 4.8 million, and comprises a land area of just under 10,000 square kilometres. These characteristics result in a low population density of approximately 5 people per hectare.

Melbourne has a radial passenger train network with major lines converging in the central city. It also has an extensive tram network, primarily servicing Inner Melbourne, and a bus network predominantly servicing Middle and Outer suburban areas.

Reflecting Melbourne’s car orientated development, rates of car ownership are high, with an average of 1.7 motor vehicles per household, creating a predominantly sprawling, car-dominated urban environment. Nearly two-thirds of residents (67%) travel to work by car compared with just 16 % travelling by public transport and 5% walking or cycling (Australian Bureau of Statistics 2016). While the use of alternate modes is showing modest upward trends in use, particularly within inner-city areas, this is from a low base. For instance, approximately 1% of residents cycle to work and 16% travel by public transport (Australian Bureau of Statistics 2016).

In this thesis reference is made to three sub-regions: “Inner Melbourne”, comprising the central business district and medium-density older inner suburbs; “Middle Melbourne”, comprising more established low to medium density suburbs; and, “Outer Melbourne”, comprising largely

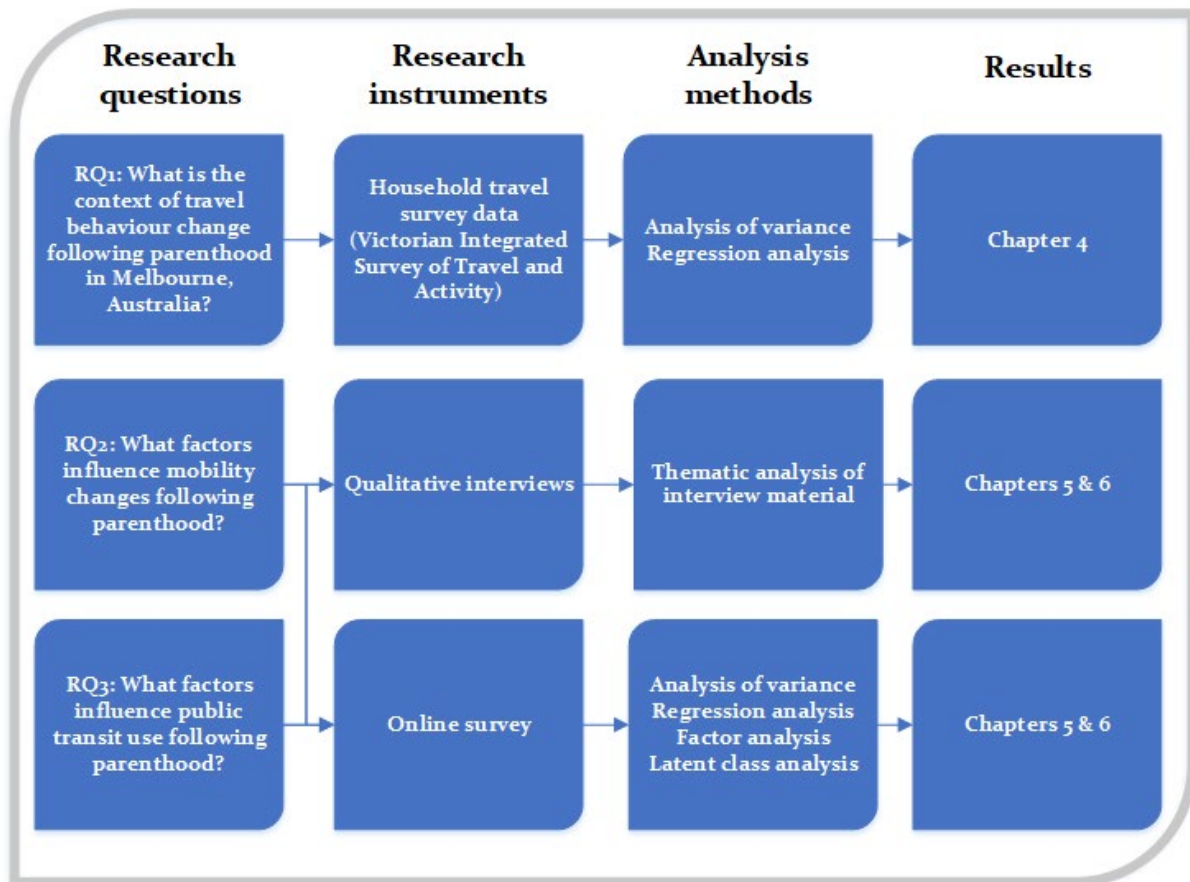
low-density residential developments. Notable variations in mode use are apparent by location. For instance, 56% of weekday trips in Inner Melbourne are by private vehicles compared with 74% in Middle Melbourne and 81% in Outer Melbourne. In contrast, active modes account for a larger share of weekday trips in Inner Melbourne (30%) compared with 17% in Middle Melbourne and 12% in Outer Melbourne (Victorian Government 2013).

3.3 Overview of research methods

A mixed-method approach was used to address the research questions. Mixed-method approaches draw on the strengths of both qualitative and quantitative methodologies. This allowed for in-depth exploration of a topic, characteristic of qualitative methods, but also the ability to test hypotheses and generalise findings, afforded through the use of quantitative methods (Johnson and Onwuegbuzie 2004).

An analysis was undertaken of household travel survey data using an existing secondary dataset. In addition, primary research instruments included qualitative interviews with new and expectant parents and an online survey of new parents. Figure 3.2, below, shows the linkage between the research questions, research instruments, analysis methods and the chapter of this thesis in which the results are presented.

Figure 3.2: Overview of research methods



Note: RQ2 and RQ3 are explored using both the qualitative interviews and online survey.

3.4 Research instruments

The three research instruments presented in Figure 3.1 are discussed below.

3.4.1 Household travel survey analysis

Household travel survey data was used to understand the context of travel behaviour change following parenthood in Melbourne, Australia (RQ1). The Victorian Integrated Survey of Travel Activity (VISTA) is a large-scale cross-sectional household travel survey conducted across the state of Victoria, Australia. The results of this analysis are presented in Chapter 4.

The survey was conducted in 2007/08 and 2008/09, and annually between 2012 and 2016, with new households recruited for each wave. Although a similar household travel survey was conducted in Victoria before VISTA, it was not used in this analysis as it is not directly comparable. Data from the 2007/08, 2013 and 2014 VISTA waves were used in this thesis.

The survey captures a range of information about households, household members and their daily travel behaviour. Households are randomly selected to participate. The 2007/08 survey included data from 17,000 households across Victoria, whereas the 2013 and 2014 VISTA surveys (VISTA₁₃₋₁₄) included data from a total of 8,400 households. Given the smaller size of the 2013 and 2014 surveys, we combined data from these years to ensure there was a sufficient sample size in each of the household groups to allow comparisons to be made by different household characteristics. Household weights, developed by the government agency responsible for administering the survey, were applied to the dataset. A comprehensive process was used to design the weights that took into account, amongst other factors, the representativeness of the sample and non-responding households (DEDJTR 2016).

In order to explore travel behaviour change following parenthood, we identified three household groups of interest which broadly represent a sequential order of life stages: Young Couples, Young Families, and School-Age Families. Data from the remainder of the sample, which did not fall into these three groups, were excluded from the analysis. We also excluded households outside the Greater Melbourne region. Households with children aged between both 0-4 and 5-14 were excluded in order to isolate the influence that the presence of pre-school children and school-age children has on household travel behaviour.

3.4.2 Qualitative interviews with new and expectant parents

Qualitative semi-structured interviews were conducted with expectant first-time parents and parents with young children. This method was used as the flexibility characteristic of qualitative methods is better suited to the exploratory approach to understanding this topic. Furthermore, while qualitative studies are less common in mobility biographies research, they are better placed to unpick the complexities and interconnections of events surrounding changes in travel behaviour (Müggenburg et al. 2015).

The interviews aimed to understand the factors that influence mobility changes following parenthood (RQ₂) and the factors influencing public transit use following parenthood (RQ₃). The interviews revealed the complex changes occurring among households during this

transition. As a result, three sub-questions were developed to comprehensively explore different aspects of RQ2 (see Chapter 1 for the research sub-questions). The results of the qualitative interviews are presented in Chapter 5 and Chapter 6.

Several notable themes emerged during the interviews with new parents that were further explored, quantitatively, through the online survey. Firstly, a range of mobility changes were evident among new parents. Secondly, the period following parenthood coincided with a number of other changes among households. The significant changes occurring among households suggested it may disrupt the formation of travel habits. As such, testing new parents' habits, frequency of life events and travel mode changes formed a core part of the online survey.

3.4.2.1 Sample

We recruited male and female participants who were either expecting their first child or had at least one child aged between 0 and 5 years. Although strict demographic quotas were not applied the sample aimed broadly to reflect the general population of parents of young children residing in Melbourne, Australia. Further, males are often underrepresented in qualitative studies examining parents' travel behaviour (see, for examples, Lanzendorf 2010, McLaren 2016). As such, we placed a particular focus on actively recruiting males to attain a more balanced gender split. In addition, towards the end of the data collection process, we conducted targeted recruitment in order to recruit single parents and low-income households, as these two groups were initially underrepresented in the sample. Despite these efforts, males continued to be somewhat underrepresented in the final sample. Table 3.1 outlines the socio-demographic characteristics of the participants.

Participants were recruited through postings placed on Facebook pages and physical locations targeting this demographic, such as daycare centres and babywear stores. In addition, participants were recruited using chain sampling as well as through the researchers' personal networks

Table 3.1 Participant characteristics (qualitative interviews)

Characteristic	Variable	Number of participants	
		n=25	%
Gender	Male	8	32%
	Female	17	68%
Household composition	Dual parent household	21	84%
	Single parent household	4	16%
	Other	0	0%
Household ownership car	Carless household	3	12%
	1 private vehicle	13	52%
	2 or more private vehicles	9	36%
Residential location	Inner Melbourne	7	28%
	Middle Melbourne	10	40%
	Outer Melbourne	8	32%
Socio-economic index decile ranking for area (Victoria, Australia)	Low (1-4 decile)	5	20%
	Medium (5-7 decile)	7	28%
	High (8-10 decile)	13	52%
Employment status	Employed (part-time or full-time)	16	64%
	Stay-at-home parent	8	32%
	Student	1	4%

3.4.2.2 Interview

Between July and October 2017, twenty-five semi-structured interviews were conducted with expectant first-time parents and parents of small children in Melbourne, Australia. Seven interviews were conducted in-person and the remaining 18 by telephone, all conducted by the same interviewer. Typically, the interviews lasted about 40 minutes each but varied in duration from approximately 20 minutes through to over an hour. In compensation for their time, participants were given a \$40 (AU) voucher for a major supermarket chain. We audio-recorded and then transcribed the interviews.

Guest et al. (2006) propose undertaking a minimum of 12 qualitative interviews for a relatively homogenous group of individuals sharing perspectives or experiences on a common topic (Guest et al. 2006, 79). The sample of parents was homogenous in terms of their parenting status but came from a diverse range of backgrounds, particularly concerning partnership and

caregiving status. Given this, a minimum of 20 interviews was deemed necessary to account for this diversity. After conducting 25 interviews the frequency in which new themes were identified had greatly reduced. Although additional interviews could have been undertaken, the likelihood of identifying new themes had diminished. As such, this was deemed an appropriate point at which to conclude data collection.

3.4.2.3 Interview content

An interview guide was used that asked participants a range of questions regarding their travel behaviour. In addition, we asked about broader changes in their life, both recent and anticipated, that might influence their mobility practices. Further, we asked about social influences on their travel choices as well as their attitudes and perceptions towards different travel modes. The three expectant first-time parents were also asked about how they anticipated their travel would change once they became a parent. Example questions included:

- Can you tell me about anything in your life that has changed since you were planning, or found out that you were expecting, your first child? This could be things such as housing, employment, partnership, or transport changes, and for you, your partner, or both.
- Can you tell me about daily travel in your household?
- Can you tell me about your access to transport in your household?
- Has the way you travel changed since you've become a parent? What do you think may have prompted the changes?

A key strength of qualitative research is its flexibility that allows for new lines of inquiry to be explored as they emerge (Johnson and Onwuegbuzie 2004). As such, not all participants were asked the same set of questions. As new themes emerged, these themes were explored in subsequent interviews.

3.4.3 Online survey of new parents

Using findings from the literature review, analysis of VISTA household travel survey data and interviews with new and expectant parents, we developed a survey for parents with young children. An online survey was selected as the preferred method to reach potential participants. While online surveys have limitations in terms of reach, particularly regarding older respondents, we felt those limitations were less relevant for this demographic.

The survey aimed to:

- quantify different mobility trajectories among new parents (RO2b)
- examine the differences in attitudes and socio-demographic characteristics between the mobility trajectories (RO2b)
- understand the determinants of car-use habits (RO2c)
- understand the relative importance of factors influencing public transit use among new parents and how this varies by different characteristics (RQ3).

The results of the analysis are presented in Chapter 5 and Chapter 6.

3.4.3.1 Survey structure

The survey was conducted online and coded into a web survey using Qualtrics software. As the population group was anticipated to be time-poor, some effort was taken to ensure the survey length was limited to a maximum of ten minutes. The survey was structured into the following sections: car-use habit strength; pre-parenthood and current mode use; life events; transport and housing attitudes; barriers to public transit use; and, lastly, demographic information.

Within transportation research, two measures are commonly used to measure travel habits, the *self-reported habit index* (SRHI) and the *response-frequency measure of habit* (RFM). The RFM measure defines a habit as a type of automatically activated behaviour and aims to test the automaticity or script-based nature of habit. Reflecting this definition, the RFM asks respondents to quickly select the travel mode they would use to access different destinations (Verplanken et al. 1994). The SRHI is a 12 point scale that in addition to questions regarding the frequency and automaticity of the behaviour includes questions regarding the extent to which an individual identifies with that behaviour (Verplanken and Orbell 2003).

In developing the SRHI, Verplanken and Orbell (2003) conducted a study testing respondents' bus-habit strength using both the SRHI and RHM. There was a significant and strong correlation between the two measures (Verplanken and Orbell 2003). Of the two measures, the SRHI is more commonly used (Gardner et al. 2012). However, the RFM is best suited to testing context related choices (such as travel mode choices) whereas the SRHI can be applied to a

broader range of situations (Verplanken and Orbell 2003). The RFM was used as it enabled travel habits to be succinctly captured for multiple modes.

The RFM measure of habit is placed first in the survey to ensure the responses are not clouded by later questions about the respondents' mode use. Respondents were asked to select the travel mode that first comes to mind to access the following ten activities: visit friends or family; visit a local shopping centre; visit a local park; attend a major event; visit local shops; go to the movies; visit a local café; visit a pub or restaurant; go to a sports event; grocery shopping. The activities were selected as relevant destinations for this group and separated into two question sets to differentiate between travel with, and without, children. The options exclude regular activities, such as work or study. The level of car-use habit is determined by the frequency with which respondents selected the car (driver or passenger) as the travel mode. Other options respondents could choose from included 'public transit', 'cycling', 'walking' or 'other'.

Questions regarding mode use changes asked about the period one year before becoming a parent for the first time and currently. The travel modes included a car (driver or passenger), public transport, cycling, walking and other.

In order to keep the questionnaire succinct, the section regarding life events only asked about events that would be relevant to this demographic group. This was due to survey completion rates decreasing when respondents are faced with a wide range of options regarding life events (Rau and Manton 2016). In addition, rather than including the event of childbirth, we derived this life event from another question regarding the number and age of each of the respondents' children. The question asked about the number of times the following events occurred during the period one year before becoming a parent until the present: changed jobs; took a period of parental leave; moved house; separated from partner; moved in with partner; purchased a car; sold a car; and started or finished an education course.

Respondents were also asked about their attitudes regarding transport and housing, on a five-point Likert scale. Most of these questions were sourced from the extensively tested Netherlands Mobility Panel survey (for a summary, see Hoogendoorn-Lanser et al. 2015). In addition, we included two questions regarding public transport safety and satisfaction and two questions regarding housing preferences relevant to this group.

The penultimate set of questions asked about factors influencing public transit use. We developed these questions from the factors identified during the interviews as influencing parental mode choice.

Finally, demographic questions included the respondents' pre-parenthood and current household car ownership, age-group, employment status, gender, education level, relationship status, licence status, primary caregiver status and the number and age of their children. In terms of the respondents' households, we asked about their household income, current and pre-parenthood vehicle ownership levels, tenure status, and home postcode.

3.4.3.2 Recruitment

Survey participants were primarily recruited through posting a survey link on Melbourne based Facebook pages and groups targeting this demographic. Participants from the qualitative research were also invited to complete the survey. In addition, several participants were recruited through the researchers' personal networks. Survey participation was incentivised with a prize draw offering a \$200 voucher for an Australian supermarket chain. In total, 1,051 respondents started the survey and 903 completed the survey, representing a completion rate of 86%.

Parents with at least one child aged five years or younger, living in Greater Melbourne, were recruited to the survey. The sample aimed to be broadly representative of parents with young children in Greater Melbourne. A non-probability purposive sampling method was used. After reviewing the demographic characteristics of respondents, including partnership status, location, household income and gender, it was apparent that male participants were underrepresented. As a result, we revised the survey promotion on social media to specifically target male respondents.

3.4.3.3 Sample and weighting

Overall, the sample was representative across most characteristics identified. However, as shown in Table 3.2, approximately 83% (n=746) of survey respondents were female. Given females were overrepresented in the survey, we applied gender weights to the dataset. A simple calculation was conducted dividing the proportion of female responses by 50% (representing the proportion of females among the general population) and likewise for the male responses (Stopher 2012). This resulted in each female response being weighted by 0.61 and each male response being weighted by 2.96. Unless otherwise stated, the online survey analyses presented in this thesis apply these gender weights.

Table 3.2 Participant characteristics (online survey)

Characteristic	Variable	Survey respondents		2016 Greater Melbourne HH with children aged 0-4	Census, All HH
		Unweighted	Weighted		
Gender	Male	17%	50%	50%	49%
	Female	83%	50%	50%	51%
Household composition	Dual parent family household	92%	93%	84%	34%
	Single parent family household	8%	7%	10%	10%
	Other	-	-	6%	56%
Household car ownership	No car	3%	3%	2%	9%
	1 car	32%	32%	24%	33%
	2 or more cars	65%	65%	74%	55%
Household* income	Less than \$499 per week	4%	5%	17%	13%
	\$500 - \$999 per week	11%	11%	19%	17%
	\$1000 - \$1499 per week	17%	17%	17%	16%
	\$1500 - \$1999 per week	21%	20%	13%	12%
	\$2000 - \$2499 per week	14%	13%	11%	18%
	More than \$2500 per week	34%	34%	23%	24%
Household location	Inner urban	12%	14%	-	-
	Middle urban	44%	43%	-	-
	Outer urban	38%	37%	-	-
	Regional	6%	6%	-	-
Children*	Children per household (mean)	1.5	1.5	1.8	0.8

Notes: '-' indicates data is not available; '*' indicates Census data based on households with dependent children aged 15 years and younger.

The full sample is used in the results presented in Chapter 6, which explores the factors influencing public transit use among families with young children. We also aimed to understand the mobility trajectories (Section 5.2) and determinants of car-use habits (Section 5.3) among *new* parents. Given this focus, we excluded parents with children aged six years or older from the analysis (n=145).

3.5 Analysis methods

In this section, five analysis methods are discussed. Analysis of variance was used in both the analysis of VISTA household travel survey data (Chapter 4) and the online survey of new parents (Chapters 5 and 6); regression analyses were used to compare differences in travel behaviour by life stage (Chapter 4) as well as to understand the effect of life events on car-use habit strength (Chapter 5.4); Thematic analysis was used to categorise the interview material (Chapters 5.2 and 6); Latent class analysis was used to identify mobility trajectories following parenthood (Chapter 5.3); and, finally, factor analysis was used to group attitudinal statements into a smaller set of variables (Chapter 5.4).

3.5.1 Comparative statistics

Independent sample t-tests and one-way between groups analysis of variance tests (ANOVA) were used to compare differences across groups in both the VISTA (Chapter 4) and online survey datasets (Chapters 5 and 6). For instance, in Chapter 4, in order to understand whether car use and ownership declined between 2007 and 2013/14, we conducted a comparative analysis of the VISTA₀₇ and VISTA₁₃₋₁₄ datasets. For each household group, independent sample t-tests were undertaken to examine changes in the following characteristics: household location; mean household vehicle ownership; mean household vehicle, public transit and walking trips.

3.5.2 Regression analyses

In Chapter 4, the travel behaviour of household groups is explored using data from the Victorian Integrated Survey of Travel Activity (VISTA). The analysis aimed to understand the context of travel behaviour change following parenthood in Melbourne, Australia (RQ₁). In order to understand the extent to which factors influencing mode use frequency varied by life stage, we used negative binomial regression models. Negative binomial regression, a type of Poisson

regression, is useful for analysis that includes dependent variables with high levels of dispersion (Hoffmann 2016). We conducted three models for car, public transit and walking trips respectively. The dependent variable used was the number of trips per household by each of the respective modes. As there was a relatively wide distribution of the number of trips per household compared with the mean number of trips, this type of regression model was deemed most appropriate.

In Chapter 5 (Section 4), multiple linear regression was conducted using data from the online survey. This aimed to understand, holding other factors constant, whether the frequency of life events weakens or strengthens car-use habits (RO₂C). Car-use habit strength was used as the dependent variable, measured on a scale of 0 to 10. Independent variables included a variable to test life event frequency, as well as attitudinal factors and several individual and household characteristics identified in earlier research as factors influencing car-use habit strength.

3.5.3 Thematic analysis

Chapter 5 (Section 5.2) and Chapter 6 (Section 6.3) present the results of the qualitative interviews with new and expectant parents. A Thematic Analysis of the interview material was conducted based on the process outlined by Braun and Clarke (2006). Thematic Analysis shares many similar characteristics with other methods employed to analyse qualitative data, such as grounded theory. However, an important distinction from grounded theory approaches is that Thematic Analysis is broader in its application and not singularly aimed at theory building (Guest 2012).

Following an initial analysis of the data, a preliminary set of codes was developed. As data from later interviews were collected, these codes were then refined and sub-categories developed. Two further frameworks were used to interpret themes from the interview material. Firstly, we used the mobility biographies approach, which stresses the important linkages between life events and changes in travel behaviour, to explore the findings discussed in Chapter 5 (Section 5.2). Next as the sub-categories relating to public transit use were refined, similar themes arose to those that became apparent in the synthesis of literature examining factors influencing travel behaviour among families with young children (McCarthy et al. 2017). As part of this earlier work, we developed a framework of factors influencing *travel mode choice* among this group,

discussed in Chapter 2. Given this, we decided to use this framework in order to synthesise the findings regarding factors influencing *public transit* use among the participants.

3.5.4 Latent class analysis

Latent class analysis (LCA), a cluster-based modelling technique, was used to identify the types and size of mobility trajectories following the transition to parenthood and the attitudes, preferences and socio-demographics associated with each trajectory (RO2b). LCA uses a set of indicators to determine a 'latent' or undefined variable (in this analysis, the latent variable was the 'mobility trajectories'). This method provides several advantages over other clustering methods. Advantages include that it probabilistically rather than deterministically assigns respondents to groups; established criteria can be used to determine the appropriate number of classes; and, it can accommodate variables with different scale types (Vermunt and Magidson 2002). Given the advantages, this method is becoming increasingly common in travel behaviour research. The methods and results of this analysis are presented in Chapter 5 (Section 5.3).

Classes were determined based on six indicators outlining respondents' pre and current travel mode use of the car (driver or passenger), public transport and cycling. In addition, socio-demographic and attitudinal characteristics were included as active covariates predicting class membership. The sample used in this analysis was limited to participants who had become a new parent within the previous six-years (n=758). This was to ensure that the timing between pre and current travel mode use was relatively comparable among participants.

3.5.5 Factor analysis

The online survey included twelve attitude questions. We conducted a factor analysis to reduce these questions to a smaller set of scales to use in the regression analysis (Chapter 5.4). Factor analysis aims to create a smaller set of variables with similar characteristics that capture the substantive variability of the existing variables. A principal component analysis, using the oblique rotation method, was conducted. This method was selected given our primary interest was to reduce the number of variables to a smaller set of factors for use in further analysis (Tabachnick 2014).

3.6 Conclusion

This Chapter has provided an overview of the research instruments and analysis methods used in this thesis. The research instruments include VISTA household travel survey data, qualitative interviews with new and expectant parents, and an online survey of new parents. Analysis methods include comparative statistics (Chapter 4 and Chapter 5), regression analysis (Chapter 4 and Chapter 5.4), thematic analysis (Chapter 5.2 and Chapter 6), latent class analysis (Chapter 5.3) and factor analysis (Chapter 5.3). More detail on the respective instruments and analysis methods used to address each of the research questions are provided in the journal papers included in Chapters 4 and 5.

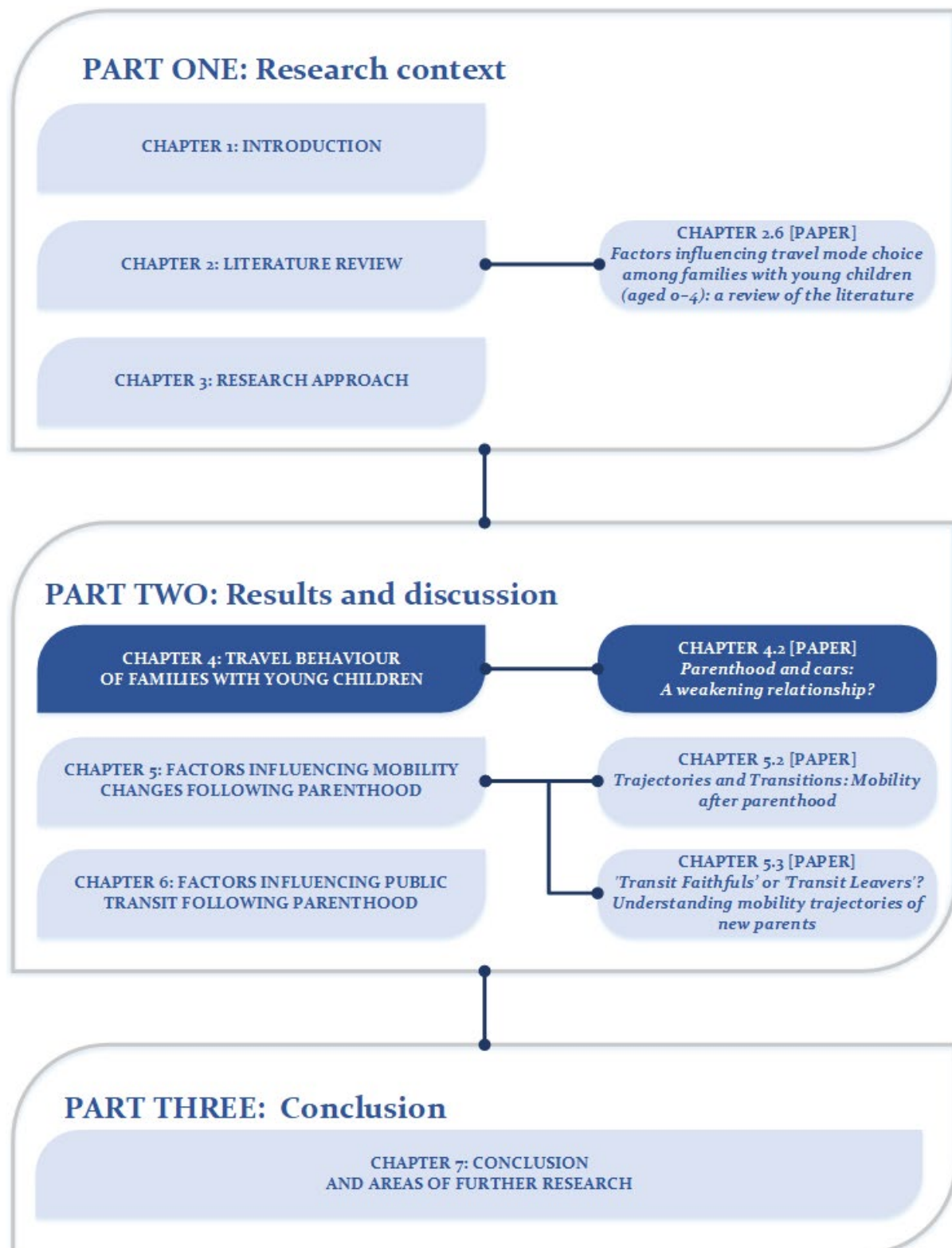
PART TWO:

Results and discussion

Chapter 4

Travel behaviour of families with young children

Figure 4.1 Thesis structure



4.1 Introduction

Chapter Two, the literature review, showed the extensive body of work demonstrating that car use and ownership tends to increase following parenthood. However, while an extensive body of work has demonstrated changes to travel behaviour occur following parenthood, this literature primarily emanates from Europe. Given the notably different mobility contexts between Europe and Australia, this Chapter examines travel behaviour by life stage in Melbourne, Australia. In doing so, it answers research question 1: “What is the context of travel behaviour change following parenthood in Melbourne, Australia?”. Moreover, this Chapter aims to examine whether changes may be apparent in levels of car use and ownership and the extent to which different socio-demographic characteristics predict vehicle trips. This Chapter is presented as a journal paper:

McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2018). "Parenthood and cars: A weakening relationship?" *Transportation*. <https://doi.org/10.1007/s11116-018-9963-7>

4.2 Paper: *Parenthood and cars: A weakening relationship?*

Using data from the Victorian household travel survey (VISTA) this paper explores differences in travel mode use by life stage in Melbourne, Australia. Three household groups, representing a sequential order of life stages, are examined: Young Couples, Young Families, and School-age Families. The first part of the paper examines whether changes in mode use frequency are evident between 2007 and 2013/2014. This is then followed by an exploration of the characteristics predicting vehicle, walking and public transit trips, among the three groups. The paper concludes with some discussion of the policy implications of these findings and areas of future research.



Parenthood and cars: A weakening relationship?

Laura McCarthy¹ · Alexa Delbosc¹ · Graham Currie¹ · Andrew Molloy²

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Abstract

A wide body of research supports the notion that the travel behaviour of families with children tends to be car dependent. Yet recent literature suggests a more varied set of travel practices are emerging among this group. Using data from a large-scale household travel survey, we explored whether changes are evident in levels of car use among three household groups in Melbourne, Australia. The three groups were selected to broadly represent a sequential order of life stages: Young Couples, Young Families, and School-age Families. Chi square and two-tailed *t* tests were used to examine changes in travel behaviour between 2007 and 2013/2014. Negative binomial regression analysis was then conducted to examine characteristics predicting vehicle, walking and public transit trips, among the three groups. Vehicle trips decreased for all groups between 2007 and 2013/2014; the decline was greatest among households with children present, both young and school-age. This suggests that a shift towards more sustainable travel behaviour is indeed apparent among families with young and school-age children in Melbourne. However, further research is required to understand the causes of the decline and to examine evidence of the decline in other locations.

