The built environment and its impacts on the walkability for children within primary school catchment areas: Case studies of primary schools in Auckland

Anh Tang

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Abstract

This research focuses on disclosing policies and built environment factors that help explain the lack of walkability in the catchment areas of primary schools in Auckland, especially with the advent of Covid-19. Three case studies of Sylvia Park School, Takapuna Primary School and Newmarket Primary School were investigated in support of this study. The main question of this research is how spatio-material components might affect the walkability of children within primary school catchment areas. The quality of the walking environment was investigated through four key criteria: *connectivity*, *land use patterns*, *safety,* and *quality of pathway and path context*. International case studies from the Netherlands, the US and Australia have been selected to investigate to identify how their planning strategies and urban design measures promote walkability. The research intent is to interpret the influence of materiality on children's walkability and, from that, make suggestions for the revision and improvement of planning regulations in New Zealand.

Keywords: walkability, walkable neighbourhood, children, schools, built environment components, policies.

Abbreviations Table

Name	Abbreviations
New Zealand	NZ
United States	The US
United Kingdom	The UK
New Zealand Transport Agency	NZTA
Ministry of Transport	MoT
Ministry of Education	MoE
Auckland Council	AC
Auckland Transport	AT
Auckland Plan 2050	AP
Regional Land Transport Plan	RLTP
Auckland Transport Alignment Project 2018	ATAP

CHAPTER 1: INTRODUCTION

1.1. Introduction/Background

Walking has benefits for children, including building physical health, promoting independent mobility and enhancing social interaction, as well as reducing environmental pollution and the costs of traffic congestion (Yeung, Wearing & Hills, 2008). The use of private vehicles has significantly increased in many countries, associated with a reduction in active travel (Cooper, et al., 2003). In NZ, a third of children remain inactive, which leads to high rates of child obesity (Ikeda et al., 2018). This issue is seen in Auckland, where rapid population growth has put a lot of pressure on the transport network. High pressure results in more road risks, such as decreased walking rates among children, especially to and from school.

This research aims to disclose built environment components and policies that help explain the lack of walkability in primary school catchment areas in Auckland. It will start with a literature review to provide a sound understanding of the notions of pedestrians, walkability and walkable neighbourhoods. Four criteria that significantly affect the walkability of children within the catchment areas will be identified: *connectivity*, *land use patterns*, *safety* and *quality of pathway and path context.*

Furthermore, the study will demonstrate understanding of NZ's policies and provisions to improve walking capacity and road safety around primary schools, such as AP 2050, RLTP and design guidelines made by AC, AT, NZTA and other relevant authorities. It will help identify the limitations associated with the policy provisions and the challenges policymakers encounter in delivering solutions to increase walking rates in Auckland.

It will then investigate international case studies to identify how planning strategies and urban design measures promote walkability in general. With a wide range of coordinated policies, necessary programmes and pedestrian infrastructure, planners have successfully modified traffic patterns, prioritized active travel modes and improved walkability. These methods can be adapted for primary schools in Auckland to increase walking rates among children.

Secondly, the research will investigate the built environment of three case studies of primary schools in Auckland: Sylvia Park School, Takapuna Primary School and Newmarket School. By investigating a range of physical factors, the case studies will be compared and contrasted in response to the research question of how the built environment components affect walkability for children.

In consideration of the current situation of the global pandemic, the importance of walking for children cannot be underestimated. Covid-19 has affected human health and economic development significantly. It has radically changed our travel habits, reducing travel demand and public transport use. Schools, shops and restaurants are closed, while people are encouraged to work from home (McKibbin, 2020). As many parents are working from home, they are more likely to walk their kids to school instead of dropping them off by car or sending them on school buses. In light of these changes, walking has become more common and is a favoured mode of transport for essential journeys within short distances. This means walking could become the new norm in many car-dependent places. Therefore, it is a once-in-a-lifetime opportunity to reshape cities and design more walkable spaces, especially around primary school catchment areas.

1.2. Research aim

The research intent is to disclose the relationship between the built environment within catchment areas and the walkability of children. In particular, the research will look into four criteria: *connectivity*, *land use patterns*, *safety*, and *quality of pathway and path context*. Initially, the main purpose of catchment areas is related to the reinforcement of more walkable neighbourhoods. However, in recent years catchment areas haven't significantly increased walkability in many places, which raises the needs for changes in the policy framework.

1.3. Study areas

1.3.1 Case studies

The research investigates three primary schools in different areas of Auckland to identify how the built environment has affected the walking access of children within the school catchments: Sylvia Park School, Takapuna Primary School and Newmarket School. These primary schools were selected because each is unique in terms of location and surrounding land uses, creating diverse physical settings. The locations in the Auckland region are shown in *Figure 1*.

1.3.2 Case study approach: Multiple cases

Case studies are required to represent the topic of study empirically. This research will use the multiple case study approach to understand the similarities and differences between case studies. This approach helps to analyse the data within each situation and across situations. Also, they can be used to predict similar results or portend contrasting results for predictable reasons. Often, evidence generated from multiple case studies is reliable and robust, which allows a wider exploration of the research question (Yin, 1994). Within this research, three case studies are selected to identify walking conditions and identify the relationship between the built environment and walkability around catchment areas.

1.4. Research question

How do spatio-material components have impacts on the walkability for children within primary school catchment areas?

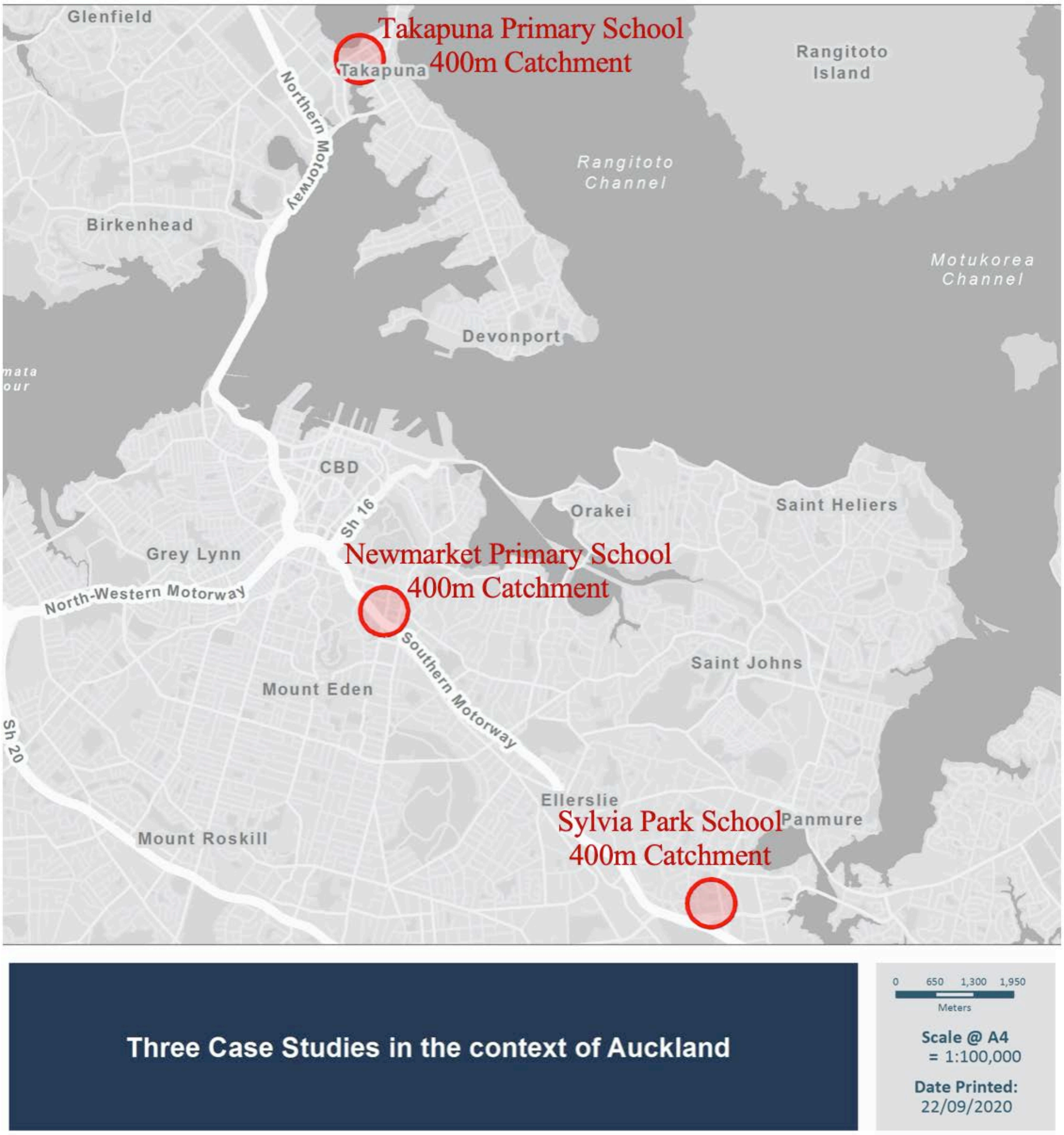


Figure 1: Locations of three case studies in the Auckland region

(Source: Auckland Council Geomaps, edited by author)

CHAPTER 2: METHODOLOGY

2.1. Data Collection Methods

The research used a mixed methodology to obtain a variety of data related to the built environment components and policy provisions.

2.1.1 Observation

The built environment within catchment areas was assessed through observation in field research, to capture a big picture and holistic perspective on how physical factors affect children walking to school.

The site observation was carried out within the potential walking distance of 400m around studied schools. In urban planning, this 400m buffer refers to a pedestrian shed covering the average walking distance of a five-minute walk, which is the reasonable distance people are willing to walk before opting to drive. In Clarence Perry's neighbourhood unit concept (1929), the neighbourhood is self-contained with the primary school located in the centre. His idea suggests schools should be within the 400m radius or five-minute walking distance and accessible by all residents (*Figure 2*). This distance also determines public access to different types of land uses and measures how walkable a neighbourhood is (El-Geneidy, et al., 2014).

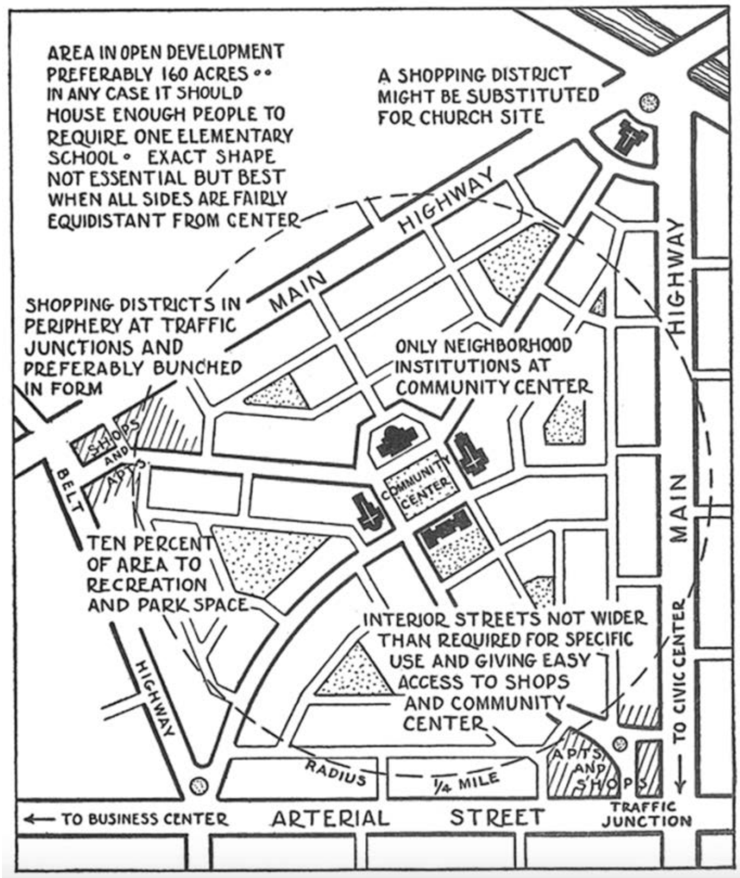


Figure 2: Clarence Perry's neighbourhood unit concept (Perry, 1929)

This methodology helps distinguish a range of dimensions of the catchment areas: human activities and different spatio-material components, as well as the way people interpret these and act on them. This method of field research is chosen instead of other research approaches because it is less expensive, easier, and less time consuming to obtain primary data (Gaber & Gaber, 2007).

2.1.1.a. Methods

I made fieldnotes in a field diary record to interpretations and observations. This helped annotate different physical components in the study areas. The data was generated from settings, interactions and situations at each case study, collected in text documents to be later used for analysis.

2.1.1.b. Results

Information from the site observation was categorized into four groups:

- Connectivity of road network
- Local land-use patterns
- Safety from traffic and social crime
- Quality of pathway and path context, width, signage, lighting, paving and landscaping

2.1.2 Photographic recording

Photographic research takes into account eye-level views and requires images to be obtained through the observation of spatial variables and recognizable objects. Planners often use this method to provide visual evidence for particular planning issues (Gaber & Gaber, 2007). In this research, the photographic method was used to observe significant people, activities, infrastructure (Mason, 2002).

2.1.2.a. Methods

I used a camera to capture what is within the study areas. This method cannot reveal anything related to feelings about what is happening or interpretations of the setting. However, it will record pictures as the primary form of visual data to help with data analysis (Mason, 2002). So, the collected data for this methodology was in the form of images.

2.1.2.b. Results

Information obtained from the photographic recording is related to:

- Barriers such as highway, motorway, busy arterial roads, and railway
- Quality of pathway and path context

2.1.3. Geographic Information System (GIS) mapping

The investigation was supported by using GIS (Geographic Information Systems) research strategy to analyse the focused areas. It will provide a consistent and clear understanding of the street network, connectivity and crash patterns within catchment areas. From this, the relationship between built environment factors and walkability for children within catchment areas was established (Mason, 2002).

2.1.3.a. Methods

I used the GIS software and Auckland Council Geomaps to map out the 400m ped-shed of study areas. In addition, I will provide maps of crash patterns that involved pedestrians within the catchment areas using NZ Transport Agency (NZTA) data. The collected data in the form of maps was used to analyse the study areas.

2.1.3.b. Results

Information obtained from the GIS mapping methods is related to:

- Connectivity of the road network
- Safety within the school catchment

2.1.4. Documentation

The research will retrieve data from Government and local council policies and reports, such as Auckland Plan 2050, Regional Land Transport Plan, design guidelines from NZTA and Ministry of Education.

2.1.4.a. Methods

I selected all relevant policies and regulations documents within the New Zealand framework and record the collected data in the form of text-based document. The data was used to analyse the impacts of policies on the physical settings and walking rates within study areas.

2.1.4.b. Results

- Policies and provisions that encourage walkability

2.2. Data analysis

These research methods will produce several forms of data, comprising texted-based documents, images and maps. I will aggregate all the data gained from the case studies and note the similarities and differences of the spatio-material components between them. The data was transformed into textual forms for data analysis. I will then assess these findings using four criteria provided in the literature review to find out the relationships between the built environment and walkability within the catchment areas.

Chapter 3: Literature Review

This literature review will provide a thorough understanding of the notion of pedestrians, walkability and criteria for the built environment that contribute to the walkability of a neighbourhood. The four most important built environment components will be identified to explain how they might influence walking rates of children within catchment areas. It will also review how New Zealand and overseas countries design their built environment and implement policies and regulations to encourage children walking to schools.

3.1. Pedestrians

There are many ways to define a pedestrian. The Compact Oxford English Dictionary defines a pedestrian as *"a person walking rather than travelling in a vehicle".* This definition refers to a transport mode to get from origins to destinations which is comparable to other modes such as cycling, driving or using public transport. Later, the American Heritage Dictionary expanded the definition of pedestrians to those who walk for the non-transportation purposes, such as shopping, exercise or social interaction (Lo, 2009).

