Comparing Health Services Access Across Regions of Melbourne: A Case Study of Diabetes Services

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Submitted in total fulfilment of the requirements of the degree of Master of Philosophy – Public Health

December 2017

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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANOVA:</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>ANZSIC:</td>
<td>Australian and New Zealand Standard Industrial Classification</td>
</tr>
<tr>
<td>ASRR:</td>
<td>Australian Social and Recreation Research</td>
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<tr>
<td>CBD:</td>
<td>Central business district</td>
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<tr>
<td>CALD:</td>
<td>Culturally and linguistically diverse</td>
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<tr>
<td>EIU:</td>
<td>Economic Intelligence Unit</td>
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<tr>
<td>FCA:</td>
<td>Floating catchment area</td>
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<tr>
<td>GAIC:</td>
<td>Growth areas infrastructure contribution</td>
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<tr>
<td>GASPT:</td>
<td>Growth areas social planning tool</td>
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<tr>
<td>GTFS:</td>
<td>General transit feed specification</td>
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<tr>
<td>GIS:</td>
<td>Geographic information systems</td>
</tr>
<tr>
<td>HCOOLI:</td>
<td>High car ownership on low income</td>
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<td>HiAP:</td>
<td>Health in All Policies</td>
</tr>
<tr>
<td>hr:</td>
<td>Hour</td>
</tr>
<tr>
<td>JTW:</td>
<td>Journey to work</td>
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<tr>
<td>km:</td>
<td>Kilometre</td>
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<tr>
<td>LGA:</td>
<td>Local government area</td>
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<tr>
<td>m⁻¹:</td>
<td>Metres per second</td>
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<tr>
<td>OECD:</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>OD:</td>
<td>Origin destination</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>PPP:</td>
<td>Public private partnerships</td>
</tr>
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<td>PSP:</td>
<td>Precinct structure plans</td>
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<tr>
<td>SAULT:</td>
<td>South Australian Urban Land Trust</td>
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<tr>
<td>SDGs:</td>
<td>Sustainable Development Goals</td>
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<tr>
<td>SDOH:</td>
<td>Social determinants of health</td>
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<tr>
<td>T2DM:</td>
<td>Type 2 diabetes mellitus</td>
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<tr>
<td>TOD:</td>
<td>Transit oriented development</td>
</tr>
<tr>
<td>VAMPIRE:</td>
<td>Vulnerability Assessment for Mortgage, Petroleum and Inflation Risks and Expenses</td>
</tr>
<tr>
<td>VISTA:</td>
<td>Victorian Integrated Survey of Travel and Activity</td>
</tr>
<tr>
<td>VPA:</td>
<td>Victorian Planning Authority</td>
</tr>
<tr>
<td>WHO:</td>
<td>World Health Organization</td>
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Appendix 1: Manuscript: Health service access in urban growth areas: examining the evidence and applying a case study approach. *Australian Planner*, 2016. 53(2): 83-90.

Appendix 2: Manuscript: Comparing private and public transport access to diabetic health services across inner, middle, and outer suburbs of Melbourne, Australia. *BMC Health Services Research* (Under review: resubmitted with revisions on 8th December 2017).
Preface

This research began in 2012 as a PhD through the (then) VicHealth McCaughey Centre for Community Wellbeing at the Melbourne School of Population and Global Health, The University of Melbourne. My passion for public health stems from a career as a Registered Nurse in which I have worked in many clinical areas including neurosurgery/neuro-trauma at The Alfred Hospital, the Emergency Department at Monash Medical Centre and Dialysis at Caulfield Hospital. Whilst working in these clinical areas I cared for with patients who had renal failure. Patients requiring renal haemodialysis are required to attend a facility three times a week, every week, for treatment. In my clinical practise I saw patients relying on a range of transport options, from taxis, family, patient transport vehicles and public transport. Transport to health services, at times, had a significant impact on my patients’ lives. This made me want to better understand how populations access health services. After starting my PhD candidature, delivery of dialysis services in Victoria changed with a focus of providing more dialysis in people’s homes. Given that type 2 diabetes mellitus is one of the major causes of renal failure and will place a significant burden on the health care system, it was chosen as a case study for this research.

This research was converted from a PhD to an MPhil after the birth of my three children. My eldest child was born in May 2013 and my twins were born in September 2015. Given the current demands of my family life my focus is on my children; however I know that I will have future opportunities to pursue my research interests.
Acknowledgements

There are many people I would like to acknowledge and thank. Firstly to my wonderful and inspirational supervisors Professor Billie Giles-Corti and Associate Professor Hannah Badland; thank you for giving me the opportunity to be mentored by you. Thank-you for all your dedication and support; you always push me to be my best. Thank you to my advisory panel Carolyn, Suzanne, Iain and John for your guidance and expertise. Thank you to my fellow colleges at The University of Melbourne and RMIT for all the support and laughs. To my wonderful family and friends, I could not have done this without you. A huge thank-you to my mum for all her love, support, and of course babysitting, without you, this thesis would not be possible. To my amazing husband Peter, your never-ending support, encouragement and love always keeps me going. Finally, to my three beautiful daughters, Ella, Sasha and Freya, who help me strive to do my bit, to make this world a better place. I love you all to the moon and back.
Declaration

I declare that:

This thesis comprises my original work towards a Master of Philosophy – Public Health.

Due acknowledgement has been made in the text to all other material used.

The thesis is less than 50 000 words in length, exclusive of tables, bibliographies, maps and figures.

Rebecca Madill

20th December 2017
Abstract

Introduction

Melbourne, located in Victoria, has some of the fastest growing municipalities in Australia with the population in Melbourne growing from a current 4.5 million residents to an estimated 8 million by the year 2050. Much of this population growth is occurring in urban growth areas up to 50-100kms away from the central business district (CBD), as well as infill areas across inner and middle suburbs of Melbourne. Infrastructure in urban growth areas, such as health services, may be lacking if they are not built and delivered simultaneously alongside housing. Access to health services is a key social determinant of health (SDOH). As urban growth areas develop, there will be greater requirement for health infrastructure and services to be located in these areas in order to meet the increasing demand of the growing population and to ensure equitable access to services.

Primary health care services, such as general practitioners and pharmacists, serve the majority of health care needs for consumers across Melbourne. However evidence suggests that a higher density of such services exists within inner and middle suburbs of Melbourne. This means residents living more centrally likely have greater access to primary health care services compared with those living in outer suburbs and urban growth areas. Previous studies have shown inequities of access to health services exists in rural compared with city areas, however there is little published research about access to health services in urban growth areas compared with established areas of cities.
Type 2 diabetes mellitus (T2DM) is a major chronic health condition in Australia, with some of Melbourne’s urban growth areas having some of the highest prevalence across Australia. People with T2DM are required to frequently access a number of primary and secondary health care services. Using T2DM as a disease case study, this research explores travel times to diabetic health care services for populations residing in inner, middle and outer suburbs of metropolitan Melbourne. Currently, little is known about differences in travel times when using private and public transport to access primary and secondary health care services across Melbourne generally and Melbourne’s urban growth areas. Therefore, this research aims to examine the extent to which inequities exist when accessing health services for T2DM across Melbourne for both private and public transport.

**Method**

A literature review was undertaken which considered access to health care services in urban growth areas with a focus on spatial and social access. Penchansky and Thomas identify five domains of health care access being: availability, accessibility, accommodation, affordability and acceptability. This research focused on spatial accessibility to health services for T2DM. The study area was metropolitan Melbourne divided into five regions of inner, middle, outer established, outer urban growth areas and outer fringe areas. Diabetic health services of interest were identified through Diabetes Australia Victoria and included general practitioners, optometry, pharmacy, podiatry, dieticians, endocrinologists, diabetic educators and physiotherapists/exercise physiologist. Following this geographic information systems (GIS) software was used to map the location of selected diabetic primary and secondary health care service providers across metropolitan inner, middle, outer established, outer urban growth and outer fringe areas of Melbourne. An origin-destination matrix was used to estimate travel distances from point of origin (using a total of approximately 50,000 synthetic residential addresses) to the closest type of
each diabetic health care service provider (destinations) across Melbourne. ArcGIS was used to estimate travel times for private transport and public transport, and comparisons were made by area.

Results

This research indicated increased travel times to diabetic health services for people living in Melbourne’s outer urban growth and outer fringe areas compared with the rest of Melbourne (inner, middle and outer established). Compared with those living in inner city areas, the median time spent travelling to diabetic services ranged between 2.46 and 23.24 minutes (private motor vehicle) and 12.01 and 43.15 minutes (public transport) longer for those living in outer suburban areas. Compared with middle suburbs it was 1.1 minutes and 21.22 minutes (private motor vehicle) and 8.29 minutes and 40.62 minutes longer (public transport) for those living in outer suburban areas. Irrespective of travel mode used, results indicated that those living in inner and middle suburbs of Melbourne have shorter travel times to access a range of diabetic health services, compared with those living in outer areas of Melbourne. Private motor vehicle travel times were approximately four to five times faster than public transport modes to access diabetic health services in all areas.

Discussion

Plan Melbourne refresh, Melbourne’s foremost strategic land use document, outlines the need for a 20-minute city. This is where essential services such as primary health care can be accessed within a 20 minute trip across Melbourne; this research highlights health services inequity gaps when accessing essential primary health care services. Key social infrastructure planning documents such as the Australian and Social Recreation Research (ASRR) document Planning for Social Infrastructure in Growth Areas and the Growth Areas Social Planning Tool (GASPT), consider
health services planning in a broader context of planning for social services. Neither tool has been validated to test their efficacy when planning health services in urban growth areas. Evaluation of these tools is required to help plan for equitable access to health services in urban growth areas.

Those living in urban growth communities spend considerably more time travelling to access essential diabetic health services, particularly specialists’ services, than those living in established areas across Melbourne. To increase equity of access more specialist diabetic services, in particular, are required in outer suburban areas. Given that Melbourne is in a time of planning for its forecasted population growth, examining current access to health services for common and increasing non-communicable diseases could ensure equitable health services access.

To reduce health services access inequities gaps, integrated planning is needed, where health services are planned alongside transport system and land use planning. Integrated planning allows for health services provision closer to people’s homes thus reducing travel times and increasing equity of access for those who rely on public transport, additionally integrated planning will provide better access to these services by public transport. As the population in urban growth areas continues to expand and the demographic profile changes, further investigation is warranted to explore alternative ways to delivery diabetic health services to people living in these areas.
Chapter 1: Introduction

1.0 Background - The Australian Context

Addressing access to health care is critical as Australia’s population grows. The 2016 census data indicated that Australia’s population was 23 million people [1], and it has been predicted that by the year 2056 Australia’s population is estimated to grow to between 30.9 to 42.5 million people [2]. Already 90% of Australians live in urban settings [2], with urban being defined as cities or towns larger than 1,000 people whereas rural areas consist of populations outside any towns or localities [3], and rapid population growth since the mid-2000s continues to put pressure on our cities [4]. Melbourne is located in the state of Victoria, Australia. Melbourne’s population continues to grow at a rapid pace from a current 4.5 million to up to 8 million residents by the year 2050 [5]. Much of this recent and predicted population growth is occurring in metropolitan suburban fringe developments, known locally as ‘urban growth areas’ or ‘urban growth corridors’ [5, 6]. These settings are typically characterised by low residential density neighbourhoods, often located between 50-100kms from major city centres [6, 7].

Melbourne’s urban growth areas are estimated to house approximately 40% of new homes [5, 6], with Melbourne’s largest growth corridor being the north and west metropolitan region. In 2010 it was predicted that in the municipality of Wyndham the population was expected to grow from 180,000 people to 350,000 over the next fifteen to twenty years [8]. The Victorian State Government plans to house and manage this ongoing population growth through: 1) infill housing, being where land in inner and middle suburbs of Melbourne are redeveloped to provide mostly medium density housing [5]; and 2) urban growth areas, to develop and house new communities on greenfield sites or undeveloped land on Melbourne’s urban fringe [5].
Overall, Australians have very good health. Australia is one of only nineteen countries where life expectancy is over 80 years of age [9]. In 2010, Australia ranked third compared with six other ‘Organisation for Economic Co-operation and Development’ (OECD) countries (Canada, Germany, Netherlands, New Zealand, United Kingdom, United States of America) in terms of overall health care [10, 11]. However, it ranked lower in areas of health equity and health care access [10, 11] it is ranked fourth and equal lowest with the United States of America [10]. This is because many health services are unevenly distributed across a given region, with the majority of services found in established areas as opposed to urban growth areas [12]. By way of example, in Victoria a 2010 report contended that 40% of Victoria’s health care services are located within a 10 km radius of the city. However, only 20% of Melbourne’s population live within this catchment, implying substantial health service delivery inequities across the region [10, 12].

Historically, in 1973, the establishment of the Federal Department of Urban and Regional Development under the Gough Whitlam Labour government focused on providing access to services and providing public transport in developing urban areas [13]. Australia has also had policies in place since the 1970s to manage urban development and change. For example, during the 1990s in South Australia, social planning was implemented into urban planning, including community and social infrastructure, employment opportunities and safety [14]. As populations continue to grow in urban fringe settlements across Australia, the issues of providing services to growing communities in suburban Australia has been addressed, historically in the 1980’s, through documents such as the South Australian Urban Land Trust (SAULT) [15]. The SAULT, which considers guidelines for the development of land in urban areas; and more recently the Victorian Health Priorities Framework 2012-2022 [10] which considers an overview and plan for managing Victoria’s health service provision; alongside Planning for Community Infrastructure in Growth Areas [16] and the Growth
Areas Social Planning Tool [17] which focus on providing community infrastructure in growing urban developments; and Plan Melbourne refresh Melbourne’s strategic land use document; all focus on some aspects of planning for health services in outer suburban areas. Whilst documents such as these provide broad planning guidelines there has been little focus on the needs required specifically for health services access and planning in urban growth areas. Therefore, greater attention is required for health services planning in Melbourne’s suburban fringe to ensure equity of health services access for future generations [18].

1.1 Defining the health care provision in the Australian context

In Australia, there are three main health care streams: primary, secondary and tertiary health care services. Primary health care services are the most commonly accessed section of the health care system and refer to services including, but not limited to: general practitioners, community nursing services and community health centres [10]. Secondary health care services include: specialist services for people with specific illnesses and/or complex or chronic conditions, such as radiology, some allied health and drug and alcohol services [10, 16]. Tertiary or acute health care treatment is usually provided by hospitals and includes emergency services [10]. It is acknowledged that tertiary health care facilities particularly hospitals, cannot be provided ‘locally’ in all settings. General practitioners and community health centres have a key role in providing primary health care facilities in communities, including Melbourne’s urban growth areas, and should therefore be locally accessible [12].

The social determinants of health (SDOH) consider the conditions in which people live, work and play, and consider health beyond physical wellbeing [19]. The SDOH consider factors that can impact
on health such as social support, access to employment, stress and family life [19]. Considering there are many social factors that influence health, including as access to health care, [19] and people in Melbourne’s urban growth areas may experience health access inequities [18], the SDOH are a salient consideration of this research. Furthermore, the rise in chronic, complex conditions and an ageing population suggests an ongoing need for health services; demand is likely to grow over time [12] and access to health services, particularly primary and secondary services, is a substantial contributor to the SDOH [19].

1.2 Melbourne’s urban growth areas

Melbourne’s earlier population growth was concentrated in the South Eastern suburbs, yet from approximately 2006 it began to intensify in the North West [5, 6]. In Melbourne the urban growth zone was introduced approximately 10 years ago and enough land was released to provide housing for approximately 90,000 more dwellings in designated growth areas [20]. The aim was to allow for the potential for proficient and co-ordinated infrastructure planning to produce an urban form with supporting public transport infrastructure, to ensure a decreased dependency on car usage [21]. Given that Melbourne is in a population growth period, strategic development and plans for urban growth corridors are being made for the next 30 to 40 years [22]. Planning for services, transport, road networks and housing now, will impact access to the SDOH for communities in many years to come.

Melbourne has many attractive assets and in 2017, The Economist Intelligence Unit (EIU) rated Melbourne the world’s most liveable city, out of 140, for the seventh year in a row [23]. Liveability is determined by assessing five broad categories: stability, healthcare, culture and environment, education and infrastructure [23]. In spite of Melbourne’s liveability ranking, it is facing a number of
development pressures including adapting to an increased and ageing population, being economically competitive and increasing social inequality [21]. For a few, labour and housing markets have created opportunity, however it has further marginalised those who are more disadvantaged by making it harder for such individuals to live in areas where there is insufficient access to public transport, employment, education and other essential services [21]. Furthermore EIU has also rated Melbourne as one of the twenty most expensive places to live globally [24].

Melbourne’s urban growth areas have been a point of contention [25]. Some positive outcomes of extending the urban growth boundary include providing de-centralised and additional opportunities for employment and economic development [26]. However, concerns remain regarding long term health and social effects if poor planning occurs in these areas [27]. Urban growth areas are characterised by low density neighbourhoods with poor access to transport, services and public open space [28]; these factors in turn lead to lower levels of physical activity and decreased access to healthy foods which can act as pre-cursors to chronic diseases such as T2DM and cardiovascular disease [28]. Thus, it is increasingly recognised that Australian cities will face considerable pressure in the years ahead [29, 30]. If urban growth areas are not adequately planned, one concern is that disadvantage and poor health will increase for those living in these new communities [6, 31].

A lack of social planning in growth areas can contribute to financial stress for families, higher rates of domestic violence, lack of social cohesion, difficulties managing care and work responsibilities and higher rates of physical and mental health problems [32]. Breen [6] argues that without localised social and economic opportunity, many residents who live on the urban fringe are required to travel long distances for employment and other non-discretionary services; this in turns impacts discretionary time, such as with family and friends, which can lead to greater pressure on families,
increased financial costs and increased social isolation. Together, these can further exacerbate health and mental health issues for the vulnerable [6, 33].

1.3 Planning for new communities in Melbourne

Approximately 40% of all new housing for Melbourne will occur in master planned communities in urban growth areas [5]. Master planned communities are often driven by the private sector and consist of large scale housing developments which often occur on the outer edges of a city [34]. Master planned communities provide urban development companies an opportunity to plan integrated towns. However there is currently a lag in service delivery with houses being prioritised over health and other social infrastructure [6], resulting in residents travelling outside their community to access indispensable services, such as primary health care services [18]. Urban growth areas are traditionally car dependant as implementing essential infrastructure for public transport such as bus routes is often protracted [6, 33]. This lack of local access to services along with high reliance on car use can add pressure to already vulnerable populations [6, 32].

Melbourne’s urban growth areas are being developed where previously there was little or no infrastructure, housing or services [16]. When such communities are planned and built, hard infrastructure is often prioritised. Hard infrastructure includes roads, water, sewage and other basic utilities [5, 31]. Research indicates that aside from the hard infrastructure, there are a number of other social infrastructure requirements when planning for new communities including education, pre-schools, primary and secondary schools; health services, maternal and child health services, community and primary health care services such as general practitioners and pharmacists; libraries; youth services; aged services; performing arts; public open space including sports and recreation facilities; and indoor sports and recreation facilities [16, 35]. This list is not exhaustive. These
services are important as they provide an opportunity for networks which enhances individual and community health and wellbeing as well as providing equitable distribution of resources [36].

### 1.4 Health services access in urban growth areas

A paucity of literature exists in regards to planning for health services in urban growth areas [5, 12]. Whilst previous research has investigated access to health services (both geographically and socially) [37-40], many of these studies focus on differences in rural and urban settings. For example, a study by Carson et al [41] considered access to primary mental health services across Adelaide, Australia. Access was measured by number of mental health services available per 100 000 population, showing access declined linearly from urban to rural regions. Another study by Coffee et al [7] also demonstrated that access to cardiac health services, as measured by time along the road network, was greater for urban compared with rural counterparts. Whilst these studies compared health service access in rural and urban locations, none have specifically focused on access to health services in urban growth areas in Australia.

Studies that focus on access to health services in urban growth areas are absent. This is in part due to the rapid nature in which urban growth areas are currently developing [18]. As such an integrated and evidence based approach is needed for planning health care services in urban growth areas. By understanding current access to health services in urban growth areas, planners can identify the required location and distribution of land required to provide primary and secondary health care services needed for rapid population growth [16, 18]. Through comprehension of where current health services are located in urban growth areas it can ensure services can be delivered where they are needed most, that is in areas that have low numbers of primary health care services, for
example. Having this understanding can enable planners to ensure resources are planned for and
distributed equitably [18, 32].

Whilst broad scale health planning is available [16], location-specification, detailed health services
that are able to adequately meet user population needs in reference to age, gender, ethnicity and
socio-economic status are required [18]. Appropriate planning is required when considering access
of essential primary and secondary health care services in new and growing communities. This
research extends knowledge in regards to health services access and planning in Melbourne’s urban
growth areas.

Additionally, information about how health services are accessed, particular in urban growth areas,
can guide planners to ensure sufficient public transport is available. Even in the most developed
countries not everyone has access to private transport [42]. Providing a range of transport options is
particularly important for disadvantaged populations who are often more reliant on public transport,
related to the high cost of owning and running private motor vehicles [43, 44]. Therefore, providing
adequacy of public transport can increase equity of access to health services. To date research into
the mode of transport used when accessing health services, specifically in urban growth areas, is
severely lacking. This research aims to address this by exploring travel time and mode of transport to
primary and secondary health care services.

1.5 Why investigate health care access in urban growth areas?

Many Australians have adequate access to primary health care services, however there are
significant gaps for a range of populations and service areas [45]. Examples of populations include
indigenous Australians and potentially vulnerable populations such as those from CALD backgrounds, youth populations and the elderly [6, 46, 47]. Areas that experience primary care access gaps include but are not limited to rural and remote areas and new urban growth areas [6, 32]. Of concern is that those individuals who are the most in need or who face disadvantage are often those who require greater access to primary health care services. Better access to primary health care services has other benefits such as less unnecessary admissions to hospitals [48]. Additionally, early intervention provided by primary and secondary health care services has been shown to have significant impacts on beneficial population health outcomes [45].

Given the challenge of timely delivery of health services in urban growth areas, inequities in accessing health services will likely continue to widen [49, 50]. An example of timely implementation of health care services includes maternal and child health services being built in conjunction with residential housing to ensure residents have access to this service once they move in [16]. The impact of this on health status is already evident. Compared with the whole of Melbourne, life expectancy for males is lowest in the inner west, outer west urban growth areas and for females in outer east, outer west and outer north eastern urban growth areas [10, 12]. Additionally, urban growth areas are characterised by diverse demographic challenges which place additional pressures on the health care system. These include: high birth rates of 2.21 or above in some growth areas compared with the state average of 1.8 [51] (that can be up to 50 to 60 babies born weekly in some Melbourne growth areas) [52]; high cultural diversity, for example 43% of residents in Whittlesea city council (one of Melbourne’s fastest growing urban growth areas) speak a language other than English compared with 29% in Greater Melbourne [32], and high youth populations [6, 32].
1.6 Diabetes and health care

This research focuses on access to primary and secondary diabetic health services, specifically for type 2 diabetes mellitus (T2DM). T2DM was chosen as it is a common (and increasingly) complex chronic health condition characterised by increased blood sugar levels [53]. This can occur because a person does not produce enough insulin or conversely the cells do not respond adequately to insulin production [53, 54]. There are two main types of diabetes mellitus; type 1 diabetes mellitus which is an autoimmune disease where the bodies’ immune system breaks down the insulin producing cells of the pancreas causing increased blood glucose levels [53, 54]; and T2DM is the most common type of diabetes and occurs due to a reduced production of insulin and the body becoming resistant to high blood glucose levels [53, 54]. Gestational diabetes mellitus can occur during pregnancy however usually subsides once a women has given birth [53].

T2DM accounts for approximately 85% of all diabetes mellitus cases in Victoria and is often attributed to lifestyle factors such as obesity and smoking [55]. Between 2011-2012 T2DM affected approximately 1.7 million Australians and almost 185,000 Victorians [55]. T2DM is predicted to increase and affect approximately 3.5 million Australians by 2033, however this number is largely underestimated as many people with T2DM are not being diagnosed [55].