Keywords Car-dependency · Life stage analysis · Family travel · Children's travel · Parenthood

Introduction

Many developed nations have policies aimed at reducing levels of private car use. However, the formation of effective car reduction policies requires an understanding of how the travel needs and aspirations differ among both households and individuals (Müggenburg et al. 2015). This research need has prompted a wide body of literature examining travel behaviour at different life stages (Zimmerman 1982; Ryley 2006; Kitamura 2009; Oakil et al. 2014).

✉ Laura McCarthy
laura.mccarthy@monash.edu

¹ Department of Civil Engineering, Institute of Transport Studies, Monash University, 23 College Walk, Clayton, VIC 3800, Australia

² Department of Economic Development, Jobs, Transport and Resources, Melbourne, VIC, Australia

Research within the life stage approach supports the notion that the travel behaviour of families with children tends to be car dependent (Kitamura 1988; Ryley 2006; Zwerts et al. 2008; Kitamura 2009). However, recent literature, primarily from Europe and North America, suggests a more diverse set of mobility practices are emerging among this group (Lanzendorf 2010; Schwanen 2011; McLaren 2016).

The emergence of this literature, together with the apparent success of policies promoting sustainable travel among the general population (see, for example, Buehler et al. 2016), suggests that it may now be timely to question the widely held assumption that car dependence characterises travel for families with children. Is a shift towards more sustainable travel behaviour evident among such families? If so, is this shift apparent in auto-orientated cities, such as Melbourne, Victoria?

This paper examines whether lower levels of car use is evident among families with children in Melbourne, Victoria. It does this using household travel survey data from two periods, 2007 and 2013–2014, to analyse the transport and household characteristics of three groups: young couple households without children, households with pre-school aged children, and households with school-aged children.

After discussing the relevant literature and describing the data analysis methods, this paper outlines the results of this analysis. It concludes with a discussion of the policy implications and outlines areas for future research.¹

Literature review

Travel behaviour among families with children

A breadth of literature has examined the critical role by which socioeconomic (Dargay 2001), environmental (Cervero 2002) and psychological (Sheller 2004; Anable 2005) factors influence travel behaviour. Nonetheless, examining the life stage of households provides “a convenient base for empirical analysis, a composite variable combining imperfectly, but adequately many of the major sources of variation among households” (Jones et al. 1983 in Kitamura 2009, 688). The life stage approach to understanding travel behaviour contributes to a richer explanation of why travel behaviour can vary among otherwise homogeneous populations (Kitamura 2009).

One of the most important findings of life stage approaches to understanding travel behaviour is that very different travel behaviour is evident between households with and without children (Goodwin 1983 cited in Kitamura 2009). Studies examining travel behaviour of families with children indicate that, compared with other household groups, they are generally less multimodal (Scheiner 2014), have lower levels of public and active transport use (Zwerts et al. 2008), have higher rates of car ownership (Ryley 2006; Nolan 2010; Oakil et al. 2014), and generally display car dependent travel behaviour (Ryley 2006; Scheiner and Holz-Rau 2007).

Numerous factors can explain the propensity for higher levels of car dependence among households with children. Family-style housing tends to be located in outer urban areas,

¹ A version of this paper, titled “Is car orientation among families with children on the wane? Evidence from Melbourne, Australia”, was presented at the 2017 Australasian Transport Research Forum. A further modified version of this paper, titled “Are Changes Afoot? Signs of declining car orientation among families with children”, was presented at the 2018 Transportation Research Board Conference.

with poorer access to alternatives to travel by private car. Accommodating a child's travel demands as well as their own increases the complexity of parents' travel behaviour (Kitamura 2009). This results in trip chaining and complicated trip schedules being a common feature of travel in households with children (Dowling and McKinnon 2014) and make it difficult for parents to use some alternatives to travel by private car, such as carpooling (Ferguson 1997).

In addition, families with young children often experience a multitude of psychosocial and structural factors which influence mode choice (McCarthy et al. 2017). For instance, parents travelling with young children are more likely to carry equipment such as prams or pushchairs which can make travelling by public transit often prohibitively challenging (Fritze 2007). Furthermore, parenthood introduces new expectations concerning parental travel, such as social norms associating parenthood and car ownership (Rau and Sattlegger 2017). Overall, these many factors tend to encourage car use and discourage the use of alternative modes.

A wide body of literature has examined the growing car dependency of school-age children, with particular regard to school travel and children's independent mobility (Mackett 2002; Pont et al. 2009; Fyhri et al. 2011; Panter et al. 2013; Schoeppe et al. 2013). The factors explaining the growing propensity for school-age children's car dependent travel, and the commensurate decline in independent mobility, are complex but include increasing school-travel distances (McDonald 2008; Easton and Ferrari 2015), an increasing perception of risk and increasing labour force participation of women (Fyhri et al. 2011). The significant growth in school-age children's car dependent travel presents concerning implications for children's health and development (Mackett 2002; Faulkner et al. 2009; Lubans et al. 2011).

Emergence of sustainable travel behaviour

While numerous studies indicate that families with children generally have car-dependent travel behaviour, recent research reveals some examples of the emergence of more varied travel patterns among this group (Lanzendorf 2010; McLaren 2016). In a qualitative study, Lanzendorf (2010) conducted retrospective interviews with parents of small children in Germany. This research demonstrates that, despite car use increasing among some families following the birth of their child, other families' car use actually decreased (Lanzendorf 2010). Similarly, McLaren (McLaren 2016), through interviews with parents in Vancouver, Canada, highlights a broad range of travel practices among households with children. These range from highly auto-dependent through to a reliance on a range of alternatives to conventional car use and ownership (McLaren 2016). These variations suggest that there is greater diversity in mobility practices among families with children than often assumed.

Furthermore, increasing research attention has been drawn to sustainable mobility patterns observed in some of the millennial generation following parenthood (McDonald 2015, Guthrie and Fan 2016). For example, Lavieri et al. (2017), in an analysis of US travel survey data, showed that the travel behaviour of young millennial parents was no different to their childless counterparts (Lavieri et al. 2017). Similarly, Guthrie and Fan (2016) conducted a study examining public transit trends between 2000 and 2010 in a medium-sized city in the US. The study demonstrated that while historically adults from a household with young children were less likely to use public transit this characteristic is no longer associated with a lower likelihood of public transit use. The authors note the upgrade of public

transit infrastructure in the intervening period and that this is the period during which many of the millennial generation transitioned into childrearing years (Guthrie and Fan 2016).

The above findings provide promising results regarding sustainable mobility among families with children. However, two of these studies were qualitative and observed a small group of people, and as such while they provided insightful results, due to the nature of this type of study it is not possible to make more general claims about the population. Despite these limitations, the findings from these recent studies still give reason to think that a transition toward less car-dependency among families with children may be increasingly feasible, and potentially becoming increasingly prevalent. What is still unknown, however, is the extent to which this is happening in practice.

Methods

This analysis aims to examine trends in mode use among families with children in order to understand whether car dependency is declining. Further, it seeks to understand what predicts mode use among different life stages.

Data source

We examined variations in travel behaviour by life stage using data from the Victorian Integrated Survey of Travel Activity (VISTA). VISTA is a large-scale household travel survey conducted across Greater Melbourne and regional Victoria. This analysis uses data from the 2007 and 2013–2014 survey years from the Greater Melbourne sample. The 2007 VISTA (VISTA07) survey obtained data from approximately 17,000 households across Victoria, while the 2013 and 2014 VISTA surveys (VISTA13-14) comprised data from approximately 8400 households. We combined data from the 2013 and 2014 surveys to ensure there was a sufficient sample size in each of the household groups to allow for segmentation of the results by different household characteristics.

The survey captures a range of information about the household as well as household residents and their travel patterns. All household residents, excluding those aged 0–4, complete an individual household travel diary for a specified day. The individual travel diary captures demographic characteristics and detailed information about their daily travel. The survey forms are delivered and picked up from the households in person. Respondents self-complete the travel diary and household survey form.

Households are randomly selected from a complete list of all residential addresses within the study area. The study area is divided into smaller clusters and a number of households are selected relative to the size of each cluster area. Household weights, developed by the government agency responsible for administering the survey, were applied to the dataset. A comprehensive process was used to design the weights that takes into account, amongst other factors, the representativeness of the sample and non-responding households (DEDJTR 2016).

We explored three household groups of interest in both the VISTA07 and VISTA13-14 survey datasets. We selected these groups to broadly represent a sequential order of life stages (although we acknowledge that not all families follow this sequential trajectory). The groups were as follows:

- Group 1: Young Couples
 - In a relationship (married or de facto)
 - One or both partners aged at least 20 years and less than 40 years
 - Two person household.
- Group 2: Young Families
 - Households of any size, with at least one child aged 4 years or younger
 - Includes single and dual parent households, as well as other household composition types (for example, multi-generational households)
 - No children aged between 5 years and 14 years (inclusive).
- Group 3: School-age Families
 - Households of any size, with at least one child between 5 and 14 years of age (inclusive)
 - Includes single and dual parent households, as well as other household composition types (for example, multi-generational households)
 - No children aged 4 years or younger.

The first group “Young Couples” aimed to capture the travel behaviour of couples prior to becoming parents. To this end, we selected couples in a relationship, and the age limitations were broadly set to include adults of typical childbearing age. The second and third groups were selected in order to isolate the effects of a child’s age on household travel behaviour. As such, the criteria was the same for both “Young Families” and “School-age Families”, with the exception of the age of the children included in the respective groups.

The age of children in group 2, “Young Families” was selected because in Melbourne children begin schooling when they are five. It is well established that structuring travel around the school day can have a significant influence on household travel behaviour. For group 3 “School-age Families”, the child’s age was set at between 5 and 14 years (inclusive). We evaluated the merits of including children aged up to and including 17 years (the year before teenagers can legally drive independently). However, we considered the differences in mobility between a child aged 5 and a child aged 17 to be too great. At age 14, while independent mobility is increasing, children are still largely dependent on their parents for their travel needs.²

We excluded from analysis the remainder of households that did not fall into these three groups. Households with children aged between both 0–4 and 5–14 were excluded in order to isolate the influence that the presence of pre-school children and school-age children have on household travel behaviour. In total, approximately 19,500 households (77%) were excluded from the analysis.

VISTA07 includes a larger total sample compared with the combined VISTA13-14 dataset. Given this, the sample size for the selected household groups is smaller in VISTA13-14. Nonetheless, the percentage of households and people in each group remained relatively consistent between the two periods (see Table 1).

² For instance, McDonald (2006) showed that 54% of trips made by US 14-year-olds were made with their parents, whereas this drops to just 26% of trips among 17-year-olds (McDonald 2006).

Table 1 Sample size, VISTA07 and VISTA13-14

Survey period	Young Couples [n (%)]	Young Families [n (%)]	School-age Families [n (%)]
2007	1006 (28%)	801 (23%)	1732 (49%)
2013–2014	672 (28%)	602 (24%)	1131 (48%)

Data limitations

As VISTA is a cross-sectional survey, we are not observing the same groups of people over time. As such, it is not possible to disentangle life cycle effects from cohort effects among the three groups used in this analysis. Further, the analysis comprises data from two survey periods; while both provide large samples, the timeframe between the two surveys is relatively short, and the limited number of years included in the analysis makes it difficult to derive conclusive results regarding long-term trends. Due to changes in survey methodology, data from earlier Victorian travel surveys are similar, but not directly comparable. Further, VISTA 2013–2014 included an additional prompt to capture incidental trips, which is partially responsible for an overall increase in walking between the two survey years.³ Given this, walking trips are likely to be underrepresented in the 2007 dataset. As such, results comparing changes in walking trips between the survey years must be interpreted with caution.

Two further limitations were observed. Firstly, as we are interested in differences in travel behaviour by life stage, we have selected household as the unit of analysis rather than the individual. While we recognise individual factors, such as age and gender, influence travel behaviour, we are unable to adequately account for these factors in the regression analysis. Finally, we are also using “trip” rather than more granular “stop” data. A “trip” in the survey is defined as: “a one-way travel movement from an origin to a destination for a single purpose (including picking up and delivering passengers), but perhaps by multiple modes” (DEDJTR 2015).

Analysis methods

Chi square tests and two-tailed *t* tests were used to compare changes in car dependency between 2007 and 2013–2014, among the three household groups. Next, negative binomial regression models were tested in order to examine the extent to which household characteristics predict vehicle, public transit, and walking trips.

Examining trends in car dependency between 2007 and 2013–2014

In order to understand whether car dependency has declined between 2007 and 2013/2014, we conducted a comparative analysis of the VISTA07 and VISTA13-14 datasets. For each

³ An additional question was added to the end of the 2013/14 survey as follows: “Thinking about all the travel made on this day, are there any additional activities that have not already been reported in the Travel Day Form?”. If sufficient information was available a trip was imputed otherwise a follow-up call made to the respondent if further information was required.

household group, independent sample t tests were undertaken to examine changes in the following characteristics:

- household location
- mean household vehicle ownership
- mean household vehicle, public transit and walking trips.

Changes between the two periods were deemed measurably different if the significance (2-tailed) value was less than 0.05. Different mobility measures can provide an indication of car dependency. The measures that we used in this analysis included: a decline in the number of vehicle trips; a decline in the proportion of vehicle trips; and a decline in car ownership levels. If a change in one or all of these measures were observed, this would be interpreted as a change in the level of car dependence.

Regression analysis

We conducted regression analysis to first determine whether the survey year is still significant when controlling for other relevant factors and, second, to compare the extent to which household characteristics influence mode use among households of different life stages. We used a negative binomial regression model. Negative binomial regression is a type of Poisson regression but which better accounts for data that has high levels of dispersion. In this dataset, there is a relatively wide distribution of the number of trips per household compared with the mean number of trips. Given the high levels of dispersion in this dataset, this type of regression analysis was deemed the most appropriate. This regression technique has been applied in other studies using count data with similarly high levels of dispersion (see, for example, Mondschein and Taylor 2017).

We tested a number of independent variables in the analysis, presented in Table 2, below. Firstly, as we are interested in examining whether the survey year is still significant when controlling for other factors, we created a dummy variable for the survey year. From the initial analysis of the data, differences in travel mode use depending on whether the day

Table 2 Descriptive statistics of independent variables

	Model 4: Young Couples		Model 5: Young Families		Model 6: School-age Families	
	2007	2013/2014	2007	2013/2014	2007	2013/2014
Mean population density (People per sq. KM)	2889	3340	2322	2616	2100	2395
Mean HH income quintile	3.8	3.8	3.4	3.5	3.4	3.4
Mean HH vehicles	1.6	1.6	1.8	1.8	1.9	1.9
Mean HH residents	2	2	3.5	3.5	4.0	4.0
Mean # adults employed	1.6	1.8	1.0	1.5	1.1	1.6
Mean # children	N/A	N/A	1.4	1.4	1.9	1.9

of travel was a weekend or weekday were apparent. Given this, we also created a dummy variable to test whether the travel day was a weekend or weekday.

We included several household variables well-established to have a strong effect on mode use. Specifically, household income,⁴ car ownership and population density. McDonald (2006), analysing US travel survey data, demonstrated that children from households with higher incomes are likely to undertake more trips (McDonald 2006). Increasing population density and decreasing levels of car ownership are well established to be strongly correlated with decreases in vehicle trips and increases in walking and public transit trips (Cervero and Kockelman 1997; Chen et al. 2007; Van Acker and Witlox 2010). We would expect a similar pattern evident in this dataset, whereby households living in denser urban areas and owning fewer cars to take more trips by walking and public transit and fewer vehicle trips. Further, we anticipate that low-income households will take fewer trips overall, by all modes, than high-income households.

Households with more residents are likely to undertake more trips overall than households with fewer residents. To account for this, we tested a number of different variables, and combinations thereof, to address differences in household size. The variables we experimented with included the total number of residents, the total number of adults, the number of employed adults and the total number of children.⁵ The inclusion of the latter two provided the best model fit. As such, we used these two variables in the models presented in Tables 3, 4, 5.

In total, nine regression models were run. Regression models were run for each life stage with vehicle trips as the dependent variable. This was then repeated with public transit trips, and, lastly, with walking trips as the dependent variable. Models were held to be measurably different if the significance (2-tailed) value was less than less than 0.05. As negative binomial regression is a type of logistic regression, and as such does not provide *r* squared scores, we used McFadden's pseudo *r* squared in order to determine the model fit. McFadden's pseudo *r* squared provides values ranging from 0 to 1, as with *r* squared, however, they are interpreted differently. Values of between 0.2 and 0.4 "represent an excellent fit" (McFadden 1977, 35). In order to interpret the effect of each of the dependent variables, adjusted odds ratios (OR) are used.

Results

Figure 1 uses the combined 2007 and 2013–2014 datasets to provide baseline travel behaviour for each of the three groups per-household and per-person (including children). This baseline travel behaviour echoes previous research findings that car ownership and the number of car trips increase in households with children while public transit use decreases. Walking trips remained stable between Young Couples and Young Families, before dropping for School-age Families.

⁴ To allow comparability in household income between years, the survey data was provided in the form of household income quintiles. Household incomes for the full dataset are categorised into five groups ranging from 1 (lowest income group) to 5 (highest income group).

⁵ The number of employed adults increased between the survey years among young and school-age families. While the exact reasons for the difference are unknown, it is likely a combination of a survey sample anomaly, an improved economic climate in the 2013/2014 survey period and a gradual long-term trend of increasing mothers' workforce participation.

Table 3 Changes in household transport characteristics between 2007 and 2013–2014

Household group	Transport characteristic	Survey period	Mean	SD	Statistical test
Group 1: Young Couples	Mean HH vehicle trips	2007	4.5	3.71	$t(1664) = 1.93, p = 0.05^*$
		2013–2014	4.2	3.36	
	Mean HH walking trips	2007	1.0	1.96	$t(1599) = -1.79, p = 0.07^*$
		2013–2014	1.1	1.86	
	Mean HH public transit trips	2007	0.7	1.26	$t(1664) = 2.35, p = 0.02^{**}$
Group 2: Young Families		2013–2014	0.6	1.13	
	Mean vehicle ownership	2007	1.6	0.74	$t(1605) = 0.44, p = 0.66$
		2013–2014	1.6	0.71	
	Mean HH vehicle trips	2007	7.4	5.77	$t(1240) = 2.97, p = 0.00^{**}$
		2013–2014	6.5	5.55	
Group 3: School-age Families	Mean HH walking trips	2007	1.0	2.22	$t(1362) = -3.84, p = 0.00^{**}$
		2013–2014	1.5	2.66	
	Mean HH public transit trips	2007	0.3	0.80	$t(1362) = -1.73, p = 0.08^*$
		2013–2014	0.4	0.90	
	Mean vehicle ownership	2007	1.8	0.67	$T(1362) = 0.85, p = 0.40$
Group 3: School-age Families		2013–2014	1.8	0.79	
	Mean HH vehicle trips	2007	10.2	7.30	$t(2693) = 3.12, p = 0.00^{**}$
		2013–2014	9.4	6.87	
	Mean HH walking trips	2007	1.1	2.07	$t(2693) = -4.93, p = 0.00^{**}$
		2013–2014	1.5	2.35	
Group 3: School-age Families	Mean HH public transit trips	2007	0.6	1.16	$t(2655) = -0.06, p = 0.95$
		2013–2014	0.6	1.18	
	Mean vehicle ownership	2007	1.9	0.75	$t(2622) = -0.13, p = 0.89$
		2013–2014	1.9	0.72	

Variables in bold indicate the result is significant: **indicates significant at $p < 0.05$, *indicates significant at $p < 0.10$. Data weighted by household

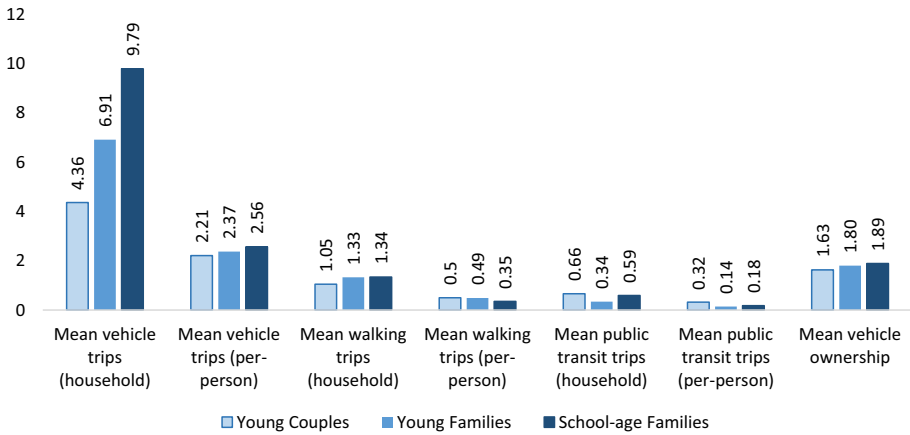


Fig. 1 Baseline travel behaviour. *Source:* VISTA 2007 and VISTA 2013–2014, pooled and weighted by household

Trends in travel behaviour between 2007 and 2013–2014

Changes in household locations between 2007 and 2013–2014

Young Couples (Group 1) are more likely to locate in Inner Melbourne; in contrast, Young Families (Group 2) and School-age Families (Group 3) are more likely to reside in Outer Melbourne. In the 2013–2014 period, nearly half of Group 2 (47%) and Group 3 households (50%) resided in Outer Melbourne. These geographical differences between the three groups have remained relatively consistent between 2007 and 2013–2014. However, in between these two periods, it became more likely that both Group 1 [χ^2 (2, $n = 1549$) = 0.097, $p = 0.001$] and Group 2 [χ^2 (2, $n = 1445$) = 0.132, $p = 0.000$] would reside in Outer Melbourne. There was no significant change between location and survey year for Group 3 (χ^2 (2, $n = 2950$) = 0.059, $p = 0.006$).

Changes in transport characteristics

As depicted in Table 3, mean household (HH) vehicle trips *decreased* for all groups between 2007 and 2013/2014; the change was greatest among Group 2 (decreasing by 0.9 mean HH trips) and Group 3 (also decreasing by 0.9 mean HH vehicle trips). Conversely, walking trips increased among all three groups. The increase was greatest among Groups 2 and 3, increasing by 0.5 and 0.4 mean HH walking trips respectively. As noted earlier, this change could in part be attributed to the adjustment in the survey methodology used for counting walking trips. Nonetheless, the change is greatest for Group 2 and 3 indicating that the change is likely to be attributed to more than the adjustment in survey methodology. Interestingly, public transit trips increased by 0.1 mean HH trips among Group 2 but decreased by the same amount among Group 1. No significant changes were observed to vehicle ownership among the three groups.

Figure 2 shows that the proportion of vehicle trips continues to be highest among Group 3, School-age Family Households, and lowest among Group 1, Young Couples. The

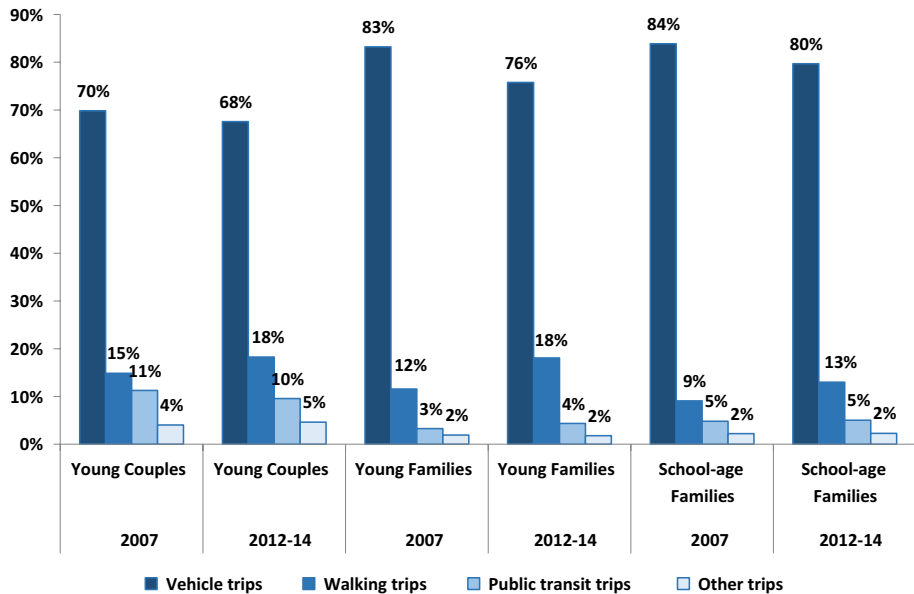


Fig. 2 Proportion of household trips by mode and household type, 2007 and 2013–2014. *Source:* VISTA 2007 and VISTA 2013–2014, pooled and weighted by household

proportion of vehicle trips declined between the two survey periods among Group 1 (by 2 percentage points), Group 2 (7 percentage points), and Group 3 (4 percentage points). Walking, as a proportion of trips, increased slightly among all groups. The proportion of public transit trips increased among Group 2 and decreased among Group 1. This indicates that a decline in car dependency is apparent among all groups, but the decline is greatest among families with children, both young and school-age.

It is worth noting that the reductions in driving have occurred even though couples and families with young children were more likely to reside in Outer Melbourne in 2013–2014 compared to 2007. We also note that the proportional increase in walking trips is in part likely to be attributed to the change in survey methodology in the 2013–2014 year that corrected for underreported walking trips.

Effect of household characteristics on household trips

Tables 4, 5 and 6 present the results of the negative binomial regression models, run for each of the three life stages, predicting household vehicle trips, public transit trips and walking trips, respectively. All models are statistically significant.

The first part of this analysis aimed to understand whether, controlling for all other variables predicting vehicle trips, mode use had changed between the survey years. As Table 4 shows, the 2013/2014 survey period was associated with fewer vehicle trips for *all* groups. Compared with 2007, *ceteris paribus*, Young Couples were 8% less likely to take a vehicle trips, Young Families were 18% less likely and School-age Families 5% less likely. This echoes findings described earlier in this paper regarding declining vehicle trips and supports the notion that car dependency is indeed declining among households with children.

Table 4 Regression models, household vehicle trips

Predictor variables	Model 1: Young Couples			Model 2: Young Families			Model 3: School-age Families		
	OR	95% Wald Confidence Interval for Exp(B)		OR	95% Wald Confidence Interval for Exp(B)		OR	95% Wald Confidence Interval for Exp(B)	
		Lower	Upper		Lower	Upper		Lower	Upper
(Intercept)	1.91	1.42	2.56	2.30	1.67	3.18	2.69	2.18	3.33
2007 period	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
2013/2014 period	0.92	0.82	1.03	0.82	0.72	0.94	0.95	0.87	1.05
Weekday travel	0.74	0.65	0.84	0.94	0.82	1.07	1.14	1.05	1.25
Weekend (dummy)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Population density	0.95	0.92	0.98	0.94	0.90	0.98	0.98	0.95	1.01
HH income quintile	1.08	1.02	1.14	1.10	1.05	1.16	1.10	1.06	1.14
HH vehicles	1.58	1.44	1.73	1.24	1.13	1.36	1.26	1.18	1.36
#Adults employed	1.07	0.94	1.20	1.12	1.00	1.27	0.99	0.92	1.06
# Children				1.37	1.23	1.53	1.27	1.20	1.35
N	1567			1269			2547		
McFadden's R ²	0.07			0.07			0.07		

Variables in bold indicate significant at $p < 0.05$. Data weighted by household

Table 5 Regression models, household public transit trips

Predictor variables	Model 4: Young Couples			Model 5: Young Families			Model 6: School-age Families		
	OR	95% Wald Confidence Interval for Exp(B)		OR	95% Wald Confidence Interval for Exp(B)		OR	95% Wald Confidence Interval for Exp(B)	
		Lower	Upper		Lower	Upper		Lower	Upper
(Intercept)	0.20	0.13	0.32	0.16	0.08	0.31	0.06	0.04	0.09
2007 period	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
2013/2014 period	0.77	0.65	0.92	1.09	0.83	1.42	0.87	0.75	1.01
Weekday travel	5.54	4.16	7.38	3.99	2.74	5.80	4.83	3.95	5.91
Weekend (dummy)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Population density	1.11	1.07	1.16	1.11	1.03	1.19	1.17	1.12	1.24
HH income quintile	1.08	0.99	1.18	1.21	1.09	1.34	1.08	1.02	1.15
HH vehicles	0.48	0.42	0.55	0.38	0.31	0.46	0.72	0.65	0.80
#Adults employed	1.16	0.96	1.41	1.42	1.12	1.80	1.46	1.30	1.65
#Children	1.00			0.78	0.61	0.99	1.29	1.17	1.42
N	1567			1270			2548		
McFadden's R ²	0.15			0.17			0.13		

Variables in bold indicate significant at $p < 0.05$. Data weighted by household

Table 6 Regression models, household walking trips

Predictor variables	Model 7: Young Couples			Model 8: Young Families			Model 9: School-age Families		
	OR	95% Wald Confidence Interval for Exp(B)		OR	95% Wald Confidence Interval for Exp(B)		OR	95% Wald Confidence Interval for Exp(B)	
		Lower	Upper		Lower	Upper		Lower	Upper
(Intercept)	0.17	0.12	0.26	0.54	0.36	0.82	0.41	0.31	0.53
2007 period	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
2013/2014 period	1.41	1.22	1.64	1.83	1.54	2.16	1.57	1.39	1.77
Weekday travel	1.15	0.97	1.36	1.14	0.96	1.36	1.65	1.46	1.86
Weekend (dummy)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Population density	1.20	1.16	1.25	1.20	1.14	1.25	1.13	1.08	1.18
HH income quintile	1.17	1.09	1.26	1.26	1.17	1.35	1.20	1.14	1.26
HH vehicles	0.78	0.70	0.87	0.73	0.65	0.82	0.75	0.69	0.82
#Adults employed	1.42	1.19	1.68	0.86	0.74	1.01	0.95	0.86	1.05
#Children				0.89	0.77	1.04	1.12	1.03	1.21
N	1567			1270			2548		
McFadden's R ²	0.09			0.11			0.09		

Variables in bold indicate significant at $p < 0.05$. Data weighted by household

Among all groups, increasing population density and decreasing vehicle ownership is associated with an increase in walking and public transit trips and a decrease in vehicle trips. Given the well-known relationship that exists between both population density and vehicle ownership with travel behaviour, this is not a surprising finding. However, perhaps surprisingly, increasing density was associated with a *decrease* in vehicle trips among Young Couple and Young Family households but this was not a significant predictor among School-age Family households. This suggests car dependency among families with school-age children is somewhat more resistant to change than other groups.