Over time, the notion of pedestrians has been expanded but is still somewhat ambiguous. Taking into account social equity, *"any mobility-impaired person using a wheelchair"* has been added, as well as stationary pedestrians, because their contribution is significant to active living and street life. This definition is supported by legislation, s217 of Title 23 of the US Code and Wisconsin Pedestrian Policy Plan (Wisconsin Department of Transport, 2020).

The amount of academic research on pedestrians is less than the study of motorized vehicular modes. This inattention to pedestrians implies a lack of serious investment in planning and research, which underestimates the importance of pedestrian transportation (Lo, 2009). However, it is necessary to understand the definition of pedestrians in the field of urban planning because it strongly influences how they are accommodated in the design of the urban environment. In this research, the study group of pedestrians is limited to primary school children aged 5 to 12 who could walk to commute between home and school. This will help address the issues related to walkability for children within catchment areas.

3.2. Walkability and Walkable Neighbourhood

For many decades, the concept of walkability has been considered in many fields of study such as urban planning, public health and psychology (Brownson et al., 2009; Rafiemanzelat, Emadi, & Kamali, 2017). Later, in the post-modernist planning era, the topic of walkability became more popular in numerous discussions related to transportation planning as well as policy and legislation requirements. That raises a specific question of what is walkability and its related idea of a walkable neighbourhood.

Based on different research and practice discussions, Forsyth (2015) highlights the term walkability is used to refer to several phenomena. There are three main sets of discussions using the term walkability. In particular:

(1) the means for creating walkability
(2) the perceived outcomes of walking
(3) proxy for better urban places

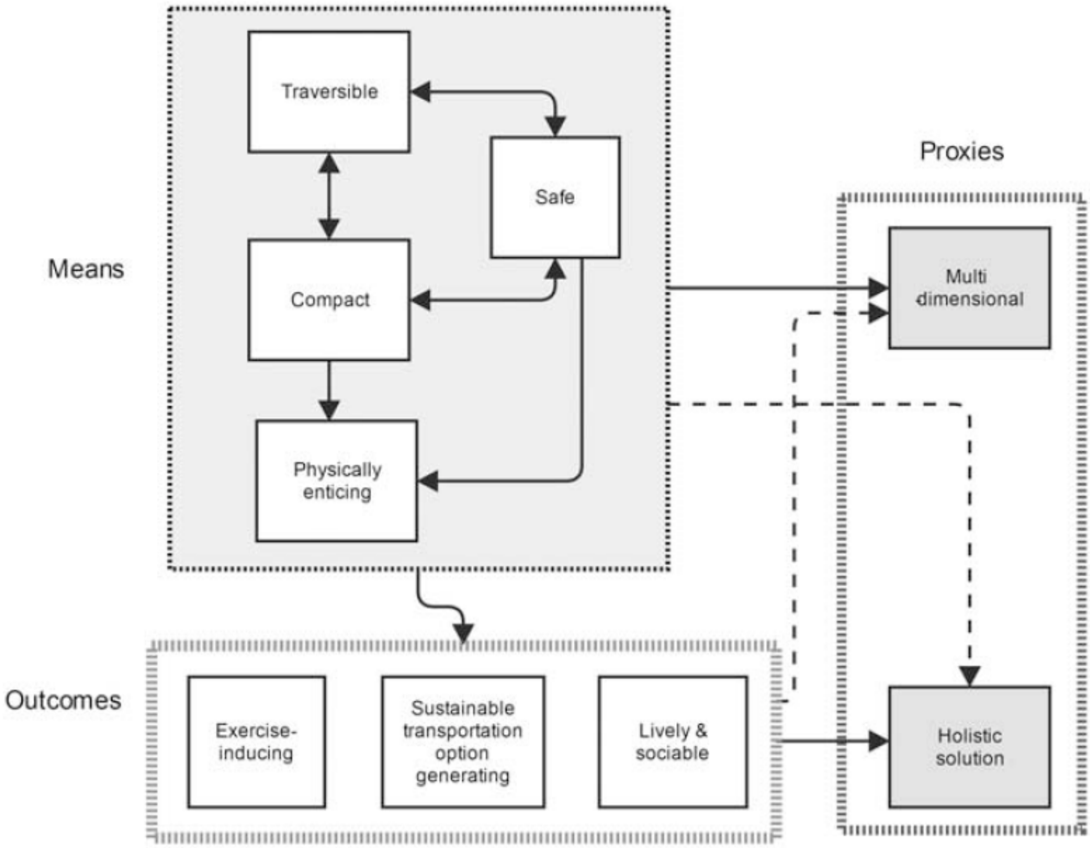


Figure 3: Framework linking definitions of walkability and walkable places (Forsyth, 2015)

The relationships between the themes of walkability and associated definitions are conceptualised in *Figure 3*. Due to a variety of definitions in the literature, many people often use the term ‘walkability’ or ‘walkable’ to indicate different things. The conflict in definitions of walkability has affected how urban planners and designers create walkable neighbourhoods, measure walkability and assess their benefits and costs in real life. The lack of consensus on defining walkability also creates conflict on how it can be translated into specific metrics for the measurement and evaluation of urban space, making it challenging to guide practice (Forsyth, 2015; Lo, 2009).

In this research, walkability was defined from the physical design perspective to identify how the built environment helps encourage children to walk. It refers to all components of the built environment, which enables easy walking access to different destinations within a neighbourhood

(Sallis, & Glanz, 2006; Shelling, 2010). Urban planners and designers use this term as a way to describe a sustainable environment for human activities by pedestrian base (Rafiemanzelat, Emadi, & Kamali, 2017).

Talen & Koschinsky (2013) make a concise definition of a walkable neighbourhood: *"a safe, well-serviced neighbourhood, imbued with qualities that make walking a positive experience"* (p. 43). Positive walking experience is described by Speck (2012) as pedestrian routes and facilities (sidewalks, streets and paths) are safe, comfortable and interesting. These components will be explored in *Section 3.3. Criteria for the design of a successful pedestrian network*.

Many studies (Calthorpe, 1993; Duany, Speck, & Lydon, 2010; Lee, & Talen, 2014) have agreed on the common characteristics – compact, high density, mixed-use, pedestrian-oriented streets, good pedestrian infrastructure, rich amenity and transit-oriented development. Significantly, walkable neighbourhoods could bring many benefits to citizens. They help solve problems related to the obesity crisis, physical and mental health as well as environmental injustice, traffic congestion, and economic and social isolation (Forsyth, 2015; Southworth, 2005; Talen & Koschinsky, 2013).

3.3. Criteria for the design of a successful pedestrian network

Studies (Handy, 1996; Mandic et al., 2017) have shown walking distance is one of the most consistent physical factors that influence people's decision to walk. Children usually make relatively fewer walking trips with increasing distance (Shelling, 2010; Yeung, et al., 2008). In the US, a distance of 1.3km or less results in a higher likelihood of children walking to school. The rates of walking for children residing between 1.3km and 2.3km from school were a third less than for those who live within 1.3km. Beyond 2.3km, this rate decreased to near zero (Mandic et al., 2017).

School zones usually help estimate the distance and travel time for children within a particular neighbourhood. However, primary schools in New Zealand nowadays are fewer and tend to serve wider geographical areas, making it harder for children to walk (New Zealand Now, 2020).

On the contrary, Southworth (2005) recognizes the measure of distance itself is not an adequate indicator of walkability. The quality of the built environment is the key to inspiring decisions to walk rather than drive. In this research, four most important attributes are selected to present the successful and high-quality pedestrian network:

- Connectivity
- Land use patterns
- Safety
- Quality of pathway and path context

3.3.1. Connectivity

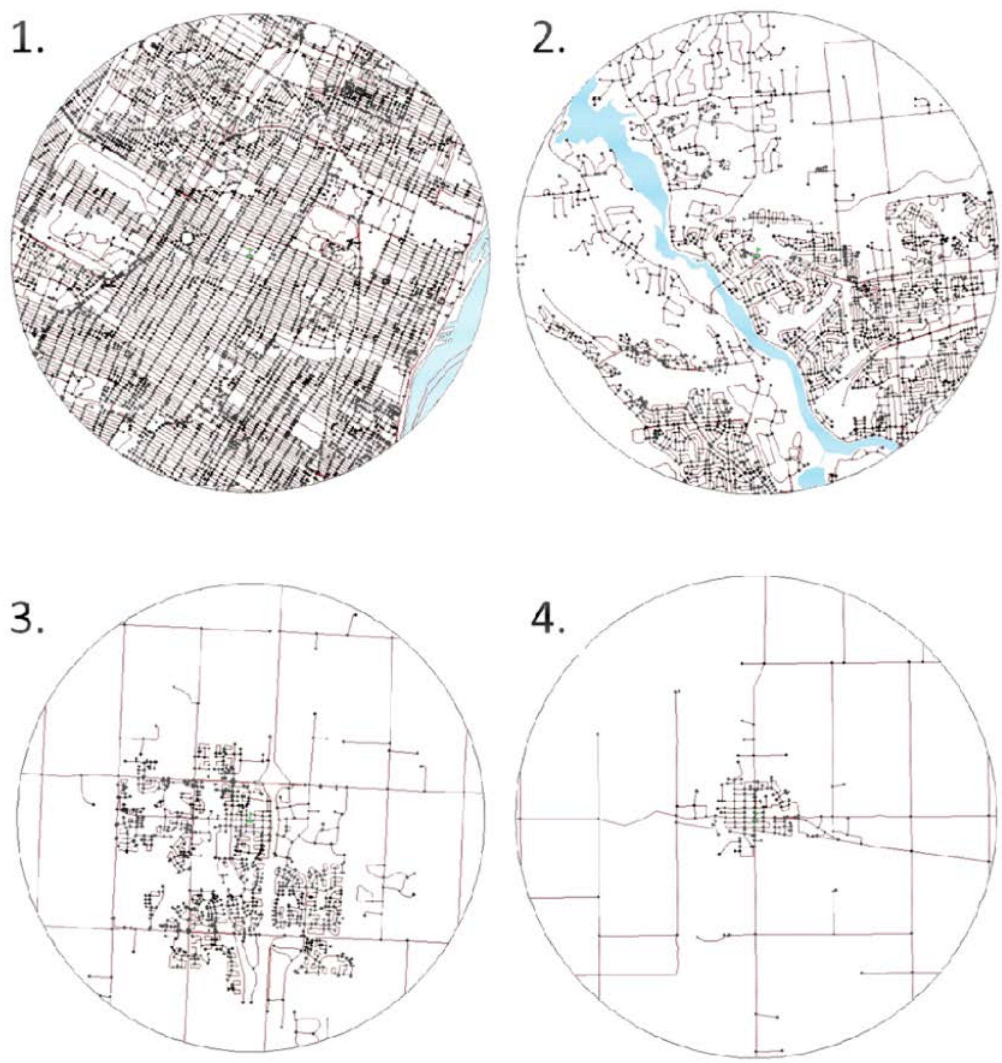
Connectivity is the presence of different pedestrian routes, path continuity and the absence of significant barriers from origins to destinations (Moura, Cambra, Goncalves, 2017). A walkable neighbourhood with high connectivity should have the street layout in a grid pattern that offers pedestrians direct routes from one location to another, as shown in the gridiron pattern in *Figure 4* (Sallis & Glanz, 2006). However, residential street patterns have become fragmented. Especially from the 1970s, street networks lost connectivity as a result of incremental infill, creating patterns that are described as loops and lollipops, or lollipops on a stick (*Figure 4*).

	Gridiron (c. 1900)	Fragmented Parallel (c. 1950)	Warped Parallel (c. 1960)	Loops and Lollipops (c. 1970)	Lollipops on a Stick (c. 1980)
Street Patterns					
Intersections					
Lineal Feet of Streets	20,800	19,000	16,500	15,300	15,600
# of Blocks	28	19	14	12	8
# of Intersections	26	22	14	12	8
# of Access Points	19	10	7	6	4
# of Loops & Cul-de- Sacs	0	1	2	8	24

Figure 4: The loss of connectivity and walkability for residential street patterns in the US overtime (Southworth, & Owens, 1993).

Features of the pedestrian environment could be barriers to pedestrian access and affect street connectivity: arterials, cul-de-sacs, rivers, railway lines and disconnected cul-de-sacs (Southworth & Ben-Joseph, 2003). Children in these areas could be more exposed to traffic issues, including high traffic volume and speed, which make them less likely to walk (Ikeda et al., 2018).

The level of connectivity is divided into quartiles from highest to lowest street connectivity in *Figure 5*. The combination of principal components – average block length, intersection density and connected node ratio – are used as indicators for street connectivity measure (Mecredy, Pickett, & Janssen, 2011).



Notes: 1 = highest street connectivity quartile, 2 = second street connectivity quartile, 3 = third street connectivity quartile, and 4 = lowest street connectivity quartile.

Figure 5: Different street connectivity quartiles (Mecredy, et al., 2011)

The average block length is the mean length of all blocks within a neighbourhood, and intersection density refers to the total number of all three-way and four-way intersections in that area. Studies (Southworth, 2005; Southworth & Owens, 1993) have indicated small block sizes and a high density of intersections are associated with a high level of street connectivity. A higher connected node ratio of real nodes to dangle nodes indicates fewer cul-de-sacs and increased street connectivity (Mercredy, et al., 2011).

The issues of connectivity are best addressed when a neighbourhood is being designed instead of remedying once it is already in place. The barriers to pedestrian access should be minimized. For example, urban planners and designers should consider connecting cul-de-sacs to provide pedestrian path continuity. Connectivity retrofits can be carried out with traffic calming devices or pedestrian overpasses or underpasses across the barriers (Southworth, 2005; Southworth & Ben-Joseph, 2003 & 2004).

3.3.2. Land use patterns

A walkable neighbourhood provides an accessible and diverse pattern of land use activities to serve local interests. Mixed land uses within a neighbourhood can help reduce the travel distance to destinations, which provides opportunities for walking (Thornton et al., 2011). It should allow residents to reach most local services within 10-20 minutes walking (Southworth, 2005). Diverse social activities include residential, commercial, elementary schools, parks, fitness centres, grocery stores and services. In contrast, single-use areas such as residential neighbourhoods or industrial areas usually are associated with monotonous views and long travel distance to destinations, making it less comfortable to walk (Azmi & Karim, 2012).

Historically, schools located centrally within neighbourhoods and surrounded by mixed land uses are more likely to facilitate walking (Mandic et al., 2017). In 1929, Clarence Perry provided the concept of 'neighbourhood unit' with the primary school located in the centre of the neighbourhood, making it easy for children to walk to school from home and protecting them from high-speed traffic (El-Geneidy, et al., 2014). But nowadays, schools are usually located at the edges of neighbourhoods, inaccessible by walking. Land use diversity and intensity is best addressed at the beginning of the development process to create a fully functional pedestrian city (Southworth, 2005).

3.3.3. Safety

Pedestrian safety is a critical aspect of walkability. The lack of provision for infrastructure or inadequate pedestrian facilities are usually barriers to walking, which lead to a high injury level. Land-use policies in many US cities have created walking and cycling experiences that are dangerous, unpleasant and inconvenient. The built environment that supports automobile travel is not safe and comfortable for pedestrians. Pedestrians are 23 times more likely to be killed than automobile passengers (Federal Highway Administration, 2003).

American Walks uses the data of pedestrian injuries and deaths as an indicator for walking statistics and ratings of walkable neighbourhoods (Talen & Koschinsky, 2013). Factors associated with the formulation of traffic safety include traffic speed, sidewalk width and condition, length and location of crosswalks, crossing times for different groups (elders, children, vision-impaired), pedestrian signage and traffic control signals, path surveillance and street night light (Pucher & Dijkstra, 2003; Southworth, 2005). In practice, traffic calming techniques such as speed bumps, narrow streets, roundabouts, raised crosswalks and landscaping were adopted in many countries to slow the traffic flow and promote pedestrian-friendly streets. The implementation of traffic calming in The Netherlands has reduced crashes and accidents by 20-70%, depending on the nature of neighbourhoods (Pucher & Dijkstra, 2003).