T2DM has been chosen as a case study for this research because it emphasises the burden placed on the health system and because people with T2DM have a high and ongoing demand for health services access. Additionally, T2DM affects people from a range of demographics and socio-economic status, therefore though the focus on T2DM for this research speaks broadly in regards to health services access across Melbourne. According to Diabetes Australia Victoria, a person with T2DM will regularly need to access a range of primary and secondary health care services to manage
their disease including general practitioners, diabetes educators, dieticians, endocrinologists, podiatrists, pharmacists, optometrists or ophthalmologists, and mental health services [56].

The Australian Institute of Health and Welfare (2014) reported that the prevalence of self-reported diabetes in persons over 18 years of age was 8.5 % in the lowest socio-economic group compared with 3.9% in the highest socioeconomic group [57]. Furthermore, in 2004 the Australian Bureau of Statistics contended that 24.7% of all diabetics lived in the most disadvantaged areas, compared with 13.7% in the least disadvantaged areas across Australia [58]. The north and west region of Melbourne, a known urban growth area, not only has the highest prevalence of all types of diabetes compared with any other region in metropolitan capitals across Australia [59], it is also comprised of vulnerable populations such as increasing numbers of elderly people [60]; the rate of T2DM increases with age, with almost one in five people over the age of 75 having T2DM between 2014-2015 [61]. This highlights the need to have the appropriate services in place to deliver appropriate health care to those most at risk.

1.7 Study Aim

To examine the extent to which there are inequities in accessing diabetic health services by private and public transport across Melbourne’s metropolitan region.

1.8 Research Objectives

- To review international and national literature of health services access and planning in growth areas.
• To identify models of health services planning that could be adapted and utilised in Melbourne’s urban growth areas.

• To use spatial data to identify any inequities in access to diabetic health services by private and public transport modes across Melbourne’s inner, middle and outer established, outer growth areas and outer non-growth areas.

1.9 Significance of the Research

This research contributes knowledge of travel times to diabetic health services via private and public transport across inner, middle, outer established, outer urban growth and outer fringe areas of Melbourne. Whilst studies have identified differences in health services accessibility between urban and rural settings [7, 41], few studies have considered differences in access to health services within a metropolitan area. Therefore, this research contributes knowledge to the field through the examination of intra-city variations and health services access for a case study disease.

Additionally, few studies have considered access to both primary and secondary health care providers. Through the examination of diabetic health services, this research was able to do both. This is also true for transport as few studies have considered access to health services for both private and public transport; however, given the importance public transport can have for disadvantaged populations, particular when accessing health services, it was included in this research. Therefore, this research is unique in that it: 1) compares access to diabetic health services across five areas of metropolitan Melbourne; 2) considers access to both primary and secondary diabetic health services; and 3) compares access to diabetic health services via private and public transport.
1.10 Study Delimitations

This research was conducted within the following parameters:

- It considered access to primary and secondary health services required for the management of T2DM only.
- It used Geographic Information Systems to measure spatial access to health services through a measure of time in minutes.
- Residential addresses were sourced through a synthetic model and were not actual representations of residents who have T2DM.
- The study area was metropolitan Melbourne, Victoria, Australia.

1.11 Study Limitations

Limitations of the study include:

- It should be noted that planning for health services in urban growth areas was a key focus of the literature review and the review did not focus on implementation of health services in urban growth areas, and this is an area for future research.
- It did not consider access to other primary and secondary health services other than those listed in the methodology chapter.
- Health services data were sourced from secondary sources and therefore data sets may be incomplete, which may have caused bias.
- Journeys conducted for the road network and public transport network were captured at a standardised single time point.
• An assumption was made that people access health services from their place of residence and did not account for access to health services from other destinations, such as the workplace.

• Generalisability: this study focused on one metropolitan area in Melbourne, Australia. These results may not apply to other Australian cities or an international audience. However as many Australian cities, such as Sydney in New South Wales and Brisbane and the Gold Coast in Queensland, are facing similar population and infrastructure challenges as Melbourne these the results may be relevant in such scenarios.

1.12 Research Contributions

This research was undertaken to fulfil the requirements of a Master of Philosophy through the Centre of Health Equity at the Melbourne School of Population and Global Health, The University of Melbourne. My primary supervisors, Professor Billie Giles-Corti and Associate Professor Hannah Badland, were my main supervisors for this project. I also had an advisory panel whose expertise I drew on to guide my project. The advisory panel was chaired by Professor Carolyn Whitzman from Architecture Building and Planning, and also consisted of: Associate Professor John Furler from the Department of General Practice; Dr Suzanne Mavoa, Melbourne School of Population and Global Health and Dr Iain Butterworth from the Victorian Department of Health and Human Services.

For the technical aspects of using Geographical Information Systems (GIS) software, I sourced guidance and assistance from Dr Suzanne Mavoa from the Centre of Health Equity at The University of Melbourne and Ms Rebecca Roberts from Healthy Liveable Cities Group, Centre for Urban Research, RMIT University. Rebecca Roberts trained me in geo-coding. Dr Suzanne Mavoa was
responsible for helping source some of the geo-coded data (Pitney and Bowes data set) and for running the road network and public transport calculations. Ms Rachel Sore formerly from the Statistical Consulting Centre at The University of Melbourne was engaged for statistical advice regarding analysis approaches. I was responsible for compiling and analysis of statistics.

Additionally, I undertook two subjects in order to upskill for this research:

- Semester 2, 2012 Logistic and Linear Regression (POPH90144), Melbourne School of Population and Global Health, Faculty of Medicine, Dentistry and Health Sciences, Grade: Distinction.
- Semester 1, 2014 Foundations of Spatial Information Subject (GEOM9008), Faculty of Engineering at The University of Melbourne, Grade: Distinction.

1.13 Scholarships

2012: Australian Post Graduate Award

2012: Melbourne Studentship

2015: Windermere Foundation 2015 Doctoral Scholarship in Health

1.14 Publications

Published


1.15 Thesis Structure

This thesis is comprised of 5 chapters. The first chapter provides a background to the research and includes the research aims and objectives. The second chapter is an overview of the literature followed by chapters 3 and 4 which are the methods and results respectively. A discussion is presented in chapter 5.
Chapter 2: Literature Review

Section One – Theoretical lens and background

2.1 Search strategy

Literature was sourced from English language grey and academic literature, nationally and internationally. Given there are different health care systems and political landscapes globally, international literature was used to define health access and to provide examples of how health care services are accessed. The national literature was used to convey the current situation of health services access in Australia and Melbourne. Reviewing grey literature was necessary to provide a local and state-government policy context for the study, as well as relevant non-government organisations, such as universities and research institutes. Searches were conducted across key Victorian government websites such as the Victorian Department of Health and Human Services, Department of Transport, Planning and Local Infrastructure, the Victorian Planning Authority and relevant local government organisations. Reference lists were identified from relevant web pages and scanned for further literature. Recommendations were also made from members working within these organisations to other relevant literature sources.

Academic publications were sourced through a number of databases including: Web of Science, Scopus, Medline, Global Health, PubMed Central, Academic Search Complete, Australian Architecture Database, Google Scholar, and Informit Plus Text Databases. Search terms were derived by using the key phrase of ‘health services access and planning in urban growth areas’ and variations of this terminology. A combination of the following key search terms were used: health service*, health access*, urban growth area*, growth area*, spatial access*, social access*, health equit*,
urban plan*, land use plan*, tool and model*. Additionally, reference lists of sourced articles and reports were scanned for further relevant literature. Criteria for inclusion included being: written in English, available as full text, and related to primary and/or secondary health service access.

2.2 Theoretical lens - Social determinants of health and the built environment

A re-emergence of urban planning and public health disciplines working together is evident [62-66]. Such collaboration aids understanding of how broader social and built environmental factors influence population health. It has been argued that since the early emergence of public health and urban planning working together for city planning, the two disciplines have become disconnected over the years. Public health has focussed more on individual and bio-medical factors, with less consideration of the wider SDOH [62-64]. Urban planning has been focussed on designing cities with less consideration of health impacts [62-64]. The recent proliferation of articles calling for re-emergence between these two fields is abundant [62-66] highlighting a paradigm shift away from bio-medical models of public health, towards a wider understanding of SDOH, including impacts of urban planning [19, 66].

Additionally, there has been increased awareness of the impact city and metropolitan developments have in terms of facilitating or constraining health and well-being for various outcomes [14], including physical activity, obesity [67], and mental health [68]. With the advent of the ‘new public health’ agenda and increased importance placed on understanding the SDOH, researchers are moving beyond siloed public health or urban planning models to broaden their scope of enquiry to consider the places where individuals live, work and play, and the impacts these have on health [69].
As rapid urbanisation and population growth continues there is growing awareness of the impact the built environment has on health [70]. Evidence indicates an association between the built environment in urban and suburban environments with modern ‘epidemics’ of non-communicable diseases, such as T2DM, cardiovascular disease and certain cancers [71, 72]. It has been argued that such ‘epidemics’ are related to factors such as physical inactivity and obesity, which are perpetuated by increasingly low density urban environments with poor access to public transport and services, and inversely a higher reliance in car usage [71, 72]. Linking the impact of the built environment to health outcomes is gaining greater momentum as cities continue to expand and planning for increased urbanisation will impact the health and well-being of future populations. A well-established evidence base recognises that the built environment and guiding urban planning policies can influence residents’ health and wellbeing outcomes [73, 74]. For example, positive population health outcomes can be promoted by designing cities that provide opportunities for individuals and communities to be active [69] such as offering a range of transport options, including public and active (i.e., walking, cycling) options [5, 69].

The New Urban Agenda and Sustainable Development Goals (SDGs) call for a change to current urban planning principles and practices through a focus on health and environment, in order to support the health and wellbeing of the global community [75]. Developed by the United Nations, the SDGs identify seventeen actionable goals to ensure a more prosperous future by ending poverty and protecting the planet [75]. The aim is to work with nations and governments to take responsibility in providing a more sustainable model for urban development [75]. This can be undertaken through inter-sectoral collaboration and integrated planning [76]. The SDGs also call for shift from motorised transport to a focus on active and public transport, as this will not only benefit the health of individuals but also the planet [76].
The SDG’s support the principles of the SDOH as they consider broader social conditions that affect people’s health and wellbeing. The SDOH are the multi-tiered conditions in which humans are born, grow, age, live and work, and includes the health system; it acknowledges that health is also shaped by a number of external forces such as economics, politics and power [77]. Wilkinson and Marmot [19] identified ten SDOH of health including social gradient, stress, early life, social exclusion, work, unemployment, social support, addiction, food and transport, however this list is not exhaustive [19, 78]. The SDOH can be viewed through a health inequality and inequity lens [77]. People exist in a complex milieu and health is affected by multiple influences, from the way cities are governed and designed to the social environment in which people live [19, 79].

2.3 Health inequalities and inequities

Health inequalities are defined as differences between the least and most advantaged in a given group (defined by such traits as wealth, power, racial class, ethnicity and gender) irrespective of differences between the most and least affluent members of society [80]. Health equity conversely, views health and its determinants from a justice perspective. That is, it considers the broader determinants that affect health [66]. An example of health inequity in Australia is the substantially lower rates of life expectancy amongst Aboriginal and Torres Strait Islander population, for those who were born in 2010-2012, life expectancy was approximately 10 years lower than the rest of the population, life expectancy for Indigenous Australians being 69.1 years for males and 73.7 years for females, compared with non-indigenous Australians with life expectancy 79.7 years and 83.1 years, respectively [81]. Thus, health inequities can be defined as inequalities that are unjust, deemed unfair, and are avoidable. Health equity has foundations in the principles of social justice, morality and cooperation [66, 82] and stem from systemic inequalities, where repeated prejudices and
injustices are reinforced, for example, government policies continuing to marginalising those who are already disadvantaged [80].

Understanding the impact accessing health services has on health outcomes began with the Black [83] and Whitehead reports [84]. Both of these reports examined health differences among United Kingdom social classes and explored the underlying causes of those differences. The reports discovered inequities in health care, attributable to factors such as sex, region and country of birth, were prevalent and that, in some cases, health inequities were widening. The Black report contended that as health has its roots in biology, changing the perceptions of clinicians to consider SDOH as opposed to biological processes was a necessary step in tackling health inequities [83]. Although access to health services in Britain has improved over the years, there is evidence that increasing the availability of health services alone is insufficient for creating good health [83, 84]. Therefore, aside from the physical location of health services, consideration must be given to other factors that impact health and wellbeing of populations and their ability to access services such as social and cultural factors [85].

2.4 Defining health care access

The root of the word ‘access’ from Latin and French origins denotes ‘the means or opportunity to enter a place’ [86]. In health care, ‘access’ is often referred to as access ‘to’ health care [87]. In broad terms, this can been defined as the ability of individuals to navigate health care resources to improve their health, with health care access being conceptualised in many ways [88]. However, Penchansky and Thomas [85] discuss five domains of access, being: availability, accessibility, accommodation, affordability and acceptability. Availability refers to the supply of health services, including the number and type of existing services [85, 88]. Accessibility incorporates the physical
location of services in relation to individuals and resources required, such as transport and monetary
or time costs to reach a service [85, 88]. Accommodation incorporates the manner in which services
are organised to accept individuals’ needs, such as opening hours, walk-in and telephone facilities,
and the individuals’ ability to adapt to these factors [85]. Affordability refers to the cost of health
services to individuals and organisations, additionally individuals’ perceptions of value relative to
cost is also notable [85]. Finally, acceptability includes community and cultural factors that
contribute to the ease of utilisation by individuals as well as the delivery of health services to
individuals encompassing a variety of characteristics [85, 87].

Levesque et al [87] concurs with Penchansky and Thomas’ definitions of access and acknowledges
common operational definitions of access to health care, including geographical or spatial access,
economic access, and social access to health care [85, 87]. Where spatial access is the physical
environment or entities bounded in space [89], economic access includes financial enablers or
barriers [87] and social access includes non-spatial aspects such as social, cultural or political factors
however may also have geographic expression [89]. For example, a study by Wang, Rosenberg, and
Lo discovered that Chinese immigrants in Toronto had a high preference for a Chinese speaking
physician, regardless of the location [90]. This is an example of social access (cultural preference for
a physician) with geographic expression as migrant communities may cluster closer to culturally
preferred health and community services. Levesque et al [87] conclude that the concept of access to
health care is complex and multi-dimensional, going beyond the availability of physical resources. As
argued, there are many avenues in which health care access can be and have been explored,
however for the purposes of this review, only spatial and social access will be considered as these
are the most pertinent for health services access in urban growth areas.
2.5 Access to health services in urban growth areas

The literature review revealed two main themes related to accessing health care. These were spatial and social access to health care. Each theme is discussed in detail below.

2.6 Spatial access to health care

2.6.1 Service to patient ratios

A common measure of health care access used in Australia was the number of doctors to number of patient ratios [91]. In 2012, Australia had its highest number of registered doctors with 91,504 registered doctors and 79,653 (93%) employed in the medical workforce [91, 92]. However whilst doctor numbers have increased over time, the Australian Health Workforce Report contends that doctor numbers are unevenly distributed across the health care services, tending to be less accessible for Australians living in urban growth areas, regional and rural areas [92]. The Australian Health Workforce also predicts a short fall in doctors of approximately 37,000 by 2025 due to the increasing demand on health services [92]. Doctor to patient ratios provide an indication of the availability of doctors within a geographical area [93] however they do not consider whether the distribution of doctors across a region is equitable or the spatial relationship between neighbour local government areas.

2.6.2 Travel time and distance

Spatial health care access is commonly measured using the actual distance or time taken to travel to the health service locations [42, 94]. However defining what constitutes ‘good’ or ‘high levels’ of access to health services remains difficult [95, 96] because what constitutes ‘good’ access to health
care services has not been agreed upon nationally or internationally [95]. In Victoria, Melbourne’s recent urban design plan, *Plan Melbourne refresh*, aims for a ‘20-minute city’, where essential services, such as primary health care will be accessible within a twenty minute trip, whether via public or private transport depends on the area [5]. The proposed 20-minute journey to access essential services (including health services) is a planning metric that can be used to provide some context for health services access.

Acceptable travel times to primary and secondary health services via private car have been investigated internationally. A study by Tackett et al [97] explored general practitioner and specialist physician (cardiologists for example) access via private car in rural and metropolitan Massachusetts, USA. The authors reported 89%–99% of participants had high levels of specialist physician accessibility using a travel time threshold of 30 minutes [97]. The authors concluded that rural residents on average travelled approximately six to fifteen minutes longer to access specialists compared with urban counterparts [97]. However, the authors did not consider travel times to physicians or specialists via public transport. Brabyn and Barnett [98] also used a 30 minute threshold to evaluate access to general practitioners when travelling by private car in rural and metropolitan New Zealand [98]. They found that approximately 10% of the population fell outside this threshold, all of whom lived in rural areas.

A national study conducted in Australia, by Coffee et al [7] considered access to cardiac health services, where ambulance transport was used to measure access to cardiac health services after a cardiac emergency (except in very remote Australia where private vehicles were used as a measure of access). The authors also considered private car travel to post-acute cardiac health services (rehabilitation service modelling) [7]. The findings showed that approximately 71% of the Australian population had very good access to acute and post-acute cardiac services, as defined by a one hour
trip via emergency transport for an acute event or private transport for post-acute cardiac health services [7]. This study showed that ambulance coverage within the metro area, which included fringe areas, was within one hour [7]. Those who travelled greater than one hour to access cardiac services were mainly residents living in rural areas of Australia [7]. However, whilst this study looked at within city variations in spatial access to cardiac health services, such as inner city and urban fringe travel times, considering access to health services specifically within growth areas was not a focus of the study.

Another study conducted by Shah et al [99] considered access to physiotherapists and family physicians in Saskatchewan, Canada. The authors used GIS techniques to create a 25km buffer around census subdivisions and from this created an accessibility score to physiotherapists and family physicians. Similar to the previous studies, the results indicated higher accessibility to health care services in inner urban municipalities with decreased accessibility in more remote municipalities and rural areas. Additionally, their study indicated that people who were 65 years of age and over, on low incomes or had barriers accessing health services, such as immigrants and aboriginal populations, had reduced access to health services, particularly in remote municipalities and rural areas [99]. Whilst this study indicates populations living in urban growth areas have poorer access to health services, the means of measuring accessibility was not linked to time or transport.

2.6.3 Public Transport and health care access in urban growth areas

To date, few studies have considered health services access via public transport [95]. Distance, travel times, and service frequency are potential barriers for those seeking to access health services by public transport [6, 95]. Furthermore, public transport users tend to be more vulnerable
populations, including the elderly, or people from CALD backgrounds [6, 44, 95]. Hence, having a variety of transport options available, particularly public transport services, could improve health care access and equity [6, 31]. Lovett et al [95] compared general practitioner access by private car and public transport access in primarily rural areas (Cambridgeshire, Norfolk, Suffolk) of the United Kingdom. They found 67% of residents lived within a five minute car trip to their nearest general practitioner. When travelling to the same general practitioner by public transport (after accounting for the frequency of services) 82% had ‘good access’ (defined as access to a bus four times a day from their area to their general practitioner); however, 13% of the study population lived in an area with no daily return bus trips to a general practitioner [95]. Those with inadequate public transport services to access health services tended to live further away from town centres and were more reliant on private transport [95].

Another study by Rocha et al [100] examined access to emergency dental supply in Melbourne, Victoria with consideration to public transport by access and supply. The catchment area of the study population was a 50km radius from The Royal Melbourne Dental Hospital, which is located centrally. Of their study population, 80% lived within a 400m radius to a bus stop, 18% were within 400m to a tram stop and 21% were within 800m of a train station. However when the authors adjusted for ‘high frequency’ bus stops, these are bus stops within 400m of home with services at least every half an hour [101], this accounted for 65% of the study population. The authors purport that when considering issues of access to health services it is not just the availability of public transport but the frequency of the services that impact health care accessibility [100]. Their study however did not take into account travel time for patients to The Royal Melbourne Dental Hospital.

Traditionally, urban growth areas have been poorly serviced by public transport and tend to be car-dependent settings [102, 103]. The Victorian Integrated Survey of Travel and Activity 2007-08 (VISTA
07-08) found that median distances to travel to work was higher in urban growth areas than suburbs located closer to the city [104]. For example, the Melbourne metropolitan median travel distance to work was 14.3 kilometres, for those living in Melton (one of Melbourne’s growth areas) the median distance was 32.5 kilometres [104]. A study by Currie and Senbergs considered households with ‘high car ownership on low incomes’ (HCOOLI) to explore car usage in Melbourne’s urban growth areas [44]. Findings suggested that car usage by HCOOLI households in outer Melbourne was 5.2% more frequent, and car trips 38% longer than HCOOLI households in the middle suburbs of Melbourne [44]. Given that approximately 40% of Melbourne’s health services are located within a 10km radius of the CBD [12], work travel times may serve to provide a crude indication that if health facilities continue to be located centrally in Melbourne, people living in urban growth areas need to travel further to access these services.

2.7 Social access to health care

2.7.1 Health care access and the SDOH

Closely associated with spatial access is social access [94]. Social factors that might contribute to health access and utilisation include: culture, sex, income, race, age, mobility, family and work commitments, and socio-economic position [94, 105-107]. The ‘inverse care law’ first proposed by Hart in 1971 suggests that health services are distributed inversely to population health needs [108, 109]; those living in socially deprived neighbourhoods tend to have poorer health access [108, 110] and therefore poorer health outcomes [111].

SDOH research indicates that health inequities have a social gradient, and that higher levels of disadvantage are associated with poorer health outcomes [112]. This has been demonstrated in the
United Kingdom where national primary health care is free, however health inequities still exist. The gap between the least and most deprived neighbourhoods show a noticeable health gradient, and the worst health outcomes exist for those living in the most disadvantaged neighbourhoods [112]. In Australia people living in areas of most disadvantage are approximately three times more likely to visit their general practitioner twelve times or more during a year compared with those living in areas of least disadvantage [93].

Nevertheless, the inverse care law has been contested [67, 113]. Witten et al. [67] found a positive correlation between access to a range of services in disadvantaged neighbourhoods across four New Zealand cities; disadvantaged inner-city areas had a greater number of health care facilities compared with less disadvantaged suburban areas. Macintyre et al. [113] demonstrated that variability of access to health resources and area deprivation in Glasgow were dependant on the type of resource (e.g., pharmacies, dentist, physician) and how deprivation was measured. The authors used a subset of the 2006 Scottish Index of Multiple Deprivation focusing on data such as employment, health education and welfare benefits to measure deprivation [113]. Together, these studies lend support to Lineberry’s ‘ecological’ hypothesis, suggesting that the location of urban resources is more related to the age, history, geographical location, residential density, and residential/commercial mix of different areas, rather than the ‘inverse care law’ per se [113].

2.7.2 Social domains of health care access

Of the five domains of health care access recognised by Penchansky and Thomas [85, 88] accommodation, affordability and acceptability incorporate social factors that can contribute to health care access. A study by Ward et al [114] highlights accommodating individuals’ personal preferences for a specific general practitioner and the availability of general practitioners had
greater impacts than distance when considering access to primary health care services. Affordability is another social factor that heavily influences individuals’ ability to access to primary health care services. In their research, Wallace and MacEntee [115] demonstrated that when accessing dental care in Canada, people on low incomes would often delay accessing health services due to cost and only accessed services when longstanding and multiple dental conditions required input. Lastly, Hurley et al [46] conducted a study with older Greek migrants accessing community based health services in Australia and found not only did cost, transport and availability of services impact on health services access, language, literacy and cultural attitudes also had a significant impact. Additionally, their research indicated that their study population were more likely to rely on family members for health services access [46].
Section Two – Planning for health services in Melbourne’s urban growth areas

2.8 Models for health service delivery and planning

When considering health services planning there are a number methods that can be used: disease projection and simulation models [116]; mathematical models which consider population needs analysis and projected services [117]; liveability indicators [118]; and health geomatics [119]. Modelling for health care is often specific. For example, a study by Erridge and colleagues [120] used modelling to predict future radiotherapy requirements for patients in Scotland. However, a systematic review concluded that while modelling techniques can inform health care planning, further research, such as health impact assessments and land use planning, are recommended to assess how effective the implementation of these models to health services planning actually are [117].

