Masters of Urban Resilience and Renewal

Weather or not to go: The travel impact of nuisance flooding and heavy rain for disabled and older people

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Abstract

Transport systems are foundational, shaping the places that people can go, however, they are not equitable for everyone. Sea level rise and more intense rainfall are expected to create larger and more frequent floods as well as more widespread surface flooding. The aim of this study was to better understand how increased surface flooding and heavy rainfall will impact the journeys of those who cannot drive and identify solutions for Ōtautahi (Christchurch). Interviews were conducted with disabled and older people, who are typically most reliant on public transport and have the highest accessibility needs. Poor weather tends to amplify existing transport barriers and leading to increased isolation and reduced wellbeing. From the interviews, analysis was completed to assess the value of bus shelters. The moderating effect of bus shelters on bus ridership was measured for rainy days, finding a medium relationship on weekdays. Areas of middle deprivation have access to the most shelters on the network and have access to the most sheltered and seated stops per population yet stops in areas of higher deprivation tend to have a higher use across all types of infrastructure. Failing to consider the impacts of future heavy rainfall and excess water on the streets for pedestrians could further exacerbate transport inequalities and impede goals of transitioning away from cars and carbon emissions.

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1 Introduction

Flood risk is increasing in Ōtautahi (Christchurch), Aotearoa (New Zealand) from land subsidence, urbanisation, and sea level rise. This means that not only is the risk of a major flood higher, but there is an increasing presence of nuisance flooding. This provides an opportunity to utilise the concept of urban resilience to prepare Ōtautahi for the future challenges of climate change. Research on the impact of nuisance flooding is limited and typically focuses on car users and road networks. In the time of negative predictions of climate change, there is a need to both reduce carbon emissions and prepare transport networks for the effects of climatic changes. There is significant research on factors to enable transitioning away from cars into active modes, however, the extreme weather patterns may discourage the use of active modes and more research is need on how to make public transport systems resilient to attract and retain bus users.

Additionally, Ōtautahi is a car dependent city with a high ownership of cars. Cities that have been designed for cars are known to have inequitable transport systems, where people who cannot drive have limited urban mobility. Older and disabled people often have the inability to drive and also have the highest accessibility needs, making public transport and navigating poor designed streets difficult. Nuisance flooding and increased periods of heavy rainfall will compound the inequality for people without the protection a car.

This research, conducted as part of a Master of Urban Resilience and Renewal, is intended to be an exploratory study to better understand how increased surface flooding and heavy rainfall will impact the journeys of those who cannot drive, and identify solutions. The combination to study small scale flooding and rainfall with a pedestrian lens has not been done previously. The research has three themes: urban planning considerations for areas subject to coastal hazards, increasing urban resilience of public transport, and increasing equity in transport through increase flood resilience. This research was conducted in two phases, firstly a qualitative phase that included interviews with disabled and older people. Then a quantitative analysis was conducted analysing the population movements of over 65 people and the value of bus shelters. An area of focus was Woolston, Heathcote and the Sumner areas. It was important to use this study to share the voices of disabled and older people.

Notes for the reader

Terminology

A few notes about terminology need to be caveated to the reader. Humans have a wide range of physical and mental capabilities. Disability is a term that is difficult to define and has a history of oppression and stigma and now is sometimes a label worn with pride. The term ‘disabled people’ has been used throughout this thesis and is based off advice from members of the disabled community. Additionally, the terms accessibility and mobility are used commonly both in both transport and disability sectors. While it is hoped that context will provide which meaning of the words is meant to be taken, in this thesis accessibility has only been used in the context of disability, while mobility has been used in both. Where possible ‘urban mobility’ has been used to reference mobility with an urban transport context.

This research also often assumes disabled people to have lower incomes and to face financial barriers as statistics commonly portray that to be the case. However, it is noted that this can be an ecological fallacy, where not all disabled people fall into the same financial group. It is rather

recognised that many access barriers are worsened by a lack of finance, and those are the barriers that were intended to be highlighted.

Positionality

I am appreciative of the people who have contributed to this research and am grateful for their sharing of stories, allowing me to see into their world. I am Pākehā, in my 30s, and not in the disabled community, so I recognise that I am outsider looking in and do not have lived experience of disability or know the experience of aging intimately, so there will be nuances that I have missed. I have attempted to de-centralise my perspectives and open my mind with compassion. Being female and queer myself, I am impassioned to support another more suppressed minority and remove stigma towards disabled and older people. I have attempted to place people at the heart of this thesis, potentially at a higher priority than the practicalities of building and maintaining good transport networks.