Like population density, household income is a strong predictor of travel behaviour. In this analysis, higher household incomes were associated with an increase in trips by *all* modes among households with young and school-age children and associated with an increase in vehicle and walking trips among Young Couple households. This reflects earlier analysis from McDonald (2006) showing children from low-income households are likely to have fewer trips overall than their counterparts from high-income households (McDonald 2006). This presents a somewhat concerning trend for families with children living in low-income households. Not only are children from these households likely to experience fewer opportunities for incidental physical activity otherwise gained through walking but, as McDonald (2006) showed, they are also less likely to participate in social and recreational activities with commensurate impacts of their health and well-being.

We expected households with more adults in employment to have a strong influence on the number of vehicle and public transit trips. Interestingly, however, the number of adults in employment is positively associated with an increase in public transit trips among both Young Families and School-age Families. However, this variable was not significant in predicting vehicle trips among any of the groups. This is a somewhat surprising finding but

perhaps reflects the high level of car saturation in the case study location coupled with the role of public transit being most commonly used for commuting.

Models run for the life stages of Young Families and School-age Families included variables for the number of children aged 17 years or younger in the household. The number of children in the household was associated with an increase in vehicle trips among both Young Families and School-age Families. In contrast, the number of children in a household was associated with more walking and public transit trips among School-age Families but conversely fewer walking and public transit trips among Young Families. This likely reflects the differing levels of activity participation and independent mobility between very young and school-age children.

Discussion and conclusion

Has car dependency among families with children decreased?

Exploring changes in travel behaviour between 2007 and 2013/2014 revealed that mean household vehicle trips declined for all groups included in the analysis. While the extent of the decline is small, the greatest decline is among families with children, both young and school-age (Groups 2 and 3). Further, the results of the regression analysis showed that controlling for all other variables predicting vehicle trips, the 2013/2014 survey period was associated with fewer vehicle trips among families with young children. These findings show that car use has indeed decreased between the survey years.

In addition, public transit use among Young Families has remained unchanged. This is a particularly remarkable finding given mean public transit trips declined for Group 3 (School-age Families) and declined as a proportion of all trips for Group 1 (Young Couples). And note that this occurred even though the majority of families with children live in Melbourne's Outer suburbs, and the proportion of families with young children living in Outer suburbs increased between the survey years. Moreover, despite an increasing proportion of families with young children living in Melbourne's car dependent Outer suburbs, the number and proportion of walking trips increased for all three groups, particularly among families with young children. While a change in survey methodology explains *part* of this increase, it does not explain the *entire* increase.⁶

Private cars provide families with children an important means to access a range of activities, particularly within auto-orientated cities (Dowling 2015). Nonetheless, a wide body of research shows high levels of car use among families with children result in fewer social interactions (Andrews et al. 2014), lower levels of physical activity (Anderson and Butcher 2006; Mackett 2014) and increasing financial stress (Dodson and Sipe 2008; Kitamura 2009). Given the myriad of social, economic, and health problems resulting from high levels of car use among families with children, this evidence that car use is declining is a very promising finding.

⁶ Internal analysis undertaken by the government agency responsible for administering this survey revealed that approximately half of this increase is attributed to the increased reporting of incidental walking trips (DEDJTR 2015).

What influences travel behaviour among different life stages?

Overall, the effect size of the household variables tested tends to be greatest in Young Couples and lowest in School-Age Families. Young Families tend to be somewhere in-between. This suggests that Young Couple households are more able to adjust their travel behaviour to accommodate changing circumstances compared to households with children.

Among households with children, the number of children in the household is the strongest predictor of vehicle trips. This is likely to be attributed to the dependent nature of children's travel. Accommodating children's growing travel demands also increases the complexity of household travel. This then leads to the private car being the preferred travel mode in order to meet the additional travel demands, generally spread over wider distances, within time constraints.

Even after controlling for the other variables, among Young and School-age Families, statistically significant changes are apparent in vehicle trips between the two survey periods. This indicates that other factors not accounted for in these models, such as travel attitudes and preferences, are influencing a decline in vehicle use among these groups.

Housing and transport policy implications

Increasing uptake of alternatives to conventional car use and ownership

While a decline in car use is evident among households with children, their travel behaviour continues to be *more* car dependent than Young Couple households. This suggests more research is needed to understand barriers to using sustainable transport modes among these groups. In particular, transportation researchers have highlighted the potential of alternatives to conventional car use and ownership, such as car sharing or cargo-bikes, for use by families with children (Dowling 2015; Thomas 2016). These alternatives can provide families with young children a sustainable alternative for longer trips, which would otherwise be by private vehicle. However, little is known about the barriers that families with children may experience using these emerging travel modes. Future research exploring the use of alternatives to conventional car use and ownership among families with children will assist transportation planners and policymakers to address barriers for this group.

Location of family-friendly housing

This analysis demonstrated that vehicle ownership and housing location are significant predictors of *decreased* vehicle trips, as well as *increased* walking and public transit trips, among households with children. That household vehicle ownership and household location have a relationship with mode use is not a new finding. Nonetheless, it supports the notion that, while households with children generally have car dependent travel patterns, it is indeed feasible for this group to have less car dependent travel behaviour, provided the environment is conducive. For example, numerous researchers have highlighted the importance of locating affordable family-friendly housing in areas within proximity of good walking and public transport infrastructure (see, for example, Delbosc 2016; McLaren 2016) where low or no car lifestyles are more feasible.

Travel among low-income family households

The results of the regression analysis highlight disparities in travel between low-income and high-income households. Increasing household income was associated with greater trips by *all* modes among Young Family and School-Age Family households. The health implications resulting from the loss of physical activity, otherwise gained through incidental walking, are well documented (Mackett 2002; Anderson and Butcher 2006). Similarly well documented is the finding that children from low-income households are likely to have fewer trips for social and recreation purposes (McDonald 2006). These factors are likely to have predictably negative impacts on children's health and well-being. As such, this finding reinforces previous research, which emphasises the need to address the health and economic problems experienced by car dependent, low-income families living in urban fringe areas (Dodson and Sipe 2008).

Areas of future research

Differences in travel behaviour between households with young and school-age children

Among households with children, the effect of household characteristics on vehicle trips tends to be more pronounced among Group 2, Young Families, and less pronounced among Group 3, School-age Families. There are several possible explanations for the apparent resistance to changes in travel behaviour among families with School-age children. An extensive body of literature has examined the prevalence of car dependency among families with School-age children. The lack of variation in mode use by different household characteristics could reflect that this group are less able to adapt their travel practices to changing economic or geographic circumstances.

However, cohort effects could also explain the greater car dependency among families with school-age children. Parents of school-age children are more likely to form part of Generation X. Conversely, parents of young children are more likely to form part of the millennial generation. Some millennials are adopting more sustainable travel behaviour (McDonald 2015; Delbosc 2016; Guthrie and Fan 2016), which could explain the lower levels of car dependency among families with young children compared with families with school-age children. Further research disentangling cohort and life stage effects on mode use, will contribute to a more robust explanation for differences in travel behaviour between families with young and school-age children.

Causes of declining car use among families with children

This paper has highlighted a remarkable trend; that car use is declining among families with children in Melbourne. That the decline can be observed among both households with and without children, suggests that broader transportation trends may explain some of the decline. Nonetheless, understanding why the decline was greatest among families with children warrants further investigation. Future research, examining whether similar trends are evident in other auto-orientated cities, would assist to understand better the

causes of the decline. For example, to what extent can the decline in vehicle trips be attributed to the growth of online commerce site replacing shopping trips?

Conclusion

This analysis has revealed that a shift towards lower levels of car use is indeed apparent among families with young and school-age children in Melbourne. Given a wide body of literature highlighting the negative consequences of high levels of car use among families with children, this is a very promising finding. Further research is required to understand the causes of the decline and to examine evidence of the decline in other localities. This, in turn, will assist the formation of future transport policies tasked with reducing car use among this group.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Laura McCarthy is a currently undertaking her PhD at Monash University. Her PhD research applies a life course approach to explore travel behaviour changes following parenthood, with an emphasis on public transit use.

Dr. Alexa Delbosc is a Senior Lecturer at the Monash Institute of Transport Studies in the Department of Civil Engineering. She draws from her research-based Master's in social psychology from Harvard University and PhD in Transport from Monash University to study public transport, travel behaviour and the changing travel habits of young people.

Professor Graham Currie is a renowned international public transport research leader and policy adviser with over 30 years' experience. He is the director of the Public Transport Research Group (PTRG) in the Monash University Department of Civil Engineering. In 2017 Professor Currie was elected as a Fellow of the Academy of Technology, Science and Engineering (ATSE).

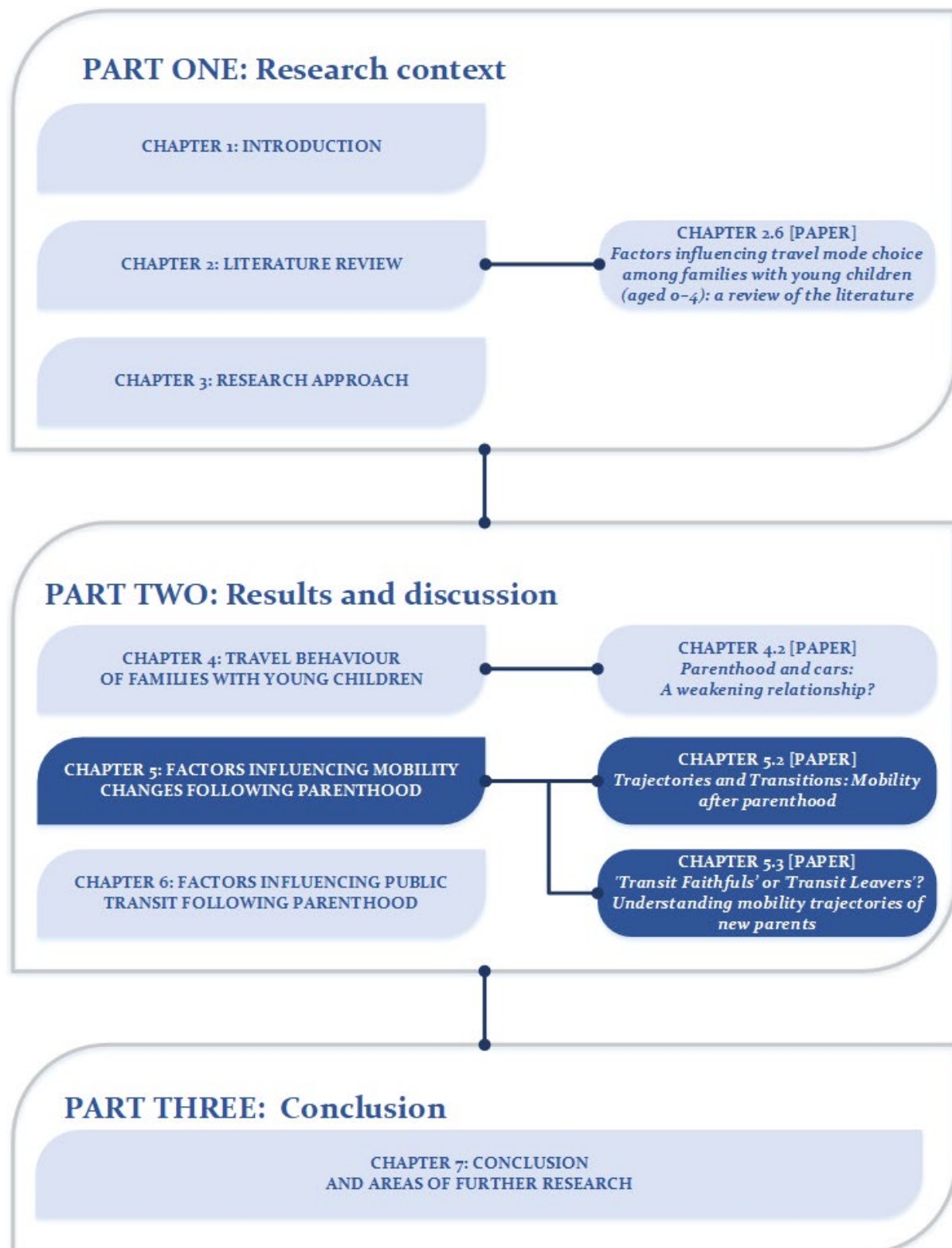
Andrew Molloy is Manager of Data Modelling and Analysis and Transport for Victoria, focusing on usage of the Victorian public transport network. He draws on his background in data analytics and market research covering transport, health sciences and town planning.

4.3 Conclusion

This Chapter provided the context of travel behaviour changes within the case study location, Melbourne, Australia. The findings presented in this Chapter support the existing body of work, primarily from Europe, that shows car use and ownership tends to increase following parenthood. Car use and ownership were lowest among young, childless couples and highest among families with school-age children. In contrast, public transit and walking trips were highest among young childless couples and lowest among families with school-age children. Moreover, the findings underscored the importance of housing location, household vehicle ownership and household income in predicting levels of vehicle, public transit and walking trips. The next Chapter explores what factors influence these mobility changes, following parenthood.

Chapter 5 Factors influencing mobility changes following parenthood

Figure 5.1 Thesis structure



5.1 Introduction

Chapter Four provided the context regarding travel behaviour among families with young children in Melbourne, Australia. This reinforced a wide body of literature, primarily from Europe and North America, that shows that parenthood is a life stage strongly associated with increases in car use and ownership. With that context in mind, this Chapter presents the results of the qualitative interviews and online survey regarding factors influencing mobility changes following parenthood. This Chapter is structured by research objective into the following sections:

- Section 5.2: Paper: Trajectories and transitions - mobility after parenthood

This section aims to understand different mobility trajectories following parenthood (research objective 2a) using the results of the qualitative interviews with new and expectant first-time parents. It explores the minor and major life events prompting travel behaviour changes and identifies five distinct qualitative mobility trajectories among participants.

- McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2019). "Trajectories and Transitions – mobility after parenthood". Transportation (In press). <https://doi.org/10.1007/s11116-019-10051-5>

- Section 5.3: Paper: 'Transit Faithfuls' or 'Transit Leavers'? Understanding mobility trajectories of new parents

This section quantifies each mobility trajectory and identifies differences in the attitudes and socio-demographic characteristics between each mobility trajectory (research objective 2b) using the results of the online survey. It concludes with some discussion of the policy implications and suggests targeted interventions relevant for each group.

- McCarthy, L., A. Delbosc, G. Currie and A. Molloy (2019). "'Transit Faithfuls' or 'Transit Leavers'? Understanding mobility trajectories of new parents". Transport Policy. 78: 105-112. <https://doi.org/10.1016/j.tranpol.2019.04.007>

- Section 5.4: Factors influencing new parents' car use habits

This final section, using the results of the online survey, explores the factors influencing new parents' car-use habits, including the impact of different combinations of life events (research objective 2c).

5.2 Paper: Trajectories and transitions – mobility after parenthood

Using the results of the qualitative interviews with parents of small children, this paper explains how and why travel practices change and evolve following the transition to parenthood. It does this by first examining the long-term processes facilitating changes in travel behaviour. Next, it explores different mobility trajectories observed among participants. It concludes with some discussion of the policy implications of these findings.



Trajectories and transitions: mobility after parenthood

Laura McCarthy¹ · Alexa Delbosc¹ · Graham Currie¹ · Andrew Molloy²

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Abstract

Life events, such as childbirth or retirement, provide a crucial opportunity in which an individual's habitual travel routines are disrupted and they may be especially susceptible to changing their travel behaviour. The transition to parenthood is one such period in which numerous life events occur but also in which car orientated travel practices tend to be adopted. While much is known about how travel behaviour changes during this period, there is little research explaining the processes in which car orientated travel practices are adopted. This paper addresses this gap using the results from twenty-five semi-structured interviews with parents of young children. The interviews illuminated that while a general pattern of increasing car orientation was apparent among most participants, five distinct mobility trajectories were evident. These ranged from those who had little change in their car dependent travel behaviour through to respondents from formerly carless households who experienced a dramatic rise in car use. Further, it became apparent that the first few years following the birth of a child is a period in which numerous changes can act to punctuate stable travel routines. Each change represents an opportunity to intervene and encourage the adoption of more sustainable travel behaviour. However, these findings suggest that in order to encourage families to adopt more sustainable travel practices, planners and policymakers would need to address the many transport and housing factors facilitating car orientated travel practices.

Keywords Travel behaviour change · Life transitions · Mobility biographies · Car orientation · Children's travel

Introduction

In response to the growing awareness of the many problems associated with increasingly auto-orientated urban environments, programmes aimed at reducing private car use are urgently sought. Life events, such as childbirth or retirement, provide an opportunity in which an individual's habitual travel routines are disrupted. During these periods, an

✉ Laura McCarthy
laura.mccarthy@monash.edu

¹ Institute of Transport Studies, Department of Civil Engineering, Monash University, 23 College Walk, Melbourne, VIC 3800, Australia

² Department of Transport, Melbourne, VIC, Australia

individual may be more likely to actively deliberate their travel options and be especially susceptible to changing their travel behaviour. The transition to parenthood is one such period in which numerous life events and changes in travel behaviour occur.

Although changes to travel behaviour do occur, these changes tend to be in favour of new car orientated travel practices (Ryley 2006; Zwerts et al. 2007; Scheiner and Holz-Rau 2013). Understanding the travel behaviour of families with young children is particularly timely as many millennials, a large generation comprising over one-third of the global population (United Nations 2015), are approaching this life stage. If millennials adopt car orientated travel behaviour during this transition it will have a major long-term impact on the sustainability of the transport system (McDonald 2015; Delbosc 2016; Oakil et al. 2016a, b).

Despite forming an important group of transport users, the travel practices of families with young children are significantly under-researched. There is little research about the process in which car orientated travel practices are adopted following the transition to parenthood. What changes occur among families transitioning to parenthood that could explain why these new travel practices are adopted?

Using the results of twenty-five semi-structured interviews with parents of small children, this paper aims to explain how and why travel practices change and evolve following the transition to parenthood. It does this by firstly exploring different mobility trajectories observed among participants. Next, it examines the long-term processes facilitating changes in travel behaviour. It concludes with some discussion of the policy implications of these findings.

Literature review

Mobility biographies theoretical framework

Habit has traditionally been considered an important factor in decisions about mode choice (Banister 1978; Aarts et al. 1997; Gärling and Axhausen 2003). However, certain key life events may disrupt habitual behaviour and provide additional opportunities to influence mode choice (Bamberg 2006; Beige and Axhausen 2012; Oakil et al. 2014; Clark et al. 2016). The mobility biographies approach, sometimes referred to as the life course perspective, provides a theoretical framework for considering travel behaviour changes. According to this theory, travel behaviour remains relatively stable until a key event disrupts it. Life events provide a period within which people consciously evaluate the costs and benefits of travel by different modes on new routes or under new circumstances. These life events, when travel behaviour routines are disrupted, provide an opportunity to change travel behaviour.

Lanzendorf (2003) puts forward a theoretical framework to examine the relationship between travel behaviours developed throughout an individual's life and a broad range of life events. Lanzendorf's 'mobility biographies' approach recognises that the current travel choices made by an individual are influenced by a broad range of events, attitudes and other characteristics developed over an individual's life course (Lanzendorf 2003). Considering events as part of a life trajectory has begun to provide a richer account of why some people are more likely to switch modes following a key event.

Müggenburg et al. (2015), expanding on Lanzendorf's (2003) mobility biographies framework, put forward an updated theoretical framework to consider the relationship

between travel behaviour changes and life events. Recognising that a change in one area of an individual's life will have ramifications in multiple other areas of an individual's life, Müggenburg et al.'s framework emphasises the interconnectedness between private and professional life events, long-term mobility decisions and processes, and exogenous interventions. Each life event has the potential to prompt a disruption in travel routines, triggering a model of action. The trigger of a model of action, that account for aspects influencing travel choices such as attitudes and social norms (see, for example, Ajzen 1991), can help explain differences in the adoption of travel behaviour changes in response to a life event.

Plyushteva and Schwanen (2018), in a recent qualitative study demonstrating the everyday processes which can prompt changes to household travel patterns, note studies adopting the mobility biographies approach tend to focus on 'major' life milestones (Plyushteva and Schwanen 2018). These studies tend to focus on the adult members of a household and do not usually consider the impact of 'micro' or child-focussed milestones, such as a child's evolving ability to walk to destinations. These 'micro transitions' may also have a significant impact on some aspects of household travel, and are likely to occur more often than 'major' transitions. Yet to date their influence on household travel behaviour is relatively unknown.

Parenthood and travel behaviour changes

The transition to parenthood impacts all areas of an individual's life (Buhr and Huinink 2014). This period can create changes to work, education, housing, income and leisure routines for both parents. Given the many changes occurring during the transition period it is unsurprising that numerous studies, undertaken in a range of regional contexts, demonstrate that car use and ownership tends to increase following the birth of a child (Prillwitz et al. 2006; Oakil et al. 2016a, b; de Haas et al. 2018; Klein and Smart 2019) and is higher among families with children (Ryley 2006; McCarthy et al. 2018). This is attributed to a range of factors which tend to facilitate car use among families with young children and discourage the use of alternate modes (McCarthy et al. 2017).

In terms of car ownership changes, with data from the German Socioeconomic Panel, Prillwitz et al. (2006) demonstrate car ownership increases following the birth of a first child (Prillwitz et al. 2006). Clark et al. (2016), exploring changes in car ownership and life events using data from the UK Household Longitudinal study UK household panel study, found that both formerly carless and also two-car households shared an equal likelihood of transitioning to a single-car household following the birth of a child (Clark et al. 2016).

Schoenduwe et al. (2015), using data from a Swiss transport survey, show that the most notable travel mode changes occur after the birth of the first child while subsequent children have less influence on travel practices (Schoenduwe et al. 2015). Scheiner and Holz-Rau (2013), using data from the Germany Mobility Panel, show that walking increases following the birth of a child, while public transit and cycling use decreases. The authors attribute the increase in walking to the common practice of taking babies for walks (Scheiner and Holz-Rau 2013).

In contrast to the quantitative studies discussed above, Lanzendorf (2010) in a qualitative study, demonstrated that while car use increased for some new parents following childbirth, a broader range of mobility changes were evident than those captured in the quantitative studies. The retrospective study, undertaken in a medium-sized city in Germany, focused on examining the effect of a range of life events, including childbirth, on travel behaviour. Participants were grouped into three categories based on their pre-parenthood mode use: Car, Intermodal

(Car and alternate modes) and Green modes (public transport, cycling, walking). Surprisingly, the mobility changes included two participants who shifted from car users to non-car users following the birth of their child and several “Green mode” users who continued to primarily travel by a combination of walking, cycling or public transport. Although this is a small qualitative study, it demonstrates that while increases in car use and ownership typically occur following the birth of a first child at the aggregate level, not all parents experience this mobility change.

The studies discussed above were undertaken in a range of countries and regional contexts. Some use panel data from national surveys (for example, Clark et al. 2016) while others focused on specific regions within countries (for example, Lanzendorf 2010). Despite the differences in location, at the aggregate level, a common finding of increased car use and ownership and a corresponding decline in alternate modes is apparent.

It should be noted that much of this literature derives from Europe yet the present study was undertaken in Australia. In very general terms, the mobility context of Australian cities is considerably more car-dominated than European cities. Despite this, recent research examining the travel behaviour by life stage in Melbourne, Australia, shows that car use and ownership is higher among families with young and school-age children compared with childless couples (McCarthy et al. 2018). This suggests that a similar pattern of increased car orientation is evident in auto-orientated locations, such as Australia, following the transition to parenthood.

A pertinent finding emerging from work examining gendered differences in travel behaviour is the role of caregiving status (see, for examples, Rosenbloom 2006; Crane 2007). Although there are modest signs of change, women continue to perform the majority of domestic responsibilities and child-serving transportation (Schwanen 2011; Fan 2015; Taylor et al. 2015; Craig and van Tienoven 2019). A recent study examining parental mobility patterns across four countries, for instance, demonstrated that although variations in the extent of the gender gap differed between countries, women consistently carried out the majority of trips with, and for, children (Craig and van Tienoven 2019). Likewise, Zwerts et al. (2007), in a qualitative study of new parents in Belgium, show that female, primary caregiving, participants adopted “taxi driver” like travel patterns soon after the birth of their child but the equivalent change is not observed in their male partners (Zwerts et al. 2007). This suggests the additional childcare responsibilities invariably influence the way in which women travel and can, in part, explain differences in women’s travel, such as more complex travel schedules (Rosenbloom 2006) and undertaking more trips but of shorter distance (Crane 2007).

A number of predominantly quantitative studies, discussed above, have examined *how* travel behaviour changes following the birth of a child. Further, these studies have examined significant life events, but not the ‘micro’ events which may also influence mobility changes. As such, while much is known about *how* travel behaviour changes, less is understood about *why* these changes occur. This paper, utilising the mobility biographies approach, seeks to identify both the major life events as well as the subtle minor transitions that influence travel behaviour, among households following the transition to parenthood.

Methodology

We used qualitative research methods to understand parental decisions regarding their transport use, and the attitudes, preferences and motivations that may help explain their choices. The flexibility characteristic of qualitative methods is better suited to the exploratory approach to understanding this topic. Furthermore, while qualitative studies are less

common in mobility biographies research, they are better placed to unpick the complexities and interconnections of events surrounding changes in travel behaviour (Müggenburg et al. 2015).

Study location

Melbourne is the second most populous city in Australia, with 4.7 million people. The majority of Melbourne's residential areas have been developed in order to accommodate private vehicle use, with most population growth continuing to be in low-density outer suburban areas. Reflecting this car-dominated urban environment both car use and ownership is comparatively high. Melbourne households have on average 1.7 vehicles per household and nearly two-thirds of residents (67%) travel to work by car. While the use of alternate modes are showing modest upward trends in use, particularly within inner-city areas, this is from a low base. For instance, approximately 1% of residents cycle to work and 16% travel by public transport (Australian Bureau of Statistics 2016).

The city has a radial public transit network with major train lines converging in the central business district. It also has an extensive tram network, servicing inner and middle suburbs, and a bus network primarily servicing middle and outer suburban areas.

Interview participants

We recruited expectant first-time parents and parents with at least one child aged between zero and five years old. A non-probability purposive sampling method was used to recruit participants. Strict demographic quotas were not applied, however, the sample aimed broadly to reflect the general population of parents of young children residing in Melbourne, Australia. Further, males are often underrepresented in qualitative studies examining parents' travel behaviour (see, for examples, Lanzendorf 2010; McLaren 2016). As such, we placed a particular focus on actively recruiting males to attain a more balanced gender split. In addition, towards the end of the data collection process, we conducted targeted recruitment in order to recruit single parents and low-income households, as these two groups were initially underrepresented in the sample. Despite these efforts, males continued to be somewhat underrepresented in the final sample. Table 1 outlines the socio-demographic characteristics of the participants.

We recruited participants through postings placed on Facebook pages and physical locations targeting this demographic, such as daycare centres and babywear stores. In addition, we recruited participants using chain sampling as well as through personal networks.

Interviews

Between July and October 2017, twenty-five semi-structured interviews were conducted with expectant first-time parents and parents of small children in Melbourne, Australia. Seven interviews were conducted in-person and the remaining 18 by telephone, all conducted by the same interviewer. Typically, the interviews lasted about 40 min each but varied in duration from approximately 20 min through to over an hour. In compensation for their time, participants were given a \$40 (AU) voucher for a large supermarket chain. We audio-recorded and then transcribed the interviews.

Table 1 Characteristics of participants

Characteristic	Variable	Number of participants	
		n = 25	%
Gender	Male	8	32
	Female	17	68
Household composition	Dual parent household	21	84
	Single parent household	4	16
Household car ownership	Carless household	3	12
	1 private vehicle	13	52
	2 or more private vehicles	9	36
Residential location	Inner Melbourne	7	28
	Middle Melbourne	10	40
	Outer Melbourne	8	32
Socio-economic index decile ranking for area (Victoria, Australia)	Low (1–4 decile)	5	20
	Medium (5–7 decile)	7	28
	High (8–10 decile)	13	52
Employment status	Employed (part-time or full-time)	16	64
	Stay-at-home parent	8	32
	Student	1	4
Caregiving status	Primary caregiver	17	68
	Non-primary caregiver	5	20
	N/A	3	12
Number of children	Expectant first-time parents	3	12
	Parents of 1 child	13	52
	Parents of 2 or more children	9	36
Age of youngest child	N/A	3	12
	0–1	13	52
	2–3	8	32
	4–5	1	4

An interview guide was used that asked participants a range of questions regarding their travel behaviour. In addition, we asked about broader changes in their life, both recent and anticipated, that might influence their mobility practices. Further, we asked about social influences on their travel choices as well as their attitudes and perceptions towards different travel modes. The three expectant first-time parents were also asked about how they anticipated their travel would change once they became a parent. Example questions include:

- Can you tell me about anything in your life that has changed since you were planning, or found out that you were expecting, your first child? This could be things such as housing, employment, partnership, or transport changes, and for you, your partner, or both.
- Can you tell me about daily travel in your household?
- Can you tell me about your access to transport in your household?
- Has the way you travel changed since you've become a parent? What do you think may have prompted the changes?

A key strength of qualitative research is its flexibility that allows for new lines of inquiry to be explored as they emerge (Johnson and Onwuegbuzie 2004). As such, not all participants were asked the same set of questions. As new themes emerged, these themes were explored in subsequent interviews.

Analysis

We conducted a thematic analysis of the interview material. Our approach to this method was based on the process outlined by Braun and Clarke (2006). We used thematic analysis as it is a flexible and practical research tool that can yield comprehensive and multifaceted interpretations of qualitative material (Braun and Clarke 2006). In order to categorise the interview material into themes we used abductive inquiry, which shifts between inductive and deductive approaches (Morgan 2007, 71). Using data from the first few interviews, an inductive approach was used to identify a preliminary set of themes. As data from subsequent interviews were collected, we then used a deductive approach to refine these themes and identify sub-themes.

In addition, in interpreting the findings we were guided by the mobility biographies approach, which emphasises the importance of the interconnectedness of life events and the corresponding influence on travel behaviour. We used this to develop a framework, specific to the first few years of a child's life, proposed in Fig. 2.

We concluded data collection after we had completed 25 interviews. At this stage, the frequency in which new themes were identified had greatly reduced. While we could have continued with further interviews, we deemed the value in doing so had greatly diminished given the low likelihood of new themes emerging. Further, this number of interviews exceeds the approximate guide suggested by Guest et al. (2006) of 12 for a relatively homogenous group of individuals sharing perspectives or experiences on a common topic (Guest et al. 2006, 79). Among our sample, while all participants were new parents there was some diversity (e.g. partnership and caregiving statuses) which we expected to generate different perspectives. As such, we considered the additional 13 interviews sufficient to capture these contrasting perspectives.

We assigned participants a number (e.g. "P13") and a code which signified whether they were a mother or father and the age of their child or children. For example, "Father of a 3 year old_P13" signifies the participant was a father with one child aged 3 years, identified as participant 13. These codes have been used in the remainder of this paper.