Often planning for health combines various techniques that require collaboration from a number of sectors [47], however consensus as to the most suitable method for health services delivery and planning particularly for growth areas has not been defined [116]. Additionally, many models do not have health equity as a core concept. Choosing models of health services planning that have health equity as a core concept indicates that health services will be planned from a ‘whole of population’ approach, that is, it will not only take into consideration the resources required for health services it will consider if health services are: 1) physically accessible as conceptualised through location, accessible via public transport, easy to navigate, disability friendly; and 2) socially accessible, such as being receptive for CALD clients as well as elderly and youth populations [6, 16, 121].
In terms of planning for health services in urban growth areas considerations for health care costs need to be identified and can include: competing demands for resources such as land, finances, industry, transport [21]; uneven distribution of population growth [21]; and migration trends, including areas of settlement and specific demographic requirements [16]. Therefore, identifying an appropriate method for health services planning remains challenging and consensus amongst policymakers internationally and nationally is unresolved. This resonates particularly with health services planning in urban growth areas, as decisions are being made now that will have long term consequences.

Health impact assessments investigate potential positive and negative health outcomes of programs or policies from a range of disciplinary backgrounds with the use of tools, measurements and procedures [122, 123]. Land use planning considers the needs of a number of stakeholders and aims to impartially deliver a mix of services that adequately serve the population [123, 124]. Health impact assessments and land use planning are reasonable planning approaches as both models consider some of the information required when planning for health services, whether it be planning for future social and community services or larger scale infrastructure requirements, such as public transport networks. The models do not account for the specific numbers of health services or practitioners required for a service area and neither model has been used exclusively for health services planning in urban growth areas [123].
2.9 What is social infrastructure?

Social infrastructure incorporates elements from a number of disciplines such as, public health, urban planning and the social sciences, and can be seen as a foundation for fostering social cohesion. Social infrastructure can also be coined ‘soft’ or ‘community’ infrastructure [16, 31, 35]. Definitions of social infrastructure have conventionally been broad [125] and can include ‘lists’ of services such as; schools and education facilities, community centres, health care facilities, arts and cultural activities, emergency services, employment and training opportunities, sporting and recreation facilities, public and community transport [31, 35, 125]. Ideally social infrastructure services are provided in response to community needs [31] and should be flexible to changing community dynamics as communities expand, develop and transform [35]. Social infrastructure services are provided for all members of the community at all stages of the life cycle, and include services for vulnerable and disadvantaged populations [126]. Social infrastructure services can be publically or privately owned and either commonwealth, state, council or non-council facilities [16].

Arguably, social infrastructure goes beyond community facilities and services destinations. Social infrastructure are often places where individuals and groups, work and play and therefore it provides opportunities for people to create, socialise and interact, often creating community pride and connection [16]. It also provides communities and their members with a sense of identity, as the positioning of social infrastructure services determines the final layout of the community, impacting on unique community characteristics and personality [16]. Ultimately social infrastructure has the potential to enhance the quality of people’s lives through; the promotion of equity, improved personal well-being, increased community connectivity, skill development and community resilience [31, 126]. Therefore, the core purpose of social infrastructure is to build communities and bring people together [35]. The matrix in which social infrastructure is situated is designed to have a
‘positive ripple effect’, that is, through delivery and planning of social infrastructure services in new urban communities, the benefits to society and communities will continue to resonate immeasurably.

2.10 Why is social infrastructure important?

Social infrastructure aids in decreasing social isolation and increasing community connectivity, which in turn, improves people’s mental health and wellbeing [6, 14]. The importance of social factors and their influence on health has been an emerging theme since the World Health Organization (WHO) commissioned *The Social Determinants of Health: The Solid Facts* in 1998 [14, 19]. Social inclusion movements have been gaining momentum internationally as well as becoming more pronounced in Australia [126] with increased awareness that ‘*investment in human and civic assets is vital to economic prosperity and social wellbeing,*’ p. 10 [126]. Integral to the social impact on health are the places where people live, work, play and connect. The Young Foundation in the United Kingdom [127] argues that there is a clear connection showing that people who have stronger social networks are happier and have an increased sense of wellbeing compared with those who do not.

According to the Grattan Institute of Australia, approximately one quarter of Australia’s population live by themselves and people who live by themselves are more likely to be lonely and are at risk of becoming social isolated [128]. The literature regarding social isolation and health is growing with more recent studies suggesting social isolation can affect health of older people ‘*through biological processes associated with the development of cardiovascular disease*’ p.377 [129] and that this was independent of social isolation affected by health related behaviours [129]. This is supported by a
meta-analytical review by Holt-Lunstad et al [130], which looked at 148 articles to determine the relationship between social isolation and risk mortality. The authors discovered that people who are socially connected have 50% decrease in risk of mortality in comparison to people with poor social connections the authors argue this is the same affect to mortality as quitting smoking [130]. Furthermore the study explains that populations from the general community with strong social relationships are more likely to live longer compared with similar individuals with poor social relations [130].

Being socially connected ties into the notion of social capital, and Baum et al [14] suggests that social networks and personal relationships between people are important on both an individual and community level, contributing overall to wellbeing. The benefits of social capital can include individuals being less prone to depression, decreased rates of suicide, and to provide resilience against, colds, heart attacks and cancer [131]. Social capital is further attributable to reduction in crime, child abuse, welfare dependency, and drug abuse [131]. Providing the conditions to build social networks can be relatively inexpensive for local councils as well as individuals and can include simple activities such as sending children within the same family to the same school, becoming a member of a sporting team or club, having a street party, or attending or hosting local festivals [127]. There is evidence to suggest however that socio-economic status has a bearing on people’s social capital; people of lower socio-economic status arguably have lower levels of social capital [132, 133]. Baum [14] contends the relationship is complicated, and acknowledges there is some evidence to suggest those from a more affluent socio-economic background live in environments where social capital is distributed more evenly.
In terms of social infrastructure provision it is arguable as to whether people living in areas with a
decreased number of services, experience the same sense of community connectivity, and therefore
benefit from aspects related to social capital, as to those living in well facilitated areas [6]. It is worth
considering the impact, equity of access to health services, in urban environments has on social
capital and in turn health and wellbeing [14]. In Melbourne’s urban growth areas, activity and
participation in sports and recreation are lowest when compared with other suburbs of Melbourne
[32]. This is in spite of such areas having a younger population, and youth tend to have high activity
levels [16]. A theory is that due to population growth in Melbourne’s urban growth areas, provision
of facilities in urban growth areas are lagging and do not have the same sports and recreational
development opportunities when compared with other areas across Melbourne [16].

Casey [31] contends that governments, particularly in Australia, are beginning to recognise that
there is a social cost involved for not providing adequate social infrastructure. Brown and Barber
[125] debate that planning for social infrastructure provision is core for social sustainability; social
sustainability includes an equity based approach, ensuring that residents have access to services,
transport and employment opportunities in new and emerging communities. The need to
incorporate social infrastructure in the planning process is evident and is becoming an increasing
requirement in both public and private planning sectors [31].

Whilst many metropolitan regions have been affected by economic uncertainty and instability,
changes in employment and income, Casey [31] maintains that these problems have been
exacerbated for people living in areas with poor planning and inadequate delivery of social
infrastructure services. In light of this, many governments are implementing curative measures as a
reactive response to initial poor planning of such services [31]. Furthermore, growing research,
largely international, suggests the initial economic costs of implementing social infrastructure far outweighs the long term financial and societal costs of not providing such services [31, 134, 135].

2.11 Social infrastructure and health services planning in urban growth areas outside Victoria

Planning for health services in growth areas is an emerging research area and Melbourne is not unique in facing the challenge of rapid population growth and increasing demand for infrastructure; nearly all states in Australia are confronted with similar issues. Reports from both state governments and local councils on proposals to manage future health services demand have originated from areas such as the State of Queensland [31, 126, 136, 137]. The population of Queensland is expected to grow from 4.8 million in 2016 to 6.8 million in 2036, a projected increase of 50,000 per annum with the majority of this growth occurring in South East Queensland [138]. Managing this population growth is further complicated with social polarisation occurring through the clustering of lower and higher income housing, with lower income households located on the urban fringe of South East Queensland [31, 126] (similar to the housing patterning seen in Melbourne). Specifically, Redland City Council in Queensland is expected to create 21,000 new dwellings by the year 2031 [137] and have developed a Redlands City Council Social Infrastructure Strategy to address this challenge [137]. The council’s social infrastructure strategy focuses on sustainability through early investment in growth areas communities, fostering partnerships and alliances to deliver on infrastructure and a focus on health and wellbeing [137]. Furthermore, recommendations from South East Queensland highlight the need to build capacity in social infrastructure to manage health services and other community services demand.
Another growth area, Seaford, located on the southern fringe of Adelaide, provides an example of social infrastructure planning based on theory and practical approaches to social health [14]. According to Baum et al [14] key factors in Seaford success included: determination from key government figures particularly health policy planners; commitment to the health promotion ideologies as purported in the declaration of Alma Ata; and proficient intersectoral collaboration between different levels of government and between key external stakeholders, such as developers. The authors contend that the positive outcomes experienced in Seaford demonstrate what can happen when policy and planning are implemented effectively, with many actors contributing to the outcome [14].

Internationally, the London Thames Gateway [134] and Cambridgeshire social infrastructure projects [135] in the United Kingdom are examples of planning for predicted large population growth. The London Thames Gateway project identified a need for coordinated social infrastructure planning and implementation related to increased population growth, as such they developed the “London Thames Gateway Social Infrastructure Framework” (LTG-SIF) Project” [134]. The framework targeted four broad social infrastructure categories to base the LTG-SIF on: education; health and social care; recreation and leisure; and emergency and essential services [134]. The toolkit then provided details to consider implementation of these projects such as stakeholder engagement, land use policy, identification of current services and subsequently future services, population impact and community participation and engagement [134]. Both the London Thames Gateway and Cambridgeshire social infrastructure projects have a focus on active community participation; connectivity between people and active and public transport; sustainability; and collaboration between government agencies and key stakeholders [134, 135].
Local and international examples demonstrate that social infrastructure planning is a dynamic process and is continuously shaped in response to community needs and input. Therefore, standards for social infrastructure should be used as a guide only with the aim of being responsive to the community [20, 31]. Alongside planning, the implementation process of social infrastructure also needs to be considered. Failing to provide strong social infrastructure has long-term consequences and costs [6, 14]. This is particularly relevant in communities that are already disadvantaged or are prone to potential disadvantaged. Planning and implementation of community infrastructure is a process, it takes time and investment; community consultation will assist the community in taking ownership of the outcomes [31, 134]. Community planning of social infrastructure occurs across a variety of stakeholders and requires investment in time, resources, people and money [31, 135].

2.12 Urban growth areas planning

The Victorian Planning Authority (VPA) is responsible for urban growth areas planning for the Melbourne region. It commences with a growth corridor plan; that is a land use framework and transport plan which provides a strategy for the development of community precincts in Melbourne’s urban growth areas over the next 30 to 40 years [139]. Once growth corridor plans are delineated, precinct structure plans (PSPs) are provided. PSPs can take anywhere from 24 months to 42 months to gain approval [140]. These outline where specific services such as town centres, roads, bus networks, public open space, health and community services, education facilities, housing and employment hubs are to be located [22]. PSPs align closely with social infrastructure planning as they consider the future needs for growing communities [32]. Greater consideration needs to be given to Melbourne’s changing demography for both urban growth areas and infill areas. Even though the VPA outlines a social infrastructure strategy for urban growth areas, housing is still the main development focus and there is less attention on essential infrastructure such as public
transport, employment, schools and health services however planning for such services is warranted to accommodate changing population needs [139].

2.13 Plan Melbourne refresh

Alongside social infrastructure planning, consideration of health services planning need to be aligned with Melbourne’s recent strategic land use document, *Plan Melbourne refresh* [5]. Plan Melbourne outlines strategies to accommodate for Melbourne’s growing population to ensure economic viability, ongoing liveability of residents and ongoing sustainability of resources [5]. Metropolitan activity centres are a focus of the strategy, where health, education and employment are clustered in a range of strategic locations across Melbourne, and activity centres are being planned for in Melbourne’s urban growth areas. Whilst the strategy for activity centres recognises the importance of key major health sites such as hospitals, and having public transport to these centres [5], there is no focus on accessing primary or secondary health care.

2.14 The Australian Social and Recreation Research

The Australian Social and Recreation Research (ASRR) worked with growth area councils in 2008 from Melbourne’s north and west region and developed the *Planning for Community Infrastructure in Growth Areas* document [16]. This document has specific and detailed plans of health services and other social infrastructure required for communities as they are developing. Similar to Plan Melbourne’s activity centres, ASRR call for services to be co-located around community hubs, where a number of key services are provided locally. Specifically, health services required for growth areas include a range of primary and secondary services and are centred on the needs of the community,
including the availability of children and family services, women services, youth services and aged services.

Furthermore, the ASRR research provides benchmarks for the projected number of services required in proportion to the number of residents. For example, for 10,000 to 20,000 residents, the document provides details for the number and types of health services required for this growing community [16, 35]. This is repeated for different population categories. Additionally, the ASRR document considers the number of professionals required as well. For example, one general practitioner facility may be required for a community and within this it is recommended there be eight practitioners with ten consulting rooms [16, 35]. This level of detail is crucial for integrated and co-ordinated health services, land use and public transport planning in urban growth areas. As yet this tool has not been validated. One of the challenges of this model is potentially delivering health services in a community that has not reached its full potential of residents, therefore ongoing assessments of service usage is one method to determine if the required number of health services to meet community needs is present.

2.15 Growth areas social planning tool

Further to the above two strategies, the Growth Areas Social Planning Tool (GASPT) [32] was launched in 2014 and was led by Whittlesea City Council on behalf of other growth area councils along with key stakeholders including state government departments and local health agencies. The GASPT was developed in response to a lack of coordinated social planning efforts to date and to address the lag in service delivery in urban growth areas and the impact this has on communities, such as increased travel time to education and employment, increased social isolation and financial
pressures [32]. Where PSPs are developed for land use planning the GASPT was developed for coordinated delivery of social and community services in urban growth areas and the GASPT aligns with PSPs [32]. Until the GASPT was developed there was no clearly defined method for social and community services planning in growth areas. Whilst the GASPT provides clear guidelines, to date, there are no examples of the successful implementation of the tool although evaluation and feedback are highly recommended [32].

2.16 Health services, SDOH and social infrastructure

The *Fair Society, Healthy Lives* [112] report argued that health inequalities arise from social inequalities and that focusing solely on eliminating, for example financial disadvantage, will not reduce health inequalities adequately. A universal approach to health inequities must be undertaken, that is, tackling disadvantage at all levels across society [112]. Additionally a ‘whole of government approach’ is seen as the way forward to improve health services planning and access [141]; for example, the South Australian Government have introduced Health in All Policies (HiAP). Similar to the SDOH lens, HiAP was founded with the realisation that population health outcomes are affected and governed by many areas that do not have jurisdiction over the health portfolio [28]. HiAP works in collaboration with a number of government departments by applying a health lens analysis approach to public policy across various government departments [142], for example ‘water security’ which used HiAP to assess health impacts associated with alternative sources of water supply [143]. Ongoing research and evaluation of HiAP indicated areas that have applied the approach effectively, have increased the focus of health and wellbeing in public policy [144]. By having health as a primary focus within government policies, such as those that govern agriculture, transport, housing, education and economics, population health can be improved and financial and
resource pressures on the health system can be reduced [28]. As Keleher [66] states population health planning should be part of a sub-role to a wider social services plan.

2.17 The case study of Selandra Rise

A growing number of social infrastructure tools have been developed in response to the predicted rapid population growth nationally and internationally [17, 35], however evaluation of social infrastructure projects are lacking. Selandra Rise, a master planned community located in Melbourne’s south east growth area, is an exception where a five year longitudinal study into the health and wellbeing of residents was conducted [33]. Selandra Rise was recognised to have delivered some social infrastructure services alongside housing. That is, the community had access to public open space, a high school and a community hub, approximately six months after residents moved in and access to public transport via buses (delivered three years after residents had moved in) [33]. Delivery of these social infrastructure and public transport services was considered ‘early’ compared with other master planned communities in Melbourne’s urban growth areas.

Findings from Selandra Rise found that 86% of residents used a private motor vehicle to travel to work, and that 79% of households owned two or more cars, highlighting the car dependant nature of this urban growth area [33]. The Selandra Rise study also found that because of the long commute times to access employment, less time was spent with families, engaging in community activities and partaking in physical activity, which was connected with weight gain for some residents [33]. Being overweight is one of the major risk factors of developing T2DM, however increasing physical activity can reduce the risk developing the disease [54].
Challenges of the Selandra Rise project included striking the right balance between delivering social infrastructure early and the economic viability of services. Services may face financial difficulty initially until an appropriate population base has been established to adequately support and fund amenities in new urban growth areas [33]. This is particularly a problem in low density growth areas such as Selandra Rise.

Overall the Selandra Rise project recommends planning for growth areas with health and the SDOH as a central focus. Specifically, focus on local employment and public transport options are suggested [33]. Ongoing evaluation of Selandra Rise and other social infrastructure projects are required to determine the long term health and social impact of residents in urban growth areas. Evaluation of social infrastructure planning tools in new communities and the impact of implementing these tools in growth areas on population outcomes, are areas for further research.
2.18 Summary of literature review

This literature review found a lack of solid evidence evaluating health services access in Melbourne’s urban growth areas. Given the rise in complex and chronic health conditions [12] alongside rapid population growth [2] with diverse communities [6] research is needed into how primary and secondary health care services are planned and accessed in urban growth areas. Currently health services in Melbourne, Victoria are located more centrally [10] yet life expectancy is lower in the inner west and urban growth areas compared with greater Melbourne [12].

This review focussed on spatial and social access to health care [87]; however when conceptualising primary and secondary health care access in urban growth areas there were no clear definitions for what constitutes satisfactory access or travel times to health services. When studying accessibility to primary and secondary health care services, private motor vehicles appear to be the main mode of transport considered in the literature [97, 98]. However, given the importance of public transport for certain populations (e.g., older adults) [95], coupled with the known lack of public transport available in urban growth areas [6, 44], this is a salient area for investigation. Additionally, Melbourne is now aiming for a 20-minute city [5]; therefore travel times and transport modes (public or private) to health services in urban growth areas need to be examined in this context.

Prioritising health services access and planning in urban growth areas is gaining momentum, both nationally and internationally. As populations grow, demand on health services will increase, and ensuring equitable access to health services can help reduce inequities. Social infrastructure planning is gaining momentum as it helps support the SDOH and ensures greater equity of access to health services. Additionally, providing public transport to health services likely reduces health inequities and disadvantage in communities. To date research into various modes of transport when
accessing health services, specifically in urban growth areas, is severely lacking. Melbourne is growing rapidly and strategic development and plans for growth corridors are being made for the next 30 to 40 years.
Chapter 3: Methods

3.1 Study area

The study area for this research was the inner, middle and outer areas of Melbourne, Victoria, Australia. As there are variations in population and infrastructure across outer metropolitan suburbs in Melbourne, this region was further divided into outer established areas, outer urban growth areas and outer fringe areas (Figure 1 and Table 1) as described below. Areas of Melbourne were divided into five categories with the use of Local Government Areas (LGA), which are a spatial unit for which a local council assumes responsibility of a geographical area [145].

- **Inner areas** are defined as areas of metropolitan Melbourne within approximately 7 to 10kms from the CBD [5].
- **Middle areas** are defined as areas of metropolitan Melbourne within approximately 10 to 20kms from the CBD [5].
- **Outer established areas** are defined as those greater than 20kms from the CBD, on the outskirts of Melbourne that are not experiencing rapid population growth, and which have established infrastructure and suburbs [5].
- **Outer urban growth areas** are defined as those greater than 20kms from the CBD, located on the outer periphery of Melbourne, and classified as urban growth areas by the State Government of Victoria, as opposed to infill areas that exist in the inner and middle areas of Melbourne [5]. Outer urban growth areas are in a phase of rapid population growth requiring new services and infrastructure [5, 16].
- **Outer fringe areas** are defined as those greater than 20kms from the CBD, on the outskirts of Melbourne with increased development and population growth at the state average, but not experiencing the rapid population increase of urban growth areas [5, 16].
Rapid population growth was measured as outlined by the Victorian State Government in their growth areas corridor plans [5, 146], where they expect an increased number of housing in these areas. Across Melbourne’s four growth corridors there are expected to be up to 422,000 new dwellings and an increase of up to 1.19 million people over the next 30-40 years [146]. Whilst this accommodates for approximately 40-50 % of the states estimated growth, the rest will occur in infill areas across Melbourne [5]. Infill areas do not experience the same infrastructural demands as urban growth areas and the population growth is spread across a larger geography than that of urban growth areas [5, 32]. For example, the population growth for Cranbourne East, 2016-2017, in Melbourne’s south east growth corridor was 27.4% compared with 2.7% in Greater Melbourne [147].
Figure 1. Local Government Areas of Melbourne classified by inner, middle, outer established, urban growth areas and outer fringe areas.
### Table 1: Local government areas classified by inner, middle and outer area boundaries across metropolitan Melbourne

<table>
<thead>
<tr>
<th>Melbourne area classifications</th>
<th>Inner</th>
<th>Middle</th>
<th>Outer - Established</th>
<th>Outer- Growth Area</th>
<th>Outer- fringe areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne</td>
<td>Banyule</td>
<td>Brimbank</td>
<td>Casey</td>
<td>Mornington Peninsula</td>
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<tr>
<td>Port Phillip</td>
<td>Bayside</td>
<td>Frankston</td>
<td>Cardinia</td>
<td>Nillumbik</td>
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<tr>
<td>Stonnington</td>
<td>Boroondara</td>
<td>Greater</td>
<td>Hume</td>
<td>Yarra Ranges</td>
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<td></td>
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<td>Dandenong</td>
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<td>Yarra</td>
<td>Darebin</td>
<td>Knox</td>
<td>Melton</td>
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<td></td>
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<td></td>
<td>Glen Eira</td>
<td>Whittlesea</td>
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<td>Maroondah</td>
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<td></td>
<td></td>
<td></td>
<td>Hobsons Bay</td>
<td>Wyndham</td>
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<td></td>
<td>Kingston</td>
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<td>Manningham</td>
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<td>Maribyrnong</td>
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<td></td>
<td>Monash</td>
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<td></td>
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<td></td>
<td>Moreland</td>
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<td></td>
<td></td>
<td></td>
<td>Moonee Valley</td>
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<td></td>
<td></td>
<td></td>
<td>Whitehorse</td>
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</tr>
</tbody>
</table>
3.2 Identifying diabetic health services

Diabetic health services were selected based on the services required for diabetic patients as recommended by Diabetes Australia Victoria [56]. These include general practitioners, optometry, pharmacy, podiatry, dieticians, endocrinologists, diabetic educators, physiotherapists/exercise physiologist and psychological services [56]. For the purpose of this study, primary health care providers were defined as services that do not routinely require a referral whereas secondary health services were defined as those services usually requiring referrals [148]. Even though some tertiary facilities provide primary and secondary health care services, tertiary health services such as hospitals were excluded from the analysis. Health service location data were collected for all LGAs across metropolitan Melbourne as well as LGAs immediately adjacent including: Murrindindi Shire, Mitchell Shire, Macedon Ranges Shire, Greater Geelong and Moorabool Shire. This was to account for ‘edge effects’, that is, where people may access services close to home, yet lie outside that of metropolitan Melbourne’s boundary [94, 149].