2 Literature Review

2.1 Urban Resilience

The concept of 'urban resilience' has become popular in addressing the multidimensional complexities of climate change. There are varying definitions due to the wide range of fields that have adopted the term, however at a fundamental level, resilience is related to the ability of a system to restore functionality after a disruption (McClymont et al., 2020). In the field of transport, resilience was defined as "…the ability of a system to resist, reduce and absorb the impacts of a disturbance, maintaining an acceptable level of service (static resilience), and restoring the regular and balanced operation within a reasonable period of time and cost (dynamic resilience)" (Gonçalves & Ribeiro, 2020, p.3). Resilience has become an attractive theory with a positive spin compared with concepts such as 'vulnerability' (Meerow et al., 2016).

Climate change will bring increased flood risk from sea level rise and extreme weather patterns. Flooding will increase disruption to transport networks, creating the need for enhancing transportation system resilience. Flood risk is particularly problematic in the context of increasing populations of urban cities, causing more disruption and impacting more people in an single event (Gonçalves & Ribeiro, 2020). The strategy of resilience prepares cities for future uncertainties, especially in the context of climate change (Meerow et al., 2016).

2.2 The Importance of Transport Systems

2.2.1 Car dependence

A transportation network is a foundation of a city, as it provides mobility, flow of goods, and aid in disaster responses (Logan & Guikema, 2020). Mobility also enables participation in society and connection with others (Vella-Brodrick & Stanley, 2013). Aotearoa has developed a dependence on the motor vehicle, with 93.5% of households owning a car. Many Kiwis rely on the use of a car to access their regular destinations for essentials, creating a disadvantage to those who do not have access to a car (Curl, Watkins, et al., 2020). Further to this, the distance to essential amenities is increasing, which has created the concept of urban deserts, such as food deserts, which are urban areas where the closest supermarket is more than 1.6km away, a distance difficult for many to walk. These increased distances to essential amenities further exacerbates inequities (Anderson et al., 2022).

2.2.2 Weather and active transport

With the pressures of climate change, there are increasing calls to curb greenhouse emissions and encourage a shift to sustainable transport options (Azolin et al., 2020). Increasing priority is being put into active modes including public transport, walking and cycling, to incentivise uptake. These modes not only have carbon reduction benefits but also a wide range of health, social, anti-pollution benefits. The challenge with active modes is they are less convenient and offer limited protection from weather, with many studies finding a negative relationship between extreme weather and active mode journeys (Böcker et al., 2013; Ton et al., 2019). In a 2021 online survey of nearly 5000 New Zealanders, 24% and 31% found walking and cycling not enjoyable because of the weather respectively, which was a slight reduction from the previous year's survey (Waka Kotahi & The Research Agency, 2022). Other studies have shown that rain has an impact on bus patronage, typically in similar cities such as Brisbane, rain reduces ridership, although in cycling cities such as the Netherlands, bus patronage was seen to increase as cyclists chose to utilise the shelter of a bus

(Lin et al., 2020). An Oregon study found that extreme temperatures and heavy rainfall had a negative effect of ridership, which was even more sensitive in low income areas (Ngo, 2019).

2.2.3 Bus shelters

Providing bus shelters is one method to address the impacts of weather on public transit. Bus shelters have been seen to have a small moderating effect on bus ridership for weekdays in Salt Lake City on extreme weather days (Miao et al., 2019), though few published studies assess the influence of bus shelters on ridership.

2.3 Nuisance flooding

Predicted sea level rise and intense rainfall events are likely to cause water to remain on streets for longer in flood prone areas, increasing frequency of nuisance flooding. Nuisance flooding (sometimes referred to as surface flooding or minor flooding) is low level flooding typically not large enough to cause significant damage or impact safety and is often overlooked. There is no consistent definition or agreement on the depth of nuisance flooding. However, nuisance flooding is commonly referred to as flooding that does not cause loss of life, significant damage, or evacuations, but is something that is capable of causing a disruption to routines, reducing property values and loss of income (Fant et al., 2021). Nuisance flooding is sometimes regarded as flooding from high tide events, however in this context it is from any source of water including precipitation and rivers. Moftakhari et al. (2018) propose a defined depth of up to 10cm for nuisance flooding based off the availability of technology to measure shallow flooding as well as practical reasons, such as the typical height of most car undercarriages being 13cm.