Pedestrian crashes and criminal safety issues are the primary cause of children's injuries and deaths, which concern parents and influence their decisions in allowing children to walk to school (Dellinger, & Staunton, 2002; Grossman, 2000; Sallis, & Glanz, 2006). However, it is important to address the walking experience as an opportunity for children to become more confident and independent, and to keep them safe throughout life (Romero, 2015). Thus, journeys on foot need to be carefully planned to ensure safety level (Carse, Goodman, Mackett, Panter, & Ogilvie, 2013; Pooley, et al., 2011).

Pooley et al. (2005) categorize school journeys as a short-distance trip, which should focus on traffic safety. This requires planning to provide designated streets and paths to schools that are safe for children. Walking School Buses are one of the most popular programmes to encourage children to walk. Children usually wait at designated stops and join a group led by an adult. In Denmark, Safe Routes to School reduced traffic crashes involving children by up to 85% (Untermann, 1990; Staunton, Hubsmith, & Kallins, 2003).

3.3.4. Quality of footpath and path context

The quality of pathway is an essential element to walkability. Studies have shown the least suitable pedestrian paths share common characteristics such as auto-oriented streets, a lack of designated crosswalks, a treeless streetscape with wide traffic lanes, flashy signs, glaring lights, noise and air pollution. Obstacles include chaotic and poorly designed street frontage, and features that dominate the sidewalks such as mailboxes, traffic control signs, utility poles and rubbish bins (Southworth, 2005).

Furthermore, the quality of pathway also contributes to children's perceptions of danger. Mitchell, et al. (2007) and Banerjee, et al. (2014) found low-quality footpaths, presence of litter and cracked pavements adversely affected the quality of school trips. The development of pedestrian facilities does not necessarily increase walking rates among those children who are driven to school to suit their parents' work schedules, or those whose homes are too far from schools. However, environmental interventions and quality footpaths can modify the walking rates within a neighbourhood in general (Sallis, & Glanz, 2006).

Footpaths should provide for the safety and needs of all pedestrians. Ideally, they should be continuous and have a smooth surface without irregularities that could make walking difficult for some. Footpaths should be wide enough for at least 2-3 people to walk past each other or walk together in a group, depending on the demand of each urban area. Trees and vegetation enhance pedestrian-friendly environments, help define the streetscape, and shade pedestrians from the sun (Mitchell, et al., 2007; Southworth, 2005).

To further encourage walking, it is important to create interesting walks, as monotonous views along the way will not invite and engage people (Speck, 2012). This requires urban planners and designers to create urban landscapes and a path that is easy to read and follow. Elements that help generate an interesting and comfortable walking experience include the visual interest of the built environment, views, street landscapes, visible activity, and lighting. A neighbourhood should provide focal points from one place to another, as well as rich vistas and small-scale details along the path to make the walking experience more enjoyable, as shown in the townscape in *Figure 6* (Southworth, 2005; Speck, 2012).

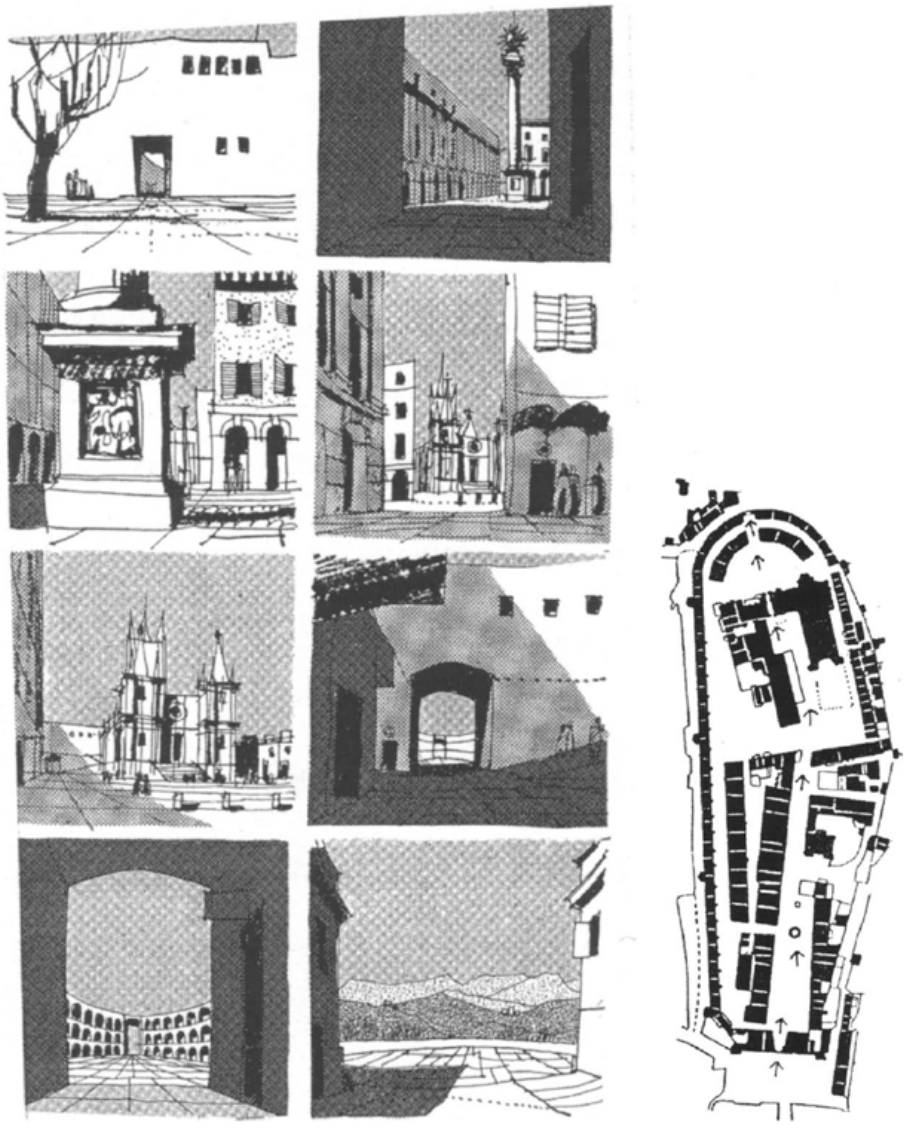


Figure 6: The neighbourhood design that provides exciting and interesting chain of revelations (Cullen, 1961)

The provision of safe and interesting footpaths can promote walking in the school catchments. However, improvements in the quality of path networks alone only create small increases in walking and are not enough to reverse the situation. No one element can develop a walkable neighbourhood, but a combination of many built environment components will (Ogilvie, Egan, Hamilton, & Patticrew, 2004; Victoria Walks, 2020). Nevertheless, adults and children in areas with high connectivity, short distances and sufficient pathways are more likely to walk than communities with longer commuting distance and low connectivity (Duncan & Mummery, 2005).

Social factors also have a significant impact on the rates of walking to school in children: age, gender, ethnicity, demographics, culture, and school decile. Social problems influence parental decisions in allowing children to walk to school (Yeung et al., 2008). For example, children of 5-6 years old do not have sufficient skills to handle safety issues and traffic consistently; thus, they are not likely allowed to walk to school alone (Whitebread & Neilson, 2000). Even though social factors are not the main focus of this research, it is worth mentioning that the combination of both physical and social elements can result in enormous impacts on travel behaviour and the walking experience of children from home to school (Martinez-Gomez et al., 2011).

3.4. Post Covid-19

Covid-19 is, "*a new type of coronavirus that can affect your lungs and airways*" (Ministry of Health, 2020). Worldometer (2020) recorded nearly 35.8 million cases and approximately 1 million deaths by October 2020. As a result, social distancing will need to be applied now and, in the future, if we are unable to eliminate it (Michael, 2020).

This pandemic has radically changed our travel habits, reduced travel demand and public transport, while increasing active transport modes such as walking and cycling. Schools, shops, restaurants and services are closed while many people are encouraged to work from home and may continue to do so (*Figure 7*) (Kick, 2020; McKibbin, 2020). Up to 40% of people could be working from home most of the time if conditions demand social distancing; the impact on the transport network and travel behaviour would be dramatic (Michael, 2020).

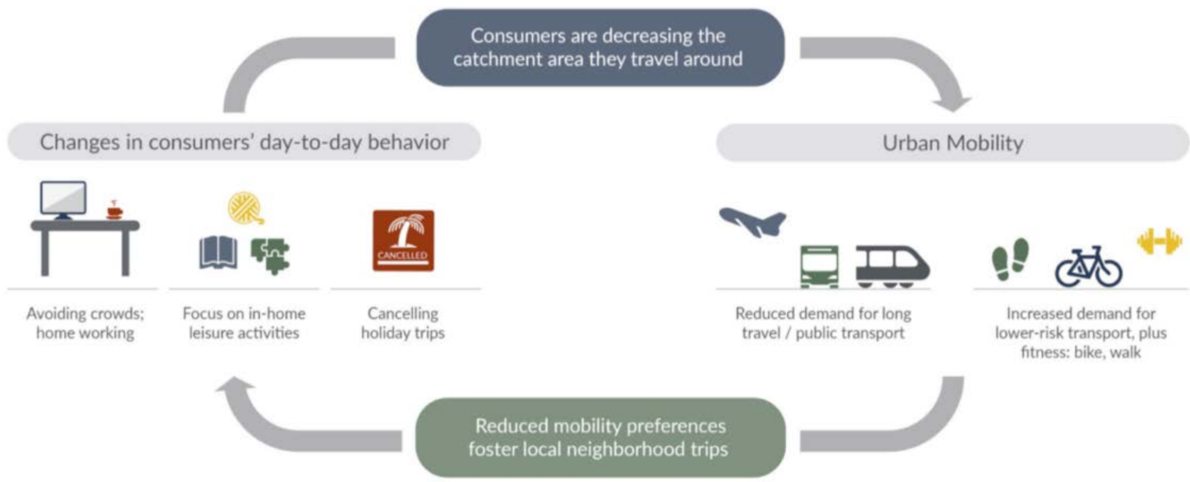


Figure 7: Impacts of Covid-19 on travel behaviour to foster local habit (Kick, 2020)

As many parents are working from home, they are more likely to walk their children to schools instead of dropping them off by car or sending them on school buses. Walking has become more attractive and is favoured for essential journeys within short distances. These unusual times of ours are similar to E. M. Forster's notion in *The Machine Stops* (1909), of a system used for *"bringing people to things, instead of bringing things to people"* (Michael, 2020, p.551). Walking could become the new norm in many car-dependent places, especially in low-density neighbourhoods outside the central city. Therefore, it is a once-in-a-lifetime opportunity to bring the community together, reshape cities and design more walkable spaces, especially around primary school catchment areas – through provisions for the built environment and pedestrian facilities (Glover, 2020; McKibbin, 2020; Michael, 2020).

3.5. Relevant policy documents that influence walking rates in Auckland, New Zealand

The idea of sustainable urban transport promotes the use of active modes of transport (walking, cycling) and public transport (Matthews, & Imran, 2015). However, the direction of transport planning in Auckland has historically been in the opposite direction, with policies that promoted the construction of road networks and little investment in active transport. In this environment, the car has advantages over active transport modes – flexibility, speed, safety and personal space (Yeung et al., 2008) This has generated an inefficient transport system dominated by private vehicles: an estimated 80% of trip legs in Auckland are made by cars (Alam, Wadud, & Polak, 2013; AC, 2018; Jakob, Craig, & Fisher, 2006; Stats NZ, 2013). Thus, urban planning needs to shift its focus and attention to the institutional barriers to improve walking in Auckland.

3.5.1. Auckland Plan 2050 by Auckland Council (AP)

The AP reveals significant lack of travel choices, resulting in congestion and reduced life quality. One of its aims is to improve the transport system by concentrating on the development of sustainable transport choices through government funds and transport policy. It also recognizes the importance of walking because it is the main factor for short and medium journeys (Auckland Council, 2018).

The AP aims to increase use of active transport and public transport from 40% in 2001 to 73% in the Morning Peak Target by 2040. However, current walking journeys in Auckland only account for 14% of trips taken. Thus, they need to target more accessibility, by improving public transport, and integrating land-use with transport to create mixed-use development for shorter trips and walkable neighbourhoods (Auckland Council, 2018; Ministry of Transport, 2018).

However, the plan has limitations. Very little attention is given to active transport. Although it is a long-term vision for Auckland transport over the next 30 years, only one target is stated: The Morning Peak Travel Target, for both walking, cycling, and public transportation. (Faherty & Morrisey, 2014).

Moreover, the AP does not focus on schools as a part of land use. It provides no specific target towards the improvement of walkability for children in the catchment areas, even though the child injury rates in NZ are alarming. Safekids Aotearoa (2015) reveals 97% of all child hospital admissions over five years between 2008-2012 were classified as unintentional injuries, with 27% of them associated with motor vehicle traffic crashes.

3.5.2. Regional Land Transport Plan (RLPT) and other programmes supporting walkability by AT

The three-year programme in the RLPT is built on the strategic approach of the Auckland Transport Alignment Project 2018 (ATAP). The package aims to improve walking, cycling, and public transport network initiatives to support urban and greenfield development (Auckland Transport, 2018). Notably, unlike the AP, the RLPT has specific targets for both walking and cycling. Thus, it is suggested that the AP should change to ensure the directions for policies and actions align across the relevant authorities.

Many programmes have been set out within the RLTP to increase walking. For example, the Safer Communities programme uses a localized approach to improve walking and make the roads safer in selected neighbourhoods. However, this programme only focuses on addressing issues in priority areas (such as selected schools and town centres) with a large number of trip generators (AT, 2018b). Also, it is costly and time-consuming as it requires long processes of community feedback and consultation with communities, Local Boards, Police, matawaka and mana whenua. Furthermore, the actions taken to increase walkability in a specific community do not necessarily work for others.

AT also provided the Travelwise School programme which focuses on improving road safety, increasing active transport mode and public transport, as well as reducing congestion around schools at peak times. This programme provides separate actions to achieve different outcomes for walking and cycling, including the Walking School Bus – to encourage children to walk to school and reduce vehicles (AT, 2020a). There are also several walking specific resources – the Pedestrian Game, walking ideas booklet, walking benefit posters – to raise awareness on walking and safety issues through education (AT, 2020b).

Sylvia Park School and Newmarket Primary School have undertaken the Travelwise School Programme to improve road safety and increase walking rates among children. This is the fundamental step the school has taken to raise communities' awareness of road risks and road traffic on primary school children.

3.5.3. Design guidelines for school communities from relevant authorities

NZ has a variety of road environments, which makes it more challenging to maintain road safety. Different road safety partners are working with schools and communities to improve safety in catchment areas, because road risk around schools is everyone's responsibility. However, the fundamental problem is seen in *Figure 40*: lack of connection between stakeholders.

The guidelines suggest design requirements for pedestrian walkways around catchment areas should be accessible, clear from obstructions and a minimum of 2.4m wide (MoE, 2015; NZTA, 2018). School areas should also avoid unintentional physical barriers, to allow better access for pedestrians (MoE, 2016).