3.3 Data collection of health services and data sources

Data collection of health services commenced in June 2014 and concluded in July 2015, with the exception of general practitioners which was collected in 2012 as part of a previous project. Data were collected from three sources, detailed in Table 2 and described below.
<table>
<thead>
<tr>
<th>Type of health service</th>
<th>Health service</th>
<th>Data source</th>
<th>Data collection date</th>
<th>Number of services geo-coded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Dieticians</td>
<td>Victoria Health Services Directory</td>
<td>2015</td>
<td>n = 457 (Melbourne’s LGA’s and LGA’s adjacent to Melbourne)</td>
</tr>
<tr>
<td>Primary</td>
<td>General practitioners</td>
<td>Victoria Health Services Directory</td>
<td>2012</td>
<td>n = 1818 (across all of Victoria)</td>
</tr>
<tr>
<td>Primary</td>
<td>Optometry</td>
<td>Axiom business points from Pitney Bowes</td>
<td>2014</td>
<td>n = 853 (across all of Victoria)</td>
</tr>
<tr>
<td>Primary</td>
<td>Pharmacy</td>
<td>Axiom business points from Pitney Bowes</td>
<td>2014</td>
<td>n = 1930 (across all of Victoria)</td>
</tr>
<tr>
<td>Primary</td>
<td>Podiatry</td>
<td>Axiom business points from Pitney Bowes</td>
<td>2014</td>
<td>N = 221 (across all of Victoria)</td>
</tr>
<tr>
<td>Primary</td>
<td>Physiotherapy</td>
<td>Axiom business points from Pitney Bowes</td>
<td>2014</td>
<td>n = 919 (across all of Victoria)</td>
</tr>
<tr>
<td>Type of health service</td>
<td>Health service</td>
<td>Data source</td>
<td>Data collection date</td>
<td>Number of services geocoded</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------</td>
<td>-------------------------------------------------</td>
<td>----------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Secondary</td>
<td>Diabetic educators</td>
<td>Australian Diabetes Education Association</td>
<td>2015</td>
<td>n = 213 (services included within a 200km radius from Melbourne’s CBD)</td>
</tr>
<tr>
<td>Secondary</td>
<td>Endocrinologists</td>
<td>Victoria Health Services Directory</td>
<td>2015</td>
<td>n = 132 (Melbourne’s LGA’s and LGA’s adjacent to Melbourne)</td>
</tr>
</tbody>
</table>

### 3.3.1 Victorian Human Services Directory

Dieticians, general practitioners and endocrinologists were sourced from the Victorian Health Services Directory [150]. When accessing and using the Victorian Health Services Directory web page, the search function was selected then the primary or secondary health services of interest, example ‘dietician’, was selected. Next the LGA of interest was selected, example ‘Melton’ [150]. A list of dieticians in Melton was then generated. This list was then copied into an Excel spreadsheet in preparation for geocoding. This process was repeated for each primary and secondary health care service (dieticians, general practitioners, podiatry and endocrinologists) and for each LGA in Melbourne as well as LGAs immediately adjacent. Duplicates of health services were removed.
3.3.2 Pitney Bowes

Optometry, pharmacy, podiatry and physiotherapy data were purchased as 2014 Axiom Business Points from Pitney Bowes Ltd, an e-commerce company [151]. The location of the business points were categorised by Australian and New Zealand Standard Industrial Classification (ANZSIC) codes. The data was transferred into an Excel spreadsheet, cleaned and duplicates removed, in preparation for geo-coding.

3.3.3 Australian Diabetes Education Association

A list of diabetic educators were sourced from the Australian Diabetes Education Association [152]. On the Australian Diabetes Education Association website, there is a search function, where Melbourne was entered as the location of choice and a 200km radius was searched for diabetic educators within this area. A list of diabetic educators was generated which were copied into an Excel spreadsheet in preparation for geocoding.

3.4 Geographic Information Systems techniques

To examine the spatial distribution of health services geographic information systems (GIS) approaches were used. GIS is a computer-based technology that integrates and analyses spatial and/or geographical data [153]. Spatial access refers to how people utilise health services within their daily activity patterns. Geographic access refers to how people utilise health care services within their geographical space. That is their geography is often centred around their home and then patterns emerge when accessing work, sporting and leisure activities, and health care [94]. ArcGIS
10.2 (ESRI, Redlands, CA, USA) was used for all GIS analyses. The selected primary and secondary diabetic health services (as identified above) were mapped using a GIS technique called geocoding. Geocoding involves using GIS software to convert street addresses to \( x \) and \( y \) coordinates to a point reference on a map [149, 154]. GIS was used to undertake network analysis using the shortest road network route between residential address and health services.

3.4.1 Residential Data

Residential address points were created using address points sourced from Vicmap Planning 2013 [155]. This was done by extracting a random sample of address points from Vicmap Planning that were located in residential address zones; identifying residential address points for patients who had T2DM was not undertaken for confidentiality reasons. Vicmap Planning is part of the Department of Environment, Land, Water and Planning Department as part of the Victorian State Government [155]. A variety of planning zones exist across Melbourne, Victoria [156]. As the aim of the study was to synthetically replicate people’s journey from home to a health facility, all planning zones that could potentially have residential points were included (see Table 3). These included all residential zoned addresses as well as address points in the capital city zone, docklands zone, mixed land use zones and urban growth zone [156]. Approximately 10,000 random address points were selected for each area of geography of inner, middle, outer established, outer urban growth and outer fringe areas.
<table>
<thead>
<tr>
<th>Included planning zones</th>
<th>Excluded planning zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>All zone codes beginning with R: residential</td>
<td>DZ7: Waterways</td>
</tr>
<tr>
<td>CCZ1, CCZ2, CCZ3, CCZ4: capital city zones</td>
<td>CDZ1, CDZ2, CDZ3, CDZ4 = Comprehensive Development Plan e.g. To provide for the land to</td>
</tr>
<tr>
<td></td>
<td>be used and developed for a golf course, hotel, function/conference centre, gymnasium/fitness</td>
</tr>
<tr>
<td></td>
<td>centre, retirement village,</td>
</tr>
<tr>
<td></td>
<td>condominiums, display homes, offices, medical centre and associated uses</td>
</tr>
<tr>
<td>DZ1, DZ2, DZ3, DZ4, DZ5, DZ6: Docklands, Yarra's Edge Precinct, Victoria Harbour</td>
<td>B1Z, B2Z, B5Z or C1Z = Commercial 1 zone</td>
</tr>
<tr>
<td>Precinct, Batman's Hill Precinct, Stadium</td>
<td>B3Z, B4Z or C2Z = Commercial 2 zone</td>
</tr>
<tr>
<td>Precinct, Comtechport Precinct and Business</td>
<td></td>
</tr>
<tr>
<td>Park Precinct</td>
<td></td>
</tr>
<tr>
<td>MUZ = Mixed use Zones. To provide for a range of residential, commercial, industrial</td>
<td>PUZ: Public Use Zone. To recognise public land use for public utility and community services and facilities</td>
</tr>
<tr>
<td>and other uses which complement the mixed-use function of the locality. To provide for</td>
<td></td>
</tr>
<tr>
<td>housing at higher densities.</td>
<td></td>
</tr>
<tr>
<td>Included planning zones</td>
<td>Excluded planning zones</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>UGZ, UGZ1, UGZ2, UGZ3, UGZ4, UGZ5: Urban growth zones and mixed use zone</td>
<td>IN1Z = Industrial 1 zone</td>
</tr>
<tr>
<td></td>
<td>IN2Z = Industrial 2 zone</td>
</tr>
<tr>
<td></td>
<td>IN3Z = Industrial 3 zone</td>
</tr>
<tr>
<td></td>
<td>TZ = Township Zone</td>
</tr>
<tr>
<td></td>
<td>PCRZ = Public conservation and resource zone</td>
</tr>
<tr>
<td></td>
<td>FZ 1, FZ2, FZ3, FZ4 = Farming Zone</td>
</tr>
<tr>
<td></td>
<td>PPRZ = Public park and recreation zone</td>
</tr>
<tr>
<td></td>
<td>CA = commonwealth land not controlled by planning scheme</td>
</tr>
<tr>
<td></td>
<td>GWZ 1, GWZ2, GWZ3, GWZ4 and GWAZ 1, GWAZ 2, GWAZ 3, GWAZ 4 = Green wedge A zone: To provide for the use of land for agriculture. To protect, conserve and enhance the biodiversity, natural resources, scenic landscapes and heritage values of the area.</td>
</tr>
<tr>
<td>Included planning zones</td>
<td>Excluded planning zones</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td><strong>LDRZ</strong> = Low density residential zone: The Low Density Residential Zone provides low-density residential development on lots which can treat and retain wastewater.</td>
<td></td>
</tr>
<tr>
<td><strong>SUZ1, SUZ 2, SUZ 3, SUZ 4, SUZ 5, SUZ 6, SUZ 7:</strong> Schedule 1 to the special use zone. To recognise or provide for the use and development of land for specific purposes as identified in a schedule in this zone.</td>
<td></td>
</tr>
<tr>
<td><strong>UFZ</strong> = Urban floodway zone</td>
<td></td>
</tr>
<tr>
<td><strong>ACZ1</strong> = activity centre zone</td>
<td></td>
</tr>
</tbody>
</table>
3.5 Power analysis and sample size

3.5.1 Power analysis

Power analysis was undertaken to determine the probability of an effect or the probability of rejecting the null hypothesis [157]. The null hypothesis of this study is: there were no inequities in diabetic health service provision by private and public transport access across Melbourne’s established areas compared with growth areas. A second reason for undertaking power analysis was to help predict the minimum sample size required of residential addresses for the network analysis model [158].

Four factors were taken into consideration when calculating the power analysis:

1. Alpha – probability of finding significance when there is none
2. Beta – probability of finding true significance
3. N – the number of the population required to determine an effect; sample size
4. Effect – the “expected” effect, ascertained from pilot or similar studies [158]

Alpha and Beta values were based on traditional methods of analysing data, where alpha was specified at 0.05, meaning there was a 5% probability of finding significance when there was none [158]. Beta was specified at 0.80, meaning that 80% of the time, there would be a statistically significant result between study groups, that is between the five regions of Melbourne inner, middle, outer established, outer growth and outer fringe areas [157, 158].
N and effect size were unknown, therefore needed to be estimated. The most common method to determine the effect size is from a pilot study [158]. However, as a pilot study had not been carried out a study which considered travels times in growth areas was required. In this case journey to work data (JTW) sourced from the VISTA 2009-10 [104] was used. VISTA data provided information in regards to travel time from place of residence to work by both private and public transport for inner, middle, outer established, outer urban growth areas and outer fringe areas of metropolitan Melbourne [104]. JTW times were anticipated to be longer trips compared with trips to health services which were anticipated as being local trips; this however did not affect the power analysis calculation.

3.5.2 Sample Size

Once the power analysis was determined sample size calculations were undertaken. Sample size calculations were conducted to ensure the results produced were robust [157]. Sample size calculations were based on the normal distribution and have a total confidence interval width of 5 minutes (+/- 2.5 minutes) for each area of Melbourne (inner, middle, outer established, urban growth areas and outer fringe areas). To calculate the sample size the longest JTW time was taken for each area of Melbourne and calculated (Tables 4 and 5). For example, in inner Melbourne, the suburb of Port Phillip had the longest mean JTW time of 32.66 minutes with a standard deviation of 17.18 minutes.
Table 4: Suburbs with longest private transport JTW travel times by area of Melbourne

<table>
<thead>
<tr>
<th>Area of Melbourne</th>
<th>Suburb</th>
<th>Private transport</th>
<th>Private transport</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>JTW mean (mins)</td>
<td>JTW SD (mins)</td>
</tr>
<tr>
<td>Inner</td>
<td>Port Phillip</td>
<td>32.66</td>
<td>17.18</td>
</tr>
<tr>
<td>Middle</td>
<td>Whitehorse</td>
<td>34.56</td>
<td>29.80</td>
</tr>
<tr>
<td>Outer Established</td>
<td>Knox</td>
<td>31.83</td>
<td>25.66</td>
</tr>
<tr>
<td>Outer Urban Growth</td>
<td>Cardinia</td>
<td>40.53</td>
<td>31.74</td>
</tr>
<tr>
<td>Outer Fringe</td>
<td>Yarra Ranges</td>
<td>34.22</td>
<td>25.37</td>
</tr>
</tbody>
</table>

Key: JTW = Journey to work; mins = minutes; SD = standard deviation
Table 5: Suburbs with longest public transport JTW travel times by area of Melbourne

<table>
<thead>
<tr>
<th>Area of Melbourne</th>
<th>Suburb</th>
<th>Public transport JTW mean (mins)</th>
<th>Public transport JTW SD (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner</td>
<td>Yarra</td>
<td>11.95</td>
<td>12.32</td>
</tr>
<tr>
<td>Middle</td>
<td>Kingston</td>
<td>26.39</td>
<td>8.01</td>
</tr>
<tr>
<td>Outer Established</td>
<td>Frankston</td>
<td>39.23</td>
<td>12.99</td>
</tr>
<tr>
<td>Outer Urban Growth</td>
<td>Cardinia</td>
<td>48.08</td>
<td>23.20</td>
</tr>
<tr>
<td>Outer Fringe</td>
<td>Mornington Peninsula</td>
<td>86.81</td>
<td>6.75</td>
</tr>
</tbody>
</table>

Key: JTW = Journey to work; mins = minutes; SD = standard deviation

The maximum sample size required for either public or private transport across either inner, middle, outer established, outer urban growth or outer fringe areas was 2,477 addresses per region (Tables 6 and 7). Accordingly, approximately 10,000 random address points were selected for each of the five areas identified across Melbourne. I visually reviewed the data distribution and it captured a varied geographical distribution of potential residential populations across the 5 areas of Melbourne; inner, middle, outer established, outer urban growth and outer fringe areas. I acknowledge that tests such as the Moran’s I test could have been conducted, as well as mapping of the selected points, to test for random distribution, and this is a limitation of the research.
Table 6: Sample size numbers of randomly generated addresses by area of Melbourne via private transport

<table>
<thead>
<tr>
<th>Area</th>
<th>Suburb</th>
<th>Mean (mins)</th>
<th>SD (mins)</th>
<th>95% CI width (mins)</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Port Phillip</td>
<td>Port Phillip</td>
<td>32.66</td>
<td>17.18</td>
<td>2.5</td>
<td>726</td>
</tr>
<tr>
<td>Middle Whitehorse</td>
<td>Whitehorse</td>
<td>34.56</td>
<td>29.8</td>
<td>2.5</td>
<td>2,184</td>
</tr>
<tr>
<td>Outer Established</td>
<td>Knox</td>
<td>31.83</td>
<td>25.66</td>
<td>2.5</td>
<td>1,619</td>
</tr>
<tr>
<td>Outer Urban Growth</td>
<td>Cardinia</td>
<td>40.53</td>
<td>31.74</td>
<td>2.5</td>
<td>2,477</td>
</tr>
<tr>
<td>Outer Fringe</td>
<td>Yarra</td>
<td>34.22</td>
<td>25.37</td>
<td>2.5</td>
<td>1,583</td>
</tr>
</tbody>
</table>

Key: CI = confidence interval; mins = minutes; SD = standard deviation
Table 7: Sample size numbers of randomly generated addresses by area of Melbourne via public transport

<table>
<thead>
<tr>
<th>Area</th>
<th>Suburb</th>
<th>Mean (mins)</th>
<th>SD (mins)</th>
<th>95% CI width (mins)</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Yarra</td>
<td>Yarra</td>
<td>11.95</td>
<td>12.32</td>
<td>2.5</td>
<td>374</td>
</tr>
<tr>
<td>Middle Kingston</td>
<td>Kingston</td>
<td>26.39</td>
<td>8.01</td>
<td>2.5</td>
<td>158</td>
</tr>
<tr>
<td>Outer Established</td>
<td>Frankston</td>
<td>39.23</td>
<td>12.99</td>
<td>2.5</td>
<td>415</td>
</tr>
<tr>
<td>Outer Urban Growth</td>
<td>Cardinia</td>
<td>48.08</td>
<td>23.2</td>
<td>2.5</td>
<td>1,324</td>
</tr>
<tr>
<td>Outer Fringe Peninsula Mornington</td>
<td>86.81</td>
<td>6.75</td>
<td>2.5</td>
<td></td>
<td>113</td>
</tr>
</tbody>
</table>

Key: CI = confidence interval; mins = minutes; SD = standard deviation
3.6 Network analysis

Network analysis was chosen for this project as it allows for a more accurate representation of travel times, as opposed to straight line or Euclidean distances [159]. Although distance is a strong geographical indicator of access to health care services, consumers are more sensitive to factors such as travel time, transport availability and cost when accessing and utilising health care services [94]. Additionally, Mavoa et al [160] highlighted in their work that travel time as a measure of access to services was more sensitive than measuring access to services via distance. Therefore, travel time was used as a spatial measure of access to services, as it provided a more responsive measure of access to services than distance, while accounting for access to transport [94].

All network analysis was undertaken in ArcGIS. Network distances have starting nodes (e.g. residential addresses) and end nodes (e.g. health service) and by using GIS software I was able to calculate the fastest travel times along a street network between the nodes [153]. The GIS software also takes into considerations aspects such as one way streets, tunnels, overpasses and turn restrictions [161].

For this study, network travel times were measured from a synthetic residential address to the nearest health service using the origin destination (OD) cost matrix function. From this, the fastest street route was determined between the two points and the estimated travel times were calculated. Network analysis was performed for each mode of transport, either public or private transport, to each type of the nearest primary and secondary diabetic health care services.
3.6.1 Origin destination matrix

The type of network analysis employed was an OD matrix which calculates the travel time between origins (i.e. residential address points) to the nearest destination of interest (i.e. health care services) [162]. From this, the fastest route was determined by connecting the origin and destination and calculating the estimated travel time along the network [153].

Two OD matrix frameworks were created to estimate the travel time between each synthetic residential address and the nearest health care facility of each type for both private and public transport modes [162]. Public transport times included walking to and from public transport stops, as well as potentially catching a bus then a train to a destination.

3.7 Private motor vehicle network

The private transport network was created using Vicmap transport road centreline data [155]. Travel times varied for different roads at different times of day [163]. Travel times were calculated during off-peak day road times that is between 10am to 3pm. Off peak travel times were used because of: 1) the larger variation in travel conditions during peak times; and 2) an assumption that many health services are more commonly accessed during non-peak periods. While this introduces bias for those who travel to health services during peak periods, this bias is consistent across the entire road network. Any other single-time point disruptions that may occur along the road network (e.g. accidents, maintenance) were not considered in the calculations.
As detailed vehicle travel time data were unavailable, off-peak travel speeds for different types of roads in the road hierarchy were estimated (see Table 8) [164, 165]. Sign posted speeds for each road type in the road hierarchy were sourced from VicRoads traffic engineering manual [165] and the Vic Roads traffic monitor report provides average travel speeds by road category (e.g. freeway, arterial) and area (inner and outer). Average travel speeds were calculated from this information (see Table 8). Average travel speeds were not available for local and collector roads. As seen in Table 8 the average travel speed for the arterial and sub-arterial networks across inner and outer regions were approximately half of the sign posted travel speed [163]. Therefore, this determined the average travel speeds across the network for collector and local roads by using half the sign posted travel speeds, i.e. on a 50 km/hr signed street, travel speeds were estimated to be 25km/hr.
Table 8: Road hierarchy and estimated private motor vehicle travel speeds.

<table>
<thead>
<tr>
<th>Road hierarchy type</th>
<th>Sign posted speed</th>
<th>Actual speed, off peak, inner LGA</th>
<th>Actual speed, off peak, middle LGA</th>
<th>Actual speed, off peak, outer established LGA</th>
<th>Actual speed, off peak, urban growth LGA</th>
<th>Actual speed, off peak, outer fringe LGA</th>
<th>Actual speed, off peak, outer established LGA</th>
<th>Estimated private motor vehicle speed (Mean, off peak, inner and outer)</th>
<th>Estimated private motor vehicle travel time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>100km/hr</td>
<td>70km/hr</td>
<td>70km/hr</td>
<td>80km/hr</td>
<td>80km/hr</td>
<td>80km/hr</td>
<td>75km/hr</td>
<td>20.83 m(^{-1})</td>
<td></td>
</tr>
<tr>
<td>Arterial or Highway</td>
<td>80km/hr</td>
<td>32.5km/hr</td>
<td>32.5km/hr</td>
<td>43 km/hr</td>
<td>43 km/hr</td>
<td>43 km/hr</td>
<td>37.75 km/hr</td>
<td>10.49 m(^{-1})</td>
<td></td>
</tr>
<tr>
<td>Sub-arterial</td>
<td>60km/hr</td>
<td>28km/hr</td>
<td>28km/hr</td>
<td>38km/hr</td>
<td>38km/hr</td>
<td>38km/hr</td>
<td>33 km/hr</td>
<td>9.17 m(^{-1})</td>
<td></td>
</tr>
<tr>
<td>Collector</td>
<td>50km/hr</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>25km/hr</td>
<td>6.94 m(^{-1})</td>
</tr>
<tr>
<td>Local</td>
<td>40km/hr</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>20km/hr</td>
<td>5.56 m(^{-1})</td>
</tr>
</tbody>
</table>

Key: hr = hour; km = kilometre; LGA = Local Government Authority; m\(^{-1}\) = metres per second

Data source: Vic Roads traffic monitor report [163] and Vic Roads traffic engineering manual [165].
3.8 Public transport network

Public transport stops, routes and timetables were sourced from Public Transport Victoria’s General Transit Feed Specification (GTFS) [166]. GTFS provides a common format for public transport schedules and geographic information which can be downloaded and used for research purpose. The GTFS provides information for all scheduled trains, trams and buses for metropolitan and regional Victoria [166]. Public transport modes used in the analysis included trains, trams and bus services.

A multi-modal network was created for the public transport network analysis using GTFS tools for ArcGIS [167]. A multi-modal network is one that creates the shortest path using network analysis taking into account the best walking or public transport option [168], and included the time spent walking to and/or travelling by public transport. The OD matrix was calculated at the same day and time (12:00 pm, Wednesday).

3.9 Statistical analysis

The final dataset contained shortest travel times in minutes from approximately 50,000 synthetic residential address points to eight diabetic health care services of interest, for both private and public transport in each of the five areas of Melbourne.
3.10 Descriptive statistics

Descriptive statistics were undertaken to analyse the differences in travel times between primary and secondary health care services, across the five metropolitan areas of Melbourne. To generate descriptive statistics the following process occurred. The network analysis generated in ArcGIS, provided tables of results with travel times from origin to destination. These files were saved as text files, and then converted to .csv files. These were then opened and saved as Excel workbook files, where further statistical analyses were performed.

Data were analysed and descriptive statistics were calculated. The mean, median, minimum, maximum and standard deviation were all calculated in Excel using the ‘Data Analysis’ function, and add-in extension to the ‘Data’ tab. Interquartile ranges were calculated in Excel using the ‘function’ button and selecting ‘quartile’. The first quartile was calculated, then the third quartile; from here the third quartile was subtracted from the first quartile to give the interquartile range.

Figures were compiled in the statistical software program MiniTab. Findings from the statistical analysis are discussed in the results chapter.
3.11 ANOVA testing – comparison of groups

Further to descriptive statistics, one way analysis of variance (ANOVA) testing was initially undertaken to determine significance of means between groups (i.e. inner, middle, outer established, outer growth and outer fringe) of each individual health service. ANOVA testing involves comparing the means between different groups and determining if any differences detected are statistically significant [169].

ANOVA single factor analysis was conducted in Excel, for each type of primary and secondary health care service, across the five areas of Melbourne. In Excel, data for individual health services were presented in columns of either inner, middle, outer established, outer urban growth or outer established suburbs. From this ANOVA testing was performed through selecting the ‘Data Analysis’ tab in Excel and then selecting ANOVA single factor. The appropriate data was then input into the formula. All values were rounded up to two decimal places. This process was repeated for each individual health service.