With increasing flooding risk in many urban coastal cities, major flooding receives a lot of attention, by the nature of it being more disastrous than minor flooding. In Aotearoa, floods are the most frequently occurring disaster and they will become more frequent in the future (Auliagisni et al., 2022). Although nuisance flooding causes less damage and loss of life in a single event, less severe flooding can be more widespread and more frequent, with greater cumulative exposure to people and assets. In general, the impacts of nuisance flooding are not well understood (Jacobs et al., 2018; Moftakhari et al., 2018)

Nuisance flooding can cause significant disruption to travel patterns, although few studies account for those who rely on public transport or assess the impacts to walking and cycling (Azolin et al., 2020; Jacobs et al., 2018). Studies tend to focus on impacts to roads and vehicles, with a study estimating that 12,000 kilometres of roadon the East Coast of United States of America is threatened by tidal nuisance flooding, with an average nuisance flooding increase of 90% between the decades starting 1995 and 2005 (Jacobs et al., 2018). The cost of the vehicles being delayed from increased high tide flooding in the US is also estimated to $28 to $37 million annually by 2050 (Fant et al., 2021).

Although largely navigable with a vehicle, increased nuisance flooding in the future is worthy of consideration from a maintenance perspective. Road works and uneven surfaces are known disruptions to travel which could worsen with cumulative expose to nuisance flooding. Local government authorities hold responsibility for maintaining local assets as well as controlling land for mitigation of natural hazards. Different to major flooding, however, additional financial aid from central government may not be available support damage from the increased presence of nuisance flooding due to it not being declared a disaster. Therefore there would be no extra funding to those who require extra support Local Government New Zealand, 2014; Moftakhari et al., 2018).

2.4 Outdoor falls is a public health concern

Increased nuisance flooding and rain will cause streets to become more slippery and increase risk of falls. Pooling of water due to poor design or maintenance can also create a requirement to detour, pushing people off the designed path, such as onto a busy road (Curl et al., 2016). Additionally, large areas of nuisance flooding may cause a detour where someone is required to venture to an unfamiliar route, and unfamiliar environments create higher risk of falling and induce high levels of anxieties (Phillips et al., 2013). In an exploratory study regarding falls among older people, 30% of people had fallen at least once in the last year, with 31% of those falls being outside. People are more likely to fall on footpaths and streets during recreational walking, and the presence of water on the street amplifies this risk and likely the perceived risk too (Curl et al., 2020).

Falls are not just a concern for older people. Outdoor falls are a neglected public health issue and have major consequences to individuals heath and families (Li et al., 2006). In Aotearoa, between 2013 – 2017, falls were the leading cause of hospitalisation for all age groups except 15-19 years and was the leading cause of injury resulting in fatality for over 65-year-olds between 2011 – 2015. Based on the research by Curl et al., (2020) above, assuming a third of all the falls were street related, the percentage of hospitalisation or fatality remains greater than the second leading cause over 65 years and significantly greater than motor vehicle accidents (Injury Prevent Research Unit, University of Otago, 2019).

The psychological relationships of falling and fear of falling should not be overlooked. In the study of older people mentioned above, people who have fallen more than once had a greater fear of falling. This fear of falling prevents people from making journeys that enable living and have negative wellbeing impacts. Additionally, there is an association between fear of falling and perceived accessibility, making access to activities feel even harder (Curl, Fitt, et al., 2020; Lättman et al., 2018).

In addition to the increased street maintenance cost from nuisance flooding, outdoor falls come at a monetary cost too and place burden on healthcare systems. The cost of Accident Compensation Corporation (ACC) claims from falls on the street and roadside was $105m with 47,000 claims in 2017/18 (Waka Kotahi NZ Transport Agency, n.d.-b). Improving street conditions for wet weather can make streets safer and more accessible, reducing barriers to people making journeys.