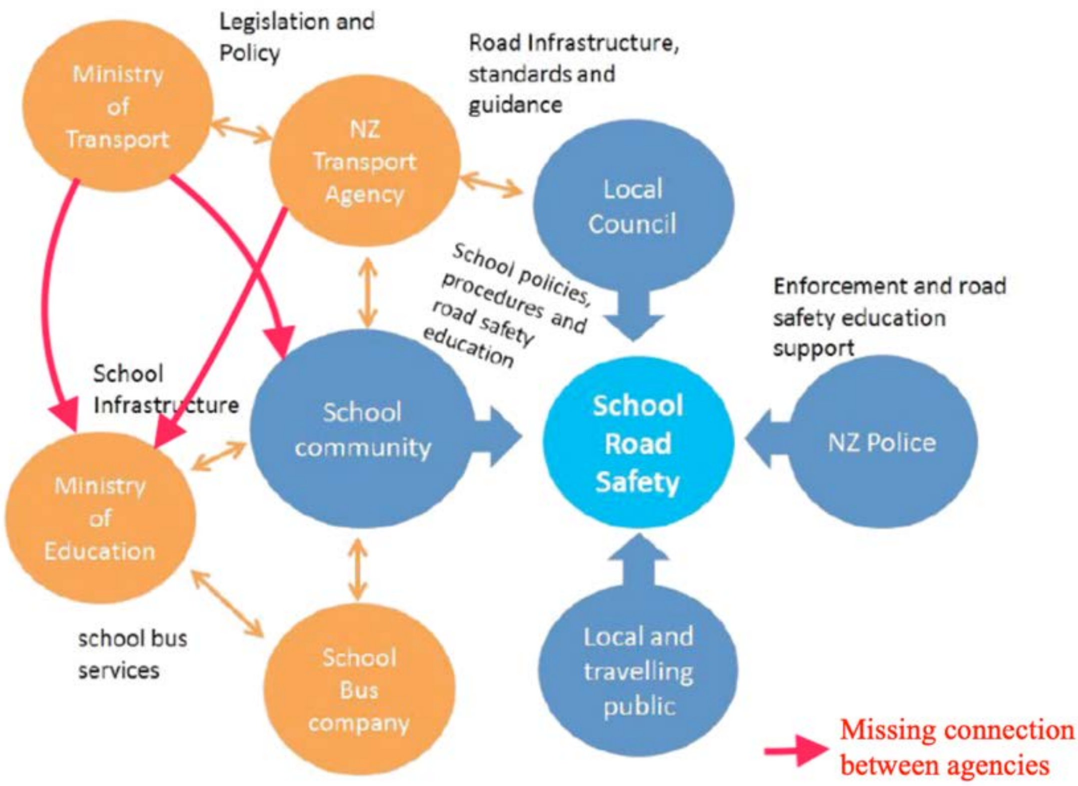


Figure 40: Responsibilities of government agencies and community groups for road risk around schools (NZTA, 2014)

NZTA (2014) provides design guidelines to help schools and local communities in reducing road hazards. By understanding the nature of risks to children and reasonable practice solutions, it allows safety issues to be addressed. The guidelines also identify infrastructural problems associated with school travel. The injury rates of school students in traffic crashes to and from school are increasing. Road risks come from inadequate crossing points and tricky intersections for children in urban areas.

Many initiatives have been provided to consider road risk improvements on the roads in the catchment areas. The toolbox for school road safety initiatives outlines effective practices:

- School policy and procedures to ensure parents and students comply with school policies and road rules.
- Road safety education and training to focus on students' learning needs within the education curriculum.

- Road safety information such as school warning signs, no stopping/parking lines, well-connected footpaths, parking and drop off areas (NZTA, 2014).

3.5.4. Innovating Street for People Programme by NZTA

In light of changes in travel behaviour and people's needs post Covid-19, NZTA has provided the Innovating Street for People programme aiming at retrofitting streets to create more space for pedestrians and cyclists as well as reduce vehicle speeds. This programme offers $7 million for council projects throughout the country (NZTA, 2020).

Many pilot projects have been carried out in Auckland. This includes Safe Schools projects to fully understand what is needed within the catchment areas before delivering permanent solutions for improvements: speed reduction, parking changes, new pedestrian crossings, new pick up and drop off areas, and speed calming measures. However, these projects are carried out as pilot projects first before they are widely implemented throughout Auckland. Thus, it will take a long time before these improvements are delivered within all catchment areas.

3.5.5. Limitations associated with policy provision

MoE (2015) and NZTA (2014) requires schools to accommodate the use of private vehicles, parking areas for dropping off students and for extended parking time. This tends to create more opportunities for car movement around schools, and conflicts with the target of creating a more walkable neighbourhood and prioritising pedestrians provided in the AP. Overall, reports from relevant authorities have identified the problems related to walkability in catchment areas, but no solutions. The conflict between provisions also makes it more challenging to generate permanent solutions.

There are gaps in designing plans, policies and guidelines to improve walking rates and pedestrian facilities in Auckland. There is a lack of clarity in how the provision of design guidelines can interact with policies to better integrate them into urban design. The guidelines do not reflect all users on the sidewalks (children, women, elderly and disabilities). This means the needs of different pedestrian groups are not accommodated to the standards. In addition, there is no guidance on design checks and audits for the management and evaluation of those provisions (NZTA, 2018).

Many countries in the International Federation of Pedestrians (IFP) have successfully implemented Walking School Bus. Living Streets Aotearoa has adopted this technique, because NZ is also a part of IFP (IFP, 2020). However, some overseas examples do not fit well with New Zealand because each place will require different solutions. Notably, walkability depends on infrastructure, safe routes to schools, active transport behaviours, and people's preferences (Dellinger & Staunton, 2002). For example, 5 to 8 years old children are more likely to take the walking school buses, while senior children want to go with their friends independently. It just depends on whether they've got a safe route to school (Education Gazette, 2018).

AT staff has reported on NZTA research stating there was a lack of walking strategy, and it often leads to the lack of prominence of walking in Auckland. They also need to meet the challenges for proper implementation of pedestrian planning and design in new subdivided neighbourhoods. Often, design outcomes do not meet design standards (NZTA, 2018). Overall, current practices in urban transportation, especially in catchment areas in Auckland, are not sustainable in the long term.

3.6. International case studies

Urban design and urban planning play an essential role in improving walkability in cities (Farherty & Morrissey, 2014). The provision of clear planning strategies and urban design measures focused on promoting walkability has increased globally, and significantly increased walkability among children (Beckx, et al., 2013). Such provision helps create high-quality accessibility while reducing pedestrian injuries and fatalities, giving more opportunities to obtain healthy exercise and longer life expectancy (Banister, 2011). In most European countries at least a quarter of urban trips are made by cycling and walking. This section will provide international examples that have successfully created quality pedestrian networks.

3.6.1. The Netherlands

The Netherlands has a wide range of coordinated policies, programmes and techniques that successfully work to improve walkability and prioritize active travel modes. They provide pedestrian infrastructure, such as extensive auto-free zones in most parts of the city centre, clearly marked pedestrian crossings and well-lit and wide sidewalks on both sides of every street. The pedestrian, cycle and car lanes are distinguished from each other through different pavement. Often, pavements are narrower than the adjacent cycle track. The street is people-oriented because it usually accommodates two pedestrian pavements, a cycle track, tram track and only a one-way road (Cycling Embassy of Great Britain, 2013).

Dutch cities made policies to modify traffic patterns to create a better walking experience. They have traffic calming on most streets in residential areas with a legal speed limit of 30 km/h or less, implemented through physical barriers including traffic circles, speed humps and narrow roads. In addition, strict enforcement of traffic regulations protects pedestrians and improves traffic safety. The law strictly requires motorists to take full responsibility for accidents with the elderly and children (Pucher, & Buehler, 2008; Pucher, & Dijkstra, 2003).

Traffic calming is widely implemented and not limited to isolated streets. Neighbourhoods have reduced overall traffic injuries and fatality rates by up to 70%. Moreover, new residential areas have land use activities – shopping, cultural centres and services – which are accessible by foot. Mixed land-use patterns reduce travel distance and encourage walking (Pucher & Dijkstra, 2003).

Equally important, traffic education and extensive training on road risks are provided for drivers and children to reduce crash rates. Drivers are required by law to drive in a way that minimizes the risk of pedestrian injuries, even if the pedestrians' behaviours and actions are contrary to traffic regulations. Moreover, children at the age of ten receive extensive traffic education and instruction on safe walking practices. They are taught traffic regulations to understand the law and how to react appropriately to dangerous road situations. Overall, several elements from policies and urban design are combined to help implement a better traffic system which supports pedestrians (Pucher & Dijkstra, 2003).

Practices focused on the people-oriented network initially came from Jan Gehl's theories of 'City for People'. Gehl was concerned about the increase in car use and accident rates because traffic planners and politicians increasingly were focused on creating more room for parking space and car traffic. This is associated with deteriorating conditions and absence of infrastructure for pedestrians, such as narrow sidewalks and a lack of lighting. Consequently, walking has become less attractive and more difficult. Gehl argued cities must have reasonably cohesive structures that offer short walking distances, safety for pedestrians, various urban functions and attractive public areas. Therefore, pedestrians must have priority in mixed traffic systems in cities and a good city should ensure walkability for its people (Gehl, 1936).

3.6.2. Portland, US

Portland has a long history of well-connected pedestrian networks and an excellent pedestrian scale. In 1998, the city created the Portland Pedestrian Master Plan which established a 20-year framework for transport improvements to increase opportunities for residents to choose walking over other transport modes and enhance the pedestrian environment. The requirements for a Pedestrian District in Portland provided in this Master Plan has aligned with this paper's criteria for a walkable neighbourhood:

- Zoning: a mix of dense land uses such as residential and commercial.
- Transit service: a frequent and convenient transit service to provide public transport services more frequently than every fifteenth minute.
- Size and configuration: a compact neighbourhood with depth and breadth rather than a linear corridor. The area of the neighbourhood should be no less than 3ha and no more than 160ha in size (City of Portland, 1998).

The city also provides Pedestrian Guides and suggests walks around for different groups of people, with the general tip, *"The easiest way to get started is to walk somewhere you are headed anyway"*. The city prioritises walking to school (City of Portland, 2020).

3.6.3. Australia

In Australia, active travel rates of primary school children are among the lowest in OECD countries. Parents and caregivers are considered the most influential decision-makers for children's travel modes to school. Thus, policies and regulations have focused on factors that can influence their perceptions such as road networks and safety, school size, school location and enrolment zones (Garrard, 2016).

Like the Netherlands, Australia has been a pioneer of traffic calming, managed by the Local Area Traffic Management or Residential Street Management. It helps to increase walking, especially children walking to school (Australian Government – Department of Infrastructure and Transport, 2013; US Department of Transportation, 1999). However, traffic calming in Australia only applies in some residential streets with reduced speed zones.

Similar to New Zealand, school amalgamations accommodate students from wider geographical areas. The policy of public-school choice significantly contributes to the increase of car travel, due to longer distances to school (Active Healthy Kids Australia, 2015). Policies should require children to attend the closest public school, as this will lead to an increase in walking. However, policies also need to ensure public schools are provided with a high-quality education, so parents do not feel disadvantaged by these limitations (Switzerland has adopted this policy to improve walking by children). Apart from these policies, individual schools have undertaken related programmes such as 'Active travel to school policy' to encourage walking and cycling to school (Garrard, 2016).

Overall, policies to improve walkability in The Netherlands, Portland, Australia, and New Zealand and suggestions for changes in the future are summarised in *Table 4* below. It is suggested that New Zealand should learn from what has been done successfully overseas to improve walkability around primary schools in the countries.

Table 1: Summary of policies in different countries and suggestions for improvements of provisions for walkability

Places	Policies	Suggestions
The Netherlands	Traffic calming policy applies on most residential streets allowing a legal speed limit of 30km/h or less and implements through physical barriers including facilities traffic circles, speed humps and narrow roads for vehicles.	This country is successful in addressing issues related to walkability and ensure safety for pedestrians, highlighted by the high walking rates within the countries. Thus, the management and evaluation processes should be kept up to ensure adequate infrastructure and safety for all road users.
	Improving pedestrian infrastructure through: - Urban design (wide, well-lit sidewalks on both sides of every street, clearly marked zebra crosswalks and extensive auto-free zones that cover most parts of the city centre). - Pedestrian zones, and cyclist zones are separated using pavement patterns to avoid misunderstanding. The street network is oriented to people, prioritising pedestrians and cyclists.	
	Provided extensive training on road risks and traffic education for both drivers and children to reduce crash rates. Drivers are required to minimise the risks of pedestrian injuries.	
Portland	Master plan provides for: compact neighbourhood, diverse land use patterns. This 20-years framework for transport improvements to increase opportunities for walking in residents. Provide Pedestrian Guide for walking trips to school and around the city.	The management and evaluation processes should be kept up to ensure adequate infrastructure and safety for all road users.
Australia	Traffic calming policy: - Only applies for some residential streets with reduced speed zones, which are primarily undertaken by motorised vehicles.	Traffic calming policy should be applied for most residential streets to reduce traffic speed and ensure safety in order to encourage walking. The government should provide high-quality education of all public schools so that parents do not feel disadvantaged from the lack of school choices.
	School amalgamations generate longer commuting distances of the kids to school and increase car travel. Even though children are required to attend the closest public school, but it results in a lack of school choices.	
New Zealand	AP targets more accessibility through walkable neighbourhoods, improving public transport, and integrating land-use with transport to create a more mixed-use development to create shorter trips. It uses the Morning Peak Travel Target to increase the rates of walking, cycling, and public transportation.	The inconsistency between targets from different plans and policies are needed to address to ensure the conflict between objectives is resolved. The provisions of design guidelines should interact with policies to better integrate them into urban design. The guidelines also need to consider the needs of all pedestrians, especially children and people with physical impairments. Furthermore, NZTA and MoT should provide guidance on design checks and audits to consider the management and changes that need to be considered in order to meet pedestrian needs.
	RLPT from AT provide separate targets for different transport modes. It aims to increase walking through different programmes including Safer Communities programme, Travelwise School programme and Walking School Bus.	
	Design guidelines suggest design requirements for pedestrian infrastructure and walkways around school catchment areas. E.g., they should be accessible routes with clear width (i.e., clear of obstructions such as light columns, street furniture, vegetation, and signposts) and a minimum of 2.4m of width. The guidelines also help schools and local communities in reducing road hazards and provide initiatives to improve road safety.	

3.7. Summary

The four most influential built environment criteria that contribute to the walkability of children within primary school catchment areas are *connectivity, land use patterns, safety, and quality of pathway and path context*. To encourage children to walk to school, a neighbourhood environment should ensure a range of factors:

- Short travel distance from home to school
- High street connectivity of small block sizes, high intersection density and high connected node ratio
- Diverse land use patterns for social activities, residential, commercial, elementary schools, parks, fitness centres, grocery stores and services
- High-quality footpaths that provide attractive landscape elements and are free of obstacles such as litter, rubbish bins, mailboxes and poles.

Overall, pedestrians are part of every roadway environment, both urban and rural. However, urban pedestrians often influence roadway design features more than those in rural areas. The high demands of vehicular traffic in congested urban areas make it much more difficult to plan adequate policy provision for the pedestrian network. Thus, provision of clear planning strategies and urban design practices must be made to protect pedestrians, the lifeblood of urban areas (American association of State Highway and Transportation Officials, 2018).

Chapter 4: Collected Data

The site visits for the three Auckland primary schools were carried out on three separate weekdays. The data was collected within the 400m ped-shed, as shown in *Figure 8,9 & 10*.