3.12 Alternate GIS methods

There are other GIS methods that can be undertaken when considering access to health services. Kernel density estimations (KDE) have been used when analysing geographical access to health care in densely populated urban areas and can be used to examine service density [94, 170]. KDE depicts the density of service providers (number per unit area) by transferring point data into a continuous spatial variable once health service data is located and geocoded [94, 170]. KDE has been used by Guagliardo et al [171] to measure spatial distribution of physician accessibility of paediatric providers in Washington, United States of America. Similarly McLaffery and Grady [172]
used KDE when analysing access to prenatal care in Brooklyn, New York, United States of America. A limitation of the KDE method and a reason it was not used for this study, is that KDE performs poorly in rural areas where fewer providers exist [94, 170]. As this study considers access in urban growth areas, where services may be sparse KDE was not the chosen methodology for this study.

Another common GIS method used when undertaking health services access research are the floating catchment area (FCA) and the 2-step floating catchment area (2FSCA) methods. The FCA is an extension of population to provider ratios, the key difference being the FCA uses floating catchments or areas rather than set boundaries [173, 174]. The size of the area is determined by a choice of maximum travel impedance, where all services contained within that area are considered accessible to populations, and all other services are not accessible [173-175]. This process creates as many catchments as there are defined populations, the boundaries for which ‘float’ and overlap [173-175].

The 2SFCA method is an expansion of the FCA method and is more commonly used in recent health research [175-177]. The 2SFCA extends on the FCA by using GIS to create a ‘second’ area. Whilst the FCA focuses on supply of health services, the 2SFCA method focuses on both supply and demand of health services by taking into account the population that are likely to use the services [175, 176]. The process of the 2SFCA method is to: 1) calculate the catchment area, through identifying all populations that fall within a distance threshold to a service, in order to calculate the population to provider ratio [175]; and 2) calculate the population catchment, by identifying each population group and finding services that fall within a distance threshold plus add the population to provider ratios, conducted in step 1 [175].
Whilst the 2SFCA method is a sophisticated GIS method for measuring health services accessibility, it was not chosen as a GIS method for this study. McGrail and Humphreys [175, 176] used the 2SFCA method in their study considering primary care services access in rural areas of Victoria, Australia and cautioned the use of the 2SCFA method in rural areas. The authors found that large catchment areas became problematic in the fringe-rural areas of Victoria related to the population size of Melbourne [175, 176].

KDE and the 2SCFA method are only a few GIS methods that can be employed when considering health services access research. Other methods include the gravity model [94, 170], interpolation [159], geographically weighted regression [159] and dasymetric modelling [159]. All potential GIS methods were researched in depth. However, given the nature of urban growth areas, that is low density urban areas with increasing populations and services, coupled with available resources, the network analysis and origin destination matrix GIS methods were deemed the most suitable. Network analysis and origin destination matrix were chosen as they have the ability to generate results that can accurately reflect travel times from two points, regardless of the population or services in an area [94]. In this respect, the methods chosen are able to impartially reflect travel times across all five areas of Melbourne: inner, middle, outer established, outer urban growth and outer fringe.
Chapter 4: Results

Due to the large sample size (~ 50,000 address points), the p-values were all significant.

Additionally the f value was larger than the f-critical value for all ANOVA tests (tables 10 &11) performed (another indication of statistical significance) [178]. As a result of these findings, descriptive statistics were used to investigate and interpret differences across the five areas of Melbourne for each health service and between private and public transport.

As demonstrated in figures 2 and 3 and Table 9, overall median travel times, for both private and public transport, increased as residential addresses were located further away from, inner Melbourne. Inner Melbourne had faster travel times to health services compared with middle Melbourne; middle Melbourne had faster travel times to health services when compared with outer established Melbourne; outer established had faster travel times to health services compared with outer growth areas; and outer fringe areas of Melbourne had the slowest travel times to health services. In general outer growth areas had faster travel times compared with outer fringe areas, however many of the travel times were similar. However, there were some exceptions to this; pharmacy (private transport) and optometry (private transport) travel times were faster in outer fringe areas compared with outer growth areas.

Travelling to diabetic health care services ranged between 5.89 (inner) to 4.02 (outer fringe) minutes faster by private motor vehicle when compared with public transport across all areas of Melbourne (Figure 2 and Table 9). Compared with those living in inner city areas, the median time spent travelling by private motor vehicle to diabetic services ranged between 2.46 and 23.24 minutes slower for those living in outer suburban areas and 12.01 and 43.15 minutes slower by public transport (Figure 3 and Table 9). Compared with middle suburbs which ranged between
1.1 and 21.22 minutes slower for private motor vehicle and 8.29 and 40.62 minutes for public transport (Figure 3 and Table 9). As seen in figures 2 and 3, irrespective of travel mode used, results indicate that those living in inner and middle suburbs of Melbourne have faster travel times to access diabetic health services for both private and public travel modes, compared with those living in outer areas of Melbourne.

Private transport travel times as shown in figure 2 were fastest when accessing primary health care services in inner Melbourne (general practitioners median travel time in minutes: 0.89 (private transport), 5.1 (public transport); access to pharmacies median travel time in minutes: 0.86 (private transport), 5.89 (public transport)). Curiously there were some extremely fast travel times when accessing some general practitioners (0.89 minutes) and pharmacists (0.86 minutes). It was postulated that if a residential address was located next to a general practitioner or pharmacy, the travel time was under-estimated as the private transport analysis did not take into account time getting into the car or waiting for traffic, and indeed may be irrelevant as it would be highly unlikely that a resident would drive to a destination located next door.

Within mode, travel times in Melbourne’s outer growth and fringe areas were similar for primary health care services and indeed one might argue the ‘clinical significance’ of 1 minute versus 3 minutes is pretty low. For example, to access pharmacies the median travel time in minutes was 3.51 (outer urban growth) and 3.26 (outer fringe) for private transport (figure 2) and 17.13 (outer urban growth) and 17.20 (outer fringe) for public transport (figure 3). Time taken to access secondary health care services were slower compared with primary health care services. The slowest travel times occurred when accessing specialist secondary health care services such as endocrinologists; median travel times for outer growth areas and outer fringe areas were 9.81
and 26.72 minutes respectively (private transport, figure 2), and 39.3 and 59.25 minutes respectively (public transport, figure 3).

Figure 2, as seen below, represents travel times for private vehicles to a range of diabetic health care services: dieticians, GPs, optometry, pharmacy, podiatry, pyhsiotherapy, diabetic educators and endocrinologists. Figure 2 indicates that maximum time spent travelling to access diabetic health care services was 100 minutes via private transport, with specialist services such as endocrinologists, diabetic educators and podiatrist having some of the longest travel times, particularly for urban growth and fringe areas of Melbourne. The shortest travel times for private motor vehicles to diabetic health care services were to common primary health care services such as GPs and pharmacists. These results are also shown in numerical value in table 9.
Figure 2: Travel times in minutes across Melbourne to diabetic health services via private transport
Figure 3, as seen below, represents travel times for public transport to a range of diabetic health care services: dieticians, GPs, optometry, pharmacy, podiatry, pyhsiotherapy, diabetic educators and endocrinologists. Figure 3 indicates that the maximum time spent travelling to access diabetic health care services was 400 minutes via public transport including time spent walking to a bus stop, or multi-modal trips including a bus and train journey. Public transport times included walking to and from public transport stops, as well as potentially catching a bus then a train to a destination. Therefore travel times could have been up to 3 to 5 hours if someone had a long distance to walk to a bus stop, had a bus and then a train to catch. A scenario such as this could impact on increased travel times depending on the closest public transport stop available.

Similar to figure 2, in figure 3 it can be seen that specialist services such as endocrinologists, diabetic educators and podiatrist had some of the longest travel times, particualrly for urban growth and fringe areas of Melbourne. The shortest travel times for private motor vehicles to diabetic health care services were to common primary health care services such as GPs and pharmacists. These results are also shown in numerical value in table 9.
Figure 3: Travel times in minutes across Melbourne to diabetic health services via public transport
### Table 9: Travel times in minutes across Melbourne to diabetic health services via private and public transport

<table>
<thead>
<tr>
<th>Primary Care Health Service</th>
<th>Private Transport</th>
<th>Public Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inner</td>
<td>Middle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dietician</td>
<td></td>
<td></td>
</tr>
<tr>
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**Primary Care Health Service**

**Podiatry**

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* Some n’s are not 10,000 because of duplicate residential address points when running the model
Table 10: ANOVA testing from residential origin to health service destination via private transport across the Melbourne region

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Table 11: ANOVA testing from residential origin to health service destination via public transport across the Melbourne region

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Chapter 5: Discussion

Section One – Reducing inequity and the burden of T2DM in Melbourne: the case for primary and secondary services closer to home

5.1 Primary and secondary health care services

Few studies have considered access to both primary and secondary health care services in regards to travel times and travel mode, however it is generally accepted that travel times to primary health care services are shorter than to secondary health care services. By way of example, Haynes et al describe that 99% of their study population in East England could access a general practitioner within a 17 minute car trip [179]. Whereas, a study by Onega et al considered access to specialised cancer services in the United States and found that median car travel time to National Cancer Institute designated cancer centres was 78 minutes [180].

Not surprisingly, in this research the least time spent travelling to health care services was to access primary health care services. In regards to the health services hierarchy, primary health care services are usually the first point of entry into the health care system and are likely to be accessed by many different populations, and most frequently [12]. The findings show that addresses located within inner Melbourne had the fastest travel times to access primary health care services (pharmacies and general practitioners), and those living in the outer urban growth and outer fringe areas of Melbourne experienced the slowest travel times when accessing specialist secondary health care services (e.g. endocrinologists). To improve access to health services in Melbourne’s outer urban growth areas, health planners should consider providing
more localised primary health care services, as well as providing more frequent and more choices of public transport [5, 16].

Travel times to specialist services such as diabetic educators and endocrinologists were slowest across both modes of transport as they serve particular groups, for example someone living with T2DM, and therefore there are fewer services available. As endocrinologists and diabetic educators are secondary health care services and are generally not accessed locally, compared with primary health care services, travel times were expected to be longer, and this was supported by the findings. Many specialists are based in tertiary hospital settings, therefore requiring patients to travel to hospitals to access such services [45]. As such, it is reasonable to expect longer travel times when accessing specialist services as these are accessed less frequently. Specialist services may require an alternative delivery model to provide for those living on the urban growth areas and urban fringe areas of cities.

There was marked variability by LGA type when accessing both primary and secondary health care services; some residents in urban growth areas could travel up to 196 minutes via public transport to access a general practitioner. Plan Melbourne [5] has called for a 20-minute city, where residents should be able to access essential services within a 20 minute trip regardless of age or ability and either via active or public transport. Public transport travel times of up to 196 minutes to reach basic primary health care services observed in this research, clearly do not fall within this policy imperative and highlight significant health service access inequities within Melbourne, with many areas falling well below the aspiration of Plan Melbourne’s 20-minute city.

These findings were supported by a 2015 report by the Department of Health and Human Services [181] which provides rankings for all 79 LGAs in Victoria; rankings are provided to from 1 (highest)
to 79 (lowest). The rankings compare: population; disadvantage and social engagement; health status and service utilisation; housing, transport and education; and child and family characteristics, across LGAs in the state and against the state average [181]. The report indicated that in Wyndham City Council, an urban growth area council in Melbourne’s outer west, service sites for general practitioners (ranked 68 out of 79 LGAs), pharmacies (ranked 74 out of 79 LGAs) and allied health (ranked 77 out of 79 LGAs) per 1,000 population, and were amongst the lowest in the state [181].

5.2 Private versus public transport

This research identified differences in health service access by transport modes, and this was particularly evident within urban growth areas. Similar to Lovett et al’s [95] research, private transport was consistently shown to have faster travel times when accessing all health services compared with public transport modes, however it did not account for incidental time such as walking to and from the car and time to park - which in the inner areas can add significant time (and cost). The present results also showed less variability in private motor vehicle and public transport travel times across inner and middle areas of Melbourne compared with outer suburban areas. This is due to inner and middle areas of Melbourne having more established health services and transport infrastructure which translates into greater access to health care services [5, 12].

Historically Melbourne’s public transport system has been a radial or a ‘hub and spoke’ model. That is where, public transport services, particularly train services, have carried passengers to and from home and the CBD, with little public transport operating across Melbourne [182]. As Davies purports [183] this served the city well when the majority of jobs and services were located in the
CBD, however as demographics, land use zoning and availability, and activity centres have changed, so too have journeys and how people travel to these destinations. Melbourne’s current radial public transport system continues to adequately service those who live in inner and middle suburbs when accessing health care services [182, 183], however an orbital model may need to be considered in future, to deliver better access to services to those located on the urban fringe.

There is variability in the infrastructure available in outer suburbs across Melbourne. For example, in more established outer suburban areas more transport infrastructure and services are available. An example is Frankston, which is located approximately 41 kilometres south-east of Melbourne’s CBD and has well-established public transport and health care services infrastructure [184], compared with many of the new urban growth areas [5, 6]. Despite Frankston’s location as an outer suburb of Melbourne, it was established in 1846 [184] and the train line was established in 1882 [185]. The implication of this is that the area has had time to adapt to population growth and produce an urban form that is supportive to its residents, reinforced by public transport and health services infrastructure.

Research conducted by Currie et al [43, 186] examined transport disadvantage in Melbourne’s urban growth and fringe areas. Transport disadvantage is defined as poor walkability and poor access to public transport, therefore an increased reliance on car ownership as a necessity of life on the suburban fringe [43, 44, 186]. Residents living in Melbourne’s urban growth areas were shown to experience transport disadvantage, as they were living in car-dependant areas that had low or no access to public transport [43, 44, 186]. This was exemplified in the current research with Melbourne’s outer urban growth areas and outer fringe areas experiencing some of the longest travel times to access diabetic health services when using public transport. As supported by this research, people living in urban growth areas are faced with a complex transport situation, the
geographical distance from Melbourne’s CBD coupled with a lack of other types of established transport infrastructure fosters reliance on private car ownership [6, 16].

Alongside Currie et al [43, 44], the Vulnerability Assessment for Mortgage, Petroleum and Inflation Risks and Expenses (VAMPIRE) index [187] explored factors influencing transport disadvantage, such as vulnerability and mortgage stress in relation to increased inflation, interest rates and petrol prices. Residents largely affected by such factors often live in the outer suburban areas of large metropolitan cities such as Melbourne’s urban growth areas [187]. The combination of forced transport costs related to car ownership, a lack of other transport options and increased housing stress in Melbourne’s outer urban growth areas means the monetary cost of travelling to health care services can be prohibitive for disadvantaged populations, especially for those who may not have a private car and rely on transport for hire, such as taxis [188]. This has implications such as delays or an inability to access health care when needed [6], particularly for populations who have a greater reliance on public transport to access health services [32, 43].

Additionally those who live in Melbourne’s urban growth areas tend to also be socioeconomically disadvantaged [6, 32] and are known to have a diverse population [12, 32]. Similarly, Roeger et al considered spatial access to general practitioners in metropolitan Adelaide, Australia and concluded those most disadvantaged and requiring the highest level of access to primary health care services were those living in outer suburbs [189]. Therefore, a ‘triple disadvantage’ situation may exist in Melbourne’s urban growth areas, being; less availability of health care services, less public transport infrastructure to access health care services, and a greater proportion of vulnerable populations [6, 12, 32].
5.3 Public transport and equity of access

It has been argued that decreasing patients’ travel time and having a range of transport options available to access health services are essential for increased health service equity [110, 190]. The mode of travel to access health services also requires attention as few studies have considered access via public transport [95], with the majority defining ‘access’ through private transport modes [7, 95, 97]. This study demonstrated that Melbourne’s urban growth area populations have poorer access to health services through the use of public transport with increased travel times compared to private transport, for example median travel time to a general practitioner was 3.22 minutes via private transport compared to 16.02 minutes via public transport in urban growth areas.

A reliable and well connected transport system is required for Melbourne, particularly to its outer suburbs, however, Victoria currently does not have a transport policy [5]. Plan Melbourne indicates that public transport in Melbourne’s urban growth areas will be provided through buses [5]. Criticisms of Melbourne’s current bus network include that it is slow, infrequent and cannot carry large volumes of passengers [191], often meaning people prefer to take their car. However Infrastructure Victoria has released a 30 year infrastructure and transport strategy which recommends an ‘overhaul’ of Melbourne’s current public bus transport system through expanding the SmartBus network [192]. The SmartBus network will support local bus routes and will also compliment Melbourne’s greater transit system through greater connectivity for across town trips and increased service frequency [192].
A study by Tao et al [193] in Brisbane Queensland, Australia, of its Rapid Bus Transit (RBT) (similar to Melbourne’s SmartBus) indicated that Brisbane’s RBT was a backbone element in transporting passengers from northern and southern locations of Brisbane into the CBD while the rest of the bus network catered for local trips. Furthermore the study indicated that it potentially benefited disadvantaged populations through greater transport accessibility [193]. Another study conducted by Boulange et al [194] considered the association between urban design attributes and choice of transport mode (active, public or private), and found a significant increased odds of individual public transport use when a bus stop was located within 400m and / or a train station within 800m of a household. This alongside a range of access destinations, for example located within activity centres where health services and retail services are available, encouraged public transport use [194]. Therefore, enhancing integrated planning through the provision of transport infrastructure close to people’s homes and to activity centres, alongside the use of an improved and proficient bus services across Melbourne’s growth urban areas, has the potential to increase equity of access to diabetic and other essential services and reduce disadvantage.

5.4 Transit Oriented Development: Making the most of a bus network

As Melbourne continues to expand, an increased density of services and houses along major arterial roads and public transport nodes is required. This vision is being supported through Plan Melbourne, with the aim to deliver more services and public transport early to urban growth areas [5]. Similar to this strategy are transit oriented developments (TODs). TODs increase transport sustainability [195] by focusing on land use planning around large scale public transport, such as train stations or bus terminus [196]. TODs also have a focus of mixed use, which allows people to access a range of destinations and services locally, or use public transport for the longer ‘out-of-neighbourhood’ journeys [195, 196]. Additionally, TODs have an emphasis on medium to
high dwelling densities along public transport corridors, promoting walking, cycling and public transport, and decreasing reliance on cars [196]. In order for TODs to be successful, integrated land use and transport planning are crucial to informing the site for development [5, 195, 196]. There is a focus on establishing TODs in urban growth areas, where health, education, business and other services are prioritised and co-located through planning to ensure a coordinated delivery alongside transport [5].

5.5 The relationship between T2DM and urban form

Urban planning has a strong influence on the outcome of people’s health and wellbeing [197] and by implementing urban planning principles that create healthy lifestyles, the built environment can reduce the impact of chronic conditions such as T2DM. T2DM is a non-communicable disease that is largely lifestyle related [54]. Evidence shows that people who modify their behaviours such as increased physical activity and decreased sugar intake can reduce the risk of developing T2DM by approximately 60% [54]. Provision of local and high quality transport and services can encourage active transport commutes, therefore minimising the use of private vehicles and reducing sedentary behaviour [33, 197].

Furthermore travel behaviours are habitual and residents are less porous to transport mode change once settled into a routine [198]. For example, if public transport is not immediately available to residents in urban growth areas, the opportunity may be missed to influence people’s travel behaviours [199]. Implications of car reliance for regular commuting include increased cost to residents through maintaining a vehicle, decreased incidental physical activity, as there may be limited opportunity to walk to destinations within the community, and increased isolation if more
time is spent travelling by car; this may allow less time for civic engagement, leaving potentially vulnerable populations further isolated and disadvantaged [33]. Therefore, the way in which urban growth areas are designed now, will have a lasting impact on people’s behaviours and health outcomes [6, 16].

Indeed, councils and governments are beginning to take a ‘whole of population’ approach to health planning [5, 200], so while health service access and delivery are an important component, the overall urban form is also taken into consideration. Locally, this is evidenced by the municipal and public health and wellbeing plans undertaken by local councils every four years [201], which outline a long term health strategy through, for example, the assessment and provision of public open space, sporting and recreation facilities, walking and bike paths [201]. Additionally, the Heart Foundation released its Healthy by Design report which details the role urban planning plays to promote positive population health outcomes [197]. Other international examples include New York City’s Active Design Guidelines [202] and the WHO’s Age Friendly Cities guide [203] that have health and wellbeing principles at the heart of urban planning.

5.6 Funding health services: Public Private Partnerships

Aside from the physical location and number of health services predicted to be required in urban growth areas, the financing of health services in growth areas requires consideration, and funding for infrastructure across Victoria continues to be competitive. The current backlog of social infrastructure required indicates that the co-delivery of housing and health and other services unlikely [20]. Local councils are vital in the organising and delivery of social infrastructure, however are largely restricted by financial constraints to deliver all of the desired services [31, 126, 204]. Local governments are restricted as they cannot ‘tax’ the local community for social infrastructure
services, and money is often not collected from community assets, therefore only a small proportion of the initial implementation costs are recovered [31, 126, 204]. This can lead to a ‘gap’ in services for current and future use; resulting in emerging governance structures of community facilities and promoting greater collaboration and interdependence between public, private and community groups [31, 126, 204]. As a result, funding is often sourced from various levels of government as well as the private sector.

Public private partnerships (PPPs) can help alleviate the pressure of economic viability for social infrastructure in urban growth areas, by providing support for businesses in the early phases while the population is being established. This can also translate to a higher uptake of behaviour changes to use social infrastructure and public transport as residents are more adaptable when they first move in. Plan Melbourne does acknowledge the need to work with both public and private enterprises when delivering health services across Melbourne [5]. One method, the Growth Areas Infrastructure Contribution (GAIC) was introduced to support local councils by helping pay for up to 15% of state infrastructure occurring in urban growth areas [205]. Also, PPPs are an increasingly popular avenue to fund infrastructure, including health infrastructure globally [206].

PPP’s consists of a partnership between two parties, such as a government organisation; multinational companies; private companies, either for profit or not for profit; community groups; or donor organisations [207]. Some of the main benefits of PPPs are the sharing of resources and responsibilities, optimising risk management, and having greater value for money [207, 208]. An example of a successful Victorian health care PPP is Casey Community Hospital, located in Melbourne’s south-eastern growth corridor [209]. Casey Community Hospital opened in 2004 and was a joint venture between the Victorian State Government and Progress Health Pty Ltd [209, 210]. The Victorian State Government’s contract with Progress Health is over 25 years, valued at an
estimated $120 million for the provision design, construction, maintenance, and support services of Casey Community Hospital [210]. Since the initial opening of the Casey Community Hospital, services have been added such as a neo-natal ward and further expansion of the hospital is currently underway [209]. The Victorian State Government has other examples of successful PPPs in health care provision, however most projects are related to hospitals or tertiary health care [211]. Therefore, there is scope, especially for primary and secondary health care PPPs, in urban growth areas to increase equity of health service access.

As Jefferies [208] purports, PPPs are becoming a preferred option for governments to deliver social infrastructure, particular in health care settings. Concerns with PPPs and the delivery of social infrastructure for health care involve the risks to both parties; as social infrastructure PPPs tend to have higher bidding costs with lower economic return [206, 208]. In terms of applying PPPs for healthcare delivery in growth areas, it appears to be the most viable and likely scenario, particularly as it is a policy directive of the Australian Government as an avenue for funding future health care infrastructure [212, 213]. However, concern remains as to who ultimately takes responsibility for the delivery and governance of these services once completed [206, 208]. Hence, caution should be undertaken to ensure that widening inequities do not occur through developing and planning health care in areas that are already well provisioned for health care services, such as the inner and middle suburbs of Melbourne, as opposed to urban growth and outer fringe areas.
Section Two – Future Directions: Integrated health services planning in Victoria

5.7 Health services planning in Victoria

Previously Victoria’s health system has served the region well, however the changing demographic and increased population means that it is straining to meet current demand [214]. Formerly, Victoria’s health system has run in silos, with individual health care facilities focusing on one part of a much wider and complex system [214]. Keleher [66] highlights that for future health planning to succeed increased inter-sectoral collaboration and engagement across a variety of stakeholders is required. Better connections through all parts of the health system, public, private and non-for-profit sections would improve the resilience of the current system and strengthen it for future [214]. Whilst there has been an increased focus on inter-sectoral collaboration between disciplines, for example health and urban planning, due to gaps in health services planning literature and findings from this research, this research calls for a greater focus on integrated planning.