2.5 Need for accessible transport

The shift to active transport modes is an opportunity to revolutionise transport systems to become more accessible, equitable and resilient to weather and nuisance flooding. This will enable people who are currently marginalised to have better access to transport and be included in the climate transitions, commonly referred to as a ‘just transition’. For those who cannot drive, the transportation current system has created a reliance on public transport. However, a lot of public transport is not accessible, and the street environment has many barriers, providing few transport options for people with mobility impairments. This limits people’s community participation and increases isolation (Spray et al., 2020). One compensation is the Total Mobility Scheme which provides a concession on door-to-door taxis for people who are unable to use buses or trains due to disability. The concession is typically 50% of the fare, however, caps vary regionally (Doran et al., 2022).

Car ownership is related to household income due the cost of running and maintaining a roadworthy vehicle. Due to systemic oppression, including barriers to accessing income, disabled people are less likely to have the choice to use a car (Curl et al., 2020). “More than 1 in 3 (36.3 percent) disabled

people living in households earning $20,000 or less had no private vehicle available for their use, compared with 1 in 5 (19.6 percent) non-disabled people [for the same income bracket]" (StatsNZ, 2020, p. 19). Further to this, private vehicles that can be used by those with additional mobility needs are more expensive, either upfront or to modify, making car ownership more difficult (Spray et al., 2020). Transitioning cities away from the need to use a car, creates more equitable transport systems and that are also more resilient.

Park & Chowdhury (2018) reviewed the barriers in public transport journeys from existing literature forming a vast range of accessibility issues for disabled people. They emphasized that the whole journey must be accessible, including providing adequate information for journey planning (Doran et al., 2022). Disabled people's journeys are often fragile, as there are key challenges with planning the journey with limited accessible information, crossing roads, physical barriers, unreliability of public transport, poor attitudes of staff and reaching the destination including additional challenges if one aspect of the journey doesn't work (Doran et al., 2022). Experiencing barriers can take a toll mentally. In a study that asked people who newly use wheelchairs about their stand-out experiences, four themes of mental difficulties arose; humiliation, frustration, loss, and humility (Barlew et al., 2013).

Catering to accessibility needs often makes places and systems more inclusive to everyone (van Hees et al., 2018). Additionally, Māori have higher rates of disability than Pākehā across all ages but especially ages 45-64 (28% for European and 43% for Māori) (Statistics New Zealand, 2013), therefore addressing inequalities for disabled people also addresses ethnic disparities and gives effect to the principles of Te Tiriti o Waitangi.

Aotearoa has an ageing population due to people living longer and having fewer children. The proportion of population over 65 is expected to increase beyond 2073 as highlighted in dark purple in Figure 1 below (Stats NZ, 2020b). This will increase the percentage of the population with mobility challenges as well as people unable to drive (Curl, of Otago, et al., 2020; Parr-Brownlie et al., 2020).

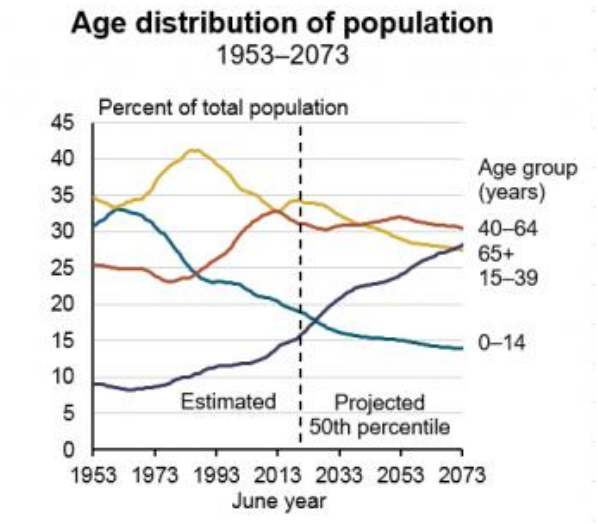


Figure 1. Aotearoa population estimates to 2073 (Stats NZ, 2020b)

There are cultural differences in the ways New Zealanders view aging which has an effect of the travel needs of older people. Māori tend to have greater respect for their elders and are more likely to have elders live in the same household as other whānau, as opposed to the colonialist view where

generations live separately and as elders become more dependent, utilise age-care facilities (Parr-Brownlie et al., 2020). Enabling older people to 'age in place' has benefits on an individual scale, such as familiarity, memories and social connections as well as benefits on a neighbour scale, creating diversity, eyes on the streets, sharing of knowledge (van Hees et al., 2018).