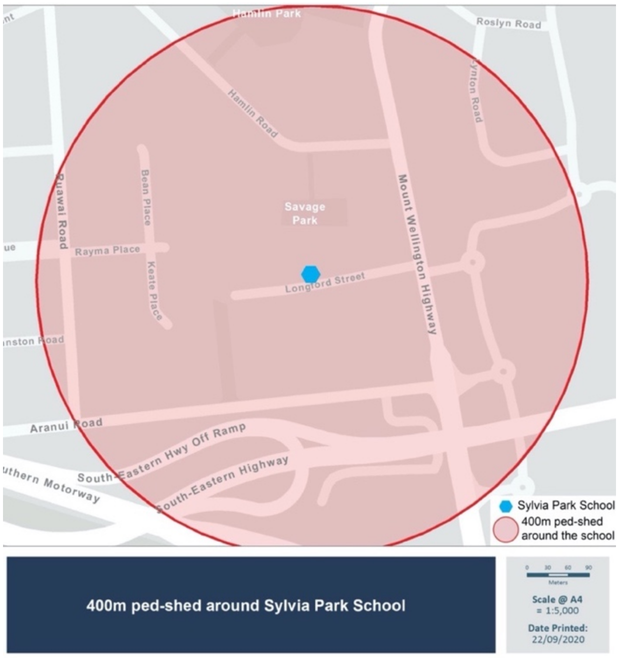


Figure 8: 400m ped-shed around Sylvia Park School catchment area (Source: Auckland Council Geomaps, edited by author)

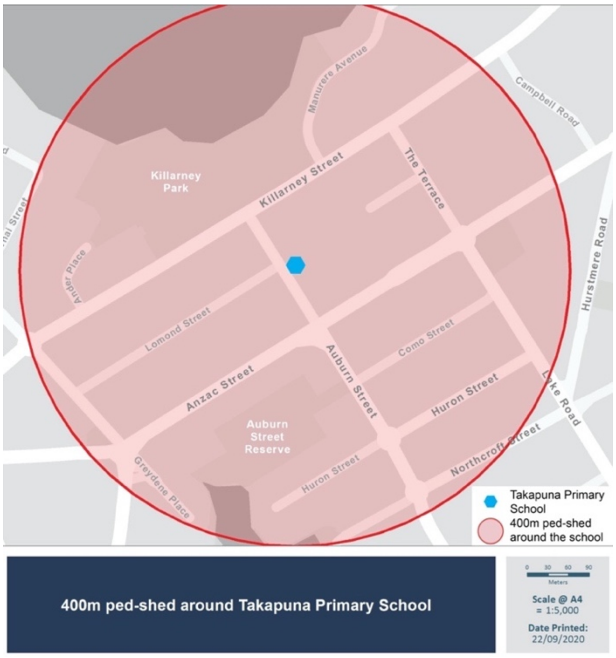


Figure 9: 400m ped-shed around Takapuna Primary School catchment area (Source: Auckland Council Geomaps, edited by author)

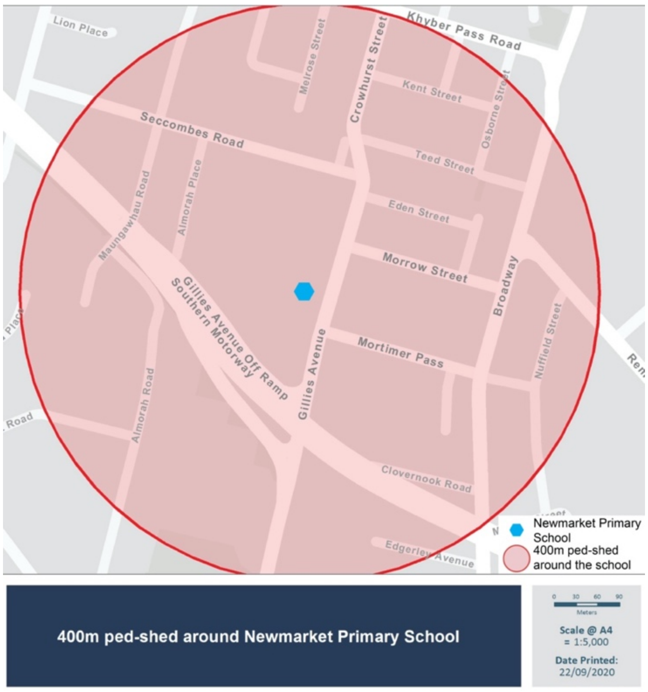


Figure 10: 400m ped-shed around Newmarket Primary School catchment area (Source: Auckland Council Geomaps, edited by author)

This section will present the findings from the site observations. The data collected at sites on the width, quality and context of pathways was recorded in Table 1 below. This table also provides information on the roads in the catchment areas as well as functions and estimated traffic volume.

Table 2: Collected data from three site visits

Primary School Catchment Areas	Names of street/road(s)	Road Classification (based on the One Network Road Classification) (NZTA, 2020)	Width of sidewalks (m)	Physical components presented at the sites that may discourage walking in children
Sylvia Park School	Mount Wellington Highway	**Regional Road / Arterial Road** (substantial passenger transport movement) Estimated traffic AADT[1]: 39,327 Estimated heavy vehicle: 7% Major contribution to the economic and social wellbeing of a region and connect to regional significant industries, places, airports, ports.	0.8 – 1.0	- 6 traffic lanes with heavy traffic movement. - Residential rubbish bins on the sidewalks.
	Longford St (main school entrance)	**Access** Estimated traffic AADT: 251 Estimated heavy vehicle: 9% Provides access and connectivity to daily journeys (school, home, farm) as well as to the wider network.	1.7 – 2.0	- Low-quality concrete sidewalks with lots of cracks. - Several parking spaces along the sidewalks.
	Hamlin Rd (school back entrance)	**Secondary Collector** Estimated traffic AADT: 1,540 Estimated heavy vehicle: 2% It links local areas between residential and economic areas.	1.2 – 1.5	- Thickset trees blocks views and reduce sightline.
	Ruawai St	**Primary Collector** Estimated Traffic AADT: 3,524 Estimated heavy vehicle: 4% Locally important road that provides a primary distributor function to link significant local economic areas.	1.0-1.5	- Residential rubbish bins were left outside which blocked the sidewalks completely
	Aranui St	**Primary Collector** Estimated traffic AADT: 4,205 Estimated heavy vehicle: 6% Locally important road that provides a primary distributor function to link significant local economic areas.	1.6	- It has only one sidewalk. The other side is adjacent to the motorway and already fenced off; thus, it is not suitable for walking.

	The path connecting Longford Street and Rayma Place	**Small Pathway** This is mainly for neighbourhood use.	1.2	- Low-quality concrete sidewalks with moldy surface on Rayma Place
Takapuna Primary School	Auburn St (main school entrance)	**Arterial Road** Estimated traffic AADT: 1,921 Estimated heavy vehicle: 2% Significant contribution to economic and social wellbeing. Critical connectivity as it may be the only route available to important places	1.2	- The sidewalk space looks much narrower with many cars parked alongside the street.
	Lomond St	**Access** Estimated traffic AADT: 259 Estimated heavy vehicle: 2% Provides local access to daily journeys (home & school).	1.2	
	Anzac St (shared school entrance for both cars and pedestrians)	**Arterial Road** Estimated traffic AADT: 22,900 Estimated heavy vehicle: 4% Significant contribution to economic and social wellbeing. Critical connectivity as it may be the only route available to important places	1.6 – 1.8m wide at the entrance, 2.2m wide near the Church	
	Como St	**Primary Collector** Estimated traffic AADT: 1,667 Estimated heavy vehicle: 4% Locally important road that provides a primary distributor function to link significant local economic areas.	5m wide	- Many large commercial waste bins were located on the sidewalks.
	Lake Road	**Regional** Estimated traffic AADT: 8,468 Estimated heavy vehicle: 6% Major contribution to the economic and social wellbeing of a region and connect to regional significant industries, places, airports, ports (other places to Devonport)	1.5m wide on the bus station (Burger King side), 3m wide on the mall side	
	Huron St	**Primary Collector** Estimated traffic AADT: 2,593 Estimated heavy vehicle: 9% Locally important road that provides a primary distributor function to link significant local economic areas.	3.5	- Lots of parking spaces available along both sides of the street

	The Terrace	**Secondary Collector** Estimated traffic AADT: 647 Estimated heavy vehicle: 2% It links local areas between residential and economic areas.	1.8	- This street is relatively steep with the highest elevation near Killarney St.
	Collins St (back entrance)	**Low Volume** (cul-de-sac) Estimated traffic AADT: 129 Estimated heavy vehicle: 2% Local street that links residential areas.	1.0	- Residential rubbish bins were left outside which partly blocked the sidewalks completely
	Killarney St	**Arterial Road** Estimated traffic AADT: 9,630 Estimated heavy vehicle: 1% Significant contribution to economic and social wellbeing. Critical connectivity as it may be the only route available to important places.	1.2	
	Lake Pupuke Drive	**Secondary Collector** Estimated traffic AADT: 2,251 Estimated heavy vehicle: 3% It links local areas between residential and economic areas.	1.2	
Newmarket Primary School	Gillies Avenue (main entrance)	**Arterial Road** Estimated traffic AADT: 18,000 Estimated heavy vehicle: 5% Significant contribution to economic and social wellbeing. Critical connectivity as it may be the only route available to important places.	2.0m at the narrowest section	- Busy traffic movement, connecting to the Southern Motorway. - Monotonous view of industrial buildings with poorly designed streetscape. - The sidewalks are also very steep.
	Broadway	**Arterial Road** Estimated traffic AADT: 25,000 Significant contribution to economic and social wellbeing. Critical connectivity as it may be the only route available to important places.	3.6	- 6 traffic lanes with heavy traffic movement. - Bus stops encroach a large part of the sidewalks and reduce walkability.
	Morrow St	**Arterial Road** Estimated traffic AADT: 6,381 Estimated heavy vehicle: 3% Significant contribution to economic and social wellbeing. Critical connectivity as it may be the only route available to important places.	4.8m on the mall side and 2.6m on the other side	- Car parking spaces are provided on both sides of the street, blocking pedestrians' views.

	Teed St	**Secondary Collector** Estimated traffic AADT: 947 Estimated heavy vehicle: 1% It links local areas between residential and economic areas.	2.0	
	Osborne St	**Secondary Collector** Estimated traffic AADT: 947 Estimated heavy vehicle: 1% It links local areas between residential and economic areas.	1.6	- Car parking spaces are provided on one side of this narrow street, blocking pedestrians' views.
	York St	**Secondary Collector** Estimated traffic AADT: 947 Estimated heavy vehicle: 1% It links local areas between residential and economic areas.	1.5	
	Crownhurst St	**Arterial Road** Estimated traffic AADT: 11,483 Estimated heavy vehicle: 3% Significant contribution to economic and social wellbeing. Critical connectivity as it may be the only route available to important places.	2.3	- Busy traffic movement with 4 traffic lanes and 2 car parking lanes. - Monotonous view of industrial building box and poorly designed streetscape.
	Eden St	**Secondary Collector** Estimated traffic AADT: 947 Estimated heavy vehicle: 1% It links local areas between residential and economic areas.	2.0	

[1]AADT: Annual Average Daily Traffic

28 photos were taken at the three sites and used to support the discussion related to the quality of path and the path context. 15 maps were generated using GIS mapping system and Auckland Council GEOMAPS system, and used to analyse the street connectivity, land use patterns and pedestrian crash patterns in the next section. Overall, the data findings are critical in identifying factors that caused the lack of walkability within the catchment areas and the reduction in walking rates among children.

Chapter 5: Results: Analysis of the observational data on the built environment of the study areas

Travel distance from home to school for children greatly affects walkability. Most schools in New Zealand have zoning restrictions to ensure children are guaranteed a place at a local school. However, zones nowadays usually cover a wide area, resulting in longer travel distance and preventing parents allowing children to walk the whole way (New Zealand Now, 2020).

Table 3: Size of three studied primary schools and their school zones
(Education Counts, 2020; Education Review Office, 2020; Takapuna Primary School, 2020)

Schools	Number of students	Area of school zone
Sylvia Park School	530	$2.9km^2$ or 290ha
Takapuna Primary School	520	$3.6km^2$ or 360ha
Newmarket Primary School	263	$3.5km^2$ or 350ha

Sylvia Park School and Takapuna Primary School have twice as many students as Newmarket Primary School. Their school zones are approximately six to seven times bigger than the potential walking area of 50ha within the 400m ped-shed, as shown in *Figure 11, 12 & 13*.

Figure 11: Newmarket Primary School Zone (Auckland Council GEOMAPS, using data from Education Counts, 2020)

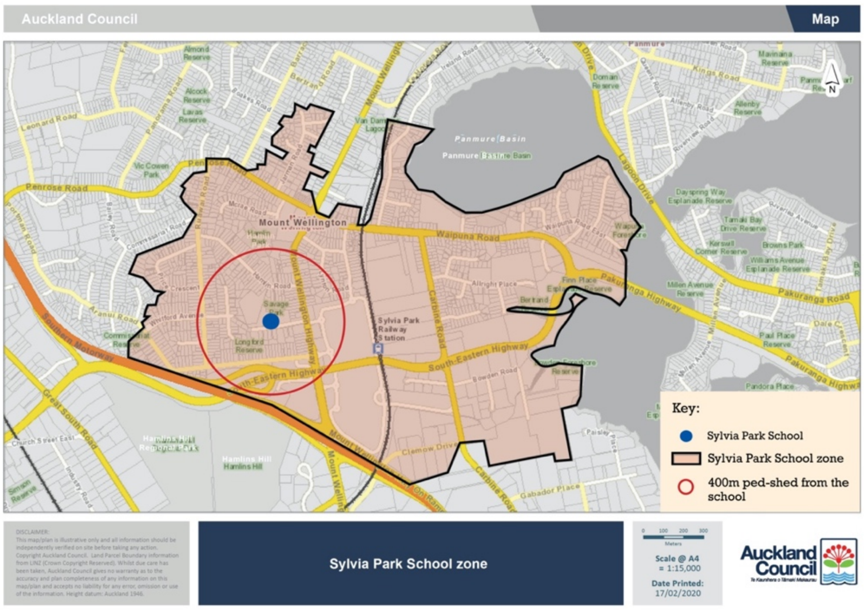


Figure 12: Sylvia Park School Zone

(Source: Auckland Council GEOMAPS, using data from Education Counts, 2020)

Figure 13: Newmarket Primary School Zone

(Source: Auckland Council GEOMAPS, using data from Education Counts, 2020)

The designation of larger school zones is the main reason for long travel distances to school and the reduction in walking rates in NZ. Most children are experiencing long travel distances to school because they reside at the edge of the zones or out of zones. For example, at Takapuna Primary School in 2017, only 59% were living in the zone (Takapuna Primary School, 2020). Theoretically, the walking rates could reduce to near zero if they reside beyond 2.3km from school (Mandic et al., 2017). In NZ, children walking to school significantly dropped from 42% in 1989/90 to 29% in 2010-14, with a 24% increase in children driven to schools (Environmental Health Indicators New Zealand, 2020).

Sylvia Park School and Takapuna Primary School are not at the centre of their school zones *(Figure 12 &13),* resulting in disadvantages for children residing at the edge of the zones. The required travel distance to school from the zone boundaries ranges from 1.2km to 2.4km. Newmarket Primary School, at the centre of its school zone, has travel distances from 800m to 1.6km from the zone boundaries to the school. However, based on the data provided in *Section 3.3* of the Literature Review, walking could be reduced by at least a third, considering the long walking distance.

5.1. Connectivity

The connectivity maps for three case studies are generated using GIS Maps in *Figure 14, 15 & 16* below. It is observed that all three studied schools have relatively low street connectivity within the 400m ped-shed.

The street network around Takapuna Primary School is slightly more connected. Street blocks are smaller, which will give children more alternative routes and help improve both physical and visual permeability of the catchment area (Bently, et al., 1985). In this case, there are many possible routes to Takapuna Primary School via Killarney Street, Lomond Street, Auburn Street, Anzac Street, Collins Street and The Terrace. However, there are only three possible entrances to Sylvia Park School: Longford Street, Hamlin Street and a small walkway at the back of the school which connects Longford Street and Rayma Place. For Newmarket Primary School, the only possible entrance is via Gillies Avenue.