Findings

Two major themes emerged during the interviews. Firstly, while a general pattern of increasing car orientation was apparent among most participants, five distinct mobility trajectories were observed. Further, the most significant change in travel behaviour was observed among households where a change in car ownership occurred. Secondly, it became apparent that the first few years following the birth of a child is a period in which numerous changes can act to punctuate stable travel routines, discussed in the second part of this section.

Mobility trajectories following the transition to parenthood

A range of mobility trajectories emerged among the participants following the transition to parenthood. Figure 1 illustrates the broad changes in levels of car orientation (the frequency of car use compared to the use of alternate modes) observed among participants and identifies five distinct trajectories. Overall, life events occurred with the same frequency among each of the groups. Further, a general upward trend in car orientation was apparent among most of the groups. The reasons for this trend will be discussed in the latter part of this section. However, as discussed below, for some households the growth is less pronounced and for a minority of households, car orientation actually declines following parenthood.

Two groups, *Involuntarily carless* and *Formerly carless* experienced the most dramatic shift in travel behaviour. Further, within the *Formerly carless* group, the extent to which car orientated travel behaviour was adopted varied. As such, this group is explored in more depth.

Continual car dependents

Six female participants (P1-6), who were primarily auto-orientated pre-parenthood, described as *Continual Car Dependents*, did not generally experience any notable travel mode shifts. This group was comprised entirely of primary caregivers, all of whom were female, and tended to live in outer suburban areas with poorer access to alternatives to travel by private car. Most members of this group took a year's parental leave from their

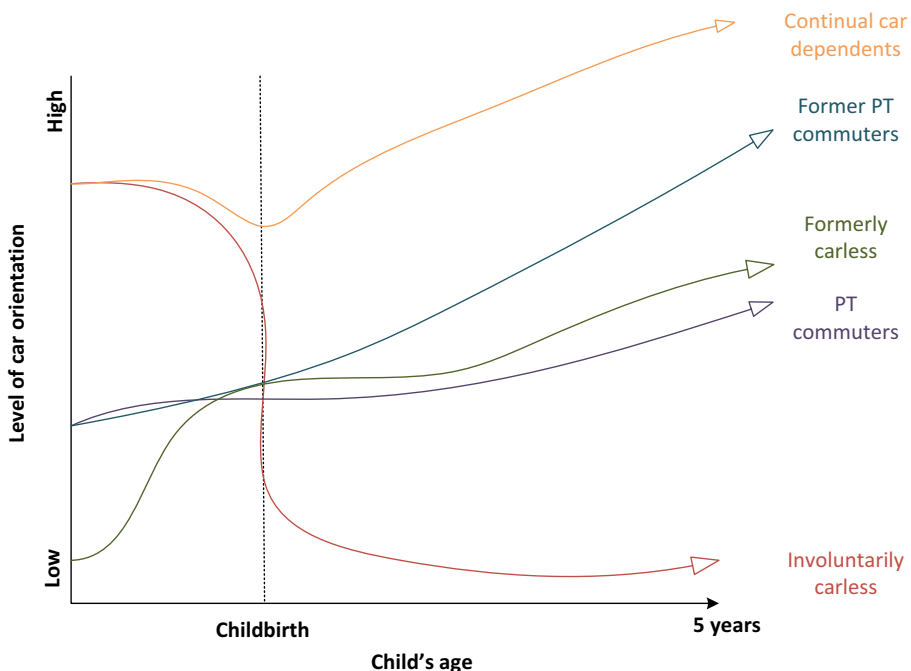


Fig. 1 Mobility trajectories following the transition to parenthood

paid employment. During this period, their travel patterns changed as more local activities are sought. Walking, primarily for recreational purposes, increases.

After the first year, car orientation tends to return to pre-parenthood levels as travel routines are adapted to incorporate both caregiving responsibilities and a return to the workforce. The majority of participants returned part-time, with the return to paid employment increasing the complexity of household travel routines, further instilling car dependent practices.

These parents generally expressed a strong preference for travel by private car due to the ease and convenience that it provides:

“I only really use the car. Just with the two kids it’s easier to throw everything in and go that way.” [Mother of a three-year-old and five-year-old_P4]

PT commuters

Two male participants (P7–8), both non-primary caregivers, comprised the *PT Commuters* group. Similar to the *Continual Car Dependents*, they did not undergo any significant changes in travel modes. Members of this group primarily used public transit for commuting both prior to and following parenthood. Both members of this group were employed full-time, residing and working in areas well serviced by public transit. The notably lesser impact of childbirth on their travel patterns, when compared with their primary caregiving partners, indicates the importance of caregiving status in facilitating changes to travel behaviour.

Former PT commuters

Six female participants (P9–14), who were all the primary caregiver, reported commuting by public transport pre-parenthood. Three members of this group were on parental leave at the time of the interview (P9–11); two members were employed part-time (P12, 13) and the final member did not return to paid employment (P14).

During the period of parental leave, similar changes to travel routines were observed as with the *Continual Car Dependents*. More local activities were sought and walking for recreation increased. As one parent describes:

“When she was very young, my mother’s group and I, we would walk like over 50 kms a week. Then they were quiet and we could actually talk... It was about getting out of the house and getting a little bit of exercise.” [Mother of a three-year-old_P12]

After a period of parental leave, the two working parents (P12, 13) changed their commute mode to private car. Participants on parental leave (P9–11) tended to express a level of uncertainty about their future travel patterns but generally anticipated their commute mode change to car once they returned to work. This was often attributed to the need to minimise their travel time in order to accommodate new childcare arrangements.

A further consideration mentioned by this group of working parents was the need to have immediate access to transport should their child need to be picked up from their childcare facility at short notice. For the two working parents (P12, 13), the return to work after a period of parental leave was a crucial milestone in their mobility biography. Attempting to accommodate work alongside childcare responsibilities resulted in complicated travel routines and reduced time available for travel. For example, as one mother, a primary caregiver, employed part-time, explained:

“I used to catch the train and then tram down [to work], but the commute is about 50 min, at least. And it’s just too long now... [other reasons include] having a car at work in case I have to leave to get to the kids, like if they were at daycare and they were sick... I work a lot of afternoon shifts, I finish at 9.30 at night, so the trains only come every 30 min at night. So if I miss one, it could take well over an hour to get home at night.” [Mother of a 1-year-old and 3-year-old_P13]

Involuntarily carless

Two single mothers (P15–16) comprised the *Involuntarily Carless* group. Both of these participants, due to extreme financial constraints, reported relinquishing a vehicle in order to economise household expenses following the birth of their child. These participants also carefully selected housing which was located in close proximity to public transit services to allow them to more easily live a car-free lifestyle. They also were able to access a vehicle, for occasional use, through a friend or family member. In these households, ride hailing and taxis were used as a transport lifeline for occasions where walking or public transit was not feasible. As one participant explains:

“And if it’s really bad weather, if I’m stuck, if it’s late, if the buses are not running it’s something like that. Not often. No more than once a week if I do. But if I’m on my own I do an Uber but if I’m with him I’ll get a taxi. That’s my backup plan anyway.” [Mother of a 1-year-old_P15]

Formerly carless

Changes in travel behaviour were most notable among the final group, participants from formerly carless households. All six members of this group were male, three were the primary caregiver and stay-at-home-parents (P17–19), two were secondary caregivers (P20–21) and the remaining group member shared caregiving responsibilities equally with his partner (P22). Among the three stay-at-home-parents, two were not in paid employment prior to parenthood (P17, 18) and the third was employed full-time, but, following a relocation due to his partner’s work, became the primary caregiver (P19). Of the remaining participants, all three were in paid employment (P20–22).

This group tended to live in areas well serviced by alternatives to private car and were often willing to compromise on housing features such as size or owning their home in order to live in such locations. Yet in this interview sample, all participants from this group purchased a private vehicle in anticipation of parenthood. This was commonly attributed to the perceived difficulty in accessing new destinations with their child, such as a doctor’s surgery or relatives living further away, by modes other than private car. In addition, access to a private vehicle in the event of an emergency was also commonly mentioned.

The car was generally purchased for use by the primary caregiver. While typically the purchase of the car resulted in a change to all household members’ travel, the most pronounced changes were among the three primary caregivers (P17–19). All three reported primarily using a mixture of walking, cycling or public transit prior to parenthood. With the purchase of the car, their travel patterns became more car orientated due to the rise of child-serving trips. While two participants (P18, 19) continued walking and cycling with their children, the third father’s (P17) travel became notably more car orientated. As he describes:

“Now, a lot of the travel, if it’s not easily accessible by walking, is by car because of the baby. So that has that changed a lot.” [Father of a 1-year-old_P17]

In contrast, their female partners all continued to use the same commute modes (public transport or cycling). This underlines the importance of caregiving status, rather than necessarily gender, in determining the extent to which travel patterns change following the birth of a child.

Along with caregiving status, pre-parenthood motivations for remaining carless help account for variations in the extent to which the car, once purchased, is used by the household. Parents in this group expressed a range of motivations for maintaining a carless lifestyle pre-parenthood. For one parent (P22), both he and his partner primarily cycled with little perceived need for access to a private vehicle. Their primary travel mode pre-parenthood was cycling, with occasional use of public transport, car sharing and ride sharing. The participant expressed the following motivations for cycling:

“We’d both prefer to cycle... It’s the convenience, the little bit of incidental exercise and the environment are probably the main things. The fact that it’s actually really good value for money is not overlooked either.” [Father of a 1-year-old_P22]

In contrast, another parent rationalised the decision on economic grounds:

“We just didn’t feel it was a worthwhile investment and we didn’t need the convenience of it at time which is why we had Go Get [a car sharing service] for whenever we really did need a car.” [Father of a 1-year-old_P17]

This suggests a range of motivating factors, including health, finance and environmental considerations, influenced the decision to maintain a carless lifestyle among these households, pre-parenthood. These differing motivations among formerly carless households help explain the extent to which car orientated travel behaviour is adopted once a car is purchased. For instance, one father (P17), a primary caregiver who expressed primarily economic reasons for maintaining a carless lifestyle pre-parenthood, indicated that their car use increased dramatically, as soon as they purchased their own private vehicle:

“I mean having that convenience, you just start using it because you have it and it’s there and it makes things easier... [Before buying a car] even if I needed to go somewhere a bit further away I would just take public transportation and carry everything with me.” [Father of a 1-year-old_P17]

In contrast, those with particular environmental values expressed a deepening cognitive dissonance between their values and their new car orientated travel behaviour. Two parents (P20, 22), both from formerly carless households, with strong pro-environmental values, sought to moderate the effects of their decision to purchase a car by joining a peer-to-peer car-sharing scheme. The motivations for joining the scheme were attributed to both economic and environmental reasons.

“...I think we would have bought it whether or not we joined. But I certainly saw it as a way of offsetting the costs and cut the environmental impact. If we’re going to have it anyway it’s better that other people can use it and don’t encourage other people to buy a car.” [Father of a 1-year-old_P22]

Given the extent of changes occurring in households, it is unsurprising that values motivating travel choices must experience some shifts in prioritisation. While environmental concerns may be maintained, accommodating the new responsibilities of parenthood suggest it

is increasingly demanding to adhere to travel behaviour which best realised those environmental values pre-parenthood.

Overall, five distinct mobility trajectories were observed. As this is a qualitative study, the five groups are not likely to be an exhaustive list nor is the size of each group likely to be proportionally representative of the general population of new parents. Recent quantitative research examining this topic, for example, generated subtly different groups (McCarthy et al. 2019). A notably absent group in our present study are parents who were involuntarily carless both prior to and following parenthood. These parents would likely face different transportation barriers to those in the *Involuntarily carless* group. For instance, both members of the *Involuntary Carless* group were able to live in transit-rich areas which continued to provide alternative transport options despite residing in a carless household. In contrast, the financial circumstances of parents who are involuntarily carless both prior to, and following, parenthood may prohibit a move to a more transit rich area and, as such, they may face considerable barriers to their transportation.

As discussed above, differing individual characteristics and attitudes were associated with each of the trajectories. For example, former PT commuters were more likely to be the primary caregiver while formerly carless households tended to hold particular pro-environmental attitudes that influenced their travel choices. Despite these differences, among most participants a general pattern of increased car use was apparent. The reasons for this are discussed in the next section.

Periods of flux and stability among households with young children

Major life events

All participants reported numerous major life events in the first few years following parenthood. Each major life event had the potential to prompt changes to travel behaviour. In addition to childbirth, these typically included moving home, exiting and returning to the workforce, and the birth of second or subsequent children. Other life events, occurring with less frequency but still having a notable impact on travel behaviour, included partnership dissolution and immigrating.

Following an event prompting changes in travel routines, a period of trialling new routines is often sought. One participant who recently moved home articulated the approach to trialling new travel routines:

“We’ve been experimenting with what works best.” [Father of a 1-year-old and 3-year-old_P19]

Participants with very young children tended to have a short-term view of anticipated changes to their travel. Typically, households looked ahead to the next milestone, such as the return to work. Beyond the next milestone, a typical response was that the extent to which their travel may change was dependent on the location of the new activities or household circumstances at that particular time. One parent of a newborn, describing the uncertainty surrounding her travel routines once she returns to work, exemplifies this:

“I think it’s going to be a nightmare doing one to childcare, one to school and me to get to work. So it’s going to have to be whatever is going to be the most easiest to manage. I don’t know what that will be. No idea. I may need to move work locations, so I don’t have so far to get across town. I don’t know.” [Mother of a 3-month-old and 4-year-old_P9]

While parents of very young children expressed a level of uncertainty over their future travel patterns, parents of pre-schoolers typically expected their travel routines to remain relatively stable. This was particularly so for parents with one child already in school, where complications regarding differing start times and locations for childcare and schooling had already been addressed. As one participant states, describing how she anticipates her future travel to change:

“I think I will be doing the same as what I’m doing here... We’d probably keep using the car as much as we do.” [Mother of a 3-year-old and 5-year-old_P4]

This suggests that the periods of stable travel routines increase as the youngest child in the household ages.

Childhood mobility milestones

Major life events had clear impacts on household travel behaviour. However, households’ travel also changed in response to gradual changes in a child’s travel needs and demands. During the early years, travel is constrained by sleeping and feeding schedules. This leads to carefully structuring travel and activities around children’s sleeping schedules, which become even more complex with two or more young children. As one participant describes:

“... both kids are of the age where they still sleep in the middle of the afternoon, typically around 1 pm or so they need a nap. And that’s definitely a lot easier if you have a car with you.” [Father of a 1-year-old and 3-year-old_P19]

Similarly, during this period, one parent reported the preference to travel by private car rather than public transit due to the former better accommodating her child’s toilet training:

“I have a toilet in my car, it’s a portable toilet, [in a car she can use it] but in a train you can’t do that.” [Mother of a 3-year-old_P3]

In response to more gradual changes in travel needs, such as a child’s physical development, households mentioned other minor transitions that influenced their travel behaviour. Summer is often described as a period in which to trial new travel modes or routines, in response to these new child-led developments. As one parent notes:

“She’s now able to start walking longer distance so we plan to do more walking in summer.” [Mother of a 3-year-old_P12].

In a similar way, for some parents, increases in a child’s extra-curricular activities can prompt a change in travel modes. One participant describes how the most notable change to his travel behaviour since becoming a parent occurred once his child’s participation in activities increased:

“[Talking about travel mode changes since becoming a parent] ...for me, I definitely started walking a lot more, until recently. Now [my child’s] weekly timetable includes some activities which are further than two kilometres away ... and to those I drive.” [Father of a 3-year-old_P18]

Low-car or carless households appeared to be more sensitive to childhood mobility milestones than high car households. Participants from low-car or carless households were more likely to identify child-related travel constraints and plan for anticipated changes. For

example, one devoted cyclist described how he was planning to cycle more once his child was physically strong enough to hold his head up:

“Once the bub is a bit older we’ll be able to get him on the back of the bike and we’ll be able to do bike stuff. But at the moment it’s like if the bub goes anywhere more than like one and a half kilometres then it’s a car trip, nearly all the time.” [Father of a 6-month-old_P20]

The interviews illuminated how a child’s developmental milestones prompt changes in household travel behaviour over a relatively short time span. This adds further complexity to frameworks such as Muggenburg et al. (2015) that demonstrate the interrelationship between travel behaviour and major life events. Figure 2, below, shows the interaction between a child’s evolving travel needs, major life events and household travel routines. This illustrates the period of continual change among households with young children.

Undoubtedly, the period following the transition to parenthood is marked by widespread changes to household travel behaviour. These changes emerge both gradually, typically in response to a child’s evolving travel needs or processes of parental socialisation, and swiftly, in anticipation of, or reaction to life events, such as moving house. Overall, the processes tend to increase the complexity of household travel and further entrench car-use practices.

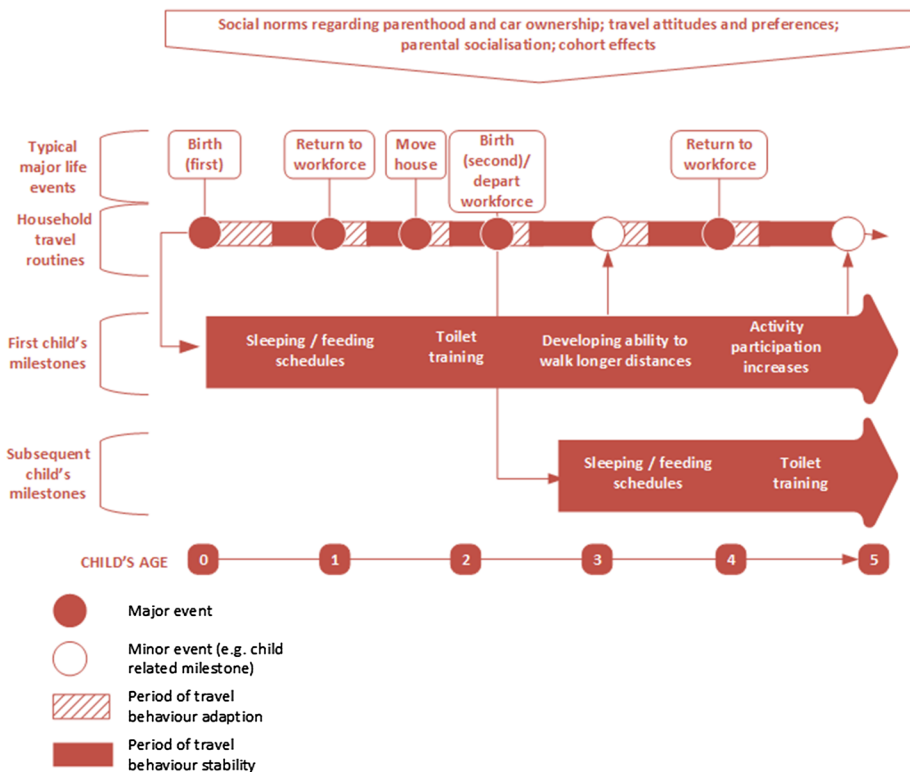


Fig. 2 Interaction between life events, child’s travel needs and changes in household travel behaviour
Source: Adapted from Muggenburg et al. (2015)

Discussion and policy implications

Overall, the findings confirm earlier research showing that the transition to parenthood is a crucial period in which significant changes to a household's mobility practices occur (Lanzendorf 2010; Scheiner and Holz-Rau 2013; Clark et al. 2016). Importantly, however, the findings demonstrate that travel practices during this period are characterised by constant changes in reaction to life events and a child's evolving needs. Further, travel mode choice during this period can be influenced by both micromilestones (such as a child's ability to walk longer distances) as well as more conventionally studied life events (such as a housing move or the birth of a second child). Micromilestones and life events, along with concrete structural and physical barriers and more abstract social pressures, tend to increase the complexity of household travel and further instil car dependent practices.

Nonetheless, the findings illuminated that not all families pursued a pathway of car orientation in the same manner. This finding echoes Lanzendorf (2010) study, that not all parents increase their car use and ownership following the birth of their child, and that for some parents it declines. However, an important difference between the two studies is the auto-orientated location in which our study was undertaken. In our study, overall, participants were more likely to display car dependent behaviour prior to parenthood. Once they became parents, use of alternate modes among this sample became relatively scarce and generally limited to specific purposes (such as commuting for the non-primary caregiver) or for specific reasons (such as due to extreme financial constraints). This suggests that in auto-orientated contexts the life event of first-time parenthood can have a more significant impact on the overall use of public and active transport modes than in less car dependent locations.

Gender and caregiving roles play an important role in shaping travel patterns (see, for example, Rosenbloom 2006; Crane 2007; Taylor et al. 2015). While traditionally females tend to adopt the primary caregiver role, in our small study, three male participants were primary caregivers. Primary caregiving participants, regardless of gender, were more likely to experience notable changes to their travel patterns compared with their non-primary caregiving partner. Further, among formerly carless households the car was generally purchased for use primarily by the primary caregiver. This finding underscores the crucial role of caregiving status, rather than necessarily gender, in determining the extent to which travel patterns change and car dependent behaviour is adopted, following the birth of a child.

Interestingly, parents with particularly strong environmental values took some measures to restrain their (and potentially others'), car use. For example, one respondent was motivated to list their vehicle on a peer-to-peer car sharing site in order to limit the amount of time the vehicle would be available for their personal use. This suggests that those parents with motivations beyond convenience or cost influencing their travel choices are likely to adopt less car orientated travel behaviour. However, overall these parents represented a small subset of those interviewed and are most likely to reflect the motivations of only a minority of the general population. As such, policy and planners would need to look at a breadth of housing and transportation measures in order to achieve car reductions among this group. These are discussed below.

Families living in dense inner-city areas, or who made a deliberate decision to locate very near public transit services, tended to have the least car orientated travel behaviour. This underscores the importance of the built environment in determining travel behaviour. As previous researchers have noted (McLaren 2016; Delbosc and Nakanishi 2017), increasing the

supply of family-friendly housing located in transit-rich neighbourhoods, in which there are both the amenities and a child-friendly environment, may help encourage families away from car orientated suburban living.

Participants identified many reasons why as parents of young children vehicle access was important. This suggests there is a strong need amongst families with young children to have vehicle access. However, the results of the interviews suggest that the need is not necessarily achieved through conventional means of private vehicle ownership. Furthermore, while for some parents their pre-parenthood expectations regarding their changing travel needs aligned with the practical reality, for others it did not. All formerly carless households purchased a vehicle once they found out they were expecting a baby but prior to the child's arrival. In households where their car use was considerably lower than anticipated following parenthood, they alluded to a level of regret regarding their automobile purchase. Transport alternatives that replicate the convenience and carrying capacities of cars, such as car sharing and electric bikes, can provide families with children a viable alternative to automobile ownership (Dowling and Maalsen 2019). Understanding the nature and type of barriers families with children experience when travelling by these alternative modes will help alternatives to conventional car ownership to better meet the needs of this group.

The mobility biography approach posits that life events provide opportunities in which an individual's habitual travel behaviour is disrupted and they actively deliberate their travel choices. It is these moments that are best targeted for travel behaviour change programmes. As these findings demonstrated, the transition to parenthood is marked by numerous life events in which disruptions to travel behaviour occur. However, as these findings and others have illuminated, while changes do occur, they tend to be in favour of car-orientated travel practices.

Nonetheless, each life event represents a chance to intervene and encourage the adoption of more sustainable travel behaviour. In order to best capitalise on these opportunities, planners and policymakers would need to address the many factors discouraging travel by sustainable modes and introduce policies which facilitate more child-friendly, urban developments. This, in turn, would assist to curb the tendency towards car-orientated mobility and housing among families with children, with potentially long-term impacts on the transportation system.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Laura McCarthy is a currently undertaking her PhD at Monash University. Her PhD research applies a life course approach to explore travel behaviour changes following parenthood, with an emphasis on public transit use.

Dr. Alexa Delbosc is a Senior Lecturer at the Monash Institute of Transport Studies in the Department of Civil Engineering. She draws from her research-based Master's in social psychology from Harvard University and PhD in Transport from Monash University to study public transport, travel behaviour and the changing travel habits of young people.

Professor Graham Currie is a renowned international public transport research leader and policy adviser with over 30 years' experience. He is the director of the Public Transport Research Group (PTRG) in the Monash University Department of Civil Engineering. In 2017 Professor Currie was elected as a Fellow of the Academy of Technology, Science and Engineering (ATSE).

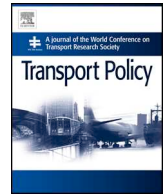
Andrew Molloy is Manager of Data Modelling and Analysis for the Department of Transport, focusing on the usage of the Victorian public transport network. He draws on his background in data analytics and market research covering transport, health sciences and town planning.

5.2.1 Conclusion

Using the results from the qualitative interviews, this paper highlighted that the first few years following the birth of a child is a period in which numerous changes can act to disrupt stable travel routines. It revealed that along with major life events, more subtle child-led ‘micromilestones’ could also influence mobility changes. Further, it showed that while a general pattern of increasing car use and ownership was apparent among most participants, different mobility trajectories were evident. These ranged from those who had little change in their car dependent travel behaviour through to respondents from formerly carless households who experienced a dramatic rise in car use. The next part of this chapter, using data from the online survey, presents a quantitative perspective of mobility trajectories following parenthood.

5.3 Paper: *‘Transit Faithfuls’ or ‘Transit Leavers’? Understanding mobility trajectories of new parents’*

Using the results from the online survey, this paper seeks to quantify typical mobility trajectories following parenthood. It does this by conducting a market segmentation analysis, to identify groups of parents sharing similar travel mode changes following parenthood. Each group is then profiled to understand their associated demographic and attitudinal characteristics. It concludes with some discussion and suggested policy interventions relevant for each group.



'Transit Faithfuls' or 'Transit Leavers'? Understanding mobility trajectories of new parents

Laura McCarthy^{a,*}, Alexa Delbosc^a, Graham Currie^a, Andrew Molloy^b

^a Department of Civil Engineering, Institute of Transport Studies, Monash University, 23 College Walk, Clayton, Victoria, 3800, Australia

^b Department of Transport, Victoria, Australia

ABSTRACT

First-time parenthood is typically associated with an increase in car orientated travel behaviour. As cities face increasing pressure to reduce growing levels of private car use, understanding the ways in which to prevent the adoption of car-based mobility during this period is becoming increasingly important. However, while much is known about aggregate changes in travel behaviour following parenthood, less is understood about differences that may exist at the individual level. Understanding these differences will help planners and policymakers to introduce more targeted policy interventions for new parents, assisting to curb the tendency towards car orientation.

A latent class analysis is conducted using data from a survey of new parents in Melbourne, Australia. The results reveal five distinct mobility patterns following parenthood. These range from a marked decline in public transit use – *Transit Leavers* – through to remarkably consistent travel behaviour prior to and following parenthood – *Transit Faithfuls*. The findings show that not all parents adopt car orientated travel behaviour following parenthood. Caregiving and employment status, as well as car ownership changes, are shown to be crucial in determining the extent to which travel behaviour changes and new car orientated travel behaviour is adopted. Moreover, each group display distinct characteristics and constraints on their travel choices. This suggests targeted interventions specific to individual groups are necessary to curb the tendency towards car-based mobility among new parents.

1. Introduction

Parenthood is a life stage in which travel behaviour typically becomes more car orientated (Ryley, 2006; Kitamura, 2009). Among first-time parents, car ownership and use typically increase, while the use of public transit and cycling decrease (Zwerts et al., 2007; Scheiner and Holz-Rau, 2013). As cities face increasing pressure to reduce growing levels of private car use, understanding ways to curb these unsustainable travel patterns requires attention. This is becoming increasingly urgent as many millennials, a large cohort comprising over a third of the global population, enter this life stage. If millennials follow previous generations and adopt car orientated travel behaviour as they transition into parenthood, it will have a significant long-term impact on the sustainability of the transport system (McDonald, 2015; Delbosc, 2016).

However, while much is known about aggregate changes in travel behaviour following parenthood, less is understood about differences that may exist at the individual level. Not all parents adopt car orientated travel behaviour following the birth of their child. So, which attitudinal or demographic characteristics are associated with adopting less car orientated travel behaviour? Understanding these differences will help planners and policymakers to introduce more relevant and targeted policy interventions for new parents. This, in turn, may assist to curb the tendency towards car orientation following parenthood and

increase the sustainability of transportation systems.

Using the results from a survey of new parents in Melbourne, Australia, this paper seeks to identify typical mobility trajectories following parenthood. It does this by conducting a market segmentation analysis, to identify groups of parents sharing similar travel mode changes following parenthood. Each group is then profiled to understand their associated demographic and attitudinal characteristics. The value of market segmentation approaches lies in formulating relevant policy interventions for specific groups and identifying those groups more primed to change their travel behaviour (Anable, 2005; Haustein and Hunecke, 2013). As such, the profiles are followed by specific policy interventions proposed for each group.

After discussing the relevant literature and describing the study methodology, this paper outlines the results from the market segmentation. Five distinct groups are profiled and described. The paper concludes with a discussion of the implication of these findings and possible policy interventions relevant for each group.

2. Literature review

2.1. Travel behaviour changes following parenthood

Two strands of transportation research have revealed important

* Corresponding author.

E-mail address: laura.mccarthy@monash.edu (L. McCarthy).

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findings regarding the way in which travel behaviour changes following parenthood. First, studies within the life course perspective examining the effect of childbirth on travel behaviour show that car use and ownership tends to increase in anticipation of parenthood (Prillwitz et al., 2006; Oakil et al., 2016), particularly among formerly carless households (Clark et al., 2016). Following the birth of a child, public transit and cycling typically decrease, while walking increases (Scheiner and Holz-Rau, 2013; de Haas et al., 2018).

Transportation research examining differences in travel behaviour by life stage shows car orientated travel behaviour adopted during the transition to parenthood endures as the household ages. Households with children generally display more car-dependent travel behaviour compared with other household groups (Ryley, 2006; Scheiner and Holz-Rau, 2007). This group is typically less multimodal (Scheiner, 2014) and use public transit and active travel less (Zwerts et al., 2007). The growth in car orientated travel behaviour is attributed to a multitude of psychosocial and structural factors which tend to encourage car-use and ownership whilst discouraging the use of alternative modes (McCarthy et al., 2017).

Although these bodies of literature underscore the highly car orientated nature of travel among families with children at the aggregate level, not *all* new parents are likely to shift towards car-based mobility. Market segmentation, discussed below, is one approach that helps identify relevant groups that would otherwise not be visible when making observations at the aggregate level.

2.2. Market segmentation examining individuals with children

Market segmentation, used widely in both consumer marketing and research, creates groups, or segments, within a population who share similar characteristics. Studies using market segmentation approaches have been widely used in travel behaviour research. The extent of these studies reflects the usefulness of market segmentation as a powerful means to identify groups within a population who can then be targeted in a meaningful and relevant way, that may more likely result in travel behaviour changes (Anable, 2005). Moreover, it allows interventions to be focused on those groups within the population who are more likely to change their travel choices (Haustein and Hunecke, 2013). Within transportation research, groups are often defined based on a combination of travel behaviour, socio-demographic and attitude characteristics (Haustein and Hunecke, 2013).