Measuring inclusive access and proving the success of investment in accessible streetscapes is a barrier to reducing inequalities for disabled and older people. When transport practitioners need to make design trade-offs to increase accessibility, it is difficult to justify when the trade-off competes with other measurable outcomes such as reducing traffic congestion or road safety (Burdett et al., 2021). The presence of people using mobility aids can be used as a proxy measure for how inclusive streetscapes (and cities) are. However, when pedestrian counting, the number of mobility aid users is not counted, only the presence of a pedestrian, reinforcing the belief of 'no data, no problem' (Burdett et al., 2021; Spray et al., 2020).

2.6 Vulnerability to flooding

Due to multidimensional inequalities, such as lack of transport, people with disabilities are more vulnerable to climate change, and because they are a group often excluded from mitigation and adaptation planning, their vulnerabilities are worsened. It is less often that people with differing abilities are vulnerable due to their capabilities, rather, because of the systemic oppression they face (Boberg & Sherwood-O'Regan, 2021; Gaskin et al., 2017; Lindsay & Yantzi, 2014).

Nuisance flooding poses a risk to transport for anyone, but journeys without the protection of a car are particularly vulnerable, and socially excluded populations will have greater impact. Mason et al. (2021) identified a framework with ten social vulnerability dimensions for flooding in Aotearoa including: exposure; children; older adults; health and disability status; money to cope with crises/losses; social connectedness; knowledge, skills and awareness of natural hazards; safe, secure and healthy housing; food and water to cope with shortage; and decision making and participation. A resilience index was intentionally not chosen due to the singular dimension of an index. Although 'health and disability' is regarded as its own dimension, the cumulative marginalisation of those with extra mobility challenges, places them higher in most of the vulnerability dimensions, often in a negative feedback loop (Boberg & Sherwood-O'Regan, 2021; Gaskin et al., 2017). Additionally, amenity access underpins the majority of dimensions, and therefore the lack of access to an adequate transport system increases vulnerability in most dimensions.

2.7 Community partner - Coastal Hazards Team (Christchurch City Council)

Christchurch City Council (the Council) is looking ahead at the challenges that coastal hazards (including inundation) will have on Ōtautahi and was a partner while conducting this research. Based on the central government guidance, the Coastal Hazards Team is seeking to establish adaptation options with different thresholds for communities at risk, with community engagement at the core of decision making. This includes identifying vulnerabilities and risks to people and assets from coastal hazards.

As the area of flooding exposure is large, the Council is using a phased approach, creating adaptation plans for smaller areas sequentially. The five adaptation areas are below in Figure 2.