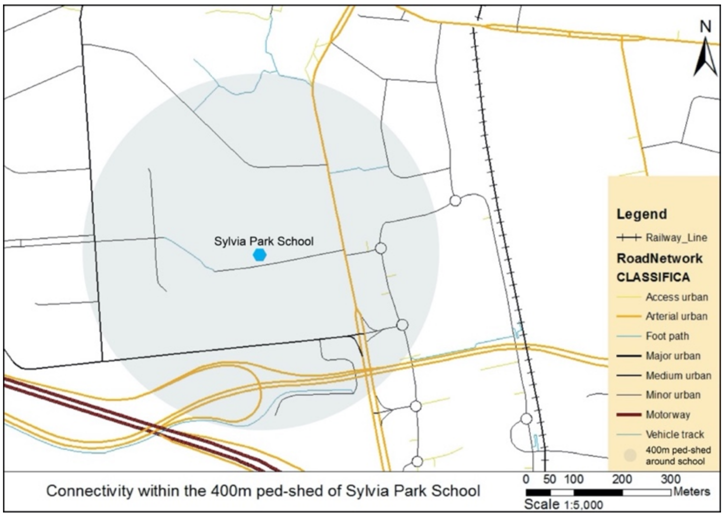


Figure 14: Street Connectivity within 400m ped-shed of Sylvia Park School (Source: GIS Maps)

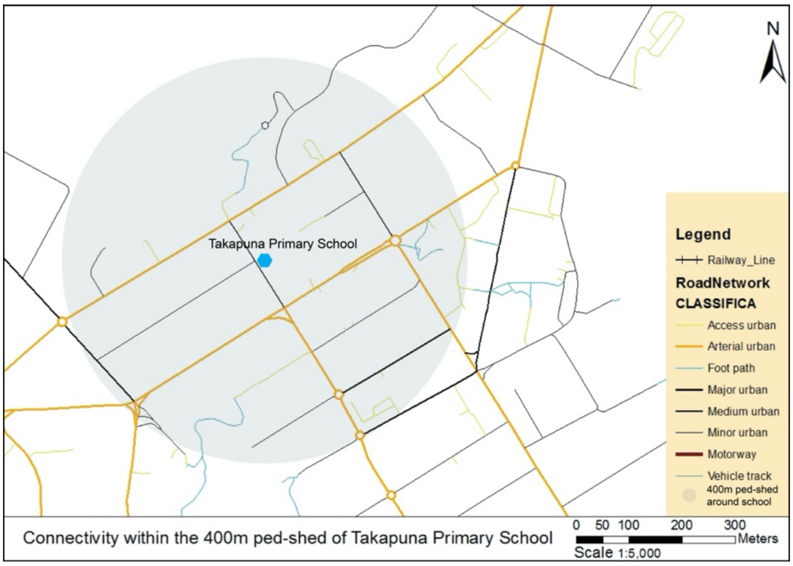


Figure 15: Street Connectivity within 400m ped-shed of Takapuna Primary School (Source: GIS Maps)

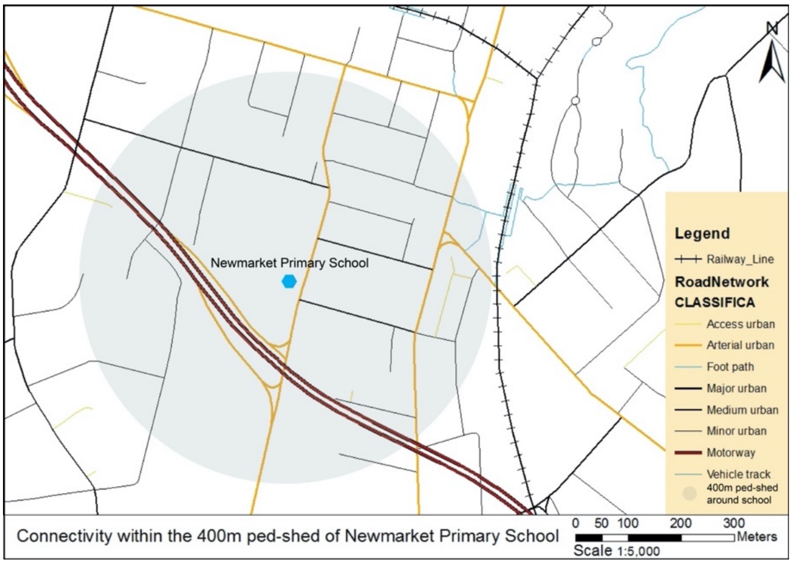


Figure 16: Street Connectivity within 400m ped-shed of Newmarket Primary School (Source: GIS Maps)

Secondly, students from those three schools face many barriers: motorways, highways, arterial roads and disconnected cul-de-sacs. Sylvia Park School is located within the catchment of Mt Wellington Highway and the Southern Motorway with extremely high traffic volume (39,327 AADT) (*Figure 17*). Newmarket Primary School is on Gillies Avenue, a busy arterial road connecting to the Southern Motorway (*Figure 19*). The 400m ped-shed of both schools are next to the railway which obstructs children who reside on the other side of the tracks. Takapuna Primary School is surrounded by busy arterial roads, such as Anzac, Killarney and Auburn Streets (*Figure 18*).

Figure 17: Mt Wellington Highway acts as a barrier for children to access school on Longford Street

Figure 18: Busy arterial roads (Auburn Street and Anzac Street) near Takapuna Primary School

Figure 19: Busy arterial roads (Gillies Avenue and Broadway) near Newmarket Primary School

Furthermore, there are also many dangle nodes and dead-end cul-de-sacs within the catchment areas. Auckland is losing its fine-grid street patterns, resulting in loops and lollipops; barriers, along with high traffic volume within catchment areas, often generate dangerous road conditions which are unsuitable for walking.

The measurement of street connectivity in *Table 3* is based on the method for street connectivity measurement in *Section 3.3.1* of the Literature Review.

Table 4: Measurement of street connectivity in three case studies (Source: Auckland GeoMAPs; GIS maps)

Within 400m ped-shed of each school	Average block length (m)	Number of three-way and four-way intersections	Connected node ratio		
			Real nodes	Dangle nodes	Ratio
Sylvia Park School	540	9	8	5	0.6
Takapuna Primary School	250	14	14	4	0.8
Newmarket Primary School	325	25	23	10	0.7

Sylvia Park School catchment area has the least connected node ratio, least number of intersections but larger size blocks. Sylvia Park School catchment area is in the fourth quartile of *Figure 5,* with the lowest street connectivity. Takapuna Primary School and Newmarket Primary School catchment areas are in the third quartile.

5.2. Land use patterns

Land use maps for each catchment area are provided in *Figures 20, 21 & 22* below. Takapuna Primary School has more land use activities within the ped-shed. The school is in Takapuna metropolitan centre, surrounded by apartment buildings, mixed housing suburban zones and business areas. The ped-shed contains recreational space, a conservation zone and a sport and active recreation zone. The mixed land use in central Takapuna provides the neighbourhood with many social and physical activities, which can create an interesting walk.

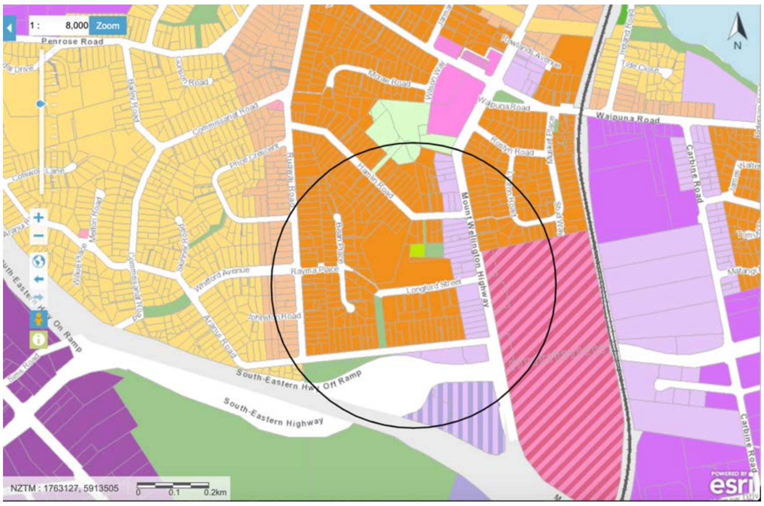


Figure 20: Land use within 400m ped-shed of Sylvia Park School (Source: Auckland Council GEOMAPS)

Figure 21: Land use within 400m ped-shed of Takapuna Primary School (Source: Auckland Council GEOMAPS)

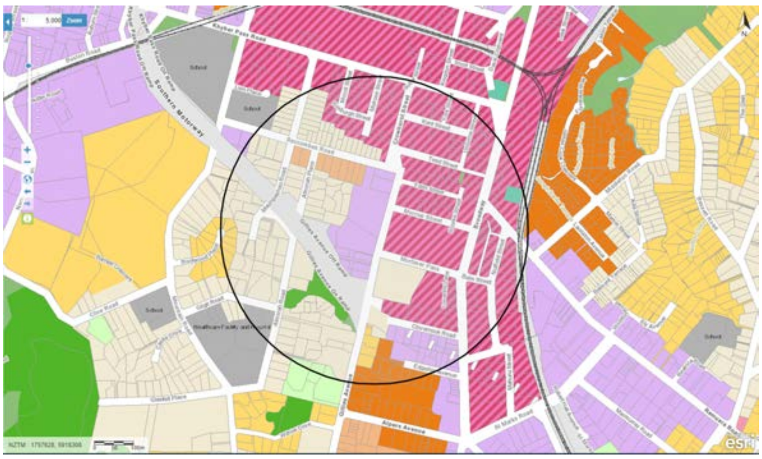


Figure 22: Land use within 400m ped-shed of Newmarket Primary School (Source: Auckland Council GEOMAPS)

Legend:

- Residential - Single House Zone
- Residential - Mixed Housing Suburban Zone
- Residential - Mixed Housing Urban Zone
- Residential -Terrace Housing and Apartment Buildings Zone
- Open Space - Conservation Zone
- Open Space - Informal Recreation Zone
- Open Space - Sport and Active Recreation Zone
- Open Space - Civic Spaces Zone
- 400m pedestrian ped shed around schools
- Business - Metropolitan Centre Zone
- Business - Local Centre Zone
- Business - Mixed Use Zone
- Business - General Business Zone
- Business - Business Park Zone
- Business - Heavy Industry Zone
- Business - Light Industry Zone

The Newmarket Primary School ped-shed contains a large business zone on the eastern side and mainly single housing on the western side, with clear separation between the land use activities around the school. Thus, children walking from the east might experience interesting walks on Broadway; but children walking from the west will face monotonous views. This is not good practice, as the design does not provide equal opportunities for a pleasant experience.

Sylvia Park School catchment area is mainly residential on the western side, with Sylvia Park Mall and light and heavy industrial zones on the eastern side. The limited land use activities and large blocks around this catchment area could create longer travel distances and monotonous views along the way.

5.3. Safety

Pedestrian crash data (1998-2018) by NZTA was used as an indicator for the safety of children within primary school catchment areas and ratings of walkable neighbourhoods. GIS maps have been formed to provide a visualization of pedestrian safety in study areas.

Figures *23, 24 & 25*, show up to 75% of pedestrians involved in crashes within primary school catchment areas were children aged 1 to 15. This indicates children are extremely vulnerable to traffic safety issues, without full awareness of the surrounding environment, and so easily hurt by vehicles on roads.

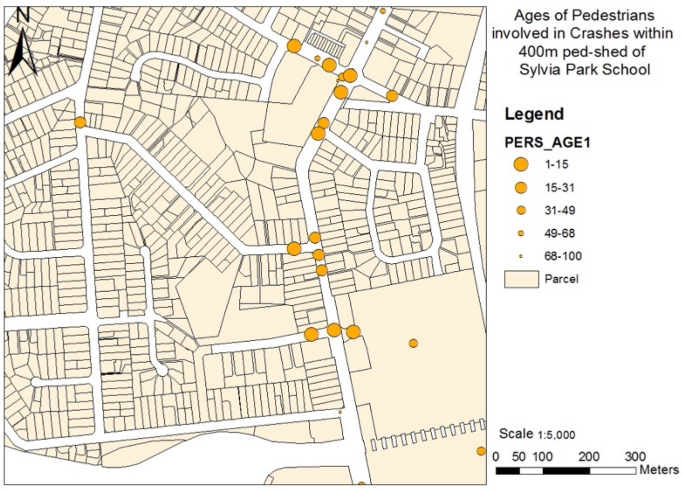


Figure 23: Ages of pedestrians involved in crashes in Sylvia Park School catchment area (NZTA Pedestrian Crash data 1998-2018) on GIS maps)

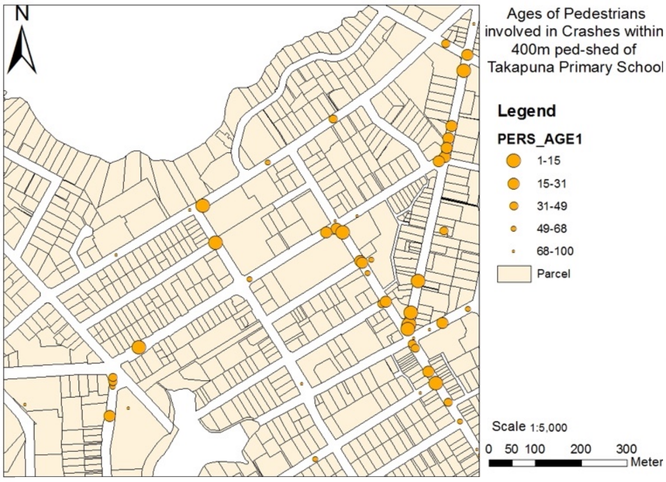


Figure 24: Ages of pedestrians involved in crashes in Takapuna Primary School catchment area (NZTA Pedestrian Crash data 1998-2018) on GIS maps)

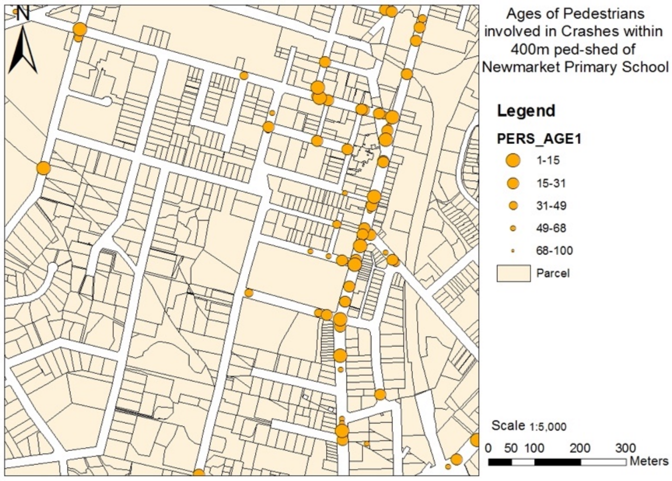


Figure 25: Ages of pedestrians involved in crashes in Newmarket Primary School catchment area ((NZTA Pedestrian Crash data 1998-2018) on GIS maps)

According to *Figure 26, 27, & 28*, many pedestrian crashes occur within the catchment areas. Most are on busy arterial roads with high traffic volume. Those crashes are categorized into fatal, severe and minor.

Crashes within Sylvia Park School's catchment area are mainly at the intersections of Mt Wellington Highway with Waipuna Road, Hamlin Road and Longford Street (*Figure 26*). Three fatal crashes happened here, together with many severe and minor crashes. One fatal crash occurred at the intersection of Mt Wellington Highway and Longford Street, the main entrance to Sylvia Park School. In many aspects, this data indicates the catchment area is dangerous to children and requires improvement.

On the contrary, crashes within catchment areas of Newmarket and Takapuna are distributed along busy arterial roads: Broadway, Khyber Pass, Anzac Street and The Terrace (*Figure 27 & 28*). In Newmarket, many crashes occurred along Broadway. The only explanation for frequent pedestrian crashes on this street is a lack of pedestrian-friendly design, which will be explained in *Section 5.4.* below.

It is important to lower speed within the catchment areas because the higher the speed, the more severe a crash could be. Nowadays, with the development of smart technologies, cars could be installed with sensors to automatically reduce the speed within the school areas.