Segmentation approaches including the presence of children as a variable show that individuals with children are typically, but not always, associated with more car orientated segments. Ryley (2006), conducted a cluster analysis based on life stage, using the results of a large Scottish travel survey. One of the major study findings was that households with children present were considerably more car-dependent than other household groups (Ryley, 2006). Anable (2005), in her seminal work incorporating attitudes towards travel in segmentation analysis, profiled six groups based on their likelihood of changing to more sustainable travel modes. Among the only two non-car owning groups, respondents with children were significantly underrepresented, whereas they were relatively evenly dispersed among the four car-owning groups (Anable, 2005). While recent research from de Haas et al. (2018), examining the impact of life events on changes between segments over time, show that increasing car dependency is evident following the birth of a child, among all segments (de Haas et al., 2018).

Interestingly, however, several studies demonstrate that individuals with children are not always associated with car-dependent traveller segments. Molin (2016), identifying groups of multimodal travellers in the Netherlands, showed that respondents with children were over-represented in the group associated with most frequent car-use but also among the group using a combination of bike and car (Molin et al., 2016). Likewise, Priwltz (2011) conducted a cluster analysis to identify segments based on individuals' daily travel patterns. This revealed that households with children were most likely to be part of the 'consistent

green travellers group' (characterised by higher combined use of cycling and public transit) followed by the 'frequent car users' group (Prillwitz and Barr, 2011). It should be noted that these studies were undertaken in differing transport contexts, had differing objectives and used different segmentation approaches and analysis variables. However, this finding, that parents with children are not always associated with car orientated groups, supports the notion that while travel patterns of families with children may often be car orientated, this is not always the case.

Numerous market segmentation analyses have been undertaken in transport research. However, to the authors' knowledge, none have specifically examined travel pattern changes following parenthood. As this is a crucial period in which car orientated travel behaviour is adopted, understanding segments that may be more primed to retain or adopt less car orientated travel behaviour is important for the formation of effective car reduction policies. This paper seeks to address this gap.

3. Method

3.1. Questionnaire and sample

The data used in this analysis comes from an online survey of new parents, conducted during 2018, in Melbourne, Australia. Participants were recruited through posting a survey link on social media and a smaller number through the researchers' personal networks. While the survey was open to parents with at least one child aged five years and younger ($n = 903$), respondents who *only* had children aged five years and younger were used in this analysis ($n = 758$). This was to ensure the timeframe to examine mode changes (between one and six years) was relatively comparable among respondents.

The survey recruited individuals rather than households as our earlier work highlighted notable differences in the extent of mobility changes by individual characteristics such as gender, attitudes and caregiving status. The sample aimed to be broadly representative of parents with young children in Greater Melbourne in terms of age, partnership status, location, household income and gender. A non-probability purposive sampling method was adopted. As shown in Table 1, the final sample was representative across most characteristics identified. However, male respondents were significantly under-represented (17% of respondents) and respondents on low-incomes were notably under-represented. To address the gender imbalance, we applied gender weights to the dataset. Each male response was weighted by 2.96, while each female response was weighted by 0.61. The results presented in this paper, unless otherwise stated, are based on the weighted dataset.

The survey questionnaire was structured into the following six sections: travel habits; current and preparenthood mode use; life events; travel and housing attitudes; barriers to public transit use; and, demographic characteristics. To identify different mobility trajectories following parenthood, the sections regarding current and preparenthood mode use, attitudes and demographic characteristics, were used.

Travel mode changes between the year prior to becoming a parent for the first-time (pre-parenthood status) and currently were derived from two questions. Firstly, respondents were asked the frequency in which they currently travelled by car (driver or passenger), public transit, cycling and walking. Respondents were provided with 8 options: 'Practically everyday', '4–6 days per week', '1–3 days per week', '1–3 days per month', '6–11 days per year', '1–5 days per year', 'less than 1 day per year', and 'never'. The next question again asked about mode use frequency, but for the period one year prior to becoming a parent for the first time. In the second question, respondents were also provided with a further option for 'Don't know/can't recall'.

The inclusion of a large number of categories in each indicator increases the number of possible patterns which poses problems for classification. As such, we reduced the number of categories in each of the six indicators from eight to three, as follows: 'frequent' = four or

Table 1
Survey respondent characteristics.

Characteristic	Variable	Survey respondents		2016 Census, Greater Melbourne	
		Unweighted	Weighted	HH with children aged 0-4	All HH
Gender	Male	17%	50%	50%	49%
	Female	83%	50%	50%	51%
Household composition	Dual parent family household	92%	93%	84%	34%
	Single parent family household	8%	7%	10%	10%
	Other	–	–	6%	56%
Household car ownership	No car	3%	3%	2%	9%
	1 car	32%	32%	24%	33%
	2 or more cars	65%	65%	74%	55%
Household* income	Less than \$499 per week	4%	5%	17%	13%
	\$500 - \$999 per week	11%	11%	19%	17%
	\$1000 - \$1499 per week	17%	17%	17%	16%
	\$1500 - \$1999 per week	21%	20%	13%	12%
	\$2000 - \$2499 per week	14%	13%	11%	18%
	More than \$2500 per week	34%	34%	23%	24%
Household location	Inner urban	12%	14%	–	–
	Middle urban	44%	43%	–	–
	Outer urban	38%	37%	–	–
	Regional	6%	6%	–	–
Children*	Children per household (mean)	1.5	1.5	1.8	0.8

Notes: ‘–’ indicates data is not available; ‘*’ indicates Census data based on households with dependent children aged 15 years and younger.

more days per week; ‘occasional’ = between 1 and 12 days a month; and, ‘rare’ = less than twelve days per year. Walking was excluded from the analysis as even with the reduction in categories for each indicator the number of possible patterns was still very high.

Most of the attitudinal questions included in the questionnaire were sourced from the Netherlands Mobility Panel (Hoogendoorn-Lanser et al., 2015). The questions aimed to test car reliance, social norms, pro-environmental attitudes and attitudes to travelling by car and public transit. Questions were asked on a five-point scale ranging from ‘strongly disagree’ to ‘strongly agree’.

The final questions regarding respondents’ demographics. Respondents were asked about their individual characteristics (gender, age-group, partnership status, caregiving status) and their household (income, postcode, current vehicle ownership, vehicle ownership one-year prior to becoming a parent, number and age of children).

3.2. Analysis methods

The objective of this analysis was to identify different groups that share similar changes in travel mode use following parenthood. Moreover, it aimed to understand the attitudes and socio-demographic characteristics associated with each group. In order to understand this, we conducted a latent class analysis (LCA) using Latent Gold software. LCA is a subset of structural equation modelling. However, in contrast to cluster-based modelling techniques, LCA probabilistically assigns individuals to classes or groups. Statistical criteria are used to determine the least number of classes which can sufficiently explain the association between the indicators. The technique is becoming increasingly common in travel behaviour research. For a succinct summary of the advantages of LCA, see Araghi et al. (2017).

Six indicator variables with three categories each were used to determine the class membership. These were derived from the questions regarding current and preparenthood mode use. Specifically, current and preparenthood frequency of car (driver or passenger), public transit and cycling use. Mode use frequency for each indicator was categorised as follows: ‘frequent’ = four or more days per week; ‘occasional’ = between 1 and 12 days a month; and, ‘rare’ = less than twelve days per year.

In addition, socio-demographic and attitudinal variables were included, all as active covariates predicting the class membership. Specifically, the following attitudinal variables were included in the analysis: ‘I only use a car if it is really necessary’; ‘I could not manage

without a car’; ‘With the environment in mind, in the past year I have consciously tried to drive a car less’; ‘It is pointless to worry about the environment, because there is nothing you can do about it on your own’; ‘Due to costs, I opt to travel by public transport instead of by car’; ‘I feel safe using public transport’; ‘Using public transport is a satisfying experience’. Three other questions testing social norms, attitudes to the cost of car travel and the extent to which a car provides freedom were not significant in predicting class membership and not included in the final model.

4. Results

4.1. Model fit

After running a series of models with between 2 and 10 classes, a five-class solution was selected as the optimal number of classes. As shown in Table 2, the five-class solution had the lowest Bayesian Information Criterion (BIC). The BIC is commonly used to determine, amongst a series of models, the optimal number of classes. Generally, when selecting the preferred model amongst a series of models, the model with the lowest BIC is chosen. Moreover, the models with more than five classes included classes with very small sizes, making interpretation problematic.

4.2. Class profiles

Profiles of the indicators used to predict class membership are displayed in Figs. 2–6 while the active covariates used in the model are

Table 2
Model fit statistics.

Number of clusters	Log-likelihood	BIC(LL)	No. of parameters	Class errors
2-Cluster	–2045	4379	46	0.02
3-Cluster	–1905	4313	80	0.04
4-Cluster	–1787	4289	114	0.01
5-Cluster	–1661	4252	148	0.01
6-Cluster	–1587	4317	182	0.01
7-Cluster	–1569	4494	216	0.04
8-Cluster	–1486	4541	250	0.02
9-Cluster	–1438	4660	284	0.01
10-Cluster	–1379	4756	318	0.01

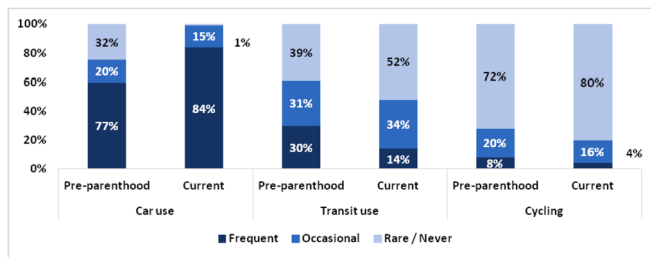


Fig. 1. Overall sample pre-parenthood and current (parenthood) mode use.

shown in Table 3. The five groups, described below, are referred to as *Transit Leavers* (Group 1), *Consistent Drivers* (Group 2), *Committed Multimodals* (Group 3), *Transit Faithfuls* (Group 4) and *Devoted Cyclists* (Group 5).

As shown in Fig. 1, among the overall sample, public transit shows the most notable decline in mode use frequency, followed by cycling. Travel by car is the only mode to exhibit an increase in use. In the year prior to parenthood, 39% of respondents used public transit rarely or not at all increasing to over half of respondents (52%) currently. In contrast, the proportion of respondents rarely or never using the car decreased from nearly a third (32%) pre-parenthood to less than 1% currently.

Overall, the most notable mode use changes following parenthood are apparent in Group 1, *Transit Leavers*, and Group 5, *Devoted Cyclists*. The remaining three groups (*Consistent Drivers*, *Committed Multimodals*, *Transit Faithfuls*) are characterised by minimal changes in mode use. Among the *Transit Leavers* members were most likely to be the primary caregiver and to work part-time. Accommodating childcare responsibilities and differing employment patterns is likely to explain the growth in car-based travel and reduced use of alternative modes among this group. As females are more likely to be the primary caregiver in this sample, this likely explains the gendered differences between the *Transit Leavers* and the other groups. In contrast, the mode-use changes apparent among the *Devoted Cyclists* can be attributed to an increase in car ownership.

4.2.1. Transit Leavers

The largest Group (39% of respondents), termed *Transit Leavers* due to the significant decline in public transit use following parenthood, is the only group to contain predominantly women (82%). The *Transit Leavers* also have the highest proportion of respondents who were the primary caregiver (68%), a stay-at-home parent (28%) and employed part-time (38%). As shown in Fig. 2, in the year prior to parenthood, half the members of this group used public transit frequently and a further 38% occasionally. This reduces to just 10% of members frequently using public transit and 58% occasionally using public transit, currently. The decline in public transit use is replaced by an increase in private vehicle use with the proportion of frequent users increasing from 69% pre-parenthood to 89% currently.

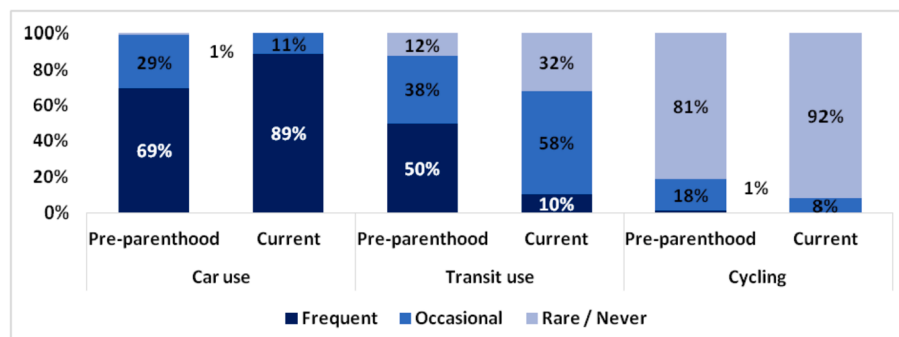


Fig. 2. Transit Leavers pre-parenthood and current (parenthood) mode use.

Overall, the *Transit Leavers* show pragmatic but reliant attitudes towards car-use (Table 2). The group scored highly in terms of “could not manage without a car” but slightly higher than average with regards to “using the car only when necessary”. Interestingly, despite this group being characterised by a decline in public transit use, attitudes regarding public transit satisfaction are highest among all the groups. Similarly, scores regarding safety on public transit are higher than both groups 2 and 3. This suggests that while public transit may currently not meet the needs of this group when their circumstances change, they may return.

4.2.2. Consistent Drivers

Consistent Drivers are the second largest group, comprising a quarter of respondents. Members of the *Consistent Drivers* continued to use cars frequently both prior to parenthood and presently (Fig. 3). Of note, while a large majority of members used public transit rarely prior to parenthood (78%), this increased to nearly all of the members (98%) currently. Like the *Transit Leavers*, the *Consistent Drivers* have a high proportion of members who are the primary caregiver (48%). Interestingly though, this group has the evenest gender split out of all groups with males comprising 52% of members. Out of all the five groups, the *Consistent Drivers* are most likely to live in Outer Melbourne (67%) and regional areas (10%) and most likely to be in the lowest income group (21%). Car ownership among this group is high, with 83% residing in a household with two or more vehicles. This clustering of characteristics suggests the group may be experiencing “forced car ownership”. This a concept applied to households, often living in urban periphery areas and experiencing aspects of social disadvantage, who are “forced” into car ownership due to a lack of transport alternatives (Currie and Senbergs, 2007).

Analogous to the *Transit Leavers*, this group shows strong attitudes regarding reliance on a private vehicle. However, the *Consistent Drivers* are the least likely to attempt to reduce their car use due to environmental reasons and most likely to agree with the statement regarding ‘It is pointless to worry about the environment, because there is nothing you can do about it on your own’. This group also has the lowest satisfaction with public transit, both in terms of safety and overall satisfaction. The high levels of car-use among this group are likely to be attributed to their location and household circumstances as well as their attitudes which are predisposed to car-use.

4.2.3. Committed Multimodals

Like the *Consistent Drivers*, the *Committed Multimodals* (17% of respondents) are characterised by minimal changes in mode use following parenthood. Members also share similar attitudes towards transport and the environment as the *Consistent Drivers*, which tend to favour car-use. However, as shown in Fig. 4, while they are frequent car-users, most members of this group are also likely to use public transit and cycle occasionally. Compared with the *Consistent Drivers*, a larger share of this group lives in middle urban areas, better serviced by public transit. Moreover, the *Committed Multimodals* have a considerably higher share

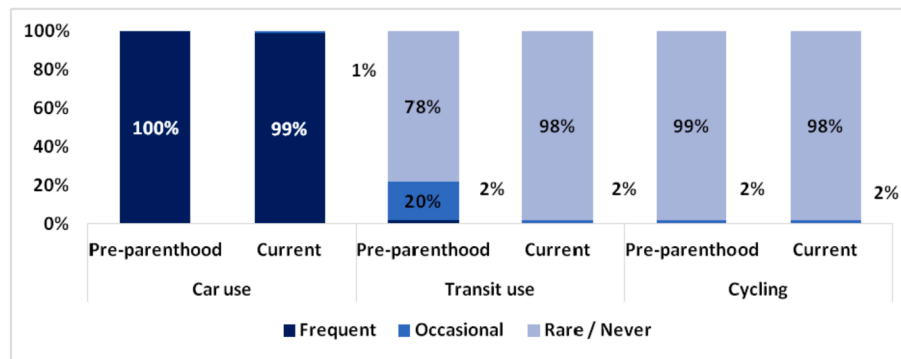


Fig. 3. Consistent Drivers pre-parenthood and current (parenthood) mode use.

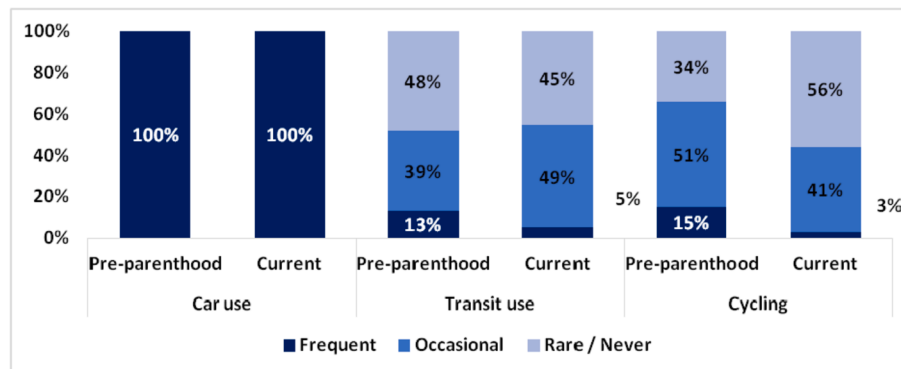


Fig. 4. Committed Multimodals pre-parenthood and current (parenthood) mode use.

of male members (82%) and those who are the non-primary caregiver. The differences between location and caregiving responsibilities could explain the greater use of public transit and cycling among the *Committed Multimodals* compared with the *Consistent Drivers*.

4.2.4. Transit Faithfuls

Transit Faithfuls, comprising 11% of respondents, are described as such given the comparatively high frequency of public transit use, both prior to parenthood and currently. As shown in Figs. 5 and 84% of *Transit Faithfuls* used public transit frequently and 15% occasionally, prior to parenthood. This drops to 64% of members using public transit frequently currently, with the remainder shifting to occasional use (35%). While this represents a decline in public transit use, the group has the highest rates of public transit usage, both prior to and following parenthood compared with the other groups. The high frequency of transit use coupled with the low frequency of car-use and cycling, as well as the higher than average employment rates, suggests that members of this group primarily use transit for commuting purposes.

Members of the *Transit Faithfuls* are most likely male (72%), employed full-time (72%) and live in Middle urban areas (62%). They are also typically from the highest income bracket (71%) and have comparatively low rates of household vehicle ownership, with most members residing in a single-vehicle household (48%) and 10% of respondents residing in a carless household. This group shows favourable attitudes towards public transit with variables regarding using public transit due to cost, safety on public transit and satisfaction with public transit all scoring higher than average.

4.2.5. Devoted Cyclists

The final group, comprising just 8% of respondents, are characterised by their comparatively high cycling rates and notable change

in vehicle ownership following parenthood.¹ Nearly half of members (46%) were carless prior to parenthood but this drops to just 1% following parenthood. However, car ownership remains the lowest of all groups following parenthood with 62% residing in a single-vehicle household. Moreover, overall vehicle use is relatively low, with just 41% of members using the vehicle frequently, and 56% occasionally.

Like the *Transit Faithfuls*, the *Devoted Cyclists* have favourable attitudes towards public transit. However, this group also shows strong pro-environmental attitudes that are likely to influence their car use. Moreover, this group scored strongly on only using the car when necessary. These attitudes coupled with notably low pre-parenthood car-ownership levels and low frequency of car use presently (Fig. 6), suggests that members of this group transitioned to car ownership with some reluctance.

Overall, current car-use is highest among the *Transit Leavers*, *Consistent Drivers* and *Committed Multimodals*, while the lowest among the *Transit Faithfuls* and *Devoted Cyclists*. Group 1 is characterised by a high proportion of part-time workers and primary caregivers, while Group 2 has the highest proportion of members living in outer urban areas, likely to be less well served by transit. In contrast, groups 4 and 5 are more likely to live in inner or middle urban areas, from the highest income group and employed full-time. Differences in household location and income as well as in caregiving and employment practices among the groups suggest different travel constraints exist. Respondents with primary caregiving responsibilities are likely to have

¹ We note this class exhibits more multi-modal travel behaviour than the *Committed Multimodals*. However, the most striking transport characteristic of this group is their continual frequent use of cycling and, as such, this is reflected in the group's title.

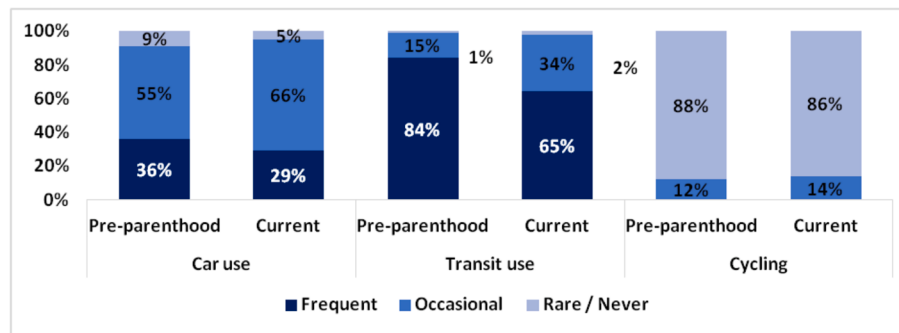


Fig. 5. Transit Faithfuls pre-parenthood and current (parenthood) mode use.

more complex travel routines as they accommodate the travel needs of their young children. Similarly, housing location and income can constrain travel choices. This suggests different policy implications for each group, discussed in the following section, are appropriate.

5. Discussion and conclusion

This analysis aimed to identify separate groups sharing similar mobility trajectories following parenthood. In doing so the findings provided two important contributions. First, in contrast to the well-established literature regarding increasing car-orientation following parenthood at the household level, the results of the latent class analysis show a range of travel mode changes are evident. While car use did indeed increase for most groups, for other groups displaying more sustainable travel patterns, minimal changes were observed. Characteristics apparent among the two groups showing shifts towards car-based mobility include a higher likelihood of being the primary caregiver, employed part-time and a stay-at-home-parent (*Transit Leavers*) as well as an increase in car ownership, specifically from zero to one car (*Devoted Cyclists*). The second notable finding is that each of these groups represents five distinct patterns of mode-use changes. This suggests that to reduce the adoption of car-based mobility following parenthood, policy interventions should be tailored for different groups of new parents.

5.1. Policy implications

Generally, travel behaviour interventions targeting segments with more favourable attitudes towards alternative modes will be more successful than attempting to convert those with less favourable attitudes towards public or active transit (Anable, 2005). As such, policy attention should be focussed on the groups which show a higher

likelihood of mode switching. Table 4 presents an overview of the type of interventions appropriate for each group.

The largest group, *Transit Leavers*, show favourable attitudes towards public transit and yet they have the most pronounced decline in public transit use. Higher than average scores for car reliance suggest that due to current constraints, their travel mode preferences favour the car. The characteristics strongly associated with this group, namely primary caregiver status and part-time employment, could explain why their travel mode preferences have become more car orientated. Accommodating a child's travel needs as well as their own is likely to increase the complexity of travel and introduce constraints regarding the new destinations and activities they need to reach within existing time travel budgets. Moreover, part-time employment is more likely to involve off-peak commutes when transit services may be less frequent and harder to accommodate day-care pickup times.

Nonetheless, while the reasons for the decline in public transit use are readily explainable, it does raise several other questions. Favourable attitudes towards public transit are typically predicated on the frequent ongoing use of this mode (Beirão and Sarsfield Cabral, 2007; Kroesen et al., 2017). If public transit is no longer meeting the current needs of these former users, how long are they likely to retain their favourable attitudes towards public transit? When the current constraints to travelling on public transit are no longer in place, will they return to public transit or will new car orientated attitudes and behaviours have formed? The answers to these questions will have significant implications for justifying funding to better accommodate new parents on public transit systems. If these users are lost permanently, investing in public transit systems in order to retain these users, seems considerably more important. Small-scale improvements, such as increasing the provision for caregiver parking at park and ride stations, have been suggested in Table 4. However, further research examining the longer-term implications of declining public transit use among this group will

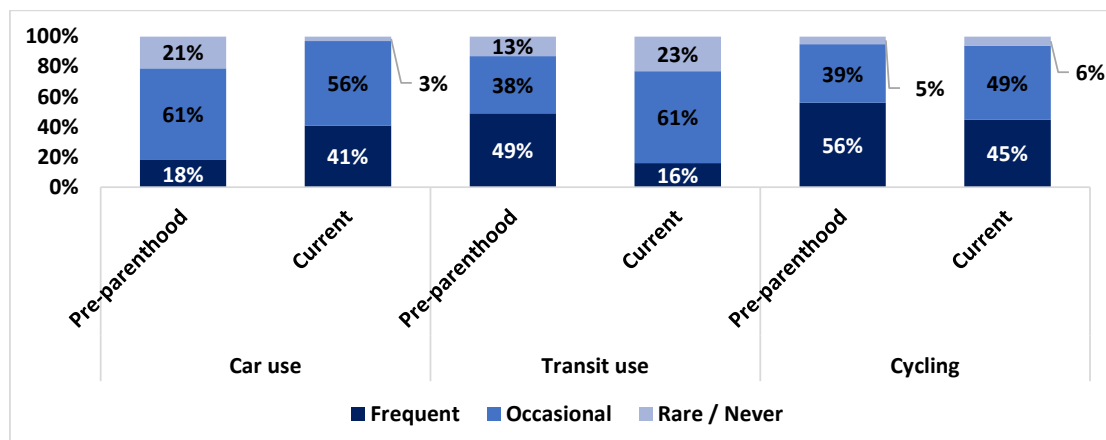


Fig. 6. Devoted Cyclists pre-parenthood and current (parenthood) mode use.

Table 3
Active covariates.

Active Covariates		TL	CD	CM	TF	DC	Sample
Class size		39%	25%	17%	11%	8%	
Gender	Male	0.22	0.53	0.82	0.72	0.76	0.50
	Female	0.78	0.47	0.18	0.28	0.24	0.50
Primary caregiver	Non-primary caregiver	0.37	0.52	0.64	0.69	0.65	0.52
	Primary caregiver	0.63	0.48	0.36	0.31	0.35	0.48
Relationship status	Single	0.09	0.07	0.10	0.06	0.00	0.07
	Couple (Married or de facto)	0.91	0.93	0.90	0.94	1.00	0.93
Full licence status	Does not have full licence	0.11	0.01	0.00	0.04	0.18	0.07
	Has full licence	0.89	0.99	1.00	0.96	0.82	0.93
Employment status	Full-time employment	0.30	0.49	0.61	0.72	0.75	0.48
	Part-time employment	0.36	0.21	0.25	0.21	0.19	0.27
	Student	0.05	0.01	0.03	0.01	0.00	0.03
	Unemployed/Job seeker	0.01	0.02	0.04	0.01	0.00	0.02
	Stay at home parent	0.28	0.26	0.05	0.05	0.06	0.20
	Unable to work	0.00	0.00	0.02	0.00	0.00	0.00
Region	Inner urban	0.15	0.01	0.12	0.22	0.34	0.14
	Middle urban	0.51	0.22	0.51	0.62	0.52	0.43
	Outer urban	0.30	0.67	0.32	0.16	0.08	0.37
	Regional	0.03	0.10	0.04	0.00	0.06	0.06
Household income	Less than \$999 per week (pw)	0.14	0.21	0.16	0.07	0.13	0.16
	Between \$1000 - \$1999 pw	0.43	0.43	0.35	0.21	0.17	0.37
	More than \$2000 pw	0.43	0.37	0.49	0.71	0.71	0.47
Pre-parenthood household vehicle ownership	None	0.02	0.00	0.06	0.20	0.46	0.08
	1	0.44	0.15	0.33	0.53	0.26	0.34
	2	0.45	0.71	0.58	0.28	0.28	0.51
	3 or more	0.08	0.14	0.03	0.00	0.00	0.07
Current household vehicle ownership	None	0.01	0.02	0.00	0.10	0.01	0.03
	1	0.44	0.15	0.18	0.48	0.62	0.32
	2	0.45	0.67	0.79	0.41	0.35	0.56
	3 or more	0.11	0.16	0.03	0.00	0.01	0.09
Age group	29 years or younger	0.13	0.31	0.24	0.01	0.01	0.17
	30–39 years	0.70	0.64	0.47	0.79	0.65	0.66
	40 years or older	0.17	0.05	0.29	0.20	0.34	0.17
Number of children per household (mean)		1.61	1.36	1.35	1.41	1.40	1.45
Attitudes [Mean – A scale of 1 (Strongly disagree) to 5 (Strongly agree)]	Car used only when necessary	2.88	2.34	2.13	3.25	3.79	2.77
	Could not manage without a car	4.21	4.29	3.93	3.04	3.31	3.98
	Pro-environmental	2.60	2.14	2.65	2.87	3.46	2.58
	Inaction towards environment	2.00	2.61	2.24	2.22	1.86	2.21
	Due to costs, use public transit	2.19	1.62	2.30	3.48	2.42	2.27
	Feel safe using public transit	3.76	2.52	2.78	4.30	3.87	3.27
	Satisfaction with public transit	3.03	2.33	2.63	2.82	2.81	2.72

Note: TL: Transit Leavers; CD: Consistent Drivers; CM: Committed Multimodals; TF: Transit Faithfuls; DC: Devoted Cyclists.

be worthwhile in order to justify more substantive investment in public transit to ensure it meets new parents' travel needs.

Committed Multimodals display promising characteristics predisposed to travel behaviour changes. While they are all frequent car users, nearly half also cycle (44%) and use public transit (54%) at least occasionally. They experienced minimal changes in travel behaviour following parenthood and are the least likely to be the primary caregiver. This suggests that parenthood has had a minimal effect on their travel choices and so more general policies encouraging an uptake in the use of public transit and active travel would be effective. As car ownership is high among this group, encouraging the use of alternate modes, such as car sharing, may assist in reducing car ownership levels which, in turn, will assist to reduce car use. However, in order for alternative modes to be utilised among this group, they must accommodate the specific needs of families with children. For example, most car sharing fleets do not include child seats, creating a barrier to using this mode when travelling with young children.

Likewise, *Transit Faithfuls* are less likely to be encumbered with childcare responsibilities and so face fewer constraints on their travel choices. However, the majority of this group use cars frequently (29%) or occasionally (66%). As they already have favourable attitudes towards public transit and the vast majority are frequent (65%) or occasional (34%) users, this suggests there is scope to convert some of these car trips to public transit trips. This could be achieved by

promoting public transit for recreational trips. Moreover, as this group signalled cost was an important factor in travelling by public transit, promoting seasonal public transit passes may be effective.