The overarching responsibility for health services planning lies with the state government of the time. Input regarding how health services are planned comes from key government organisations such as; the Victorian Department of Health and Human Services, VPA and local councils [16, 31, 214]. Lowe [215] argues that for integrated planning to be successful, it must be a joint venture at all policy levels. Currently land use, transport and health planning are disjointed and therefore delivery of essential primary and secondary health care services to urban growth areas continues to be intangible. Thus, a systematic planning approach to urban growth is essential to ensure that Melbourne’s future infrastructure demands are met to accommodate the needs of its growing population.
5.8 Current health services planning tools

Previously this thesis has considered three major planning documents for Melbourne, Plan Melbourne refresh [5], The ASRR Planning for Community Infrastructure in Growth Areas [16], and The Growth Areas Social Planning Tool [32]. All, if fully implemented, could transform the way in which health services are structured, planned and delivered in urban growth areas.

Plan Melbourne is the current planning document used by the Victorian State Government. As part of the ‘living local’ strategy Plan Melbourne recommends that ‘local health facilities and services’ should be available within a 20 minute journey [5]. The document however, does not specify what or how many local health facilities and services this will include and whether it will be primary or secondary health care services, or a mix of both. Of the three tools the ASRR is the only one to have specific details regarding health services planning and delivery in Melbourne’s urban growth areas [16, 35]. However, a critique of the ASRR document is that it provides a population to provider service model. In comparison the Plan Melbourne considers a time model; that is health services should be accessed within a 20 minute journey. Therefore, greater clarity and specificity is needed to operationalise the goals from both Plan Melbourne and ASRR.

Furthermore, as supported by the SDG’s, the Plan Melbourne strategy recognises that having access to essential services locally can promote health and wellbeing amongst residents, reduce carbon emission, and improve social cohesion and reduce social isolation [5, 75]. The Plan Melbourne strategy acknowledges that while housing developments in urban growth areas continue to flourish, more can be done to ensure coordinated delivery of land for social infrastructure requirements such as health and education services [5]. The document calls for the need for integrated land use
planning where transport, infrastructure, and essential services are coordinated and delivered as urban growth areas develop [5]. Plan Melbourne recognises that coordinated planning can help build stronger and healthier communities [5].

To achieve the outcome of more localised public transport in urban growth areas, PSPs could be amended to include directives for health precincts such as general practitioners, allied and community health services, and non-for-profit organisations, to be located next to, or in town, or activity centres in new suburbs [5]. Plan Melbourne however, does not provide specifics for utilising integrated land-use planning. The ideologies for planning health communities are present, however tangible strategies are not provided, making it difficult to ensure the required number of health services will be delivered in urban growth areas; this could be strengthened.

So, while Plan Melbourne recognises the need to provide local health services for equitable access to health services, it fails to: 1) detail the types of health services required; 2) the number of health services required per head of population and 3) the ideal scenario in which health services are to be accessed via public transport or by walking/cycling. Also, Plan Melbourne recommends that social infrastructure be delivered ‘early’ in growth areas; yet the document does not define ‘early’, and this could be clarified moving forward. Currently, no formal methods for assessing social infrastructure needs appear to be available internationally and the Victorian State Government has not adopted benchmarks indicating the number of required health services for developing communities, particularly for urban growth areas. As such, it remains difficult to hold organisations to account for not delivering local, timely, accessible and equitable health services.
5.9 Evaluation of social infrastructure and planning tools

Of the three main health planning and social infrastructure tools, Plan Melbourne refresh, ASRR and GASPT, considered in this research, consensus has not been reached as to the most appropriate tool to adopt, this is in part, a failure by the Victorian State Government to commit to any one plan which solely focuses on health services planning in urban growth areas. Any strategy that is adopted needs to utilise a land-use policy framework, to ensure that public transport is planned and delivered alongside health services to ensure equity of health services access.

To date, the ASRR document provides the most detailed information in regards to the number and types of health services that will be required in urban growth areas, and Plan Melbourne provides the access metric in which they are to be delivered, that is accessible within 20 minutes. To move forward with health services planning in Melbourne’s urban growth areas it is recommended that resources are developed to evaluate and validate social infrastructure and planning tools to provide benchmarks. Evaluating social infrastructure and planning tools can identify if they adequately represent the health service needs for growth areas communities, and can guide both health and urban professionals to plan accordingly in urban growth areas.

Recommendations arising from this research are greater specificity for the number and type of health services required in Melbourne’s urban growth areas that are accessible via public transport, and to ensure that health services are planned for equitably and resourced appropriately to facilitate an early roll-out. This is pertinent given the inequitable distribution of health services as demonstrated by this research. Once social infrastructure tools have been validated, this research calls on the State Government of Victoria to adopt benchmarks for the number and type of health services required in Melbourne’s urban growth areas and adopt a standardised access time to health
services. This can ensure the government is held responsible for the delivery of equitable health services access in urban growth areas.

5.10 Integrated planning and health service delivery

The WHO defines integrated health service delivery as ‘the organization and management of health services so that people get the care they need, when they need it, in ways that are user-friendly, achieve the desired results and provide value for money’ p. 1 [216] pg. 1. The WHO further iterates the aim is to provide services that are not disjointed and are easy to navigate; it requires a mix of political, technical and administrative resources; and is not a remedy for insufficient resources [216]. Benefits of integrated health service delivery include sharing scarce resources and multiple funding sources, that is from a combination of state or local government, non-for-profit organisations and private enterprise [217]. Drawbacks of this approach is a lack of clarity for who has ultimate governance and responsibilities of managing such resources [217].

Integrated health service delivery is important for urban growth areas as they decrease fragmentation of health service delivery [216], and accordingly is a primary directive of Plan Melbourne, ASRR, and GASPT, when considering future health service delivery in Melbourne. Plan Melbourne has a strong focus on co-location of health services with other community resources; focussing more on the physical space of health service delivery and less on the health management system [5, 16]. Beyond the physical space required for health services, consideration also needs to be given to the range of health care agencies required to deliver primary and secondary health services to urban growth areas [217].
As shown by Selandra Rise, one of the problems encountered was having the ability to provide the services before the population was established. Therefore, the successful delivery of integrated health services in urban growth areas will need to consider the timing and the delivery of the services as well as governance structures. If the density of populations were higher in urban growth areas this could help alleviate some of the financial pressures [217]. Additionally, while some predicted primary health care services will be required such as general practitioners and pharmacists, being receptive to the changing demography as it develops will also shape the types of health services required [5, 33]. Furthermore some consideration must be given to the economic viability of businesses in new growth areas. As many health services such as pharmacies are privately owned they must be seen to be commercially profitable before they are established. The government also has a role to support business in low density settings. Therefore there is a balance required between providing the necessary health services to a new community as well ensuring capability of such services[5, 33].

Currently the Victorian government highlights the need for integrated land use planning of co-delivery health services close to public transport, to increase equity of access. Planning for health services in Melbourne’s urban growth areas requires a co-ordinated approach from all sectors of government such as health, urban planning, transport, and land use [28]. Policy that supports active transport, densification of suburbs, greater accessibility to key services such as employment, health and education are recommended [121]. Infrastructure Victoria calls for a ‘whole of state’ government approach to integrated services and infrastructure planning, to decrease siloed decision making and improve service delivery coordination [192]. The focus of this research is on access to primary and secondary diabetic health services in urban growth areas, however access via public transport is poor. Therefore, this research recommends greater
integrated planning for health services in urban growth areas with a focus on providing local primary health care services and public transport to ensure greater equity of access.

Section Three – Limitations

5.11 Limitations of literature review

There are some limitations of the literature review. Different governance structures and political climates exist nationally and internationally; therefore, caution should be taken when applying international findings into a localised context. Health services access can be explored from many perspectives, however this research focussed on spatial access to primary and secondary health care services. Additionally, an assumption was made that people access health services from their place of residence. In reality many people may access health services from workplaces or other places of convenience. However, there is a need for health services near homes, particularly for those more vulnerable or infirmed.

5.12 Limitations of exploring access

The methods for this study only focused on measuring spatial access to health services, as it was deemed a sensitive indicator of equity to health care access, and is pertinent when examining access to health care infrastructure in urban growth areas [94]. This study did not consider other types of access, such as cultural appropriateness [88, 96], opening hours [85, 88], cost [85, 94], and how people access health services in respect to their daily activity patterns (e.g. services around the workplace) [94, 105]. Additionally an assumption was made that people were accessing the closest type of destination, whereas they may have a preferred provider who might be located further away. Furthermore, many of the health services examined in this thesis are privately owned and
therefore not at the discretion of the commonwealth, state or local government as to their location and therefore how accessible they are to populations. Additionally, planners also have a role to play in zoning, land use allocation, and offering incentives to attract certain types of businesses and services. Therefore examination of government policies to influence location destination is warranted.

5.13 Limitations of Methods

5.13.1 Limitations of health services data collection

The completeness and accuracy of the health services data relied on the data sources they were collected from. For example, the Victorian Human Services Directory relies on health services to upload their most current information. Therefore, once the data set was finalised, if health services had moved, closed down or opened, these changes were not reflected. Also, the health service datasets may be incomplete. For example, the Pitney Bowes data set provides information for private podiatry clinics, but does not include other locations where podiatrists may practise, such as community health centres. Additionally, any diabetic educators not recorded with the Australian Diabetes Education Association were not included in the analysis.

Another limitation was that not all diabetic health services were analysed; due to time constraints psychological services were not included. Psychological services provide a valuable health service for diabetic patients as well as the community at large [56]. Also associations were not collected for example, The Pharmacy Guild of Australia, Victoria, which is a membership organisation representing the owners of independent community pharmacies. However, this example does not represent a health service for public access. Lastly, mobile and eHealth service providers were not included as these do not have a permanent fixed address.
5.13.2 Limitations of network analysis

A limitation of both road and public transport network analysis is that they were performed at a single, off peak, time point only. Furthermore neither network analyses accounted for potential impediments in access. The road network was based on a formula using the travel speeds for each road type (e.g. freeway, arterial roads) and distance to the nearest of each type of health service. Whilst some concession was made to adjust for the average travel speed along the road network, it did not take into account other congestion variations, such as road works, accidents, parking, traffic, lights, intersections and peak travel times. Additionally, the residential addresses in this research were a synthetic simulation of where residents potentially live; the study did not consider people who actually had diabetes and the services they accessed.

5.14 Further research and exploration when considering access to T2DM health services in urban growth areas and urban fringe areas of Melbourne

This study focused on health services access and planning in urban growth areas, with a strong focus on social infrastructure planning and integrated planning. However, given that technology continues to improve and change, avenues such as eHealth and mobile health could be further explored as alternative methods of delivering health services in urban growth areas. This is particularly relevant also for the urban fringe areas of Melbourne where travel times often exceed those seen in urban growth areas. As fringe areas of Melbourne are not experiencing the same population growth as seen urban growth areas and do not have the same social infrastructure demands eHealth could have a role in providing essential services to these areas. However, it was outside the scope of this study and is an area for further research, which will likely have more relevance in the coming years.
eHealth is an underexplored option for the delivery of health services in Melbourne’s urban
growth areas and can be described as the use of technology, communications and information for
health [218]. According to the WHO, eHealth can include mHealth (mobile health), telehealth,
electronic health records, eLearning, social media and very large data sets known as big data
[219]. WHO purport that the use of mobile phones in particular has the potential to significantly
impact the delivery of health services globally, related to the increasing mobile cellular network,
continuing advancements in technology and more opportunities to integrate eHealth and
mHealth.
Conclusion

This study identified considerable inequity of access to essential diabetic health services in urban growth areas, particularly for specialist services, and when travelling by public transport. Yet, urban growth areas are considered attractive places to live related to their perceived affordability, however as many disadvantaged populations live within these areas, health services should be planned accordingly to minimise any potential health inequities. Despite Australia being one of a few countries that offer universal health care, as populations increase and resources become scarce there is greater pressure on the system. T2DM is a growing chronic health condition and there is a need to not only provide health services that are close and accessible to people’s homes, but to also provide opportunities that promote healthy lifestyles through the use of active and public transport options.

To date there has been little research into how populations in urban growth areas access health services; this research has taken a step towards addressing this gap. Understanding the current situation of diabetic health service access in urban growth areas will help health and urban planners respond by providing health services accordingly. Consensus as to how health services and social infrastructure are integrated and planned for in growth areas, both nationally and internationally remains elusive with no formal methods being adopted. This thesis calls for local social infrastructure tools to be implemented and benchmarks for the number of health services required in growth areas to be adopted. This will keep the state and local governments of Victoria accountable. Furthermore, this thesis calls for greater integrated planning between health, transport and town planners to produce an urban form that ensures greater equity of access to health services for residents in Melbourne’s urban growth areas.
Appendices

Appendix 1:

Title: Health service access in urban growth areas: examining the evidence and applying a case study approach

Authors: Rebecca Madill, Hannah Badland & Billie Giles-Corti

Abstract

Population growth, especially in urban areas, is projected to increase in the near future. In response, residential growth is commonly channelled into urban growth areas located on the suburban fringe of major city centres. There is a need for adequate infrastructure provision, such as health services, to meet the population demands in urban growth areas. Access to health services is a key social determinant of health, and having adequate access can help reduce health inequities. This review examines literature considering primary and secondary health services access in new urban growth areas, with a focus on Melbourne, Australia. Academic and grey literature were sourced and reviewed. Themes revealed include challenges in providing spatial and social access to health services. Both nationally and internationally, we found that few studies considered health services access when planning for urban growth. Further research is required to examine how health service access is planned for in urban growth areas. Such research may contribute to reducing health inequity.

Keywords: Health equity, Melbourne, Social determinants of health, Urban planning
Introduction

Currently more than 50% of the world’s population live in urban areas, and this is projected to increase to 70% by 2050 (World Health Organization 2010). 90% of Australians already live in urban settings (Australian Bureau of Statistics 2011a), and by the year 2056 Australia’s population is projected to grow to between 30.9 and 42.5 million people (Australian Bureau of Statistics 2011a). Much of this recent and predicted population growth is occurring in metropolitan suburban fringe developments, known locally as ‘urban growth areas’ or ‘urban growth corridors’ (Breen 2011; State Government of Victoria 2014). These settings are typically characterised by low residential density neighbourhoods, often located between 50 and 100 kilometres from major city centres (Breen 2011; Coffee et al. 2012).

The Australian context

Overall, Australian’s have very good health. Australia is one of only 19 countries where life expectancy is over 80 years of age (United Nations Economic and Social Affairs Population Division 2012). Compared with six other OECD countries (Canada, Germany, Netherlands, NZ, UK, and USA), Australia ranks third in terms of overall health care, but ranks lower (fourth equal) in areas of health equity and health-care access (Davis, Schoen, and Stremikis 2010; State Government of Victoria 2011b). This is because, in Australia, many health services are unevenly distributed across a region and the majority of services are found in established urban centres (State Government of Victoria 2011a). By way of example, in Victoria a recent report contended that 40% of Victoria’s health-care services were located within a 10 kilometre radius of the city. However, only 20% of Melbourne’s population live within this area. Other work examining access to cardiac services showed significant spatial differences between rural, regional, and urban centres across Australia (Clark et al. 2012). Together, this suggests that health service delivery inequities exist nationally (State Government of Victoria 2011a, 2011b).
Historically, the establishment of the Department of Urban and Regional Development under the Gough Whitlam government was charged with providing access to services and public transport in developing urban areas (Whitlam Institute 2015). As populations continued to grow in urban fringe settlements across Australia, provision of access was addressed through documents such as the ‘South Australian Urban Land Trust’ (State Government of South Australia 1981), which considered guidelines for the development of land in urban areas. More recently the ‘Planning for Community Infrastructure in Growth Areas’ (Australian Social and Research 2008) and ‘Growth Areas Social Planning Tool’ (Kyrkilis 2014) focussed on providing guidance for delivering community infrastructure in growing urban developments. However, whilst documents such as these provide broad planning guidelines, there has been little focus to date on planning for health services access in urban growth areas.

Case study area of Melbourne

This review uses the case study of Melbourne’s urban growth areas. Melbourne is located in the state of Victoria, Australia. Victoria is expected to grow to 6.5 million residents by 2051 (State Government of Victoria 2011a), it is the fastest growing state, and Melbourne is expected to be the most populated city in Australia by 2056 (Australian Bureau of Statistics 2015). Whilst population growth occurs to some extent in infill areas, being land located in inner- and middle-ring suburbs (State Government of Victoria 2014), the vast majority of population growth occurs in urban growth areas on the suburban fringe of major city centres. Accordingly, this review focuses on growth within Melbourne’s suburban fringe. Melbourne has four major urban growth corridors: the west growth corridor, the Sunbury/Diggers Rest growth corridor, the north growth corridor, and the south-east growth corridor (State Government of Victoria 2014). All urban growth corridors are characterised by anticipated large and rapid population growth over the next 20–30 years. Thus, there is increasing pressure to ensure adequate services, employment opportunities, and transport routes are in place as new communities develop (State Government of Victoria 2014).
Social determinants of health

The social determinants of health (SDOH) are the multi-tiered conditions which humans are born, grow, age, live and work, and extend beyond the health-care system to encompass the broader ‘upstream’ determinants (Wilkinson and Marmot 2003). These include the way cities are governed and designed through to the social environment in which people live (Wilkinson and Marmot 2003; Kent, Thompson, and Jalaludin 2011). A well-established evidence-base recognises that the built environment and guiding urban planning policies can influence residents’ health and well-being outcomes (Giles-Corti, Ryan, and Foster 2012; Rydin et al. 2012; Badland et al. 2014b). For example, positive population health outcomes can be promoted by designing cities that pro-vide opportunities for individuals and communities to be physically active, such as offering a range of trans-port options and infrastructure, (Giles-Corti 2006; Badland et al. 2014a).

Forecasted demand is likely to grow over time for health-care services, which is largely driven by an ageing population (State Government of Victoria 2011a). Access to health services, particularly primary and secondary services, is an important contributor to the SDOH (Wilkinson and Marmot 2003). These services are generally accessed prior to tertiary health services (State Government of Victoria 2011b), and play a substantial role in chronic disease prevention and maintenance. For example, Korda et al. 2007, demonstrated that having access to range of primary and secondary health-care services helped reduce mortality rates amongst all socio-economic groups in Australia.

Health inequalities and inequities

Health inequalities are defined as preventable differences between the least and most advantaged in a given group (defined by such traits as wealth, power, racial class, ethnicity and gender) irrespective of differences between the most and least affluent members of society (Braveman 2006). Health equity conversely, views health and its determinants from a justice perspective. Thus, health inequities can be defined as inequalities that are unjust or deemed unfair. Health equity has
foundations in the principles of social justice, morality, and cooperation (Kawachi, Subramanian, and Almeida-Filho 2002; Keleher 2011). It stems from systemic inequalities and inequities, where repeated prejudices and injustices are reinforced, for example, government policies and infrastructure provision that systematically marginalises those who are already disadvantaged (Braveman 2006).

Housing developments in urban growth areas are often positioned as being ‘affordable’ (Currie and Del-bosc 2011); therefore may be more appealing to those with lower incomes. Yet without appropriate infra-structure and services, living in these areas may contribute to inequities. Urban growth areas are characterised by diverse demographic challenges that place additional pressures on the health-care system. These include: high birth rates (50–60 babies born weekly in some Melbourne growth areas) (City of Whittlesea 2014); high cultural diversity, for example, 43% of residents in Whittlesea City Council (one of Melbourne’s fastest growing urban growth areas) speak a first language other than English compared with 29% in Greater Melbourne (City of Whittlesea 2014), and high youth populations (Breen 2011; City of Whittlesea 2014). Furthermore, urban growth area housing developments tend to foster motor vehicle reliance, thereby creating a feedback loop where communities become more vulnerable to social isolation and socio-economic disadvantage if the long-term prediction of rising oil prices occurs (Dodson and Sipe 2008). Indeed, compared with the whole of Melbourne, life expectancy for males is lowest in the outer west urban growth areas and for females in outer east, outer west and outer north eastern suburb urban growth areas (State Government of Victoria 2011a).

As populations increase in urban growth areas, additional location-specific services and infrastructure are required to meet increasing demand (State Government of Victoria 2012). Yet there is concern regarding the lag in service provision in urban growth areas (Breen 2011; Bell 2012), with residents frequently required to travel long distances to access employment, goods and services, health-care and social services (Breen 2011). The lack of access to essential services can be
exacerbated by poor access to public transport, as commonly seen in urban fringe developments (Breen 2011). Such a combination may further increase inequities of access in urban growth areas and widen health inequities (State Government of Victoria 2011a, 2011b).

Defining health service provision

In Australia, there are three main health-care streams: primary, secondary, and tertiary health services. Primary health-care services are the most commonly accessed section of the health-care system and refer to services including, but not limited to: general practitioners, community nursing services and community health centres (State Government of Victoria 2011b). Secondary health services include: specialist services for people with specific illnesses and/or complex or chronic conditions, such as radiology, some allied health, and drug and alcohol services (Australian Social and Recreation Research 2008; State Government of Victoria 2011b). Tertiary or acute health-care treatment is usually provided by hospitals and includes emergency services (State Government of Victoria 2011b). It is acknowledged that tertiary health facilities particularly hospitals, cannot be provided ‘locally’ in all settings. Instead general practitioners and community health centres have a key role in providing primary health-care facilities locally, including Melbourne’s fringe suburbs (State Government of Victoria 2011a). Given the importance of prevention for chronic and complex conditions, access to primary and secondary health services is a focus of this review.

Defining health service access

The root of the word ‘access’ from Latin and French origins, denotes ‘the means or opportunity to enter a place’ (Oxford Dictionaries 2013). In health-care ‘access’ is often referred to as ‘access to health care’ (Levesque, Harris, and Russell 2013). In broad terms, this can been defined as the ability of individuals to navigate health-care resources to improve their health, with health-care access being conceptualised in many ways (Gulliford et al. 2001). However, Penchansky and Thomas (1981) discuss five domains of access: availability, accessibility, accommodation, affordability, and
acceptability. Availability refers to the supply of health services, including the number and type of existing services (Penchansky and Thomas 1981; Gulliford et al. 2001). Accessibility incorporates the physical location of services in relation to individuals and resources required, such as transport, monetary, and/or time costs to reach a service (Penchansky and Thomas 1981; Gulliford et al. 2001). Accommodation incorporates the manner in which services are organised to accept individuals’ needs, such as opening hours, walk-in and telephone facilities, and individuals’ ability to adapt to these factors (Penchansky and Thomas 1981). Affordability refers to the cost of health services to individuals and organisations, additionally individuals’ perceptions of value relative to cost is also notable (Penchansky and Thomas 1981). Finally, acceptability includes community and cultural factors and the ease of both utilisation by individuals and delivery of health services to individuals encompassing a variety of characteristics (Penchansky and Thomas 1981; Levesque, Harris, and Russell 2013).

Levesque, Harris, and Russell (2013) concurs with Penchansky and Thomas’ (1981) definitions of access and acknowledge common operational definitions of access to health care, including geographical or spatial access, economic access, and social access to health care. Spatial access is the physical environment or entities bounded in space (Khan and Bhardwaj 1994). Economic access encompasses financial enablers or barriers (Levesque, Harris, and Russell 2013). Social access includes non-spatial aspects such as social, cultural, or political factors however may also have geographic expression (Khan and Bhardwaj 1994). For example, a study by Wang, Rosenberg, and Lo (2008) discovered that Chinese immigrants in Toronto had a high preference for a Chinese-speaking physician, regardless of the location. This is an example of social access (cultural preference for a physician) with geo-graphic expression, since migrant communities may cluster closer to culturally preferred health and com-munity services. Levesque, Harris, and Russell (2013) conclude that the concept of access to health care is complex and multi-dimensional, going beyond the availability of physical resources. As argued, there are many avenues in which health-care access can and has been
explored, however for the purposes of this review, only spatial and social access will be considered. We consider these as being the most pertinent aspects of health services access in urban growth areas within the Australian context.