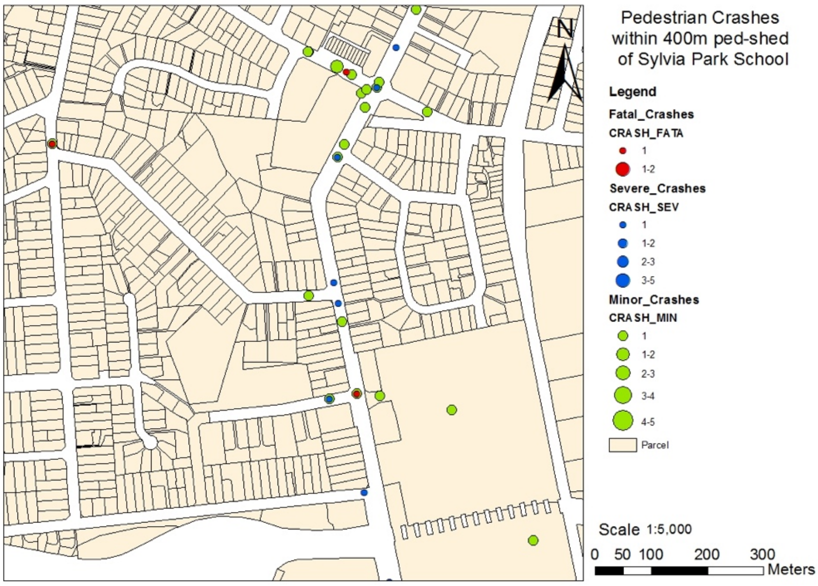


Figure 26: Pedestrian crashes within Sylvia Park School catchment area ((NZTA Pedestrian Crash data 1998-2018) on GIS maps)

Figure 27: Pedestrian crashes within Takapuna Primary School catchment area ((NZTA Pedestrian Crash data 1998-2018) on GIS maps)

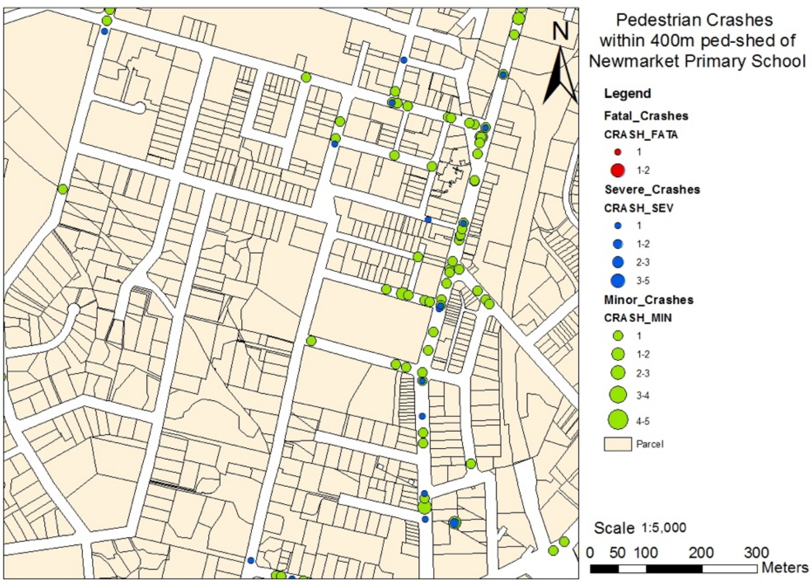


Figure 28: Pedestrian crashes within Newmarket Primary School catchment area ((NZTA Pedestrian Crash data 1998-2018) on GIS maps)

5.4. Quality of footpaths and path contexts

Site observations found all three catchment areas had school warning signs, speed limit signs, and no stop/parking lines. These help improve drivers' awareness, inform them they are approaching a school and should adjust their vehicle speed to ensure safety for children. They reduce parking opportunities and lower traffic volume on local roads. For example, during school hours, the speed allowed on Hamlin Road near Sylvia Park School and Lomond Street near Takapuna Primary is 40km/h (*Figure 29 &30*). Gillies Avenue provided a temporary speed limit of 30km/h for a construction site (*Figure 31*).

Figure 29: School warning sign and speed limit sign within Sylvia Park School catchment area

Figure 30: School warning sign and speed limit sign within Takapuna Primary School catchment area

Figure 31: School warning sign and speed limit sign within Newmarket Primary School catchment area

The sidewalks of the three catchment areas are poorly designed. They vary in size, as shown in *Table 1,* but most are much narrower than NZTA (2018) minimum sidewalk width requirements. The design guidelines from MoE (2015) and NZTA (2018) state pedestrian walkways around catchment areas should be accessible routes clear of obstructions (such as light columns, street furniture, vegetation, and signposts) and a minimum width of 2.4m. School areas should avoid unintentional physical barriers (kerbs) to allow better access (MoE, 2016).

The existing sidewalks are inadequate and unsafe for children walking to school, especially in a group. Obstacles alongside the sidewalks include thickset trees, residential rubbish bins placed on the walkways for collection, and bus stops (*Figure 32, 33 & 34*).

Figure 32: Obstacles along sidewalks within Sylvia Park School catchment area such as thicket trees (upper left) on Hamlin Road, one-side sidewalk on Aranui Street (upper right) and residential rubbish bins placed on the sidewalks of Mt Wellington Highway (below left) and many cars parked along Longford Street (below right)

Figure 33: Obstacles along sidewalks within Takapuna Primary School catchment area such as residential rubbish bins placed on sidewalks and cars parked along school entrance on Auburn Street

Figure 34: Busy bus stop as an obstacle on the sidewalks of Broadway, Newmarket

In Auckland, transport policies have implicitly provided more spaces for car parking on-street, especially on residential streets near school zones (*Figure 32 & 33*). This increases traffic and car movement in the catchment areas, consequently increasing accident rates. Moreover, parking on-street can easily block children's views when they cross the roads (*Figure 35)*. These factors concern parents and can affect decisions to allow their children to walk to school independently.

Figure 35: Height of a car in a 6 years old child's eyes, thus, car parking along streets can block children's views (Mitchell, 2007)

In addition, it was found that the sidewalks near Sylvia Park School entrances are low quality with mouldy surfaces which are slippery, cracked pavement and lack of interesting landscape elements (trees, plants, hedges).

Figure 36: Low-quality concrete sidewalks with mouldy surface on Rayma Place and cracks on Longford Street

There are no proper crosswalks near Newmarket Primary School, especially on Broadway and Gillies Avenue near the school entrance, making these busy roads dangerous for children (*Figure 37*).

Figure 37: No proper crosswalks are designed on Broadway (left) or Gillies Avenue (right) near Newmarket School

All three schools face similar issues regarding walkability and poor pedestrian infrastructure. However, Takapuna Primary School catchment area seems better designed than the others, with zebra crosswalks – which are well-integrated in the street and make it safer for children when crossing. The sidewalks have permeable brick pavers which are pedestrian-friendly (*Figure 39*). The different pavement patterns are essential in separating cars and pedestrians.

Figure 38: Clear marked zebra crosswalks on Killarney St (above left), Anzac St outside the mall (above right), and at the corner of Huron Rd and Lake Rd (below)

Figure 39: Permeable brick pavers pattern on Anzac Street's sidewalks, supporting pedestrian activities in Takapuna Primary School catchment area

Overall, the catchment areas face serious issues of low connectivity, lack of diverse land use patterns, pedestrian crash and traffic safety issues and low-quality paths. They need improvements to encourage more children to walk, while ensuring their safety. This requires implementation of good policies and high design standards from both local and central government.

Chapter 6: Conclusion

6.1. Summary of the research and suggestions for better walkability within primary school catchment areas in Auckland

The research has identified the four most influential built environment components that significantly affect the walkability of children within the catchment areas: *connectivity*, *land use patterns*, *safety,* and *quality of pathway and path context.* The analysis of the three case studies identifies Takapuna Primary School catchment area as that with most accessibility and quality design. However, three areas all face challenges for road safety, land use diversity and the quality of paths.

Pedestrians' needs should be considered at all scales; planning at local, regional and national levels must take them into account in policies, plans and programmes. These should inform and guide urban design practice through quality urban design guideline frameworks to create better walkability outcomes. However, each urban neighbourhood has its own problems which require appropriate provisions to resolve. Pedestrian facilities and path networks should be designed and planned to maximum extent instead of only meeting the minimum requirements, especially with the advent of Covid-19 (AASHTO, 2018; Southworth, 2005).

It is recommended that schools in NZ could learn from initiatives in The Netherlands and Portland. Pedestrian infrastructure improvements and facilities such as adequate sidewalks on both sides of the street and extensive auto-free zones in different parts of cities, and zones separated with pavement patterns are required. Smart technologies like sensors should be installed to reduce car speed to a safe level automatically.

Moreover, extensive training on road risks for both drivers and children is required to increase awareness of road risks and safety. Auckland needs to have the vision to develop a more people-oriented street design. Traffic calming should be implemented in residential streets, especially around primary school catchment areas to lower car travel speeds.

Overall, it is essential to assess built environment components and walkability conditions to achieve walkable neighbourhoods. For long-term improvements, actions are needed to create better walkability, including studies of the built environment and walking behaviour in different neighbourhoods, revised regulations and standards, public education in pedestrian planning and collaboration between transport planners, urban designers, and engineers.

6.2. Limitations of the research and further opportunities for the research

Several limitations should be noted in this research. The research intention is to interpret the influence of materiality on children's walkability, and from that make suggestions for the revision and improvement of planning regulations. The study uses observation, photography, mapping methods and comparative approaches to gain a thorough understanding of obstacles that can prevent children from walking to schools. However, the sample size is small, which might have limited the analysis. The data does not represent all primary school catchment areas in Auckland or NZ as a whole.

Secondly, this study is limited to the built environment. The research cannot cover other factors that could negatively affect the walking rates among children: age, gender, ethnicity, demographics, incomes, culture, and school decile.

This provides the opportunities for further research on the topic of walkability among children in primary school catchment areas in Auckland. The scope of the study could be extended to cover more case studies to provide a wider set of data. It will help identify the most common and significant challenges for active transport in the region in order to understand the issues and generate solutions. Finally, the potential differences between the socio-economic and demographics of those three primary school catchment areas can be further researched to strengthen all aspects of this study.

References

Active Healthy Kids Australia. (2015). The Road Less Travelled: The 2015 Active Healthy Kids Australia Progress Report Card on Active Transport for Children and Young People. Adelaide, South Australia: Active Healthy Kids Australia. Retrieved from http://www.activehealthykidsaustralia.com.au/siteassets/documents/ahka_reportcard_2015_web.pdf

Alam, J. B., Wadud, Z., & Polak, J. W. (2013). Energy demand and economic consequences of transport policy. *International Journal of Environmental Science and Technology*, 10(5), 1075-1082. doi: 10.1007/s13762-013-0240-1

American Association of State Highway and Transportation Officials (AASHTO). (2018). *A Policy on Geometric Design of Highways and Streets: The Green Book* (7th Ed.). Retrieved from https://aashtojournal.org/2018/09/28/aashto-releases-7th-edition-of-its-highway-street-design-green-book/

Andres, D., Speck, J., & Lydon, M. (2010). *The Smart Growth Manual*. New York: McGraw Hill Professional.

Auckland Council. (2018). Auckland Plan. Auckland, New Zealand: Auckland Council

Auckland Transport. (2018a). Auckland Regional Land Transport Plan 2018 – 2028. Auckland, New Zealand: Auckland Transport.

Auckland Transport. (2018b). Safer Communities programme. Auckland, New Zealand: Auckland Transport.

Auckland Transport. (2020a). Travelwise school programme. Retrieved on 20 Sept, 2020, from https://at.govt.nz/cycling-walking/travelwise-school-programme/

Auckland Transport. (2020b). Travelwise resources. Retrieved on 20 Sept, 2020, from https://at.govt.nz/cycling-walking/travelwise-school-programme/travelwise-resources/

Australian Government – Department of Infrastructure and Transport. (2013). Walking, Riding and Access to Public Transport: Supporting Active Travel in Australian Communities. Canberra, Australia: Department of Infrastructure and Transport.

Azmi, D. I., Karim, H. A. (2012). A comparative study of walking behaviour to community facilities in low cost and medium cost housing. *Procedia – Social and Behavioral Sciences*, 35, 619-628. doi: https://doi.org/10.1016/j.sbspro.2012.02.129

Banerjee, T., Uhm, J., Bahl, D. (2014). Walking to school: the experience of children in inner city Los Angeles and implications for policy. *Journal of Planning Education and Research*, 34(2), 123-140. doi: https://doi.org/10.1177/0739456X14522494

Banister, D. (2011). Cities, mobility and climate change. *Journal of Transport Geography*, 19(6), 1538-1546. doi: https://doi.org/10.1016/j.jtrangeo.2011.03.009

Beckx, C., Broekx, S., Degraeuwe, B., Beusen, B., & Int Panis, L. (2013). Limits to active transport substitution of short car trips. *Transportation Research Part D: Transport and Environment*, 22, 10-13. doi: https://doi.org/10.1016/j.trd.2013.03.001

Bently, I., Alcock, A., Murrain, P., McGlynn, S., & Smith, G. (1985). *Responsive environments: A manual for designers* (1st ed.). Oxford, UK: Elsevier

Brownson, R. C., Hoehner, C. M., Forsyth, A., & Sallis, J. F. (2009). Measuring the built environment for physical activity: State of the science. *American Journal of Preventive Medicine*, 36(4), 99-123. doi: 10.1016/j.amepre.2009.01.005

Calthorpe, P. (1993). *The Next American Metropolis: Ecology, Community, and the American Dream*. New York: Princeton Architectural Press.

Carse, A., Goodman, A., Mackett, R. L., Panter, J., & Ogilvie, D. (2013). The factors influencing car use in a cycle-friendly city: the case of Cambridge. *Journal of Transport Geography*, 28(100), 67-74. doi: https://doi.org/10.1016/j.jtrangeo.2012.10.013

Cervero, R. (2002). Built environment and mode choice: Toward a normative framework. *Transportation Research Part D: Transport and Environment*, 7(4), 265-284. doi: https://doi.org/10.1016/S1361-9209(01)00024-4

City of Portland. (1998). Portland Pedestrian Master Plan. Retrieved from https://www.portlandoregon.gov/transportation/article/90244

City of Portland. (2020). Portland Walking Guide. Retrieved from https://www.portland.gov/transportation/walking-biking-transit-safety/portland-walking-guide

Cooper, A. R, Page, A. S., Foster, L. J., & Qahwaji, D. (2003). Commuting to school: are children who walk more physically active? *American Journal of Preventive Medicine*, 25(4), 273-276. doi: https://doi.org/10.1016/S0749-3797(03)00205-8

Cullen, G. (1961). *Townscape*. London: The Architectural Press.

Cycling Embassy of Great Britain. (2013). How does a Dutch environment work for pedestrians? Retrieved on 18 Sept, 2020, from https://www.cycling-embassy.org.uk/blog/2013/07/03/how-does-a-dutch-environment-work-for-pedestrians

Dellinger, A. M., & Staunton, C. E. (2002). Barriers to children walking and biking to school – United States, 1999. *Journal of the American Medical Association*, 288(11), 1343-1344. doi: 10.1001/jama.288.11.1343

Duncan, M., & Mummery, K. (2005). Psychological and environmental factors associated with physical activity among city dwellers in regional Queensland. *Preventive Medicine*, 40(4), 363-372. doi: https://doi.org/10.1016/j.ypmed.2004.06.017

Duncan, S., White, K., Mavoa, S., Stewart, T., Hinckson, E., & Schofield, G. (2016). Active transport, physical activity, and distance between home and school in children and adolescents. *Journal of Physical Activity & Health*, 13(4), 447-453. doi: 10.1123/jpah.2015-0054

Education Counts. (2020). New Zealand Schools. Retrieved on 28 Sept, 2020, from https://www.educationcounts.govt.nz/find-school/school/population/year?district=&region=&school=1522

Education Gazette. (2018). The school commute on foot. Retrieved on 10 Sept, 2020, from https://gazette.education.govt.nz/articles/the-school-commute-on-foot/

Education Review Office. (2020). Newmarket School – 12/08/2015. Retrieved on 4 Oct, 2020, from https://www.ero.govt.nz/review-reports/newmarket-school-12-08-2015/#about-the-school

El-Geneidy, A., Grimsrud, M., Wasfi, R., Tetreault, P., & Surprenant-Legault, J. (2014). New evidence on walking distances to transit stops: identifying redundancies and gaps using variable service areas. *Transportation*, 41, 193-210. doi: https://doi.org/10.1007/s11116-013-9508-z

Environmental Health Indicators New Zealand. (2020). Active transport to and from school. Retrieved on 2 Oct, 2020, from https://www.ehinz.ac.nz/indicators/transport/active-transport-to-and-from-school/

Faherty, T. R., & Morrissey, J. E. (2014). Challenges to active transport in a car-dependent urban environment: a case study of Auckland, New Zealand. *International Journal of Environmental Science and Technology*, 11(8), 2369-2386. doi: 10.1007/s13762-014-0563-6

Federal Highway Administration. (2003). Accommodating bicycle and pedestrian travel: A recommended approach. Washington, D.C: Federal Highway Administration.