Finally, while a small group, the *Devoted Cyclists* experienced a notable shift towards car-based mobility following parenthood. While the group continued to display comparatively high rates of cycling following parenthood, a significant increase in household vehicle ownership and a moderate increase in car use was observed. Among the group, less than a third were likely to be the primary caregiver. This suggests that the car may have been purchased for the primary caregiver in the household as the majority of users only use the car occasionally (56%). However, the group show strong pro-environmental attitudes and generally lower levels of car reliance. This suggests that interventions prior to parenthood may be effective in preventing a rise in car ownership and a commensurate increase in car use. Moreover, promoting the environmental benefits associated with public transit and alternative modes may also be productive.

Overall, the five groups show distinct constraints on their travel choices and general attitudes towards travel. This is reflected in the differences to which their travel modes change following parenthood. Moreover, it calls for differing policy interventions, as outlined above. The research also suggests several areas of future research. Obtaining more granular location data as well as including questions to garner preferences regarding residential neighbourhoods would allow the

Table 4
Policy interventions by segment.

Group	Typical characteristics	Drivers to using alternate modes	Constraints to using alternate modes	Policy interventions	Likelihood of switching
Transit Leavers	Female; Primary caregiver; Employed part-time; Middle urban areas; Middle/high income; High car reliance	Positive attitudes towards transit; Familiarity with transit use	Caregiving responsibilities; Car reliant attitudes.	Increase off-peak service frequency; Improve transit network connectivity and density; Dedicated 'caregiver parking' at stations; Provide information about travelling with children using alternate modes	Medium
Consistent Drivers	Outer/regional urban areas; Low/middle income; High car ownership; Young; High car reliance	None	Caregiving responsibilities; High car ownership; Car reliant attitudes; Transit poor location	Promote transit as a fun activity with children	Low
Committed Multimodals	Male; Employed full-time; Non-primary caregiver; Middle/high income; Middle/Outer urban areas	Occasional cyclist and transit user	High car ownership	Promote car sharing as an alternative to a second vehicle	Medium
Transit Faithfuls	Male; Employed full-time; Non-primary caregiver; Middle urban; High-income; Positive public transit attitudes; Lowest levels of car reliance	Low car ownership; Transit-rich location; Lower levels of car reliance	Moderate level of car reliance	Promote public transit for recreational travel; Promote public transit passes	High
Devoted Cyclists	Male; Employed full-time; Non-primary caregiver; Inner/middle urban; High-income; Positive public transit attitudes; Lower levels of car reliance; Strong pro-environmental attitudes	Pro-environmental attitudes and positive transit attitudes; Low car ownership; High rates of cycling	Moderate level of car reliance	Reinforce environmental benefits of public transit and active travel; Promote car sharing as an alternative to car ownership; Cycling infrastructure improvements.	High

Source: Adapted from Anable (2005).

impact of proximity to public transit and role of residential self-selection in influencing declining public transit usage to be investigated. In addition, further research examining the long-term implications of declining public transit use among new parents would be beneficial. This would help justify greater investment to ensure public transit and active travel networks meet the needs of new parents, particularly those who are primary caregivers for their children. This, in turn, would assist to curb the tendency towards car orientation among new parents, with long-term benefits for the sustainability of transportation systems.

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5.3.1 Conclusion

In contrast to the well-established literature regarding increasing car-orientation following parenthood at the household level, the results of the latent class analysis demonstrated a range of travel mode changes are evident. While car use did indeed increase for most groups, for other groups displaying more sustainable travel patterns, minimal changes were observed. Characteristics apparent among the two groups showing shifts towards car-based mobility include a higher likelihood of being the primary caregiver, employed part-time and a stay-at-home-parent (Transit Leavers) as well as an increase in car ownership, specifically from zero to one car (Devoted Cyclists). The second notable finding is that these groups represent five distinct patterns of mode-use changes. This suggests that to reduce the adoption of car-based mobility following parenthood, policy interventions should be tailored for different groups of new parents.

The next section, drawing on the results of the online survey, explores the factors influencing new parents' car-use habits.

5.4 Factors influencing new parents' car-use habits

The results of the qualitative interviews, presented in section 5.2., found that new parents tended to face a range of major and minor life events in close succession. Using the results of the online survey, this section aims to understand factors influencing new parents' car-use habits, including the impact of different combinations of life events. Further, it seeks to understand whether the type and frequency of life events differ by socio-demographic characteristics.

The first part of this section describes the results of the preliminary factor and correlation analyses. This is followed by some descriptive analysis regarding life event frequency and the results of a regression analysis, which explores the extent to which individual and household variables, including life event frequency, predict car-use habit strength. The section concludes with some discussion and policy implications.

5.4.1 Preliminary analyses

Some of the inputs into the regression analysis required preliminary analysis, including a correlation analysis between life events and habits and a factor analysis of attitude variables. A correlation analysis was conducted to understand the direction of the relationship between car-use habit strength and individual life events. Life events are included as a count of the total number of times the event occurred from the period one year before becoming a parent until currently. In order to measure car-use habit, we used the *response-frequency measure of habit* which defines habits as a type of automatically activated behaviour and aims to test the automaticity or script-based nature of habit (Verplanken et al. 1994). More information about these variables can be found in section 3.4.3.

As shown in Table 5.1, experiencing certain life events (changed jobs, parental leave, moved house, separated from a partner, starting or stopping education) was associated with weakening car-use habits while the remaining two events (had a child and moved in with partner) were associated with strengthening car-use habits. Although not all of the correlations were statistically significant, we used this finding to create two life event variables for use in the regression analysis: “Destabilising life events” combining life events associated with weakening car-use habits and “Stabilising life events” combining the remaining two life events associated with strengthening car-use habits. Unsurprisingly, a stronger relationship with car-use habit is evident when grouping the destabilising and stabilising life events together than testing as individual life events.

Table 5.1: Correlation analysis between car-use habit strength and individual life events

Life events	Relationship with car use habit strength	Life event variables	
		Destabilising life events	Stabilising life events
Changed jobs	-0.07	X	
Parental leave	-0.07	X	
Moved residence	-0.08*	X	
Separated from partner	-0.06	X	
Started or stopped education	-0.04	X	
Had a child	0.11*		X
Moved in with partner	0.10*		X
Destabilising life events total	-0.11*	-	-
Stabilising life events total	0.15*	-	-

Note: *Correlation is significant at $p < 0.05$

We conducted a factor analysis to reduce the attitude variables into a smaller set of factors to use in the regression analysis (more information about these attitude variables can be found in section 3.4.3). While the transport attitude questions were suitable for factor analysis, the Kaiser-Meyer-Olkin (KMO) value for the housing questions was less than 0.6 indicating that these variables are not suitable for factor analysis.

A principal component analysis was used. This aims to create a smaller set of variables with similar characteristics that capture the substantive variability of the existing variables. After some investigation, a three-component solution explained 61.4% of the variance (30.6%, 16.45% and 14.5%, respectively) among 8 items, as shown in Table 5.2, below.

Table 5.2: Factor analysis results

Factors	Attitudes	Pattern coefficients		
		Component 1	Component 2	Component 3
Factor 1: Car reliance	A car gives me the freedom to go wherever I want			0.841
	I could not manage without a car			0.702
Factor 2: Reduce car use	I only use a car if it is really necessary	0.539		
	With the environment in mind, in the past year I have consciously tried to drive a car less	0.598		
	Due to costs, I opt to travel by public transport instead of by car	0.712		
	Due to costs, I drive less with the car than I actually want to	0.847		
Factor 3: PT satisfaction	I feel safe using public transport		0.883	
	Using public transport is a satisfying experience		0.870	

Note: Only factor loadings greater than 0.3 are reported.

5.4.2 Descriptive results

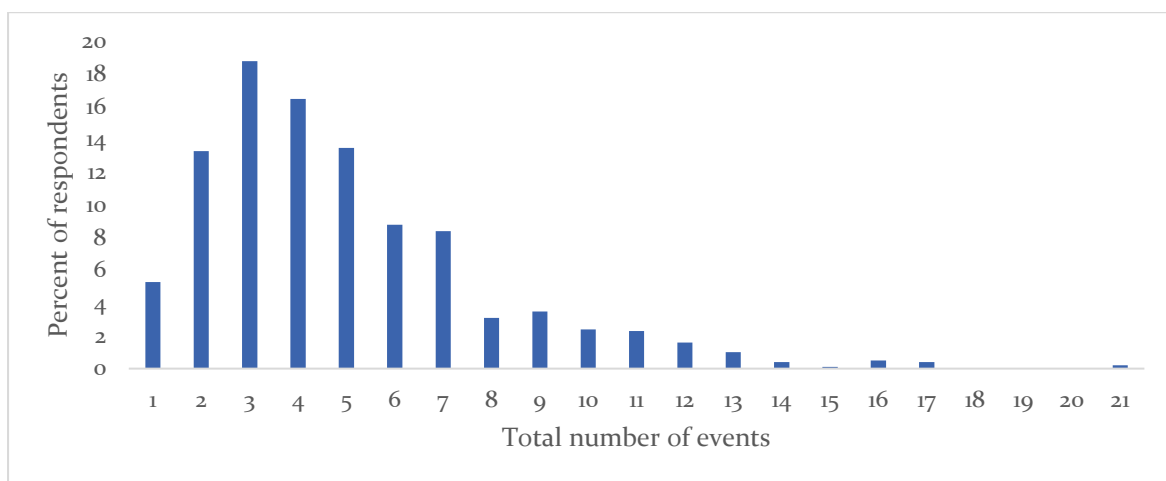
The first part of the analysis aimed to understand the frequency of life events and the degree of car-use habit among respondents. First, t-tests were conducted to examine differences in the *total* number of life events experienced by age and number of children in the household. Next, to explore differences in car-use habit strength, we conducted t-tests for gender and the number of children. To determine whether the groups' scores differed significantly, posthoc tests were conducted using the Tukey HSD test.

Life event frequency

Figure 5.4 shows the distribution of life events experienced, including childbirth, among respondents. Respondents experienced an average of 5.0 (SD =3.0) life events. Table 4 shows the total number of life events experienced by respondents. Statistically significant differences were apparent by respondents' gender and the number of children. Females were likely to experience fewer life events than males: $t(756)=2.57, p=0.01$. Likewise, respondents with one child were likely to experience fewer life events than households with two or more children: $t(559)=-9.71, p=0.00$.

The event occurring with the greatest frequency among respondents was residential relocation followed by changing jobs and taking a period of parental leave. This order is comparable to other studies examining the frequency of life events (see, for example, Clark et al. 2016). We were surprised by the relatively equal gender distribution of parental leave. However, this may be attributed to the way the description of the event was worded as no time period was stated. In Australia, eligible employed fathers are entitled to a government subsidy providing for two-week paid leave following the birth of their child. Respondents likely selected parental leave as an event even if they had only taken the standard two-week paid leave. Males were slightly more likely than females to move in with a partner. As the number of children in a household increases, so do the number of life events. This is as expected, as the life event period is likely to be shorter for parents with one child and longer for parents with two or more children.

Figure 5.2: Life events including the birth of a child(ren)



Source: Online survey data

Table 5.3: Total number of life events by gender and number of children

Number of times event occurred (mean)	Gender*		Number of children*		Total
	Male	Female	1	2+	
Have a child	1.5	1.5	1.0	2.2	1.5
Changed jobs	1.0	0.7	0.8	1.0	0.9
Parental leave	0.8	0.9	0.7	1.1	0.9
Moved house	1.1	1.0	0.9	1.3	1.1
Separated from partner	0.1	0.1	0.2	0.1	0.1
Moved in with partner	0.3	0.2	0.3	0.3	0.3
Started or finished an education course	0.4	0.3	0.3	0.4	0.4
Total	5.2	4.7	4.1	6.2	5

Note: Difference in the total number of life events is significantly different between genders and between parents of 1 vs 2+ children

Car-use habit strength

Table 5.4 shows the car-use habit strength of respondents by gender and number of children. Overall, the average respondent would use the car to reach 6.7 out of 10 destinations included in the question designed to test habit strength. Statistically significant differences were apparent by gender and number of children. Females were more likely to have weaker car-use habits than males: $t(756) = 2.2, p=0.03$. Likewise, respondents with one child were likely to have weaker car-use habits than respondents with two or more children: $t(684) = -2.3, p=0.02$.

Table 5.4: Differences in car-use strength habit by gender, number of children and life events

	Gender*		Number of children*		Total
	Male	Female	1	2+	
Car-use habit strength (mean)	6.9	6.5	6.5	6.9	6.7

Note: *Differences significant at $p<0.05$

5.4.3 Effect of life event frequency on car-use habit strength

We conducted multiple linear regression analysis to understand, holding other factors constant, the extent to which destabilising and stabilising life events impact car-use habits. We also sought to understand the cumulative impact of multiple life events as well as the extent to which other factors included in the model influence car-use habit strength.

We used car-use habit strength as the dependent variable, measured on a scale of 0 to 10. As independent variables, we included a variable to test life event frequency, attitudinal factors and several individual and household characteristics, identified in previous research as factors influencing habit strength (Şimşekoğlu et al. 2015).

We ran two models. The first included a variable for the total number of life events. Life events included in this variable were: moving house, changing jobs, parental leave, moving in with a partner, separating from a partner, starting or stopping education and having a child. The second model also tested the effect of life events but distinguished between life events associated with weakening car-use habits (“Destabilising life events”) and life events associated with strengthening car-use habits (“Stabilising life events”), as reported in the previous section. Apart from these two variables, all other independent variables were the same between the two models.

Dummy variables were created for gender. Primary caregiver, licence and relationship statuses were also tested but were not significant and not included in the final models. Although previous studies have shown age can influence car-use habits, as most survey respondents were within the 30 to 39 age bracket, the age-range did not offer enough variation to include as a variable. Dummy variables created to test household characteristics were location, vehicle ownership and income. Finally, averages were obtained of the variables comprising the three attitudinal factors, outlined in Table 2. These were then included as continuous variables on a scale of 1 to 5.

In order to identify outliers in the dataset, we used the Mahalanobis distance and Cook’s distance. Three cases exceeded the recommended critical value for the Mahalanobis distance which takes into account the number of independent variables used in the regression analysis (Tabachnick 2014). These cases were reviewed and excluded from the regression analysis. All cases were within the acceptable value for Cook’s distance.

Table 5.5 presents the results of the regression analysis predicting car-use habit strength among the survey respondents. Both models are statistically significant, and the factors included accounted for 40% of the variability in car-use habit strength in Model 1 and 42% in Model 2.

Overall, household characteristics, including income, location and vehicle ownership, had the greatest effect on car-use habit strength. This was followed by attitudes, gender and life events.

Table 5.5: Regression analysis modelling car-use habit strength

Factor	Characteristic	Model 1: Total life events			Model 2: Destabilising and stabilising life events		
		B	SE	Beta	B	SE	Beta
Life events	(constant)	9.22	0.50		8.70	0.51	
	Total life events	-0.02	0.02	-0.02	n.a	n.a	n.a
	Destabilising life events	n.a	n.a	n.a	-0.08	0.03	-0.08
	Stabilising life events	n.a	n.a	n.a	0.28	0.10	0.09
Attitudes	Factor 1: Reduce car use	-0.63	0.10	-0.21	-0.62	0.10	-0.21
	Factor 2: Satisfaction with PT	-0.51	0.08	-0.21	-0.50	0.08	-0.20
	Factor 3: Car reliance	0.30	0.08	0.12	0.32	0.08	0.13
Household characteristics	Inner urban household	-1.35	0.22	-0.19	-1.34	0.22	-0.19
	Middle urban household (Ref)	-	-	-	-	-	-
	Outer urban household	0.69	0.16	0.14	0.66	0.16	0.13
	Low-income household	0.76	0.23	0.11	0.85	0.23	0.12
	Middle-income household	-	-	-	-	-	-
	High-income household	-0.77	0.15	-0.16	-0.70	0.15	-0.15
	Household with 0 or 1 vehicle	-0.90	0.17	-0.18	-0.80	0.17	-0.16
	Household with 2 vehicles (Ref)	-	-	-	-	-	-
Individual characteristics	Household with 3 or more vehicles	-0.12	0.27	-0.01	-0.06	0.26	-0.01
	Female	-0.31	0.14	-0.07	-0.31	0.14	-0.06
	Male (Ref)	-	-	-	-	-	-
Model summary		Adjusted R^2 = 0.40; $F(11, 686)=43.89$			Adjusted R^2 = 0.42; $F(12, 680)=42.13$		

Notes: Bolded values indicate significance at $p < 0.05$.

Life event frequency

Model 1 includes the total number of life events and model 2 includes the two variables distinguishing between life events associated with weakening (“Destabilising life events”) and

strengthening car-use habits (“Stabilising life events”). Experiencing a higher number of life events was not associated with weaker or stronger car-use habits.

As expected, the life events linked with stabilising car use habits (the number of children and moving in with a partner) were associated with strengthening car-use habits while destabilising life events were associated with weakening car-use habits. The stabilising life event variable comprises two life events: childbirth and moving in with a partner. That the number of children is associated with strengthening car-use habits may reflect that the life event of childbirth serves as a proxy for the complex set of changes to mobility that occur once a parent. Parental travel often becomes more complex due to accommodating a child’s travel needs as well as their own and, in turn, is likely to strengthen car use habits.

Taken together, these models suggest that simply increasing the number of life events is not enough to stabilise or destabilise car-use habits (at least among new parents). Rather, it depends on the type of life event experienced.

Attitudes

Respondents who attempted to reduce their car use due to environmental or cost reasons (Factor 1) were more likely to have weaker car use habits. Perhaps unsurprisingly, respondents who were more satisfied with public transit (Factor 2) were more likely to have weaker car-use habits. Conversely, respondents who had stronger car-reliant attitudes (Factor 3) were more likely to have stronger car use habits. This is aligned with previous research showing the effect of attitudes on car use habit strength (Şimşekoğlu et al. 2015). Those respondents who view public transit more favourably are likely to include it as a travel mode option. Whereas those respondents who show strong car-reliant attitudes are less likely to actively evaluate alternatives to the car for most trips.

It should be noted, however, that travel attitudes and behaviours have a bidirectional relationship, with behaviours tending to have a greater influence on attitudes than attitudes on behaviours (Kroesen et al. 2017). Respondents with a strong car-use habit are likely to use the car frequently. As such, frequent car use may influence more favourable attitudes towards the car. However, the opposite may also be the case with more favourable attitudes influencing more frequent car use.

Household characteristics

Unsurprisingly, respondents from households with zero or one vehicles were more likely to have weaker car-use habits than respondents from households with two or more vehicles. Similarly, respondents from households in inner urban areas were more likely to have weaker car use habits than respondents from households in outer urban areas. These differences could, in part, be explained by the greater range of transport choices available to households due to their residential location or financial circumstances. We were surprised that respondents from low-income households were more likely to have stronger car-use habits than their counterparts from high-income households, even when controlling for other factors. This contrasts with recent research from Norway showing that low-income is associated with weaker car-use habits (Şimşekoğlu et al. 2015). However, this may simply reflect the differing mobility contexts between urban Australia and urban Norway, as the former is considerably more car dependent (Hensher 1998). Moreover, low-income households are more likely to reside in the urban periphery where housing tends to be more affordable.

Individual characteristics

Male respondents were more likely to have stronger car-use habits than female respondents. This is in line with previous research showing that females tend to have weaker car-use habits (Matthies et al. 2002). However, the difference between genders in our present study is much smaller. A crucial difference of this study is that the female respondents are all parents within a specific age-cohort rather than from the general female adult population. As such, this group is likely to experience different constraints on their travel choices.

5.4.4 Discussion and policy implications

This analysis explored the factors influencing new parents' car-use habits, with a particular focus on understanding the role of multiple life events. It is worth noting that the effect of experiencing multiple life events may be somewhat muted because our sample does not include people who experienced no significant life events in the last five years. Further, we analysed the collective impact of life events assuming all life events had an equal influence on car-use habit strength. However, the correlation analysis in Table 5.1 suggests that certain life events are more disruptive to habits than other life events. Despite these limitations, given the exploratory nature of this study we believe the following conclusions are justified.

The cumulative impact of life events was not significantly associated with weaker or stronger car-use habits. It appears that experiencing a large number of life events is not enough to change car use habits; rather, it became clear that the type of life event played a key role. The effects of 'stabilising' or 'destabilising' life events did have a cumulative impact, which counteract each other if they are experienced together.

These findings suggest that life transitions comprising more than one of the destabilising life events (such as entering or retiring from the workforce) may provide a better opportunity to influence travel behaviour than individual life events (such as changing jobs). However, further research testing this hypothesis is required. This, in turn, will assist in an improved understanding of the optimum time in which to target travel behaviour change interventions.

In addition, regression models found that other factors, specifically attitudes, household income, location and car ownership, play a more critical role in influencing habits than life events. These factors are well-established as influencing car-use *behaviours* more generally, and so that they are also strong predictors of car-use habit is not surprising. However, given habitual behaviour is more resistant to change, this underscores the importance of measures aimed at preventing the growth of car ownership. This suggests several policy implications and areas of further research, discussed below.

5.4.4.1 Addressing car-use habits of outer urban residents

The strongest predictors of car use habit strength were household location and vehicle ownership status. Households with low vehicle ownership and households residing in inner urban areas were likely to have weaker car-use habits than their counterparts in middle or outer urban areas, or with two or more vehicles. This underscores the well-established finding that housing location and vehicle ownership are important determinants of car use habits and travel behaviour (Cervero and Kockelman 1997, Van Acker and Witlox 2010).

In Melbourne, as with many other cities experiencing rapid population growth, new housing developments tend to be in outer urban areas where greenfield sites exist. However, often public transit (and in some cases walking and cycling infrastructure) are implemented only *after* new residents have moved in. This suggests that public transit should be operational *prior* to residents moving in, to ensure that the opportunities presented by weakened travel habits are

capitalised upon. This, in turn, may assist to address the stronger car-use habits apparent in outer urban areas.

5.4.4.2 *Habitual car-use among low-income households*

Even when controlling for other factors, such as location and vehicle ownership, low-income households were more likely to have stronger car-use habits than high-income households. Interestingly, this finding differs from recent research examining car-use habits of urban Norwegians (Şimşekoğlu et al. 2015). However, this is likely attributable to spatial differences between the two case study locations and that, in Melbourne, low-income households tend to reside in outer urban areas where affordable housing is more widely available.

This finding presents concerning implications for low-income households. Habitual car-use is associated with negative health and economic outcomes (Dodson and Sipe 2008, Douglas et al. 2011, Beavis and Moodie 2014). Habitual car-users lose opportunities for incidental physical activity otherwise gained through walking, cycling or public transit. In addition, the financial stress incurred by running a motor vehicle is likely to be particularly burdensome for this group.

As it can be challenging to introduce transportation measures that would specifically assist low-income households, previous research examining this group in an Australian context has emphasised the importance of more general policies that aim to facilitate low-car lifestyles (Delbosc and Currie 2012). For example, improvements to cycling and public transit infrastructure may help this group to ease their reliance on the private car. Moreover, policies *encouraging* the use of alternate modes are preferred to policies *discouraging* car-use, such as pricing mechanisms, which may exacerbate financial pressures among these households (Delbosc and Currie 2012).

5.5 Conclusion

This chapter explored the factors influencing mobility changes following parenthood. The first part of the chapter, using the results of the qualitative interviews, highlighted that the first few years following the birth of a child is a period in which numerous changes can act to punctuate stable travel routines. Further, it became apparent that while a general pattern of increasing

car use and ownership was apparent among most participants, different mobility trajectories were evident. These ranged from those who had little change in their car dependent travel behaviour through to respondents from formerly carless households who experienced a dramatic rise in car use.

The next part of this Chapter (Section 5.3) examined the mobility trajectories from a quantitative perspective. Using the results from the online survey, a latent class analysis was conducted to quantify the size of each mobility trajectory. As with the qualitative mobility trajectories, a range of changes in mobility patterns were evident. The analysis highlighted the importance of caregiving and employment status, as well as car ownership changes, in determining the extent to which travel behaviour changes and car-based mobility is adopted. Further, each group displayed distinct characteristics and different constraints on their travel choices. Reflecting this, a range of targeted interventions specific to individual groups were suggested.

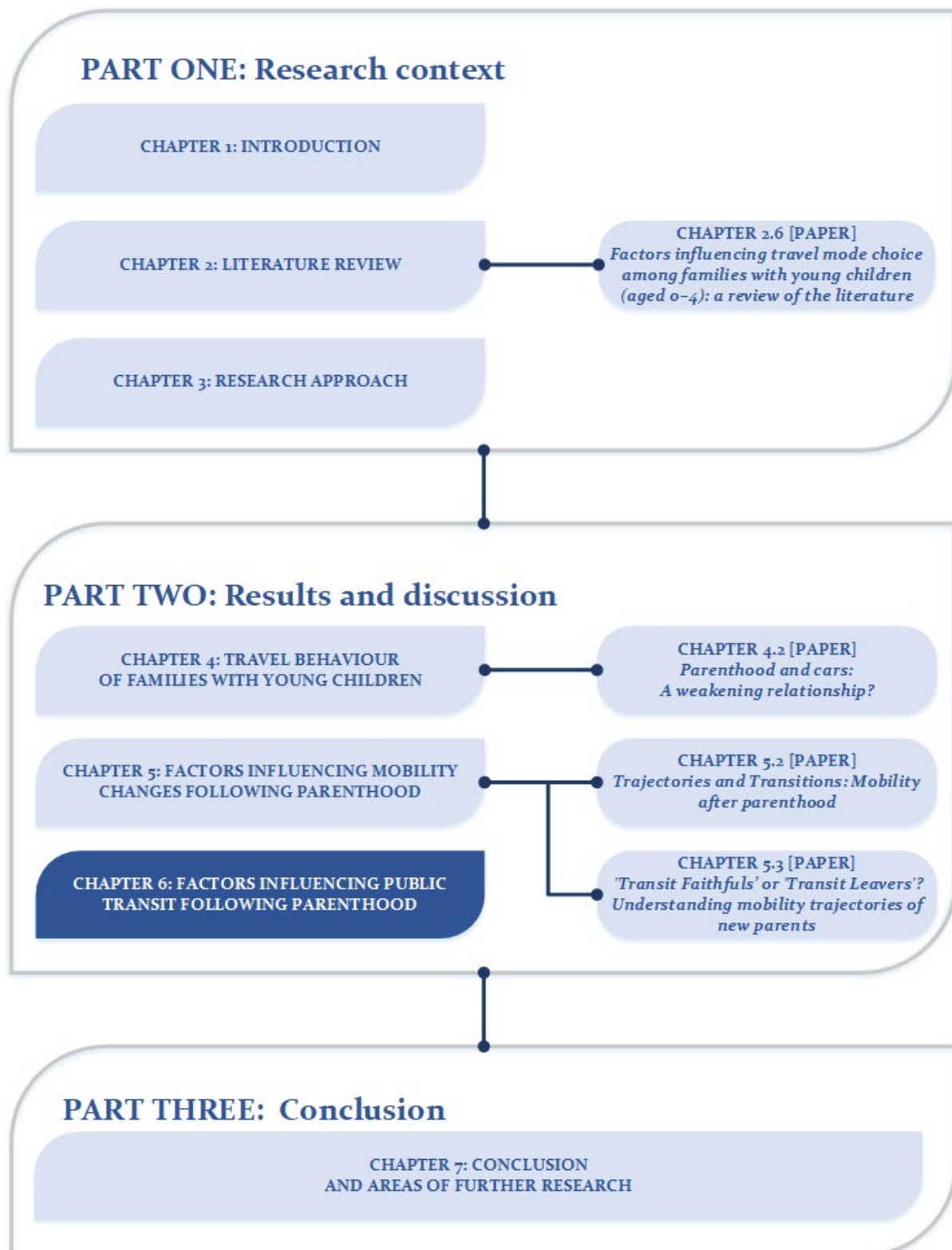
The final part of this Chapter (Section 5.4) explored the factors influencing car-use habits, including the role of life events, among new parents. It showed that weaker car-use habits are associated with a range of household characteristics, including higher household incomes and low car ownership. While the latent class analysis showed caregiving and employment statuses were crucial factors associated with travel *behaviour changes* following parenthood, these individual characteristics were not significant in influencing present car-use *habits*.

In addition, the analysis of car-use habits showed that (in combination with becoming a parent), some life events are associated with stabilising car-use habits while others have a destabilising effect. This suggests that there may be an optimum combination of destabilising life events that may weaken car-use habits and provide a wider window of opportunity in which to target travel behaviour interventions than during isolated events. However, further research is required to test this hypothesis. The next Chapter explores specifically the factors influencing public transit use following parenthood.

Chapter 6

Factors influencing public transit use following parenthood

Figure 6.1 Thesis structure



6.1 Introduction

Chapter 5 discussed the results regarding the factors which influence mobility changes following parenthood. This Chapter, drawing on the results from both the qualitative and quantitative research, focuses specifically on Research Question 3: What factors influence public transit use following parenthood? After firstly summarising the initial thesis findings regarding public transit use (Section 6.2), the results from the qualitative interviews with new parents are presented and a framework of factors influencing public transit use is introduced (Section 6.3). This builds on the framework introduced in Chapter 2, examining factors influencing travel mode choice among families with young children.

The second part of this Chapter (Section 6.4), presents the results from the online survey of new parents, the methods of which are detailed in Chapter 3. A major aim of the survey was to determine the extent to which different factors influence public transit use among new parents and how these differed by socio-demographic characteristics. After firstly outlining the results regarding the extent to which public transit use declined among participants, the factors influencing public transit use among participants are presented and discussed. The Chapter concludes with a summary of the major research findings.

6.2 Summary of thesis findings regarding public transit use decline

Chapter 2, the literature review, outlined the numerous studies that demonstrate first-time parenthood is associated with declining public transit use. This was further supported in Chapter 4, which showed a similar decline in public transit use in Melbourne, Australia, the study location. The household travel survey analysis, exploring differences in travel behaviour by life stage, showed that childless couples made on average 0.32 average daily trips per-person by public transit compared with 0.14 average daily trips per-person among families with young children (44% fewer trips).

Chapter 5.3, outlining different mobility trajectories following parenthood, showed that the group with the most pronounced decline in public transit were most likely to comprise primary caregivers, those working part-time, and females. A notable characteristic of the group with the next greatest decline in public transit use, the “Devoted Cyclists”, was that pre-parenthood nearly half of members resided in a carless household. This suggests the characteristics of employment and caregiving status, as well as increasing car ownership (specifically from zero

to one or more vehicles), are crucial in determining the extent to which public transit use declines following parenthood.

Overall, the interview findings support this earlier research that first-time parenthood is associated with a swift and notable decline in public transit use. Moreover, that first-time parenthood is a period in which car-based mobility behaviour is adopted, if it is not already. The breadth of factors that help explain declines in public transit use are described in the section that follows.