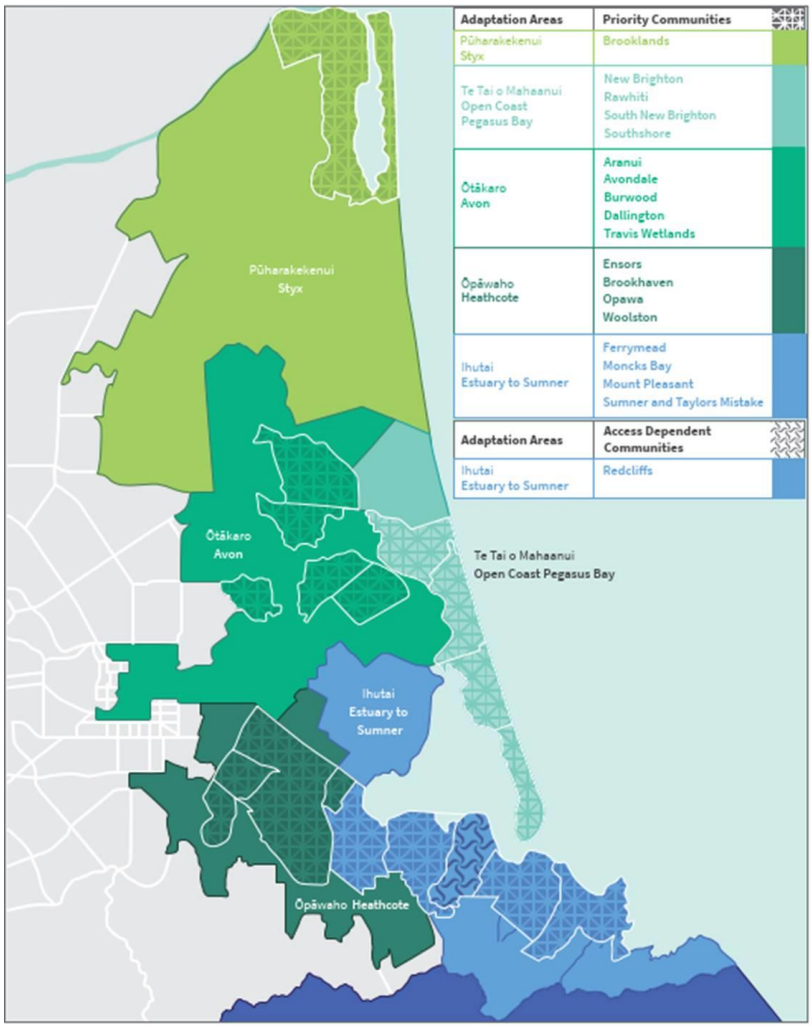


Figure 2. Coastal Adaptation Area and Priority Communities identified by the Council.

The Council has limited information on the risk and impacts for people with disabilities and therefore will benefit from insights into how different adaptation options may impact people with disabilities, what amenities are important and what additional vulnerability disabled and older people have to coastal hazards.

2.8 Research objectives

2.8.1 Aim

The threat of sea level rise and more intense rainfall patterns is bringing an incentive to reduce reliance on carbon emissions. Additionally, the threat also brings a need for cities to strategically plan how access to daily needs can be more resilient. The two combined, creates a need to consider the weather and flooding impact to active transport modes rather than cars. Mere surface flooding is predicted to impact pedestrians more without the protection of a car. There is limited understanding of the impacts of nuisance flooding, especially on active transport modes and no research that focuses on the specific needs of disabled and older people. Additionally, the re-prioritisation of active modes in transport planning brings opportunity to address the inequity and inaccessibility in transport systems.

This research intends to examine the intersection between three key topics: the movement away from car dependence, flood risk and accessibility. Studying the intersection will provide greater resilience to climatic changes for all abilities and enable Aotearoa to have a more inclusive society. Therefore, the aim of this research is to better understand how rain and surface flooding impacts the journeys of those who cannot drive.

People with different abilities experience the world in many different ways and face different barriers. To limit the scope of this research, a focus on people with physical impairments was chosen. The main reason for this was that physical barriers are most studied and known about in transport and therefore this research could build on known barriers while focusing on wet weather aspects (J. Park & Chowdhury, 2018)

The criterion of people with limited walking ability was replicated from Statistics New Zealand and Office for Disability Issues, which is based off the internationally recognised Washington Set of questions(Office for Disability Issues, 2017; Stats NZ, 2018). The questions ask about someone's ability and function rather than their medical conditions that create limitations. Adopting the disability terminology used by governmental organisations increases ease for policy adoption and provided a subset of population data that could be analysed. People with limited walking ability includes disabled people with physical impairments as well as older people with health concerns that limit their mobility.

2.8.2 Research questions

This research will attempt to answer the following question:

How does wet weather and surface flooding impact urban mobility for people with limited walking ability?

With the following sub-questions:

- What are the experiences of people with limited walking ability to date and what additional journey barriers are created?

Collecting information on past experiences of flooding will be more reliable than asking participants to predict how they might react to flooding. Gaining insights about flooding from people with lived experiences will provide the finer details about the types of barriers and the thresholds for not making a journey.

- What coastal adaptation considerations should be planned for to specifically consider the needs of people with limited walking ability?

The Council is seeking a community led process in adaptation planning, however, it risks having only the loudest voice heard. Disabled people are typically under-represented in engagement processes. Having a foundation of specific adaptation considerations for disabled people may provide insights to target initial questions. It could also lead to a more diverse range of walking abilities being part of the decision-making process.

- How can the negative impacts to urban mobility be mitigated to make journeys resilient to wet weather and surface flooding and provide more equity?

A solution focus will be included to maximize the use of the research by my community partner and other policy makers and practitioners. This question will contribute to forming recommendations for the Council.