Research aims

This paper aims to: first, review international and national evidence of health services access in urban growth areas; second, examine spatial and social access to health-care services in relation to urban growth areas; and third, use Melbourne as a case study to demonstrate the practical considerations of planning for health-care access in an urban growth areas.

Methods

Search strategy

Relevant literature was sourced from international and national grey and academic literature. Different health-care systems and political landscapes exist globally; therefore international literature was used to define health access and provide examples of how health services are accessed. National literature was used to convey the current situation of health services access in Australia and for Melbourne, Victoria. Reviewing grey literature was necessary to provide a local and state-government policy context for Victoria. Searches were conducted across key Victorian government web-sites such as the Department of Health, Department of Planning and Community Development, the Metropolitan Planning Authority, and relevant local government organisations. Reference lists were identified from relevant webpages and scanned for further literature. Recommendations were also made to other relevant literature sources from stakeholders working within these organisations.
Academic publications were sourced through a number of databases including: Web of Science, Scopus, Medline, Global Health, PubMed Central, Academic Search Complete, Australian Architecture Database, Google Scholar, and Informit Plus Text Databases. Search terms were derived by using the key phrase of 'health services access and planning in urban growth areas' and variations of this terminology. A combination of the following search terms were used: health service*, health access*, urban growth area*, growth area*, spatial access*, social access*, health equit*, urban plan*, land use plan*, and tool and model*. Additionally, reference lists of sourced articles and reports were scanned for further relevant literature. Criteria for inclusion included being: written in English, available as full text, and related to primary and/or secondary health service access.

Results

As justified earlier, health service provision and spatial access were identified a priori as being the two access measures considered in this paper, as we considered these the most relevant for the Australian urban context. Each theme is discussed in detail below.

Health service provision

SDOH research indicates that health inequalities have a social gradient, and that higher levels of disadvantage are associated with poorer health outcomes (Marmot and Bell 2012). This has been demonstrated in the UK where national primary health care is free; however, health inequities still exist. The gap between the least and most deprived neighbourhoods show a noticeable health gradient, and the worst health outcomes exist for the most disadvantaged neighbourhoods (Marmot and Bell 2012). In Australia people living in areas of most disadvantage are approximately three times more likely to visit their general practitioner 12 times or more during a year compared with those living in areas of least disadvantage (Australian Bureau of Statistics 2011b).
The ‘inverse care law’, first proposed by Hart in 1971 suggests health services are distributed inversely to population health needs (Hart 1971; Shaw and Dorling 2004). Those living in socially deprived neighbourhoods tend to have poorer health access (Hart 1971; Hiscock et al. 2008), and therefore poorer health outcomes (Baade, Turrell, and Aitken 2010). Nevertheless, the inverse care law has been contested (Macintyre, Macdonald, and Ellaway 2008; Witten, Pearce, and Day 2011). Witten, Pearce, and Day (2011) found a positive correlation between access to a range of services in disadvantaged neighbourhoods across four New Zealand cities; disadvantaged inner-city areas had a great number of health-care facilities compared with less disadvantaged suburban areas (Witten, Pearce, and Day 2011). Macintyre, Macdonald, and Ellaway (2008) demonstrated that variability of access to health resources and area deprivation in Glasgow were dependant on the type of resource (e.g. pharmacies, dentist, and physician) and how deprivation was measured. The authors used a subset of the 2006 Scottish Index of Multiple Deprivation focusing on data such as employment, health education, and welfare benefits to measure deprivation (Macintyre, Macdonald, and Ellaway 2008). Together, these studies lend support to Lineberry’s ‘ecological’ hypothesis, suggesting that the location of urban resources is more related to the age, history, geographical location, residential density, and residential/commercial mix of different areas, rather than the ‘inverse care law’ per se (Macintyre, Macdonald, and Ellaway 2008).

Yet in Australia some evidence of the inverse care law exists. A common measure of health-care provision used in Australia is the number of doctor to number of patient ratios (Murray 2012). Doctor to patient ratios provide an indication of the availability of doctors within a geographical area (Australian Bureau of Statistics 2013), but importantly, do not consider whether the distribution of doctors across a region is equitable. Currently, Australia has its highest number of registered doctors (Health Workforce Australia 2012; Murray 2012). Yet, while doctor numbers have increased over time, the Australian Health Workforce Report shows doctor numbers are unevenly distributed across a region. Compared with inner- and middle-ring suburbs, there are fewer doctors located in urban
growth areas, regional, and rural areas (Health Work-force Australia 2012). The Australian Health Workforce also predicts a short fall in doctors, being approximately 37,000 by 2025 due to the increasing demand on health services (Health Workforce Australia 2012). It is likely this will contribute to widening health inequities if current doctor socio-spatial patterning is maintained.

Health service spatial access

Spatial health-care access is commonly measured using the actual distance or time to travel to health service locations (Martin, Jordan, and Roderick 2008; Cromley and McLafferty 2012). However defining what constitutes ‘good’ or ‘high’ levels of access to health services remains difficult (Lovett et al. 2002; McLafferty et al. 2011). This is because what constitutes ‘good’ access to health-care services has not been agreed upon in the literature (Lovett et al. 2002).

Acceptable travel times to primary and secondary health services via private car have been investigated internationally. A study by Tackett et al. (2011) explored general practitioner and specialist physician (cardiologists, for example) access via private car in rural and metropolitan Massachusetts, USA. The authors reported 89–99% of participants had high levels of specialist physician accessibility using a travel time threshold of 30 minutes (Tackett et al. 2011). The authors concluded that rural residents on average travelled approximately 6–15 minutes longer to access specialists compared with urban counterparts (Tackett et al. 2011). However, the authors did not consider travel times to physicians or specialists via public transport. Brabyn and Barnett (2004) also used a 30 minute threshold to assess access to general practitioners when travelling by private car in rural and metropolitan New Zealand. They found that approximately 10% of the population fell outside this threshold, all of whom lived in rural areas (Brabyn and Barnett 2004).

Locally, a study by Coffee et al. (2012) considered access to cardiac health services, where ambulance transport was used to measure access to cardiac health services after a cardiac emergency (except in very remote Australia where private vehicles were used as a measure of
access). The authors also considered private car travel to post-acute cardiac health services (rehab service modelling). The findings showed that approximately 71% of the Australian population had very good access to acute and post-acute cardiac services, as defined by a one hour trip via emergency transport for an acute event or private transport for post-acute cardiac health services (Coffee et al. 2012). Those who travelled greater than one hour to access cardiac services were mainly residents living in rural areas of Australia (Coffee et al. 2012). However, this study did not look specifically at within city variations in spatial access to cardiac health services, such as inner city and urban fringe travel times.

As noted by Martin, Jordan, and Roderick (2008), even in the most developed countries not everyone has access to private transport. Yet, few studies have considered health services access via public transport (Lovett et al. 2002). Distance, travel times, and service frequency are potential barriers for those seeking to access health services by public transport (Lovett et al. 2002; Breen 2011). Furthermore, public transport users tend to be more vulnerable populations, including the elderly, or people from culturally and linguistically diverse (CALD) backgrounds. Hence, having a variety of transport options available, particularly public transport services, may improve health-care access and reduce equity (Casey 2005; Breen 2011). Lovett et al. (2002) compared general practitioner access by private car and public transport access in primarily rural areas (Cambridgeshire, Norfolk, Suffolk) of the UK. They found 67% of residents lived within a five minute car trip to their nearest general practitioner. When travelling to the same general practitioner by public transport (after accounting for the frequency of services) 82% had ‘good access’ (defined as access to a bus four times a day from their area to their general practitioner); however, 13% of the study population lived in areas with no daily return bus trips to a general practitioner (Lovett et al. 2002). In general, those with inadequate public transport services to access health services tended to live further away from town centres and were more reliant on private transport (Lovett et al. 2002).
Traditionally, urban growth areas have been poorly serviced by public transport and tend to be car-dependent settings (Carey 2012; Perkins 2012). The Victorian Integrated Survey of Travel and Activity 2007–2008 (VISTA 07–08) found that median distances to travel to work were longer in urban growth areas than for suburbs located closer to the city (Department of Transport 2009). For example, the median travel distance to work across metropolitan Melbourne was 14.3 kilometres. For those living in Melton (one of Melbourne’s growth areas), the median distance was 32.5 kilometres (Department of Transport 2009). A study by Currie and Senbergs (2007) considered households with ‘high car ownership on low incomes’ (HCOOLI) to explore car usage in Melbourne’s urban growth areas. Findings suggested that car usage by HCOOLI households in outer Melbourne was 5.2% more frequent, and car trips 38% longer compared with HCOOLI households in the middle suburbs of Melbourne (Currie and Senbergs 2007). Given that approximately 40% of Melbourne’s health services are located within a 10 kilometre radius of the central business district (State Government of Victoria 2011a), variations in work travel times may provide a crude indication that people living in urban growth areas could travel further to access health services.

In Victoria, Melbourne’s recent urban design plan, Plan Melbourne, aims for a 20-minute city, where essential services, such as primary health care will be accessible within a 20 minute walking, cycling or public transport trip (State Government of Victoria 2014). The proposed 20-minute trip to essential services (including health services) has the potential to be a useful planning metric to provide some guidance and benchmarking for health services access. This is of particular use, given investigation into comparative travel times to primary and secondary health services in different areas.
Discussion

Amongst other things, this review examined spatial and social access to health services. We attempted to identify appropriate access to primary and secondary health-care access, however were unable to identify any consistent definitions for ‘good’ health service provision or spatial access. When studying accessibility to primary and secondary health-care services, private cars appear to be the main method of transport considered in the literature (Brabyn and Barnett 2004; Tackett et al. 2011). However, given the importance public transport has for certain populations (e.g. older adults) (Lovett et al. 2002), coupled with the lack of public transport infrastructure available in urban growth areas (Currie and Senbergs 2007; Breen 2011), this is a salient area for future research. Additionally, Melbourne is aiming for a ‘20-minute city’ (State Government of Victoria 2014); therefore an understanding of whether health services can be accessed by various travel modes across the region has great policy relevance and subsequently requires further investigation.

Our review found a lack of consistent evidence evaluating health services access for urban growth areas. Whilst previous documents outline broad planning guidelines required for services and transport in urban growth areas (State Government of South Australia 1981; Australian Social and Recreation Research 2008), specific strategies for health services access and planning in urban growth areas is now required. This is particularly important, given those living in urban growth areas tend to have poorer health and social trajectories and outcomes, and health services tend to be located closer to the city (State Government of Victoria 2011a, 2011b).

This paper has several limitations. The focus of this review was largely on health service provision and spatial access in Melbourne’s urban growth areas. We appreciate that different governance structures and political climates exist nationally and internationally; therefore we caution applying international findings into a localised context. Health service access can be explored from many perspectives, however this review focussed two measures, being health service provision and spatial
access. Furthermore we delimited our health service scope to primary and secondary services only. Lastly, we made an assumption that people accessed health services only from their place of residence. In reality people may access health services from workplaces or other places of convenience. However, we contend there is a need for health services near homes, particularly for those more vulnerable and infirmed.

Conclusion

Prioritising health services access and planning in urban growth areas is gaining momentum, both nationally and internationally. As populations grow and age, demand on health services will increase, and ensuring access to local health services can help reduce inequities. Additionally, providing adequate public transport services to access health infrastructure services will further likely reduce health inequities and disadvantage in communities. To date research examining various modes of transport when accessing health services, specifically in urban growth areas, is severely lacking. Melbourne, as well as other cities, is growing rapidly. Strategic development and plans for growth corridors are now being made for the next 30–40 years. Therefore a unique and timely opportunity exists to work with urban and health planners and policy makers to identify strategies for improving equitable access to health services.

Funding

RM is funded by an Australian Post Graduate Award, a Melbourne Studentship and a Windermere Foundation Scholarship for Nursing. HB is supported by the NHMRC Centre of Research Excellence in Healthy Liveability Communities (#9100001), The Australian Prevention Partnership Centre, and VicHealth. BGC is supported by an NHMRC Principal Research Fellow Award (#1004900).
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Appendix 2

Manuscript: Comparing private and public transport access to diabetic health services across inner, middle, and outer suburbs of Melbourne, Australia. *BMC Health Services Research* (Under review: resubmitted with revisions on 8th December 2017).

**Title:** Comparing private and public transport access to diabetic health services across Melbourne, Australia's inner, middle, and outer suburbs

**Authors:** Rebecca Madill, Hannah Badland, Suzanne Mavoa, Bille Giles-Corti

**Abstract**

**Background:** Melbourne, Australia is experiencing rapid population growth, with much of this occurring in metropolitan outer suburban areas, also known as urban growth areas. Currently little is known about differences in travel times when using private and public transport to access primary and secondary services across Melbourne’s urban growth areas. *Plan Melbourne refresh*, a recent strategic land use document has called for a 20-minute city, which is where essential services including primary health care, can be accessed within a 20 minute journey. Type 2 diabetes mellitus (T2DM) is a major chronic condition in Australia, with some of Melbourne’s growth areas having some of the highest prevalence across Australia. This study explores travel times to diabetic health care services for populations residing in inner, middle and outer suburbs of metropolitan Melbourne.
Method: Geographic information systems (GIS) software were used to map the location of selected diabetic primary and secondary health care service providers across metropolitan inner, middle, outer established, outer urban growth and outer fringe areas of Melbourne. An origin-destination matrix was used to estimate travel distances from point of origin (using a total of approximately 50,000 synthetic residential addresses) to the closest type of each diabetic health care service provider (destinations) across Melbourne. ArcGIS was used to estimate travel times for private transport and public transport; comparisons were made by area.

Results: Our study indicated increased travel times to diabetic health services for people living in Melbourne’s outer growth and outer fringe areas compared with the rest of Melbourne (inner, middle and outer established). Compared with those living in inner city areas, the median time spent travelling to diabetic services was between 2.46 and 23.24 minutes (private motor vehicle) and 12.01 and 43.15 minutes (public transport) longer for those living in outer suburban areas. Irrespective of travel mode used, results indicate that those living in inner and middle suburbs of Melbourne have shorter travel times to access diabetic health services, compared with those living in outer areas of Melbourne. Private motor vehicle travel times were approximately 4 to 5 times faster than public transport modes to access diabetic health services in all areas.

Conclusion: Those living in new urban growth communities spend considerably more time travelling to access diabetic health services – particularly specialists - than those living in established areas across Melbourne.

Key Words: Health equity, urban growth areas, GIS, accessibility, public transport, private vehicle
1.0 Background

1.1 Health services in urban growth areas

Melbourne, in Victoria, Australia is experiencing rapid population growth with the city expected to reach approximately 8 million residents by the year 2051 [1]. Much of this population growth is occurring in low density outer suburban “urban growth areas” up to 50-100kms away from major city centres [1-3] as well as in infill areas across inner and middle suburbs of Melbourne [1]. As urban growth areas develop, they need infrastructure and services to meet the increasing demand of the growing population [4] and ensure equitable access to services [5]. Plan Melbourne, has called for a 20-minute city, which is where essential services including primary health care services can be accessed within a 20 minute journey [1]. Currently access to some essential primary health care services falls below this policy imperative (as outlined in this research), particularly for Melbourne’s outer urban growth areas.

Primary health care services, such as general practitioners and pharmacists, serve the majority of health care needs for consumers across Melbourne [5]. However, evidence suggests that a higher density of these services exists within inner and middle suburbs of Melbourne [6], compared with outer suburbs and urban growth areas. Whilst, there is evidence of considerable inequities of access to health services in rural compared with city areas [3, 7], there is little published research about access to services in urban growth areas compared with established areas of cities. For example, access to health care services is dependent on adequate transport infrastructure to ensure those residing in outer urban growth areas are not disadvantaged.

This potential inequity of access to health services is of concern as a higher prevalence of vulnerable groups such as indigenous, young, elderly and culturally and linguistically diverse (CALD) populations, are located in Melbourne’s outer urban growth areas [2, 8, 9]. Therefore, those in most
need may have poorer access to primary health care services. As such increasing access to primary health care services can aid in reducing inequities by providing services where they required most [10]. Importantly, better access to primary health care services has other benefits such as reducing admission rates for preventable causes of hospitalisation [11].

1.2 Type 2 diabetes mellitus

This study focused on health services required for patients with type 2 diabetes mellitus (T2DM). T2DM represents over 85% of all diabetes cases in Australia [12]. Between 2011-2012 T2DM affected approximately 1.7 million Australians and almost 185,000 Victorians [13]. T2DM is increasing and is projected to affect approximately 3.5 million Australians by 2033 [13]. Additionally, the Australian Bureau of Statistics contends that 24.7% of all diabetics live in the most disadvantaged areas across Australia [14]. The north and west region of Melbourne, a known urban growth area, not only has the highest prevalence of all types of diabetes compared with any other regions in metropolitan capitals across Australia [15], it is also comprised of vulnerable populations such as increasing numbers of elderly people [16], highlighting the need to deliver appropriate health care to those most at risk.

T2DM is a complex and useful condition to use to highlight issues of access to health services. A person who presents with T2DM is required to access a range of primary and secondary health care services on a regular basis. These health services include general practitioners, diabetes educators, dieticians, endocrinologists, podiatrists, pharmacists, optometrists or ophthalmologists, and psychological services [17]. This provides an indication as to the number of health services required to manage a complex chronic condition.
1.3 Spatial accessibility to primary and secondary health care services

Penchansky and Thomas denote five domains of health care access: availability, such as the number and type of health services [18, 19]; accommodation, encompassing aspects such as opening hours; affordability, which includes cost of health services to individuals and governments; acceptability, such as the cultural appropriateness of heath care facilities; and accessibility, including the relationship between the physical location of health services to individuals and travel time [19]. Spatial accessibility to health services is a domain of accessibility, focusing on geographical elements of how people access services in relation to their daily activities [20] and is a focus of this study.

Neutens [21] contends that policy makers and governments are becoming more perceptive to providing adequate, equitable and accessible health care and that decreasing spatial barriers, such as minimising travel time and distance, can increase health care utilisation. Cromely and McLafferty [20] argue that access is a function of distance decay, such that, the further the distance of a health care facility from someone’s primary place of access (usually their home), the less utilisation of that facility for the individual. This is of particular relevance to urban growth areas, as people are moving into communities where health facilities and public transport infrastructure are still being established. As a consequence, residents may have to travel outside their neighbourhood to access required health services [2]. This finding is supported by Hawthorne and Kwan [22]; they measured access using geographical distance and quality of care and found those living in suburban areas in Ohio, United States, had reduced access to health care compared with those who lived inner-city.

The present study focuses on spatial access to health services, as it is a sensitive marker of health care access equity [20] and is pertinent when examining access to health care infrastructure in urban growth areas. Primary and secondary health services across inner, middle, outer established, outer urban growth and outer fringe areas of Melbourne were chosen for investigation. Primary health
care services are, for the most part, the initial point of contact to the health care system [5] and accordingly it was hypothesised that there would be reasonable access to primary providers. Primary health care services generally do not require a referral to a specialist and include services such as general practitioners, pharmacists, physiotherapists and dieticians [23]. As T2DM requires management from a range of health care providers, secondary health care services were also included to ascertain equity of health services in order to manage this complex and chronic condition [5]. Secondary health services often include specialist services, such as endocrinologists and diabetic educators, and therefore were likely not as abundant as primary health services [23].

Apart from spatial access, this study considered transport access to diabetic health services. It has been argued that decreasing patients’ travel time and having a range of transport options available to access health services are essential for increased health service equity [24, 25]. The mode of travel to access health services also requires attention as few studies consider health services access via public transport [26], with the majority defining ‘access’ through private transport modes [3, 26, 27]. One study conducted in East Anglia, England, by Lovett et al [26] showed that for their sample population, a majority (67%) lived within a five minute car trip to their nearest general practitioner. They measured public transport access in terms of frequency of services, with 82% of the study population having access to at least four return bus trips per day to general practitioners. However, their study also found that those who had limited access to public transport, defined as having one or more return day time bus service, were more likely to live further away from town centres, and had to rely on private transport to access their general practitioner [26].

As Martin et al purport, even in cities in the most developed countries not everyone has access to private transport [28]. Moreover individuals who rely on public transport to access health services are often more disadvantaged (e.g. those who are older, younger, disabled, CALD, or have a lower
socioeconomic status) [2, 5, 8]. Transport disadvantage has implications for access to health services particularly for residents in Melbourne’s urban growth areas and the mode of transport options they have available when accessing diabetic health services. In general, however, research into the mode of transport when accessing primary and secondary health services (including diabetic), specifically in growth areas, is severely lacking [2].

1.4 Significance of the research

Global urbanisation is rapidly increasing with 1 billion more people living in urban areas in 2014 compared with 2000 [29]. As rapid urbanisation and population growth continues there is growing awareness of the impact the built environment has on health [30]. There is a link between the built environment and modern ‘epidemics’ of non-communicable diseases, such as T2DM, cardiovascular disease and certain cancers [31, 32]. It has been argued that such ‘epidemics’ are related to factors such as physical inactivity and obesity, which are perpetuated by increasingly low density outer suburban urban environments, where there is poor access to public transport and services, and inversely a higher reliance in car usage [31, 32].

Melbourne, Australia, is facing a number of development pressures including adapting to an increased and ageing population, being economically competitive and, and increasing social inequality [33]. For some, labour and housing markets have created opportunity, however it has further marginalised those more disadvantaged residents, particularly for this living in areas where there is insufficient access to public transport, employment, education and other essential services [33].
Low density neighbourhoods with poor access to transport, services and public open space [34], attributes which characterise urban growth areas – have been associated with lower levels of physical activity and decreased access to healthy foods. These are pre-cursors to chronic diseases such as T2DM and cardiovascular disease [34]. Thus, it is increasingly recognised that Australian cities will face considerable pressure in the years ahead [4, 35]. If new urban growth areas are not adequately planned, one concern is that disadvantage and poor health will increase for those living in these new communities [2, 36]. Given that Melbourne is in a population growth period, strategic development and plans for urban growth corridors are being made for the next 30 to 40 years [37]. Planning for health care services, transport, road networks and housing now, will impact access to the social determinants of health for communities in many years to come.

Whilst studies have identified differences in health services accessibility between urban and rural settings [3, 38], few studies have considered differences in access to health services within a metropolitan area. Therefore this research contributes knowledge to the field through the examination of intra-city variations and health services access for a case study disease.

Additionally, few studies have considered access to both primary and secondary health care providers. However through the examination of diabetic health services, this study was able to do both. This is also true for transport, where few studies have considered access to health services for both private and public transport; however given the importance public transport can have for disadvantaged populations, particular for health services access, it was included in this study.
2.0 Methods

2.1 Aim

The aim of the study was to examine spatial access (i.e. travel times) to a range of diabetic health services across five areas of Melbourne via public and private transport.

2.2 Methods Outline

In order to estimate travel times from home to health facilities via private and public transport this study: 1) identified locations of relevant primary and secondary health care facilities; 2) created a synthetic sample of home addresses across Melbourne; and 3) used network analysis to estimate times from the synthetic home addresses to the health facilities. Detailed methods for each of these steps are described below.

2.3 Study area

A Local Government Area (LGA) is a spatial unit for which a local council assumes responsibility of a geographical area [39]. As there are variations in population and infrastructure across outer metropolitan suburbs in Melbourne, this region was further divided into LGAs located in inner, middle, outer established, outer urban growth, and outer fringe areas (Figure 1), as described below.

- **Inner areas** were defined as areas of metropolitan Melbourne within approximately 7-10 kilometres from the central business district [1].
- **Middle areas** were defined as areas of metropolitan Melbourne within approximately 10-20 kilometres from the central business district [1].
- **Outer established areas** were defined as those on the outskirts of Melbourne that were not experiencing rapid population growth, and which have established infrastructure and suburbs [1].
• *Outer urban growth areas* were defined as those located on the outer periphery of Melbourne, and classified as urban growth areas by the State Government of Victoria, as opposed to infill areas that existed in the inner and middle areas of Melbourne [1]. Outer urban growth areas were in a phase of rapid population growth requiring new services and infrastructure [1, 40].