6.3 Factors influencing public transit use

Parents reported numerous factors which influence their public transit use, both when travelling with and without young children. Table 6.1 shows the factors grouped thematically into four categories: structural, psychosocial, household characteristics, and features of young children's travel. Structural factors include the built environment, public transit infrastructure, operations and policy, while psychosocial factors include social norms as well as attitudes and perceptions about public transit. Household characteristics include factors such as household car ownership and income while the final set of factors, child-related characteristics, include child-specific factors such as the age and temperament of the child. Table 6.1 builds on an earlier framework by McCarthy et al. (2017) examining factors influencing travel mode choice among this group.

The next part of this section explores each category of factors in greater depth. As this will demonstrate, the extent to which different factors shape parental mode choice depends on whether the travel occurs with or without young children. In particular, structural factors, such as lack of step-free access, will shape mode choices when travelling with and for young children. In contrast, household factors, such as income and car ownership, will tend to influence all members of the household, regardless of the amount of travel they do with their children.

Table 6.1: Factors influencing new parents' public transit use

Type	Factor	Child's age and influence on PT use					
		-0	0	1	2	3	4
Structural	Unable to obtain a priority seat	-	-	-	-	-	-
	Increasing distance of home or destination to nearest public transit service		-	-	-	-	-
	Unable to board crowded public transit with young children		-	-	-	-	-
	Infrequent services		-	-	-	-	-
	Travelling with a pram / stroller		-	-	-	-	-
	Childcare location close to home		+	+	+	+	+
	Lack of protection from weather		-	-	-	-	-
Psychosocial	Negative perceptions about public transit	-	-	-	-	-	-
	Perception public transit is unsafe	-	-	-	-	-	-
	Perception public transit is unsuitable for young children	-	-	-	-	-	-
	Anxiety about <i>ability</i> to board public transit with a pram	-	-	-	-	-	-
	Anxiety about potential disruption caused to other passengers	-	-	-	-	-	-
	Anxiety about disciplining or attending to a child in a public location		-	-	-	-	-
Household characteristics	Household member works in CBD	+	+	+	+	+	+
	Low income household	+	+	+	+	+	+
	Increasing car ownership	-	-	-	-	-	-
	Dual-earner household (time scarcity)		-	-	-	-	-
	Number of children in household		-	-	-	-	-
Child's characteristics	Need to structure travel around sleeping and feeding schedules		-	-	-	-	-
	Need for pram or additional luggage		-	-	-	-	-
	Ability to walk longer-distances				+	+	+
	Interest in public transit				+	+	+
	Child's personality "runner"				-	-	-
	Increase in extra-curricular activities					-	-

Note: Darker shading indicates that the influence is more pronounced at certain periods; "+" indicates a positive influence on public transit use whereas "-" indicates a negative influence.

Source: Authors analysis

Structural factors

Structural factors influencing public transit use first become apparent during pregnancy and tend to diminish as the child ages. These types of factors generally relate to features of the built environment, such as the distance to public transit services, accessibility of transit infrastructure, as well as operation and service levels. While all of these factors affect transit riders generally, as the participants illuminate below, these factors become heightened when travelling with young children.

Respondents who travelled by public transit for work during pregnancy all reported difficulties in obtaining a seat in the priority seating area. The vast majority of respondents were reluctant to request a seat, sometimes preferring to take a circuitous route and board at a quieter station.

“When I was pregnant I was always like waiting for people to offer... but I never liked to ask for the seat... People would kind of pretend they hadn't noticed that you are pregnant and just carry on looking at their iPhone.” [Mother of a 3-month-old and a 4 year-old_P9¹]

This was particularly challenging during the first trimester when they were less visibly pregnant:

“It was difficult because I was feeling really sick and there was a couple of times I nearly fainted on the tram because it was quite warm... And it was just really difficult because I couldn't ask anyone for a seat because I didn't want to tell anyone I was pregnant and it didn't look like I was pregnant so nobody would have offered me a seat anyway, so I found that the worst actually.” [Mother of a 8-month-old_P11]

Parents travelling with young children also experienced difficulties accessing priority seating. While during pregnancy most participants reported feeling reluctant to ask for a seat, participants tended to be more assertive and willing to ask for a seat when travelling with their young children. Nonetheless, the difficulty in obtaining a seat was often confounded by a lack of clarity about who has “priority” between those with mobility impairments and those travelling with young children, in an often contested space:

¹ Participants were assigned a number (e.g. “P13”) and a code which signified whether they were a mother or father and the age of their child or children. For example, “Father of a 3 year old_P13” signifies the participant was a father with one child aged 3 years, identified as participant 13.

“I don't know where the priority lies with the pram in the disability area. But usually, you go to where the wheelchair area is and they generally accommodate... We all just have to squish in the best we can.” [Mother of a 17-month-old_P15]

Parents identified a range of barriers with public transit infrastructure, particularly when travelling with a pram or pushchair. Most commonly this related to managing the gap between a train and platform as well as a lack of step-free access when boarding buses or trains.

Another factor deterring public transit use related to the infrequency of off-peak services. This barrier was exacerbated by the lengthier preparation time required when travelling with young children. As one participant described:

“They're [trains] just quite infrequent... leaving the house takes a bit of planning, so it is very difficult to adhere to a tight schedule and arrive at the train station at a specific time.” [Father of a 1-year-old and 3-year-old_P19]

Another commonly identified constraint related to using public transit during adverse weather conditions. As one parent explains:

“If it's pouring with rain and I think we need to get to the station and either drive and park the car and get out and then walk to the train.... I would just drive.” [Mother of 3-year-old_P12]

Clearly, numerous structural factors tend to discourage use of public transit use during pregnancy and when travelling with young children. While the impact of the factors tends to lessen as the child ages, factors such as infrequent off-peak services, continued to be a significant barrier to use.

Psychosocial factors

Psychosocial factors influencing public transit use tended to lessen as the child ages. Generally, new parents were more apprehensive about using public transit than parents of slightly older children. Once experience had been gained using public transit with their young children, this tended to lessen their anxiety towards future public transit trips. However, among participants, negative perceptions about public transit had a more enduring effect on their public transit use, regardless of their child's age.

Parents with positive public transit attitudes, often borne out of environmental views or a preference for a low-car lifestyle, were, unsurprisingly, more likely to use public transit with their children. These parents also generally held strong preferences regarding living in walkable neighbourhoods with good access to public transit networks. For some parents, prioritising a transit-rich location meant continuing to rent and forgoing or postponing home ownership; while for other parents it meant compromising on a smaller sized house to enable them to live in a more transit rich area. As one participant described:

“It is probably fair to say we made quite a considered decision to pay a bit for quite a small two bedroom so that we'd have close proximity to the city and lots of different options for transport and not being restricted to the car.” [Father of a 18-month-old_P22]

As well as particular housing preferences, these parents were also more likely to make modifications to the way they travel in order to continue using public transit with their children. For example, one participant described her response to an incident where platform lifts were out of order:

“No, [it didn't put me off using public transit], not really. More that I'd really consider whether I needed the pram or not. I'd try and take her in a carrier or something.” [Mother of a 3-year-old_P12]

In contrast, for other parents with comparatively neutral public transit attitudes, experiencing any difficulty using public transit was used as a reason to no longer use it. For example, one participant, after an experience of having to take an unplanned detour due to platform lifts being out of order, noted:

“We have a regular appointment at a certain place in the city and we were catching the train in and getting off at [a CBD station] and walking and now we haven't done it since, I've just driven in.” [Mother of a 1-year-old and 3-year-old_P13]

While parental attitudes and perceptions regarding public transit were more enduring, anxiety regarding public transit use was often more fleeting. For instance, several parents expressed anxiety about the ability to board certain public transit vehicles with a pram, particularly older style trams with step-only access. Typically, following the first trip on public transit, many of the concerns regarding their ability to board the public transit vehicle were alleviated. As one participant, describing his partner's first trip on a tram with their baby commented:

“...she was able to get the pram on, it fitted, and sort of instilled some confidence that okay, it does fit. And there were people there to help her.” [Father of a 4-month-old_P21]

However, a concern frequently mentioned by participants was the potential disruption that their child may cause to other passengers. While it did not always appear to deter parents from using public transit, the concern tended to persist, regardless of the frequency in which they travelled on public transit. As one participant describes:

“I think one of the things that [my partner] is concerned about and I suppose I am too, is if she gets really upset and you think about disrupting everyone on the train.” [Father of a 4-month-old_P8]

In contrast, other aspects of travel with very young children that were perceived as less socially acceptable, such as public breastfeeding, did inhibit the use of public transit. As one participant explains:

“...We would have taken the train previously. You know we've got a baby and it would have been hard on the train just because she may have needed feeding during the trip. Pulling your breast out on a train is somewhat not very well accepted by people. So we took the car.” [Father of a 4-month-old_P21]

Some parents expressed that they felt public transit is generally unsuitable for young children, while another participant felt that young children are not welcome on public transit:

“People aren't that helpful, they don't kind of jump to let you sit down, they kind of see you as an annoyance.” [Mother of 1 child aged 3 years_P16]

Several parents reported that they perceived public transit to be unsafe, particularly in certain areas, and that this was less tolerated when they travelled with their young children:

“There were a couple of instances where there's been like I guess you'd say disorderly people on board. I guess that also deterred me from catching them. Particularly, I mean, having the kids around.” [Mother of a 1-year-old and 3-year-old_P13]

In addition to a heightened sense of personal safety when travelling with young children, there was a greater perception that the network was physically unsafe. While the safety of the public transit network is a structural issue, the *perception* that the network is unsafe was a factor:

“Well it may have an advantage that I’m a stay at home husband and I may be stronger than the average housewife. So I kind of manage [boarding the older style tram with steps]. But, you know, I sort of fear that moment where you have to sprint to the tram with the kids, throw them in and then hope for the best.” [Father of a 1-year-old and 3-year-old_P19]

Overall, factors relating to the anxiety about travelling with their child on public transit tended to lessen as the child aged. Further, each public transit trip generally helped to build confidence and lessen the feelings of anxiety towards travel by this mode. Nonetheless, general attitudes and perceptions of public transit tended to be more enduring and continued to influence mode choice, regardless of the child’s age.

Household characteristics

Household characteristics that affect public transit use amongst the general population, such as car ownership and income, became even more crucial following the transition to parenthood as several participants from formerly carless households purchased a private car. Specific reasons provided for purchasing the car included: receiving strong advice from social networks about needing a car as a parent; expectations over changing travel needs and destinations; and, that the car provided immediate access to transport in an emergency. In addition, one respondent indicated that the decision was attributed to his partner’s concerns of feeling socially isolated without a car while on parental leave:

“[Discussing reasons for car purchase] I think she was concerned of feeling a bit isolated. Even where we are it’s great to go for public transit trips or a walk in the neighbourhood but to visit family who are a drive away ... we thought it was important to have the car.” [Father of a 18-month-old_P22]

Similarly, as the transition to parenthood often coincides with a reduced income due to managing new childcare responsibilities, for a minority of parents the decision to use public transit was propelled by their financial circumstances. For some low-income carless households, there was little choice but to use public transit:

“We don't have a car. So I live with the bus stop pretty much outside of my house. I live on a main road so I'm able to catch the bus to the main shops and then back again. And the train, we just catch public transit everywhere.” [Mother of a 17-month-old_P15]

Several working parents reported they thought extensively about whether to choose a childcare facility closer to their home or workplace. Generally, a facility close to their workplace is preferred but, due to the anticipated stress of travelling with a young child on public transit, a facility close to home is generally sought. This is often further complicated by finding a childcare facility with vacancies. Interviewees typically articulated the following sentiment:

“I think I would just hate to travel with my kids if it's during peak hour. That's why we decided not to go to a childcare in the city because the thought of having to bring him in a train or in a bus to the city... would be too stressful” [Mother of a 2-year-old_P10].

In contrast to working parents, stay-at-home parents were more likely to use public transit with their children. This was often in response to their child's growing interest in public transit, where trips on public transit were used as an activity in and of itself. With fewer constraints on their travel time they sought out longer journeys which they believed their children will enjoy. However, one interviewee appeared cognisant that this was only feasible for the period during which she was not in employment:

“If I was back at work I think I'd be a bit more time pressed and therefore you know, like, you wouldn't necessarily go out and do your public transport activities, you'd be like, well, you know, like you cut back on those sorts of things.” [Mother of a 1-year-old and 2-year-old_P18]

Overall, using public transit was thought to become easier as children became older, and in particular, when they no longer require a pram. However, for interviewees planning, or with, a second child, using public transit was generally perceived as not manageable with two young children.

Child's age and characteristics

The final category of factors influencing public transit use, a child's age and characteristics, included factors which both facilitated and discouraged the use of this mode. This category encompassed several anticipatable factors, such as the need for additional luggage when

travelling with young children being less conducive to travel by public transit, but also perhaps some unanticipated factors. For example, several participants stated that the personality of their child influenced their decision to use public transit with them. Specifically, parents with a child that they felt was unlikely to obediently accompany them were reluctant to use public transit. As one participant explained:

“I've got a toddler who likes to run around and would run away from me. And it's hard work when you're pushing a pram and you've got a toddler who is not going to stay by my side.” [Mother of a 3-month-old and 4-year-old_P9]

All participants with a pre-school age child commented on the desire expressed by their young children to travel by bus or train. Travelling by public transit was seen as a fun family outing and often an activity in and of itself. Interestingly, for one respondent, pressure from her children to travel by public transit was the prompt for her first trip on public transit in many years:

“For weeks the boys were saying can we go on a bus, can we go on the train... [Before that trip, the last time public transit was used] I would have to say was in the early 2000's” [Mother of a 3-year-old and 5-year-old_P6]

Despite this pull towards public transit, parents of preschool-age children also felt their car use would increase as their child began to participate in extracurricular activities, spread over greater distances. In order to accommodate these new activities within existing time constraints, the car tended to become the preferred travel mode.

6.3.1 Summary

Overall, the vast majority of factors across all categories tend to discourage public transit use and facilitate travel by private car. As the majority of factors discourage travel by public transit this invariably contributes to declining use. Nonetheless, as the previous chapter demonstrated, the extent of the decline varies by different demographic characteristics. This suggests that the extent to which different factors influence travel among new parents will vary. For instance, as primary caregivers' travel will typically include the majority of travel with, and for, their young children, the factors will likely shape their decision to use public transit more so than a secondary caregiver. The role of caregiving status and other characteristics influencing declining public transit use are explored in the next part of this section.

6.4 Quantifying changes in public transit use following parenthood

A wide body of literature has shown that the transition to parenthood coincides with a notable reduction in public transit use. This finding was reinforced by the qualitative interviews, which suggested public transit use declined particularly for non-work travel, for the primary caregiver and among formerly carless households. Using the results of the online survey, this section quantifies the extent to which public transit use declined among survey participants overall and by different socio-demographic characteristics.

In the online survey, two questions were asked regarding the frequency of mode use in the year before parenthood and currently. Transport modes included a car (driver or passenger); cycle; public transport; walking; and, other. The questions were worded as follows:

- “Currently, how often do you usually travel by the following transport modes?”
- “In the year before you became a parent, how often did you usually travel by the following transport modes?”

The results of these questions were converted from categorical to continuous variables. We assumed, on average, each day a mode was used that this equated to two trips. Where appropriate, the middle value was selected, as follows: (Practically) Everyday (7 days pw) = 730 trips annually (365 days); 4-6 days per week (5 days pw) = 520 trips annually (260 days); 1-3 days per week (2 days pw) = 208 trips annually (104 days); 1-3 days per month (2 days per month) = 48 trips annually (24 days); 6-11 days per year (8.5 days per year) = 17 trips annually (8.5 days); 1-5 days per year (3 days per year) = 6 trips annually (3 days); Less than one day a year (0.5 days per year) = 1 trip annually (0.5 day); Never = 0. Respondents that selected “don’t know” or “can’t recall” were excluded from the analysis².

² It should be noted that this approach is likely to slightly undercount vehicle trips. The household travel survey analysis, examining differences in mode-use by life stage, showed that respondents with young children made on average 2.37 daily vehicle trips per person. As we are interested in gauging the approximate changes in mode use following parenthood, and the undercount applies to both pre and post levels of mode use, we deemed this approach appropriate for our requirements.

Table 6.2 shows the mean annual change in mode use among participants, following parenthood. All changes are significant, ranging from between a -49% and 6% change annually. The greatest decline was observed in public transit trips, decreasing by 150 mean trips per year (49%). As a proportion, cycling trips also declined considerably, albeit from a much smaller starting point. Slight declines in walking were also apparent. The only mode to observe an increase was travel by car, increasing on average by 35 trips (6%) per year.

The mode-use changes among the online survey participants were quite similar to that observed in the household travel survey analysis described in Chapter 4. The household travel survey analysis, examining changes in mode use by life stage, showed that compared with couple households without children, families with children aged four years or younger had approximately half as many public transit trips per-person (56%) and a slightly higher frequency of vehicle trips (7%), while per-person walking rates were marginally less. Given the low rates of cycling among respondents of the household travel survey, this mode was not included in the life stage analysis.

Table 6.2: Mean annual change in mode use following parenthood

Mode	Mean annual trips (SD)			Statistical test
	Pre-parenthood	Current	Change in mean annual trips (% change)	
Car (driver or passenger)	581 (239)	615 (198)	35 (+6%)	$t(901) = -4.5, p=0.00^*$
Public transit	242 (286)	123 (208)	-119 (-49%)	$t(891) = 13.3, p=0.00^*$
Cycling	78 (208)	46 (176)	-32 (-41%)	$t(863) = 6.0, p=0.00^*$
Walking	381 (290)	359 (282)	-22 (-6%)	$t(889) = 2.6, p=0.00^*$

Notes: Weighted by gender (see Chapter 3 for weighting method).

Table 6.3 shows the results of paired samples t-tests comparing changes in pre and post parenthood public transit use by gender, employment status, caregiving status and pre-parenthood car ownership levels. All changes in public transit use are significant at $p<0.05$. Just under 6% of survey participants resided in a carless household one year before becoming a parent for the first time. Of the characteristics examined, this group had the highest rates of preparenthood public transit use as well as the greatest decline in mean annual trips (301 mean annual trips). While the majority (85%) of these households now reside in a household with at

least one vehicle, this group includes a small proportion who remain in a carless household (15%) and a large proportion residing in a single-vehicle household (65%). These characteristics can help explain the current comparatively high rates of public transit use.

Interestingly, female participants used public transit with greater frequency before parenthood than male participants. Despite this, the decline is greatest among female participants, with annual trips declining by nearly two thirds (62%) compared to a decline of approximately one third (32%) for males. The vast majority of female participants (85%) were likely to be the primary caregiver (compared to 16% of male participants). Primary caregivers' annual public transit use declined by over two-thirds (67%). This finding underscores the importance of caregiving status, rather than necessarily gender, in determining the extent to which public transit use declines following parenthood.

Table 6.3: Mean annual change in public transit trips by selected characteristics

Characteristic	Variable	Mean annual trips		Change in mean annual trips (% change)
		Pre parenthood	Current	
Gender	Male	217	146	70 (-32%)
	Female	266	100	166 (-62%)
Caregiving status	Primary	256	84	172 (-67%)
	Non-primary	229	161	68 (-30%)
Household pre-parenthood car ownership	No vehicle	520	219	301 (-58%)
	At least one vehicle	222	117	106 (-48%)
Employment status	Full-time	232	167	65 (-28%)
	Part-time	254	96	158 (-62%)
	Other (Stay-at-home parent; unemployed; retired; student)	247	69	178 (-72%)

Notes: Weighted by gender (see Chapter 3 for weighting method), bolded values indicate significant at $p < 0.05$.

6.4.1 Relative importance of factors influencing public transit use

The final part of this Chapter outlines the factors influencing public transit use among families with children and how this varies by demographic characteristics (RQ3). As part of the online survey, respondents were asked to assess the perceived importance of eight barriers to public transit use on a scale of 1 ("Not at all important") to 5 ("Extremely important"). This aimed to

test the relative importance of the four categories of barriers (structural, psychosocial, household and child-related) outlined in the framework of factors influencing public transit use, introduced in section 6.3. Not all of the barriers were tested due to limits in the survey length.

Overall, as shown in Table 6.4, the most important categories were household and child-related factors. The two factors rated with the highest importance relate to practicalities surrounding travel, such as the time available or the amount of equipment being carried. The factor rated with the least importance was “concern my child may disrupt other passengers”. However, more importance was placed on the other factor included to test the importance of psychosocial factors: “Other passengers are welcoming”.

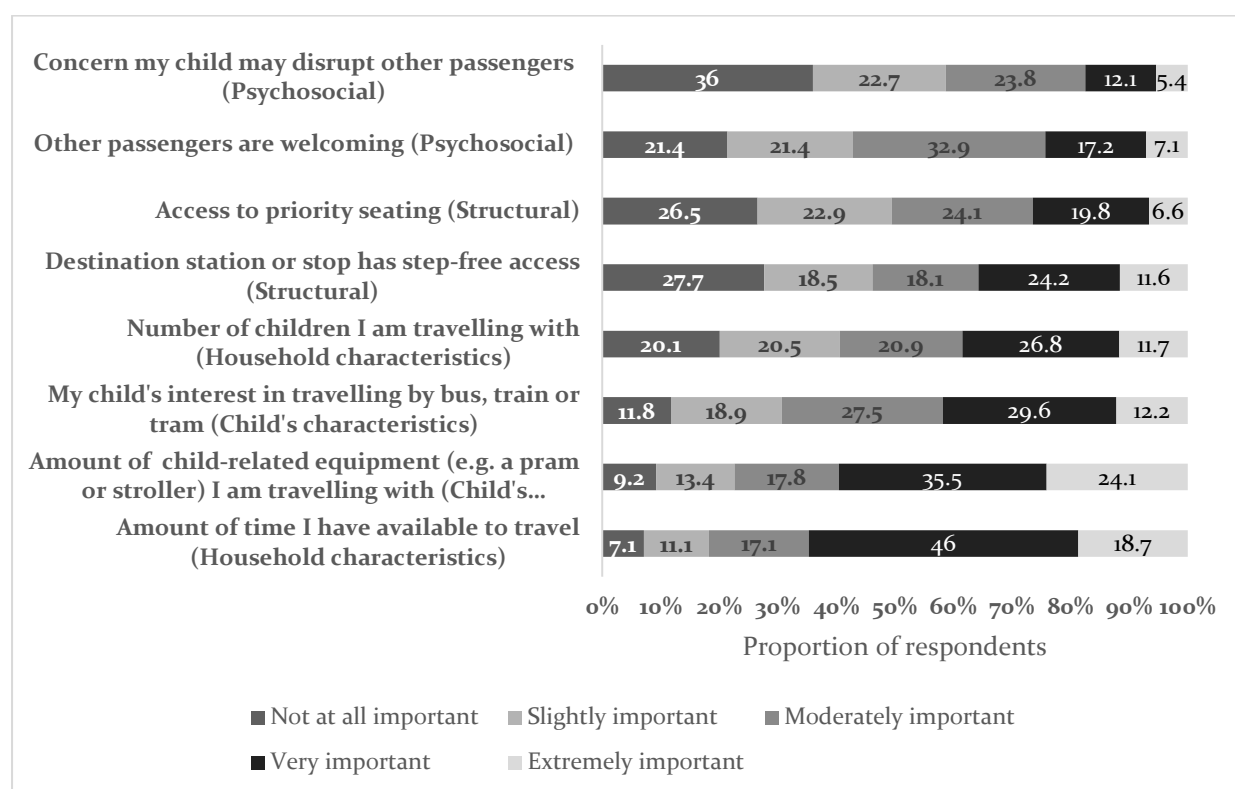
Figure 6.2 presents the same results as Table 6.4 but shows the proportion of responses in each category. Factors that had the highest and lowest mean scores tended to elicit more responses at the highest and lowest end of the scale. For instance, over a third of respondents (36%) regarded “concern my child may disrupt other passengers” as “Not at all important”. Conversely, the two factors regarded with the highest importance, amount of time available to travel and amount of child-related equipment being carried, had the greatest number of respondents evaluating as “extremely important” (19% and 24%, respectively).

Table 6.4: Factors influencing public transit

Category	Factor	N	Mean	SD
Structural	Access to priority seating	866	2.6	1.25
	Destination station or stop has step-free access	860	2.7	1.39
Psychosocial	Concern my child may disrupt other passengers	867	2.3	1.22
	Other passengers are welcoming	855	2.7	1.19
Household characteristics	Number of children I am travelling with	851	2.9	1.32
	Amount of time I have available to travel	859	3.6	1.13
Child-related characteristics	Amount of child-related equipment I am travelling with	868	3.5	1.25
	My child's interest in travelling by bus, train or tram	854	3.1	1.20

Notes: Weighted by gender (see Chapter 3 for weighting method). Mean scores are calculated based on a scale of 1 (“Not at all important”) to 5 (“Extremely important”).

Figure 6.2: Importance of factors influencing public transit use



Notes: Weighted by gender (see Chapter 3 for weighting method); excludes respondents who selected “don’t know/can’t say”.

Source: Online survey data

Table 6.5 shows differences in factors influencing public transit use by gender, frequency of public transit use with children, household size and location. The most notable differences are by gender. Overall, female participants rated all factors influencing public transit as more important than males, although not all differences were statistically significant.

Statistically significant differences were also apparent between frequent and infrequent public transit users, and also by the number of children in the household. For instance, respondents with a single-child were more likely to score factors influencing public transit use as more important than respondents with three or more children.

Interestingly, there were two statistically significant differences in factors influencing public transit use by household location. Outer Melbourne households were more likely to place a higher importance on the psychosocial factor “Concern my child may disrupt other passengers”

(Inner Melbourne M=2.0, Outer Melbourne M=2.5) and less importance on the structural factor “Destination station or stop has step-free access” (Inner Melbourne M=3.1, Outer Melbourne M=2.6) than their Inner Melbourne counterparts.

Several reasons are likely to explain the variation in scores by geographic area. Different public transit modes operate in the respective areas; outer Melbourne tends to be serviced by buses while Inner Melbourne is more widely serviced by trains and trams. These differences may influence factors such as the importance placed on step-free access or concern about disrupting other passengers. Moreover, respondents in Outer Melbourne are likely to have longer journey times than those in Inner Melbourne. Longer journey times may create more anxiety for the parent as there is an increased opportunity for the child to disrupt other passengers. Furthermore, the variation could also be attributed to the frequency with which public transit is used. Inner Melbourne respondents tend to use public transit with greater frequency than their counterparts in Outer Melbourne. The greater frequency is likely to create more familiarity with, and opportunities to encounter, barriers to use.

Table 6.5: Factors influencing public transit use by gender, frequency, number of children and location

		Gender		Uses PT at least monthly with children		No. of children			Location		
		M	F	No	Yes	1	2	3+	Inn	Mid	Out
Structural	Access to priority seating	2.4	2.7	2.5	2.7	2.7	2.6	2.4	2.8	2.6	2.6
	Destination station or stop has step-free access	2.4	3.0	2.6	3.1	2.9	2.7	2.3	3.1	2.8	2.6
Psychosocial	Concern my child may disrupt other passengers	2.3	2.3	2.3	2.2	2.3	2.2	2.3	2.0	2.2	2.5
	Other passengers are welcoming	2.7	2.7	2.7	2.6	2.8	2.6	2.5	2.5	2.7	2.7
Household characteristics	Number of children I am travelling with	2.8	3.0	3.0	2.7	2.9	2.9	3	2.7	3	2.9
	Amount of time I have available to travel	3.4	3.8	3.6	3.5	3.7	3.5	3.4	3.6	3.6	3.6
Child-related characteristics	Amount of child-related equipment I am travelling with	3.3	3.7	3.6	3.4	3.6	3.4	3.3	3.7	3.5	3.5
	My child's interest in travelling by bus, train or tram	3.1	3.2	3.1	3.1	3.0	3.2	3.1	3.0	3.1	3.1

Notes: Weighted by gender (see Chapter 3 for weighting method), bolded values indicate significant at $p < 0.05$. Mean scores are calculated based on a scale of 1 ("Not at all important") to 5 ("Extremely important").

6.5 Conclusion

This Chapter described the results from the qualitative and quantitative research regarding factors influencing new parents' public transit use. The online survey showed the extent to which public transit use decline following parenthood. On average, the number of annual public transit trips declined by approximately half (49%) among participants. This finding supports earlier research that shows public transit used declines following first-time parenthood, both within the car-dominated location of Melbourne, Australia (Chapter 4) and as highlighted in several international studies, primarily from Europe (Chapter 2).

Nonetheless, the extent of the decline in public transit use varied among the online survey participants. The decline was greatest among participants who resided in a carless household pre-parenthood, females, primary caregivers and those not in full-time employment. The decline in public transit use among participants from formerly carless households is likely to be the result of the purchase of a vehicle, prompting a change to more car-based mobility following parenthood. Other characteristics associated with a decline in public transit use (gender, employment and caregiving status) were typically clustered together. As female respondents were overwhelmingly more likely to be the primary caregiver and engaged in part-time employment, this suggests that caregiving status performs a crucial role in mediating the extent to which public transit use declines following parenthood.

A framework of factors influencing public transit use among new parents was introduced. The framework synthesised the numerous factors which, overall, tended to discourage public transit use among this group. The framework, building on an earlier framework introduced in Chapter 2, grouped the factors into four categories: structural (built environment, public transit infrastructure, operations and policy), psychosocial (social norms, travel attitudes), household characteristics, and features of young children's travel.

Typically, psychosocial factors were more important before the birth of the child, structural factors were of most importance during the very early years, while practical considerations underlying the household and child-related characteristics became more important as the child aged. Overall, while the vast majority of factors tended to "push" new parents away from public

transit, a minority of factors, such as a child's interest in public transit, acted to "pull" new parents to public transit.

While most of the factors identified by participants use were somewhat predictable, and echo findings from recent literature examining parental mobilities (Boyer and Spinney 2016, McLaren 2018), some new factors emerged. For instance, some parents commented on the personality traits of their children shaping their travel mode choices. Those with a less obedient child were fearful they may 'run-off'. Typically, driving became the preferred mode as this enabled the child's movement to be restricted.