Forsyth, A. (2015). What is a walkable place? The walkability debate in urban design. *Urban Design International*, 20(4), 271-292. doi: 10.1057/udi.2015.22

Garrad, J. (2016). Walking, riding or driving to school: what influences parents' decision making? Paper prepared for the South Australian Department of Planning, Transport and Infrastructure. Retrieved from https://www.dpti.sa.gov.au/__data/assets/pdf_file/0004/513508/Walking_riding_or_driving_to_school-_what_influences_parents_decision_making-Literature_Review_.pdf

Gehl, J. (1936). *Cities for People*. Washington DC, America: Island Press

Giles-Corti, B., Wood, G., Pikora, T., Villanueva, K. (2011). School site and the potential to walk to school: the impact of street connectivity and traffic exposure in school neighborhoods. *Health & Place*, 17(2), 545–550. doi: https://doi.org/10.1016/j.healthplace.2010.12.011

Glover, T. D. (2020). Neighboring in the Time of Coronavirus? Paying Civil Attention While Walking the Neighbourhood. *Leisure Sciences: An International Journal*. doi: https://doi.org/10.1080/01490400.2020.1774014

Grossman, D. C. (2000). The history of injury control and the epidemiology of child and adolescent injuries. *The Future of Children*, 10(1), 23. doi: 10.2307/1602824

Handy, S. (1996). Urban form and pedestrian choices: Study of Austin neighbourhoods. *Transportation Research Record: Journal of the Transportation Research Board*, 1552(1), 135-144. doi: https://doi.org/10.1177/0361198196155200119

Hansen, A. Y., Umstattd Meyer, M. R., Lenardson, J. D., & Hartley, D. (2015). Built environments and active living in rural and remote areas: a review of the literature. *Current Obesity Reports*, 4(4), 484-493. doi: 10.1007/s13679-015-0180-9

Ikeda, E., Stewart, T., Garrett, N., Egli, V., Mandic, S., Hosking, J., … Smith, M. (2018). Built environment associates of active school travel in New Zealand children and youth: A systematic meta-analysis using individual participant data. *Journal of Transport & Health*, 9(1), 117-131. doi: https://doi.org/10.1016/j.jth.2018.04.007

International Federation of Pedestrians (IFP). (2020). IFP Members. Retrieved on 10 Sept, 2020, from https://www.pedestrians-int.org/en/members-2

Jakob, A., Craig, J. L., & Fisher, G. (2006). Transport cost analysis: a case study of the total costs of private and public transport in Auckland. *Environmental Science & Policy*, 9(1), 55-66. doi: https://doi.org/10.1016/j.envsci.2005.09.001

Kick, M. (2020). Urban mobility after lockdown: Travel behaviour post-coronavirus. *Growth from Knowledge*. Retrieved on 1 Sept, 2020, from https://www.gfk.com/blog/2020/04/urban-mobility-after-lockdown-travel-behavior-post-coronavirus

Kick, M. (2020). Urban mobility after lockdown: Travel behaviour post-coronavirus. Retrieved from https://www.gfk.com/blog/2020/04/urban-mobility-after-lockdown-travel-behavior-post-coronavirus

Lee, S., & Talen, E. (2014). Measuring Walkability: A Note on Auditing Methods. *Journal of Urban Design*, 19(3), 368-388. doi: 10.1080/13574809.2014.890040

Lo, R. H. (2009). Walkability: what is it? *Journal of Urbanism*, 2(2), 145-166. doi: 10.1080/17549170903092867

Macdonald, L., McCrorie, P., Nicholls, N., & Olsen, J. R. (2019). Active commute to school: does distance from school or walkability of the home neighbourhood matter? A national cross-sectional study of children aged 10-11 years, Scotland, UK. *BMJ Open*, 9(12), 1-10. doi: https://bmjopen.bmj.com/content/bmjopen/9/12/e033628.full.pdf

Mandic, S., Sandretto, S., Garcia Bengoechea, E., Hopkins, D., Moore, A., Rodda, J., & Wilson, G. (2017). Enrolling in the Closest School or Not? Implications of school choice decisions for active transport to school. *Journal of Transport & Health*, 6(1), 347-357. doi: https://doi.org/10.1016/j.jth.2017.05.006

Martinez-Gomez, D., Ruiz, J. R., Gomez-Martinez, S., Chillon, P., Rey-Lopez, J. P., … Marcos, A. (2011). Active commuting to school and cognitive performance in adolescents: the AVENA study. *Archives of Pediatrics & Adolescent Medicine*, 165(4), 300-305. doi: 10.1001/archpediatrics.2010.244

Mason, J. (2002). *Qualitative Researching* (2nd ed.). Thousand Oaks, California: Sage Publications Inc.

Matthews, L., & Imran, M. (2015). Discursive barriers to sustainable urban transport in Auckland. *Urban Policy and Research*, 33(4), 1-24. doi: 10.1080/08111146.2014.980400

McDonald, N. C. (2008). Children's mode choice for the school trip: the role of distance and school location in walking to school. *Transportation*, 35(1), 23-35. doi: https://doiorg.ezproxy.auckland.ac.nz/10.1007/s11116-007-9135-7

McKibbin, D. (2020). How will COVID-19 change our travel behaviour? Retrieved from https://www.assemblyresearchmatters.org/2020/05/07/how-will-covid-19-change-our-travel-behaviour/

Mecredy, G., Pickett, W., & Janssen, I. (2011). Street Connectivity is Negatively Associated with Physical Activity in Canadian Youth. *International Journal of Environmental Research and Public Health*, 8(8), 3333-3350. doi: 10.3390/ijerph8083333

Michael, B. (2020). The Coronavirus crisis: What will the post-pandemic city look like? *Environment and Planning B: Urban Analytics and City Science*, 47(4), 547-552. doi: https://doi.org/10.1177/2399808320926912

Ministry of Education. (2015). Designing Schools in New Zealand: Requirements and Guidelines. Retrieved on 18 Sept, 2020, from https://www.education.govt.nz/assets/Documents/Primary-Secondary/Property/Design/Design-guidance/DSNZ-version-1-0-20151014.pdf

Ministry of Education. (2016). Flexible Learning Spaces: How the design of spaces can help student achievement. Retrieved on 16 December 2019, from https://www.education.govt.nz/assets/Documents/Primary-Secondary/Property/Design/Flexible-learning-spaces/FLS-How-the-design-of-spaces-can-help-student-achievement.pdf

Ministry of Health. (2020). About Covid-19. Retrieved on 18 Sept, 2020, from https://www.health.govt.nz/our-work/diseases-and-conditions/covid-19-novel-coronavirus/covid-19-health-advice-public/about-covid-19

Ministry of Transport. (2018). Auckland Transport Alignment Project. Wellington, New Zealand: Ministry of Transport.

Mitchell, H., Kearns, R., & Collins, D. (2007). Nuances of neighbourhood: children's perceptions of the space between home and school in Auckland, New Zealand. *Geoforum*, 38(4), 614-627. doi: https://doi.org/10.1016/j.geoforum.2006.11.012

Moura, F., Cambra, P., & Goncalves, A. B. (2017). Measuring walkability for distinct pedestrian groups with a participatory assessment method: A case study in Lisbon. *Landscape and Urban Planning*, 157, 282-296. doi: https://doi.org/10.1016/j.landurbplan.2016.07.002

New Zealand Now. (2020). Choosing a school. Retrieved on 11 Sept, 2020, from https://www.newzealandnow.govt.nz/living-in-nz/education/choosing-school

NZTA. (2014). Safer journeys for schools: Guidelines for school communities. Retrieved on 8 Sept, 2020, from https://www.nzta.govt.nz/assets/resources/safer-journeys-for-schools/docs/safer-journeys-for-schools-guidelines-for-school-communities.pdf

NZTA. (2018). Providing for walking: Research into guidance and policy. Retrieved on 8 Sept, 2020, from https://www.nzta.govt.nz/assets/resources/providing-for-walking-research-into-guidance-and-policy/Providing-for-walking-research-report.pdf

NZTA. (2020). About the Innovating Streets programme. Retrieved on 20 Sept, 2020, from https://www.nzta.govt.nz/roads-and-rail/innovating-streets/about/

Ogilvie, D., Egan, M., Hamilton, V., & Patticrew, M. (2004). Promoting walking and cycling as an alternative to using cars: systematic review. *British Medical Journal*, 329(7469), 763-766. doi: www.jstor.org/stable/25458304

Pooley, C. G., Horton, D., Scheldeman, G., Tight, M., Jones, T., Chisholm, A., & Jopson, A. (2011). Household decision-making for everyday travel: a case study of walking and cycling in Lancaster (UK). *Journal of Transport Geography*, 19(6), 1601-1607. doi: https://doi.org/10.1016/j.jtrangeo.2011.03.010

Pooley, C., Turnbull, J., Adams, M. (2005). *A Mobile Century? Changes in Everyday Mobility in Britain in the Twentieth Century*. Hampshire, England: Ashgate Publishing Limited.

Pucher, J. & Buehler, R. (2008). Making cycling irresistible: lessons from the Netherlands, Denmark and Germany. *Transport Reviews*, 28(4), 495-528. doi: https://doi.org/10.1080/01441640701806612

Pucher, J., & Dijkstra, L. (2003). Promote safe walking and cycling to improve public health: lessons from The Netherlands and Germany. *American Journal of Public Health*, 93(9), 1509-1516. doi: 10.2105/AJPH.93.9.1509

Rafiemanzelat, R., Emadi, M. I., & Kamali, A. J. (2017). City sustainability: the influence of walkability on built environment. *Transportation Research Procedia*, 24, 97-104. doi: https://doi.org/10.1016/j.trpro.2017.05.074

Rodriguez, A., & Vogt, C. A. (2009). Demographic, environmental, access, and attitude factors that influence walking to school by elementary school-aged children. *Journal of School Health*, 79(6), 255-261. doi: 10.1111/j.1746-1561.2009.00407.x

Romero, V. (2015). Children's experiences: Enjoyment and fun as additional encouragement for walking to school. *Journal of Transport & Health*, 2(2), 230-237. doi: https://doi.org/10.1016/j.jth.2015.01.002

Safekids Aotearoa. (2015). Child Unintentional Deaths and Injuries in New Zealand, and Prevention Strategies. Auckland, New Zealand: Safekids Aotearoa.

Sallis, J. F., & Glanz, K. (2006). The role of built environments in physical activity, eating and obesity in childhood. *The Future of Children*, 16(1), 89-108. doi: 10.1353/foc.2006.0009

Shelling, C. O. (2010). *Assessing School Neighbourhood Walkability: A Targeted Approach to Safe Routes to School Programming* (Master's thesis, University of New Orleans). Retrieved from https://scholarworks.uno.edu/cgi/viewcontent.cgi?article=2187&context=td

Southworth, M. (2005). Designing the Walkable City. *Journal of Urban Planning and Development*, 131(4), 246-257. doi: https://doi.org/10.1061/(ASCE)0733-9488(2005)131:4(246)

Southworth, M., & Ben-Joseph, E. (2003). *Streets and the shaping of towns and cities*. Washington DC: Island Press.

Southworth, M., & Ben-Joseph, E. (2004). Reconsidering the cul-de-sac. *Access*, 24, 28-33. Retrieved from https://escholarship.org/uc/item/1qn0g780

Southworth, M., & Owens, P. M. (1993). The Evolving Metropolis: Studies of Community, Neighborhood, and Street Form at the Urban Edge. *Journal of the American Planning Association*, 59(3), 271-287. doi: 10.1080/01944369308975880

Speck, J. (2012). *Walkable city: how downtown can save America, one step at a time*. New York: North Point Press.

Srinivasan, S., O'Fallon, L. R., & Dearry, A. (2003). Creating healthy communities, healthy homes, healthy people: initiating a search agenda on the built environment and public health. *American Journal of Public Health*, 93(9), 1446-1450. doi: 0.2105/ajph.93.9.1446

Stats NZ. (2013). Commuting pattern in Auckland: Trends from the Census of Population and Dwellings 2006-13. Retrieved on 3 Jan, 2020, from http://archive.stats.govt.nz/Census/2013-census/profile-and-summary-reports/commuting-patterns-auckland/commuting-modes.aspx

Staunton, C. E., Hubsmith, D., & Kallins, W. (2003). Promoting safe walking and biking to school: the Marin County success story. *The American Journal of Public Health,* 93(9), 1431-1434. doi: 10.2105/ajph.93.9.1431

Takapuna Primary School. (2020). Our School. Retrieved on 26 Sept, 2020, from https://www.tps.school.nz/our-school/our-history

Talen, E., & Koschinsky, J. (2013). The Walkable Neighbourhood: A Literature Review. International *Journal of Sustainable Land Use and Urban Planning*, 1(1), 42-63. doi: 10.24102/ijslup.v1i1.211

Thornton, I. E., Pearce, J. R., & Kavanagh, A. M. (2011). Using Geographic Information Systems (GIS) to assess the role of the built environment in influencing obesity: a glossary. The international journal of behavioral nutrition and physical activity, 8, 71. doi: https://doi.org/10.1186/1479-5868-8-71

United States Department of Transportation. (2020). Pedestrian Safety: Everyone is a Pedestrian. Retrieved on 15 Sept, 2020, from https://www.trafficsafetymarketing.gov/content/everyone-pedestrian

Untermann, R. (1990). Why you can't walk there from here: Strategies for improving the pedestrian environment in the United States. In R. S. Tolley (Ed.) *The greening of urban transport: Planning for walking and cycling in western cities*. London: Belhaven Press.

US Department of Transportation. (1999). Pedestrian Safety in Australia. McLean, VA: Research, Development, and Technology Turner-Fairbank Highway Research Center.

Victoria Walks. (2020). Planning for walking. Retrieved on 11 Sept, 2020, from http://www.victoriawalks.org.au/planning_walking/

Whitebread, D., & Neilson, K. (2000). The contribution of visual search strategies to the development of pedestrian skills by 4-11-year-old children. *British Journal of Educational Psychology*, 70(4), 539-557. doi: 10.1348/000709900158290

Wisconsin Department of Transportation. (2020). Wisconsin Pedestrian Policy Plan 2020. Retrieved from http://www.dot.wi.gov/projects/state/docs/ped2020-plan.pdf/.

Worldometer. (2020). Covid-19 Coronavirus Pandemic. Retrieved on 20 Sept, 2020, from https://www.worldometers.info/coronavirus/

Yeung, J., Wearing, S., & Hills, A. P. (2008). Child transport practices and perceived barriers in active commuting to school. *Transportation Research Part A: Policy and Practice*, 42(6), 895-900. doi: https://doi.org/10.1016/j.tra.2007.12.007

Yin, R. K. (1994). *Case Study Research: Design and Methods* (2nd ed.). Thousand Oaks, CA: Sage Publications Inc.

Appendices

Appendix 1: The One Network Road Classification (ONRC) (NZTA, 2020)