• *Outer fringe areas* were defined as those on the outskirts of Melbourne with increased development and population growth at the state average, but not experiencing the rapid population increase of urban growth areas [1, 40].

*Figure 1.* LGAs of Melbourne classified by inner, middle, outer established, urban growth areas and outer fringe areas.
2.4 Demographic Data

Aggregated demographic data were sourced from the Australian Bureau of Statistics (ABS) 2011 Census Data [41] to provide some social context. ABS data indicates that percentage any car ownership is higher in Melbourne’s urban growth and fringe areas. Additionally, percentage of people born in Australia was second lowest in urban growth areas and urban growth areas had residents with a younger median age.

Table 1 Demographic data for areas across Melbourne

<table>
<thead>
<tr>
<th>Area of Melbourne</th>
<th>Median weekly household income in AU$ +SD</th>
<th>Median age +SD</th>
<th>% born in Australia +SD</th>
<th>% household car ownership +SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner</td>
<td>1676.0 (171.1)</td>
<td>34.0 (3.3)</td>
<td>61.7 (10.8)</td>
<td>77.3 (11.0)</td>
</tr>
<tr>
<td>Middle</td>
<td>1321.0 (218.5)</td>
<td>38.0 (2.3)</td>
<td>62.3 (6.5)</td>
<td>88.8 (4.0)</td>
</tr>
<tr>
<td>Outer Established</td>
<td>1140.0 (175.9)</td>
<td>37.0 (1.5)</td>
<td>69.0 (16.8)</td>
<td>89.7 (3.0)</td>
</tr>
<tr>
<td>Urban Growth Area</td>
<td>1322.5 (73.0)</td>
<td>33.0 (0.9)</td>
<td>61.9 (7.1)</td>
<td>93.0 (1.1)</td>
</tr>
<tr>
<td>Outer Fringe</td>
<td>1281.0 (422.0)</td>
<td>39.0 (2.6)</td>
<td>79.5 (2.9)</td>
<td>93.9 (2.3)</td>
</tr>
</tbody>
</table>

Key: AU$ = Australian dollars; SD=Standard deviation

Source: Australian Bureau of Statistics (ABS) Census Data 2011 [41]
2.5 Identifying diabetic health services

Diabetic health services were selected based on the services required for diabetic patients as recommended by Diabetes Australia Victoria [17]. These include diabetic educators, dieticians, endocrinologists, general practitioners, optometry, pharmacy, physiotherapists/exercise physiologist, podiatry and psychological services [17]. For the purpose of this study, primary health care providers were defined as services that did not routinely require a referral whereas secondary health services were defined as those services usually requiring referrals [23].

Melbourne is a large metropolitan area. Unlike some international cities Melbourne is a major capital with no neighbouring cities. While it may have been the case that people accessed health care services in LGAs outside the study area, we collected health care service data in neighbouring areas of Melbourne to account for and minimise ‘edge effects’, that is, where people may access services close to home, yet lie outside that of metropolitan Melbourne’s boundary [20, 42].

2.6 Health services data sources

General practitioner, dietician, endocrinologist and diabetic educator addresses were sourced using the Victorian Health Services Directory [43]. After removing duplicate facilities, addresses were geocoded using geographic information systems (GIS). ArcGIS 10.2 (ESRI, Redlands, CA, USA) was used for all GIS analysis. Geocoded podiatry, optometry and pharmacy data were sourced from a commercial business points dataset [44] (Table 1). Due to lack of data psychological services were not included in this analysis.
**Table 2:** Health services: data source, date and number of health services collected

<table>
<thead>
<tr>
<th>Type of health service</th>
<th>Health service</th>
<th>Data source</th>
<th>Data collection date</th>
<th>Number of services geo-coded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Dieticians</td>
<td>Victoria Health Services Directory</td>
<td>2015</td>
<td>n = 457 (Melbourne’s LGA’s and LGA’s adjacent to Melbourne)</td>
</tr>
<tr>
<td>Primary</td>
<td>General practitioners</td>
<td>Victoria Health Services Directory</td>
<td>2012</td>
<td>n = 1818 (across all of Victoria)</td>
</tr>
<tr>
<td>Primary</td>
<td>Optometry</td>
<td>Axiom business points from Pitney Bowes</td>
<td>2014</td>
<td>n = 853 (across all of Victoria)</td>
</tr>
<tr>
<td>Primary</td>
<td>Pharmacy</td>
<td>Axiom business points from Pitney Bowes</td>
<td>2014</td>
<td>n = 1930 (across all of Victoria)</td>
</tr>
<tr>
<td>Primary</td>
<td>Podiatry</td>
<td>Victoria Health Services Directory</td>
<td>2015</td>
<td>N = 221 (across all of Victoria)</td>
</tr>
<tr>
<td>Primary</td>
<td>Physiotherapy</td>
<td>Axiom business points from Pitney Bowes</td>
<td>2014</td>
<td>n = 919 (across all of Victoria)</td>
</tr>
<tr>
<td>Secondary</td>
<td>Diabetic educators</td>
<td>Australian Diabetes Education Association</td>
<td>2015</td>
<td>n = 213 (services included within a 200km radius from Melbourne’s CBD)</td>
</tr>
<tr>
<td>Secondary</td>
<td>Endocrinologists</td>
<td>Victoria Health Services Directory</td>
<td>2015</td>
<td>n = 132 (Melbourne’s LGA’s and LGA’s adjacent to Melbourne)</td>
</tr>
</tbody>
</table>
2.7 Residential Data

Synthetic residential address points were created using address points sourced from Vicmap Planning 2013 [45]. A variety of planning zones exist across Melbourne [46]. As the aim of the study was to mimic people’s journey from their home to a health facility, all zoning classifications that could potentially have residential points were included in the data set. These included all residential zoned addresses as well as address points in the capital city zone, docklands zone, mixed land use zones and urban growth zone [46]. Residential addresses include any parcel lot where people can live (i.e. zoned as residential). Approximately 10,000 random address points were selected for each category of inner, middle, outer established, outer urban growth and outer fringe areas.

2.8 Network analysis

Two origin destination (OD) matrix frameworks were created to estimate the travel time between each synthetic residential address and the nearest health care facility of each type for both private and public transport modes [47]. Time was used as a spatial measure of access to services, as it provides a more responsive measure of access to services than distance, while also accounting for access to transport modes [20]. Consumers are also more sensitive to travel time, rather than distance, when accessing and utilising health care services [20].

2.9 Private motor vehicle network

The OD matrix was calculated for each trip, in minutes, using private transport from origin points (synthetic residential address data) to the destination point (geocoded health services). The private transport network was created using Vicmap Transport road centreline data [45].

Travel time varied for different roads at different times of day [48], therefore were calculated during off-peak day road times (between 10am to 3pm). Off peak travel times were used because of: a) the
larger variation in travel conditions during peak times; and b) an assumption that many health services were more commonly accessed during non-peak periods. While this introduces bias for those who travel during peak periods, this is consistent across the entire road network. Any other potential single-time point disruptions that may occur along the road network (e.g. accidents, maintenance) were not accounted for in the calculations.

As detailed vehicle travel time data were unavailable for these origins and destinations, off-peak travel speeds for different types of roads in the road hierarchy were estimated (see Table 2) [49, 50]. Sign posted speed for each road type in the road hierarchy was sourced from the VicRoads traffic engineering manual [50] and VicRoads traffic monitor report, which provides average travel speeds by road category (e.g. freeway, arterial) and area (inner and outer). From this, average travel speeds were calculated (see Table 2). Average travel speeds were not available for local and collector roads. As shown in Table 3 the average travel speed for the arterial and sub-arterial networks across inner and outer regions were approximately half of the sign posted travel speed [48]. Therefore, we estimated the average travel speeds across the network for collector and local roads by using half the sign posted travel speeds, i.e. on a 50 km/hr signed street, travel speeds were estimated to be 25km/hr.
<table>
<thead>
<tr>
<th>Road hierarchy type</th>
<th>Sign posted speed</th>
<th>Actual speed, off peak, inner LGA</th>
<th>Actual speed, off peak, middle LGA</th>
<th>Actual speed, off peak, outer established LGA</th>
<th>Actual speed, off peak, urban growth LGA</th>
<th>Actual speed, off peak, outer fringe LGA</th>
<th>Estimated private motor vehicle speed (i.e., Average, off peak, inner and outer)</th>
<th>Estimated private motor vehicle travel time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>100km/hr</td>
<td>70km/hr</td>
<td>70km/hr</td>
<td>80km/hr</td>
<td>80km/hr</td>
<td>80km/hr</td>
<td>75km/hr</td>
<td>20.83 m$^{-1}$</td>
</tr>
<tr>
<td>Arterial or Highway</td>
<td>80km/hr</td>
<td>32.5km/hr</td>
<td>32.5km/hr</td>
<td>43 km/hr</td>
<td>43 km/hr</td>
<td>43 km/hr</td>
<td>37.75 km/hr</td>
<td>10.49 m$^{-1}$</td>
</tr>
<tr>
<td></td>
<td>Sub-arterial</td>
<td>60km/hr</td>
<td>28km/hr</td>
<td>28km/hr</td>
<td>38km/hr</td>
<td>38km/hr</td>
<td>38km/hr</td>
<td>33 km/hr</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>Collector</td>
<td>50km/hr</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>25km/hr</td>
</tr>
<tr>
<td>Local</td>
<td>40km/hr</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>20km/hr</td>
</tr>
</tbody>
</table>

Key: hr = hour; km = kilometre; m$^{-1}$ = metres per second

Data source: VicRoads traffic monitor report [48] and VicRoads traffic engineering manual [50].
2.10 Public transport network

Public transport stops, routes and timetables were sourced from Public Transport Victoria’s General Transit Feed Specification (GTFS) [51]. Public transport modes used in the analysis included trains, trams and bus services. A multi-modal network was created for the public transport network analysis using GTFS tools for ArcGIS [52]. The multi-modal network accounted for time spent walking to and/or travelling by public transport. Public transport and walking travel times were calculated from origin points (synthetic residential addresses) to the closest destination point (geocoded health services) and were estimated using the OD matrix. The OD matrix was calculated at the same day and time (12:00 pm, Wednesday).

2.11 Statistical analysis

The final dataset contained shortest travel times in minutes from approximately 50,000 synthetic residential address points to eight diabetic health care services of interest, for both private and public transport in each of the five areas of Melbourne. Analysis of variance (ANOVA) testing was initially undertaken to determine significance of means between groups (i.e. inner, middle, outer established, outer growth and outer fringe), however due to the large sample investigated, the \( p \)-values were all significant. Therefore descriptive statistics were used to investigate differences across the five areas of Melbourne for each health service and between private and public transport.
3.0 Results

The findings for travel times to health services by private and public transport (Figures 2 and 3) across the different areas are presented below. The results did indicate a number of outliers however the data were normally distributed. The results could have been truncated however the aim of the study was to understand the potential reality of travel times to access health services across Melbourne.

Figure 2: Travel times in minutes across areas of metropolitan Melbourne to diabetic health services via private transport
Figure 3: Travel times in minutes across areas of metropolitan Melbourne to diabetic health services via public transport

The results show travel time differences between private and public transport modes and primary and secondary health care services. Travelling to diabetic health services was between 5.89 (inner) to 4.02 (outer fringe) minutes faster by private motor vehicle when compared with public transport across all areas of Melbourne. Compared with those living in inner city areas, the median time spent travelling to diabetic services was between 2.46 and 23.24 minutes slower (private motor vehicle) and 12.01 and 43.15 minutes slower (public transport) for those living in outer suburban areas. Compared with middle suburbs travelling to diabetic services was between 1.1 minutes and 21.22 minutes slower (private motor vehicle) and 8.29 minutes and 40.62 minutes slower (public transport). Irrespective of travel mode used, results indicate that those living in inner and middle
suburbs of Melbourne have faster travel times to access diabetic health services for both private and public travel modes, compared with those living in outer areas of Melbourne.

Road travel times were fastest when accessing primary health care services in inner Melbourne (general practitioner median travel time in minutes: 0.89 (private transport), 5.1 (public transport); access pharmacies median travel time in minutes: 0.86 (private transport), 5.89 (public transport)). Of note were the quick travel times when traveling to some general practitioners (0.89 minutes) and pharmacists (0.86 minutes). It was theorised that if a residential address was next to a general practitioner or pharmacist, this would account for these travel times across the road network, as the analysis did not take into account time getting to the car, waiting in traffic, or parking. Travel times in Melbourne’s outer growth and fringe areas were similar for primary health care services. For example to access pharmacies, the median travel time in minutes was 3.51 (outer urban growth) and 3.26 (outer fringe) for private transport and 17.13 (outer urban growth) and 17.20 (outer fringe) for public transport. Time taken to access secondary health care services were slower compared with primary health care services. The slowest travel times were for specialist secondary health care services such as endocrinologists; median travel times for outer growth areas and outer fringe areas were 9.81 and 26.72 minutes respectively (private transport), and 39.3 and 59.25 minutes respectively (public transport).

4.0 Discussion

4.1 Access to diabetic health services in Melbourne’s growth areas

This research highlights that access to diabetic health services is faster in inner and middle areas of Melbourne compared with established, urban growth areas and fringe areas, irrespective of transport mode. Consistent with Lovett et al’s [26] research, private transport was consistently shown to have faster travel times when accessing all health services compared with public transport.
modes. Our findings show that inner Melbourne had the fastest time spent travelling to access primary health care services (pharmacies and general practitioners). Those living in the outer urban growth and outer fringe areas of Melbourne experienced the slowest travel times when accessing specialist secondary health care services (endocrinologists).

Not surprisingly, residents living in Melbourne’s inner suburbs have the greatest spatial access to diabetic health services compared with other areas of Melbourne. For the most part, access declines linearly, whereby middle suburbs have greater access than outer established suburbs, and so forth. Our research confirms that access was even poorer in urban growth areas.

Our results also showed less variability in private motor vehicle and public transport travel times across inner and middle areas of Melbourne compared with outer suburban areas. This is in part due to the greater variability in the infrastructure available in outer suburbs across Melbourne. For example, in more established outer suburban areas more transport infrastructure and services were available in comparison with many of the new urban growth areas [1, 2]. Additionally, the Victorian Integrated Survey of Travel and Activity 2007-08 (VISTA 07-08) found that median distances to travel to work were higher in urban growth areas when compared with suburbs located closer to the city [53]. For example, the Melbourne metropolitan median travel distance to work was 14.3 kilometres, yet for those living in Melton (one of Melbourne’s urban growth areas) the median distance was 32.5 kilometres [53]. A study by Currie and Senbergs [54] considered households with ‘high car ownership on low incomes’ (HCOOLI) to explore car usage in Melbourne’s urban growth areas. Findings suggested that car usage by HCOOLI households in outer Melbourne was 5.2% more frequent, and car trips 38% longer than HCOOLI households in the middle suburbs of Melbourne [54]. Given that approximately 40% of Melbourne’s health services are located within a 10 kilometre radius of the central business district [5], work travel times may serve to provide a crude indication
that if health facilities continue to be located centrally in Melbourne, people living in urban growth areas need to travel further to access these services.

4.2 Primary and secondary health care services

Not surprisingly the least time spent travelling to health services were for primary health care services. In regards to health services hierarchy, primary health care services are usually the first point of entry into the health care system and are likely to be accessed by many different populations, and most frequently [5]. Specialist services such as diabetic educators and endocrinologists serve particular sub-groups, for example those living with T2DM, and travel times to these services were the slowest across both modes of transport. Few studies have considered access to both primary and secondary health services in regards to travel times and travel mode, however it is generally accepted that travel times to primary health care services should be faster than secondary health care services. By way of example, Haynes et al [55] found that 99% of their study population in East England could access a general practitioner within a 17 minute journey. Whereas, an American study by Onega et al [56] considering access to specialised cancer services, found that median travel time to National Cancer Institute designated cancer centres was 78 minutes.

In our study, there was marked variability in travel times by transport mode by urban area typology when accessing both primary and secondary health care services; some residents in urban growth areas travelled up to 196 minutes via public transport to access a general practitioner. This finding is inconsistent with policy directions in Melbourne. The state government’s recent strategic land use document Plan Melbourne refresh [1] has called for a 20-minute city, where residents should be able to access essential services within a 20 minute trip regardless of age or ability. These results suggest that whether this level of access is possible via private or public transport currently depends on the
area of residence. Travel times of up to 196 minutes to reach basic primary health care services observed in this study, are clearly beyond this threshold and highlight significant health service access inequities in some areas within Melbourne. To improve access to health services in Melbourne’s outer urban growth areas, integrated planning is required: i.e., health planners providing more localised primary health care services – even if delivered in temporary locations in growth areas – and transport planners ensuring access to those services by providing accessible and frequent public transport choices [1].

This research supports that those living with TD2M in outer areas of Melbourne, will need to spend considerably more time travelling to access essential diabetic health services than those living closer to the city. While not inordinate travel times for primary care services, it appears that in order to achieve equitable access, specialist services may require an alternative delivery model to provide for the increasing number of those living in urban growth areas and fringe areas of cities.

4.3 Private versus public transport

Residents living in Melbourne’s urban growth areas have been shown to experience transport disadvantage, as they live in car-dependant areas with poor access to public transport [54, 57, 58]. This was confirmed by our study. Additionally, urban growth areas in Melbourne are known to have a diverse population with residents from a range of backgrounds such as culturally and linguistically diverse groups, youth populations and the elderly [5, 59]. This finding is comparable with a study conducted by Roeger et al [60] which considered spatial access to general practitioners in metropolitan Adelaide, Australia and concluded those most disadvantaged and requiring access to primary health care services were those living in outer suburbs and with a lower socio economic status.
People living in growth areas are faced with a complex transport situation: the remoteness coupled with a lack of other transport mode options fosters reliance on private car ownership [2, 40]. Currie et al [54, 57] have explored factors influencing transport disadvantaged in Melbourne’s outer urban growth areas, including the forced transport costs often related to car ownership, due poor access to other transport options. The financial cost of travelling to health services can be prohibitive for disadvantaged populations, especially those who rely on private transport, particularly hired transport, such as taxis [61].

This has implications when accessing health services, particularly for vulnerable populations who have a greater reliance on public transport to access health services [57, 59]. Residents in Melbourne’s growth areas face a ‘triple disadvantage’ situation; they have less access to health care services and public transport to get to services, while a greater proportion of them are more vulnerable [2, 5, 59].

5.0 Limitations

Spatial access of health service locations offers one dimension of health services access. Other factors that could have been considered as part of access include cultural appropriateness [18, 62], opening hours [18, 19], cost [19, 20], and how people access health services in respect to their daily activity patterns (e.g. services around the workplace) [20, 63]. Additionally an assumption was made that people were accessing the closest type of destination, whereas they likely have a preferred provider who might not be the closest one.

Also not all diabetic health services were analysed. For example, psychological services were not included. Psychological services provide a valuable health service for diabetic patients as well as the
community at large [17]. Additionally, the health service data sets accessed from a private provider may have been incomplete or had some inaccuracies. For example, locations were provided for private podiatry clinics, but did not include other locations where podiatrists may practise, such as community health centres.

There were some limitations to the road network analysis. The road network was based on a formula using the travel speeds for each road type (e.g. freeway, arterial roads) and distance to the nearest of each type of health service. Whilst some concession was made to adjust for the average travel speed along the road network, it did not take into account other congestion variations, such as road works, accidents, parking, traffic, lights, intersections and peak travel times. Also, the model did not simulate a situation where someone may have driven to a train station and then used public transport. In Melbourne approximately 61% walk to train station, approximately 23% catch a bus or tram to a train station and approximately 12% drive their car to a train station [64-66].

Furthermore, this study lacks health outcomes, health utilization and socio-economic status data. Though the study included limited demographic data it was beyond its scope to analyse demographic and social data in relation to travel time access across areas of Melbourne. However, this could be pursued in further studies. Also, the residential addresses in this study were a sample of where residents potentially live; the study did not consider someone who actually had diabetes and their true exposure, or their unique need to utilise health care services. Instead the research was based on synthetic residential address data to estimate journey times. The actual experience of accessibility to a high demand service might provide additional contextual information. We were unable to test this using synthetic data. All health services were weighted equally, but it is likely that some services are more important than others depending on the progression of diabetes, and this was unable to be tested through this study design. There is also a danger of the ecological fallacy, whereby inferences are made about individuals based on aggregated data.
Additionally, for someone who has stable T2DM they may require review from their general practitioner every 3 – 12 months, dependant on other co-morbidities; however someone who has increased risk of complications may require monitoring from their general practitioner every 6-12 weeks [67]. One method to improve access to diabetes health services includes the use of eHealth which can include mHealth (mobile health), telehealth, electronic health records, eLearning, social media and very large data sets known as big data [68]. This present study did not test the efficacy of eHealth into diabetic health services access as it was outside the scope of the current research; however there are number of Australian studies that have investigated the impacts of ehealth delivery [69-72] and it is an area for further research when considering diabetic health services access in urban growth areas.

6.0 Conclusion

Melbourne, Victoria, is currently experiencing a rapid population increase, specifically in urban growth areas and this study identifies considerable time differences in accessing diabetic health care services, particularly specialist services. Urban growth areas are often considered attractive places to live because of their perceived affordability, however as many disadvantaged populations live within these areas health services should be planned to meet current needs and to minimise any potential health services access inequities.

Understanding the current situation of diabetic health service access in urban growth areas will help health and urban planners respond by providing health services accordingly. Plan Melbourne has called for a 20-minute city where essential services such as primary health care should be able to be accessed within a twenty minute journey of people’s homes. So far, this has not been achieved in growth areas; however it provides a planning metric for which to aim for health services accessibility.
Planning for health services in Melbourne’s urban growth areas requires a co-ordinated approach from all sectors of government such as health, urban planning, transport and land use. Through integrated planning, providing health services closer to people’s homes will reduce travel times and increase equity of access for those who rely on public transport. As the population and demographics in urban growth areas continues to expand and change, further investigation is warranted to explore alternative ways to delivery diabetic health services to people living in these areas.

List of Abbreviations

ABS Australian Bureau of Statistics

ANOVA Analysis of variance

GTFS General Transit Feed Specification

GIS Geographic Information Systems

HCOOLI High car ownership on low incomes

hr = hour

km = kilometre

LGA Local Government Area

m\(^{-1}\) = metres per second

T2DM Type 2 Diabetes Mellitus

VISTA Victorian Integrated Survey of Travel and Activity
Declarations

Ethics approval and consent to participate: Not Applicable

Consent for publication: Not Applicable

Availability of data and material:

The datasets generated and/or analysed during the current study are available at:

1. Health services are available from human services directory Victoria:

2. Address points are available from Vicmap Planning:

3. Road data were sourced the VicRoads traffic monitor report and VicRoads traffic engineering manual available from:

4. Public Transport Victoria Timetable and Geographic Information is available from:

Competing interests

The authors declare no competing interests

Funding

RM is funded by an Australian Government Research Training Program Scholarship, a Melbourne Studentship and a Windermere Foundation Scholarship for Nursing. SM is supported an NHMRC Early Career Fellowship (#1121035). HB is supported by a RMIT University VC Senior Research Fellowship. BGC is supported by an NHMRC Principal Research Fellow Award (#1004900).
Authors’ contributions

RM, HB, BGC: Designed the study RM: Undertook a literature review, was responsible for the statistical analysis and compiled the findings SM: Analysed GIS road network and public transport data. All authors read and approved the final manuscript.

Acknowledgements

The authors would also like to acknowledge Rachel Sore, formally from the Statistical Consulting Centre at The University of Melbourne for advice in regards to sample size and statistical analysis.

Authors’ information (optional)

Please note that the lead author is currently enrolled in a research higher degree at the University of Melbourne.

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