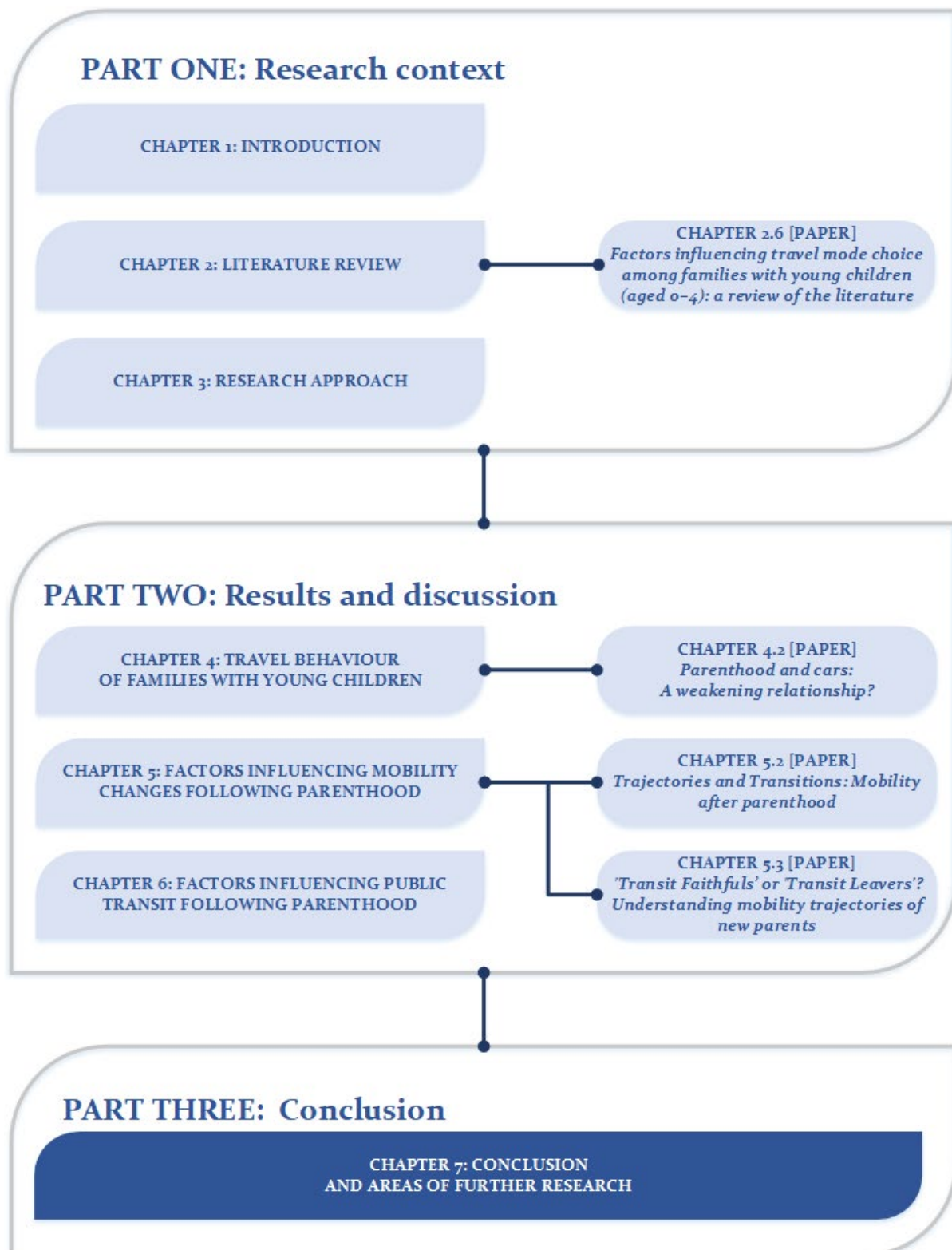
The online survey tested the relative importance of these factors, showing that while all categories were important, household and child-related characteristics were the two most important categories influencing new parents' decision to travel by public transit. These highly practical considerations underscore the importance of public transit infrastructure changes that improve accessibility and network connectivity. Overall, the findings suggest a range of policy implications, which will be discussed in the following Chapter.

PART THREE:

Conclusion

Chapter 7 Conclusion and areas of further research

Figure 7.1: Thesis structure



7.1 Introduction

This thesis explores why mobility changes, and specifically, why public transit use declines, following parenthood. This final Chapter summarises the major findings of this thesis and its contributions to knowledge. It outlines how the research questions have been addressed. It then goes on to discuss the policy implications, limitations of the research approach and areas of further research.

7.2 Summary of key findings

This research explores why public transit use declines following parenthood. As described in Chapter 1, the following three research questions and three research objectives were developed in order to address this overall aim:

- **RQ1:** What is the **context** of travel behaviour change following parenthood in Melbourne, Australia?
- **RQ2:** What factors influence **mobility changes** following parenthood?
 - RO2a: To understand different **mobility trajectories** following parenthood
 - RO2b: To **quantify** each mobility trajectory and identify differences in the attitudes and **socio-demographic characteristics** between each mobility trajectory
 - RO2c: To understand factors influencing **new parents' car-use habits**
- **RQ3:** What factors influence **public transit use** following parenthood?

Table 7.1 presents the research questions, substantive research findings and major contributions to knowledge.

Table 7.1: Summary of major research findings and contributions

Chapter	Major research findings	Contributions
RQ1: What is the context of travel behaviour change following parenthood in Melbourne, Australia? (Chapter 4)	• On average, car use and ownership increases following parenthood in Melbourne, Australia • Between 2007 and 2014 vehicle trips declined slightly among families with young and school-age children in Melbourne, Australia • Vehicle ownership, housing location, household income are associated with differences in vehicle trips among families with young children.	• An understanding of travel behaviour changes following parenthood in an auto-orientated context
RQ2: What factors influence mobility changes following parenthood? (Chapter 5)	• Travel behaviour changes during this period are prompted by both major life events and minor, often child-led, milestones • While overall increasing car-orientated travel behaviour is evident following parenthood, a diverse range of mobility trajectories are apparent. These range from a minimal change in travel behaviour to a dramatic decline in public transit use. • Caregiving and employment status, as well as car ownership changes, are shown to be crucial in determining the extent to which travel behaviour changes and car-based mobility is adopted. • Pro-environmental attitudes are shown to mediate the extent to which car-based mobility is adopted following parenthood. • While experiencing a large number of life events is not associated with weaker or stronger car-use habits, the effects of 'stabilising' or 'destabilising' life events did have a cumulative impact, which counteracts each other if they are experienced together.	• Builds an understanding of the heterogeneity of travel behaviour changes following parenthood • Identifies attitudes and characteristics associated with new parents who adopt or retain more sustainable travel behaviour • Builds an understanding of factors influencing new parents' car-use habits • Builds an understanding of the association between car-use habits changes and life events
RQ3: What factors influence public transit use following parenthood? (Chapter 6)	• A range of structural, psychosocial, household and child-related barriers deter public transit use among households with children. • While all factors were important, household and child-related characteristics were the two most important categories influencing new parents' choice to travel by public transit.	• Introduces a framework of factors influencing public transit among families with young children • Provides empirical evidence to explain why public transit use declines during the transition to parenthood

7.2.1 Context of travel behaviour change following parenthood in Melbourne, Australia

Consistent with the international literature on this topic, this analysis demonstrated that in Australia, a pattern of increasing car use and ownership following parenthood is apparent, albeit from a relatively high level of pre-parenthood car use (Chapter 4). Moreover, the analysis highlighted a promising early finding; car use among families with children, both young and school-age, declined between 2007 and 2013/14. Interestingly, this decline occurred against a backdrop of a larger proportion of families living in car dependent outer suburban areas.

7.2.2 Factors influencing travel behaviour changes following parenthood

Mobility trajectories

This thesis demonstrated that a diverse range of mobility trajectories following parenthood are evident, challenging the widely held assumption that car-based mobility behaviour is universally adopted during this life change. The qualitative interviews (Chapter 5) revealed five distinct trajectories which ranged from very little change in travel behaviour (*Continual Car Dependents*) through to formerly carless households undergoing dramatic changes to their travel behaviour. The online survey (Chapter 5) used a quantitative Latent Class Analysis to estimate mobility trajectories. The two methods demonstrated subtle differences in the trajectories as depicted in Table 7.2. A notably absent group among the online survey respondents was the smallest group of interview participants, the *Involuntarily Carless* group, who due to extreme financial circumstances, forgo car ownership. Among the qualitative interview participants, there was no equivalent group to the *Committed Multimodals*.

Table 7.2: Differences between qualitative and quantitative mobility trajectories

Mobility trajectories		Commentary
Qualitative interview group	Online survey group (% of respondents)	
Former PT Commuters	Transit Leavers (39%)	- The defining mobility change among both groups is a notable decline in public transit use. - Among both groups, participants were more likely to be female, the primary caregiver and not in full-time employment
Continual dependents car	Consistent Drivers (25)	Participants of both groups were frequent car drivers both prior and following parenthood and experienced minimal travel mode changes following parenthood.
-	Committed Multimodals (17%)	- Accounted for 17% of survey respondents - Males were underrepresented in the qualitative interviews but comprised 82% of the Committed Multimodals online survey group. This may explain why an equivalent group was not apparent among the qualitative interview participants.
PT Commuters	Transit Faithfuls (11%)	- Both groups continued to use public transit following parenthood - Among both groups, participants were more likely to be male, the non-primary caregiver and in full-time employment
Formerly Carless	Devoted Cyclists (8%)	Among the qualitative interview group, the defining transport characteristic was that they were from formerly carless households pre-parenthood. Similarly, in addition to maintaining cycling frequency, over half of the “Devoted Cyclists” were from a carless household pre-parenthood but this dropped to less than 1% following parenthood.
Involuntarily Carless	-	This was the smallest group of interview participants and is likely to represent only a minority of transport users among the general population. As such, this is likely to explain why there is not an equivalent group among the online survey participants.

Characteristics associated with travel mode changes

The results from the qualitative interviews and online survey demonstrated the importance of caregiving status, changes in household car ownership and attitudes in determining the extent to which travel behaviour changes following parenthood. In particular, Chapter 5 (Section 3) showed that the most notable decline in public transit use was among the so-called ‘Transit

Leavers' who were considerably more likely to be female, the primary caregiver and not in full-time employment. In contrast, the 'Transit Faithfuls', who were significantly more likely to be male, employed full-time and *not* the primary caregiver, experienced only marginal changes in public transit use.

The qualitative interviews helped to contextualise these findings. While traditionally females tend to adopt the primary caregiver role, three male participants of the qualitative interviews were primary caregivers. Primary caregiving participants, regardless of gender, were more likely to experience notable changes to their travel patterns compared with their non-primary caregiving partner. This finding underscores the crucial role of caregiving status, rather than necessarily gender, in determining the extent to which travel patterns change and car dependent behaviour is adopted, following the birth of a child.

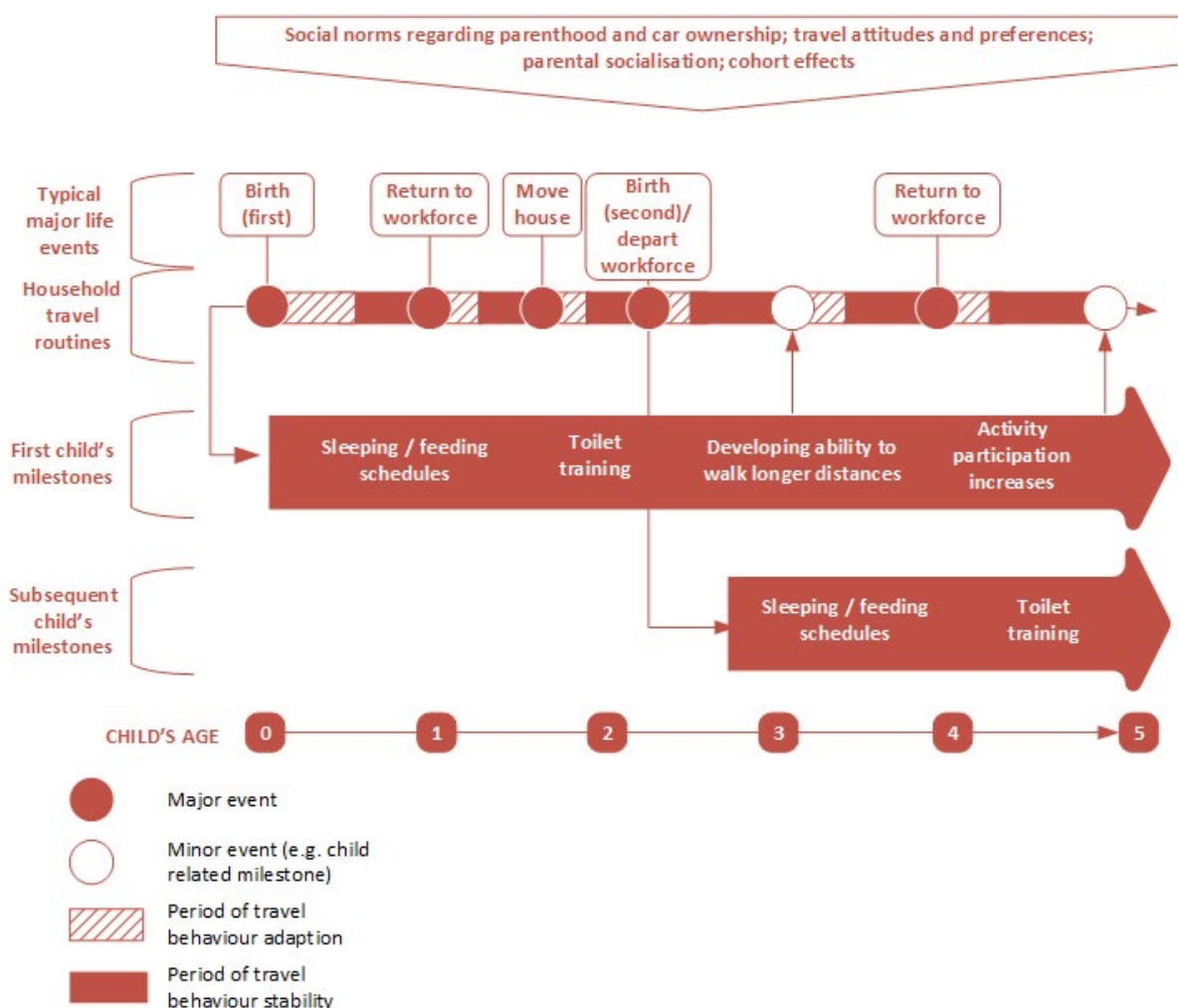
Attitudes and car ownership are well established as important determinants of car-based mobility (Dargay 2001, Van Acker et al. 2014). This finding was reflected in the qualitative interviews and online survey analysis. Qualitative interview participants from formerly carless households were likely to experience a significant change in their travel behaviour while participants with strong pro-environmental attitudes took steps to mediate the extent to which car-dependent travel behaviour is adopted post-parenthood. This is exemplified in the 'Devoted Cyclist' group identified in the latent class analysis. Members of the 'Devoted Cyclists' had the most notable increase in household car ownership following parenthood and also held the strongest pro-environmental attitudes. While car-use did increase among this group (likely due to the growth in household car ownership), their car-use was the lowest of all groups. This suggests that pro-environmental attitudes can play an important role in mediating the extent to which car-based mobility is adopted following parenthood. It should be noted, however, that this group accounted for just 8% of survey respondents. As such, they are only likely to reflect the motivations of only a minority of the general population.

Factors influencing car-use habits among new parents

A foundation of the mobility biographies approach is the notion that life events disrupt habits and stable travel behaviour. The qualitative interviews with new parents (Chapter 5) demonstrated that households following parenthood experience frequent disruptions to habitual travel behaviour with relatively short periods of stability. Moreover, participants not only reported numerous major life events potentially prompting travel behaviour changes but

also more subtle child-led mobility milestones. These findings lead to a new conceptualisation of how life events related to parenthood can influence travel behaviour (Figure 7.2).

Figure 7.2: Interaction between life events, child's travel needs and changes in household travel behaviour



Source: Adapted by the author from Müggengurg et al. (2015) based on research findings

The constant change and only brief interludes of stability suggest that car-use habits may be weaker during this period. Surprisingly, however, the online survey (Chapter 5) demonstrated that experiencing a high number of life events did not have a significant effect on car-use habit strength. Instead, the results suggest that the *type* of life event plays a crucial role. The effects of 'stabilising' or 'destabilising' life events had a cumulative impact on strengthening and weakening car-use habits, respectively. When these events are experienced together the effects are counteracted.

Overall, the strongest predictors of car use habit among new parents were attitudes, location and income. Respondents with less car reliant attitudes, attitudes more favourable to public transit and attitudes aligned with reducing car use were likely to have weaker car-use habits. Likewise, respondents from inner-city and high-income households were likely to have weaker car-use habits than their counterparts in outer-urban and low-income households.

7.2.3 Factors influencing public transit use following parenthood

Chapter 6 outlined the findings relating to declining public transit use following parenthood. Among online survey participants, annual public transit trips declined by nearly half (49%). This decline is aligned with earlier research findings that show first-time parenthood is associated with a decline in public transit use (Scheiner and Holz-Rau 2007). Nonetheless, the extent to which public transit use declined varied significantly by a range of characteristics. The decline was greatest among females, primary caregivers and respondents not in full-time employment. These characteristics tended to be clustered together (females were considerably more likely to be primary caregivers and not employed full-time) and were the dominant characteristics associated with the “*Transit Leavers*”, the mobility trajectory discussed in Chapter 5 (Section 3) with the greatest decline in public transit use.

The interviews revealed that a range of factors influence public transit use among households with children, and, overall, these factors tend to discourage travel by this mode. Building on the framework of factors influencing travel mode choice introduced in Chapter 2, these factors were grouped into four categories: structural, psychosocial, household characteristics and child’s characteristics. The online survey revealed that, while all factors were important, household and child-related characteristics were the two most important categories influencing new parents’ choice to travel by public transit.

7.3 Research limitations

Several limitations have been identified with the research undertaken as part of this thesis. Some limitations related to the recruitment methods used for the qualitative interviews and the online survey, sample limitations, survey content limitations and the geographical context in which the research was conducted.

Given the focus of this research, examining changes in travel behaviour during a life transition, a notable limitation is the reliance on cross-sectional data. Without the time limitations inherent in a PhD project, a panel study, interviewing the same participants over several years, would be the preferred method by which to collect data. As this was not feasible within the time constraints of this PhD, we instead employed retrospective questioning in the primary research methods – the qualitative interviews and the online survey. A limitation of deploying retrospective questioning is that it may introduce ‘recall error’. Certain life events are likely to be more memorable than others. For instance, the birth of a child is likely to be more easily recalled than an employment change. As a result, there may be a slight undercounting of less memorable events.

The methods used to recruit interview participants, referral and convenience sampling, are open to various potential biases. As a result, the sample is likely to differ from the general population in ways that are not directly measurable. For instance, respondents may be more likely to have an interest in transportation issues than the general population. Given the limited time and resources available to recruit participants, these methods were deemed appropriate. However, it is noted that among interview participants males, younger age-groups and low-income earners were underrepresented.

A challenge in designing the online survey was ensuring the survey length was kept to a minimum while permitting the capture of sufficiently rich data relating to life events. Ideally, understanding not only the *type* and *frequency* of life event but the *change* in travel behaviour as a result of the life event and *timeframe* that it occurred would have been useful. This would have allowed us to understand which life events are associated with an increase, or decrease, in mode-use. Moreover, it would have allowed us to determine how the recency of a life event influences car-use habits. For instance, we do not know whether a life event experienced six months prior has a similar effect on car-use habit strength as a life event experienced one month prior. However, as previous surveys in this field have had problems with completion rates, we decided to limit the survey to capture a select range of life events relevant to this group and the number of times the life events occurred.

A final limitation regards the location in which the study was conducted. Melbourne, Australia has certain characteristics, such as a low-density urban form and auto-orientated transport system, which differ from other localities. While this study fulfils an important research gap, as no studies have examined this transition in an auto-orientated context, a limitation is that it may lack relevance in other contexts. Nonetheless, the literature search revealed that the birth of the first child is a major life event prompting significant changes in travel behaviour among a range of different localities. Given this, the findings are likely to have broader geographical relevance.

7.4 Policy implications

This section presents a summary of suggested policy implications relevant to each of the three research questions discussed in Chapters 4, 5 and 6.

7.4.1 Encouraging more sustainable travel behaviour

As this thesis has demonstrated, overall, car-use and ownership are shown to increase following parenthood. This finding echoes an extensive body of previous research showing that parenthood is associated with the adoption of car dependent travel behaviour (Ryley 2006, Scheiner and Holz-Rau 2013, Oakil et al. 2016). While a range of different mobility trajectories were observed, and it was suggested that specific policy interventions are necessary for each group, several general policy findings have also been discussed. This thesis emphasised the significant role of vehicle ownership and housing location in influencing mode use among families with young children. The introduction of different housing and transportation policies could help curb the tendency towards increasing car use and ownership following parenthood.

In many Western cities, families with children are increasingly choosing apartment-style living (Carroll et al. 2011). For instance, in Australia, the proportion of children residing in apartments is gradually rising with 9% of children aged 0-4 years presently living in this type of dwelling. This growth suggests that there is an increasing demand for family-style apartments. However, in Melbourne, as in other car dominated locations, the greatest supply of affordable family-friendly housing tends to be located in the urban periphery with poor access to public transit and walking networks. In contrast, newer higher density developments in transit-rich areas typically cater to smaller childless household units (Whitzman and Mizrachi 2012).

Transportation factors, such as shorter commute times and less car reliance, are among the key motivators of apartment living identified by families with children (Carroll et al. 2011, Warner and Andrews 2019). However, research examining the experiences of families with children living in high-density environments has highlighted the many ways in which this style of housing does not meet the needs of this group. Commonly identified issues with apartment living among this group include poorly designed dwellings, limited indoor and outdoor play areas as well as limited opportunities to form meaningful social connections with neighbours (Carroll et al. 2011, Warner and Andrews 2019). Increasing the supply of family-friendly housing in transit-rich neighbours that adequately meets the needs of this group, would provide families with more housing choices. This, in turn, would provide this group with viable alternatives to suburbanising during this life stage.

Moreover, while this thesis demonstrated that parents do have a strong need for *access* to a vehicle, this is not necessarily achieved through conventional means of private vehicle ownership. For instance, qualitative interview participants from carless households were able to meet their car-based travel needs by accessing a vehicle through either informal or commercial car-sharing networks. Acquiring a car is often seen as a luxury but soon becomes a necessity thus making a return to a carless state unlikely (Dargay 2001, 809). Given this, encouraging carless households to remain carless following parenthood is likely to be instrumental in curbing long-term car-based mobility.

Alternatives to conventional car use and ownership, such as car-sharing and electric bikes, can provide a sustainable alternative for longer trips, which would otherwise be by private vehicle, for families with children (Thomas 2016, Dowling and Maalsen 2019). However, as well as mode specific barriers (such as lack of parking infrastructure to accommodate the larger width characteristic of cargo bikes (Thomas 2016)) often these alternatives are concentrated in dense, inner-city locations that also comprise good quality cycling and public transit infrastructure (Dowling and Maalsen 2019). To enable more widespread uptake of these alternatives, increasing the access and availability into suburban localities will be critical for these modes to shift from a niche to mainstream mode among this group.

7.4.2 Implications of declining public transit ridership

As discussed in Chapter 5, new parents forgoing public transit poses significant implications for overall public transit ridership. On average, online survey respondents' public transit use declined by nearly half (49%). This supports earlier research showing the significant decline in public transit ridership during this life stage (Zwerts et al. 2007, Scheiner and Holz-Rau 2013). Moreover, it represents a significant loss of loyal public transit ridership, at least in the medium term. Given a wide body of research demonstrating the difficulties of obtaining new riders, this is likely to present concerning implications for public transit operators seeking to maintain and grow their ridership.

First-time parenthood typically coincides with an increase in car-based mobility. As most factors influencing travel mode choice typically favour the car among families with young children (McCarthy et al. 2017), this is likely to contribute to more favourable attitudes towards car-use developing among new parents. The development of more favourable attitudes towards car-use may mean it is unlikely that these former public transit users return to public transit if their circumstances change. However, the long-term implications of declining public transit remain unknown and it is unclear whether parents return to public transit once child-related constraints no longer shape their travel choices.

Moreover, the implications of parents reducing public transit use have wider ramifications for the household. An emerging body of work indicates that many of the attitudes and preferences towards different travel modes are embedded at a young age (Baslington 2008). Children learn behaviours through observing and interacting with their parents, peers and other agents in their social network. The primary influence on travel behaviours, however, is their parents (Baslington 2008). If young children are predominantly exposed to car-based travel and rarely travel by public transit, this may influence their travel mode choices as an adult. Growing up unfamiliar with public transit may, in turn, nurture a new generation of travellers who overlook public transit in favour of car-based mobility.

7.4.3 Reducing barriers to public transit use

The online survey of new parents examined the relative importance of factors influencing public transit use. This highlighted that household and child-related factors, such as the amount of

time available to travel and amount of child-related equipment being carried, were of greatest importance. While these were categorised as household characteristics, in order to address these considerations infrastructural and operational changes are required. For instance, improving network connectivity and frequency, particularly during off-peak periods when families with young children are more likely to travel, would reduce journey times. This, in turn, would help to make public transit more attractive to families travelling with young children. Similarly, parents travelling with child-related equipment could be aided by an increase in the number of staff available to assist them, particularly when they are embarking and disembarking public transit vehicles.

However, public transit infrastructure improvements tend to involve significant financial investment. As discussed in Chapter 5, further research examining the long-term implications of declining public transit use would help to determine whether the type of substantive investments required to make public transit more attractive to new parents are justified.

Nonetheless, some factors deterring public transit use could be addressed through relatively minor changes. For example, numerous parents mentioned difficulty accessing priority seating, both during pregnancy and with their young children. Likewise, some parents, gauging reactions from other passengers, felt that they were unwelcome to travel with their children on public transit. Both of these could be addressed through relatively minor changes such as advertising making it clear families with young children are welcome on public transit and more visibly priority seating.

Table 7.3 provides examples of the types of improvements that have been implemented and could be more widely implemented to address factors discouraging public transit use. For more novel improvements, the location in which they have been introduced has been noted.

Table 7.3: Examples of small-scale improvements to facilitate public transit use among new parents

Category	Examples	Location
Structural	• Clearer signage identifying priority seating • Priority seating visibly different from non-priority seating • Increasing capacity of 'priority area' seating • Retrofitting ramps to allow for step-free access to public transit infrastructure and vehicles • Family-friendly public transit fares	Multiple
Psychosocial	• Advertising making it clear young children are welcome on public transit • Public etiquette campaigns regarding priority seating • Providing pregnant women with badges or sensors which activate lights located near priority seating [a less confronting means to obtain access to priority seating]	Multiple Basan, South Korea; London, UK
Household characteristics	• Encouraging childcare facilities near public transit infrastructure	Multiple
Child's characteristics	• Training for frontline staff regarding child-related issues, such as assisting lost or separated children • Public transit design features which encourage and facilitates creative play [e.g. replacing some seats with swings at bus stops] • Train carriages catering specifically to the needs of families with children [e.g. play equipment, toilets with changing facilities]	Multiple Singapore Switzerland

Source: Author's synthesis

7.5 Areas for further research

7.5.1 Evidence of declining auto-orientation in other jurisdictions

Chapter 4 found evidence of declining auto-orientation among families with children. While all groups (Young Couples, Young Families, and School-age Families) included in the analysis experienced the decline, the decline was greatest among families with children. This occurred even though families were *more* likely to live in auto-oriented neighbourhoods between the survey periods.

The reasons for this trend are not known. Further research, examining whether similar trends are evident in other auto-orientated cities, would assist with understanding the reasons for the

decline. This, in turn, will aid the development of future transport policies aiming to reduce car use among this group.

7.5.2 Understanding long-term implications of declining public transit use among new parents

Chapter 6 outlined the many barriers to public transit use experienced by families with young children. While some relatively small-scale improvements could assist this group, such as improved access to priority areas and advertising making it clear this group are welcome on public transit, more substantive improvements would require significant investment. Given this, further research examining the long-term implications of declining public transit use among new parents would be beneficial. For instance, do parents return to public transit once their circumstances change? Or, have car-based travel routines become entrenched such that a return to public transit is unlikely? If it is the latter, further research examining whether parents return to public transit once their circumstances change would help justify more investment in public transit networks to ensure they meet new parents' needs. This would ensure these public transit users are not lost permanently.

7.5.3 Influence of childhood travel mode use on adult travel choices

A similarly fruitful line of further research, which would also assist to justify investment in public transit, is understanding how travel modes used as a young child influence travel attitudes, habits and choices as an adult. Emerging research in the field of travel socialisation has examined the extent to which travel mode preferences are developed among school-age children and how this influences their perceptions of the travel modes they aspire to use as adults. This has revealed that travel mode preferences and attitudes are embedded from a young age (Baslington 2009). Moreover, a recent US study has demonstrated that living in a location with high-quality public transit during childhood, and, particularly young adulthood, increases the likelihood of using public transit later in life (Smart and Klein 2017). These two strands of transportation research highlight a need to further understand the influence of childhood mode use on future travel behaviour. Given previous work has suggested attitudes towards travel modes are developed from a young age, does the formation of positive attitudes influence the likelihood of travelling by these modes as an adult? Similarly, previous research has suggested exposure to public transit as a child influences use as an adult. However, it remains unknown

whether the frequency of use as a child is important or merely that a child has had some exposure to transit in order to foster transit use as an adult (Smart and Klein 2017).

7.5.4 Exploring barriers to the uptake of emerging transport modes

Recent qualitative research has demonstrated that emerging transport modes, such as car sharing and e-bikes, can provide a suitable transport alternative for families with children and can potentially inhibit increases in levels of car ownership during this life stage (Thomas 2016, Dowling and Maalsen 2019). However, the overwhelming use of emerging transport modes tends to be by young, affluent, urban, able-bodied individuals (Alemi et al. 2019, Young and Farber 2019). This suggests that there are barriers to the more widespread uptake of emerging transport modes by families with young children, as well as other groups at risk of transport disadvantage. As the dominance of emerging transport modes grows, groups not appropriately accommodated by these modes may be at risk of increased social exclusion. Transportation performs a crucial role in facilitating access to activities, employment and overall quality of life. Given this, further research exploring the current uptake and barriers to the use of emerging transport modes among both families with young children and other groups at risk of transport disadvantage would be beneficial.

7.5.5 Life events and disrupting habitual travel behaviour

The cumulative impact of life events was not significantly associated with weaker or stronger car-use habits. It appears that experiencing a large number of life events is not enough to change car use habits; rather, it became clear that the type of life event played a key role. The effects of 'stabilising' or 'destabilising' life events did have a cumulative impact, which counteracts each other if they are experienced together.

These findings suggest that life transitions comprising at least some of the destabilising life events (such as entering or retiring from the workforce) may provide a better opportunity to influence travel behaviour than individual life events (such as changing jobs). However, further research testing this hypothesis is required. This, in turn, will assist in an improved understanding of the optimum time in which to target travel behaviour change interventions.

7.6 Concluding remarks

As discussed at the beginning of this thesis, high levels of car use contribute to wide-ranging societal problems. Encouraging new parents to adopt or retain more sustainable travel behaviour may help to reduce the detrimental effects associated with high levels of car use. To do this, we must not only know that there is often a change in favour of car-based mobility, which tells us *how* travel behaviour changes; we must also know *why* this change occurs. As this thesis has shown *why* such change occurs, it enables us to clearly understand how such behaviour might be influenced through effective, evidence-based policy making. This, in turn, will assist to address the many problems to which high levels of car use contribute.

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