3 Methodology

3.1 Approach

The intention of this research was to learn from the experiences of people with physical impairments as well as use it as an opportunity for participants to share their voice with decision-makers and practitioners. The voices of disabled people are often left unheard due to engagement practices not being accessible, and their needs are often overlooked. There is a lack of qualitative research about disabled people in both transport and flooding, yet people with physical impairments are one of the most vulnerable groups to flooding (Gaskin et al., 2017). A qualitative approach was best for this research to get a more holistic perspective as well as being in-line with disability activists' slogan "nothing about us without us", meaning disabled people should be involved in research and decisions regarding accessibility (Boberg & Sherwood-O'Regan, 2021).

A mixed methods approach was taken, using two phases of research. For the first phase, semi-structured interviews were chosen for qualitative data collection. Prior to the interviews, an online survey was distributed to allow people to register their interest to be interviewed. The second phase was designed to add value further to the interviews, which included spatial analysis of age distribution and bus shelter locations. These analyses were dictated by the information gained in the qualitative data collection, creating an element of co-design, and providing some quantitative data to reinforce views of participants. Ethics approval was gained from University of Canterbury Human Ethics Committee and approval from the Ngāi Tahu Consultation and Engagement Group was also gained. The two phases have been written up in two different sections for readability and reflect the order the research was undertaken.

Not only are there many existing transport barriers, but there are systemic barriers that this research is not independent of, such as barriers to employment, stigma against disabled and older people, and racial inequities. This research has attempted to remain focused on barriers to travel from surface flooding and wet weather, and recognises that weather-related travel barriers are one of the many parts to address on the road to equality, and that some of the results described have wider systemic barriers influencing the results.

The age of 65 was used as a threshold of older population in this research as it is common measure of older age throughout research and policy making. It was chosen as a pragmatic measure people with higher risk of having age-related physical impairments. However, people are living longer, which on average is delaying on the onset of age-related illnesses. Only considering the population over 65 may not be fully representative people with mobility challenges, as it does not into account other factors related to aging such as morbidity and remaining life expectancy (Sanderson & Scherbov, 2013; Skirbekk et al., 2019). It also doesn't consider racial differences in health measures, with minorities Māori and Pacifika experiencing shorter life expectancies, age-related illnesses at a young age (Parr-Brownlie et al., 2020). Even though the age of 65 may not be precise, it is still used, acknowledging that turning 65 in Aotearoa may be a significant life change, with increased financial support available, as well as to remain consistent in defining aging with other available information used by policy makers.

3.1.1 Area of study

3.1.1.1 Christchurch, New Zealand

The study area is Christchurch, New Zealand, specifically the coastal adaptation areas specified by Christchurch City Council (see Figure 2. above). These communities are more at risk to flooding and are more likely to have experienced flooding and be able to share past experiences.

Christchurch is a relatively low-lying coastal city causing a wide area to be vulnerable to coastal flooding with more low-lying homes than Auckland and Wellington. After the 2011 – 2012 earthquake sequence, the land subsided increasing relative sea level rise further increasing flood risk (Parliamentary Commissioner for the Environment, 2015).

From the 2018 census, the population of Christchurch City is approximately 369,000 people, with 13% of the population reporting having some difficulty walking and 3% having a lot of difficultly walking although this varies across statistical areas (Stats NZ, 2013a).

Christchurch is a very car-focused city, with New Zealand Household Travel Survey in 2014 finding that 77% of trips in Canterbury were taken with a private car (Ministry of Transport, 2014). Public transport is only used for 2.5% of peak hour journeys in Greater Christchurch (Environment Canterbury, 2018). This high car usage assumes a car-culture where there is a lack of support and funding put into active transport modes.

3.1.1.2 Heathcote and Sumner

The intention was to select an adaptation area to focus on so that results would be directly applicable to one of them as the Council progressed its consultation with different adaptation areas. The boundaries also had the benefit of aligning to census boundaries, making spatial analysis easier. Suburbs were first considered weighing up their demographics of vulnerability, flood risk and prior levels of consultation from Council regarding flooding.

The suburb of Woolston was chosen as an area that has high vulnerability factors based on the vulnerability framework developed by Mason et al (2021) and high rates of limited walking ability as shown in Figure 3 below. The vulnerability factors for all areas within the Coastal Hazards Adaptation Areas is in Appendix A - Vulnerability. Woolston is situated by the Avon River and has had regular flooding in the Canterbury Earthquakes. It was chosen as an area that has not had a lot of consultation regarding coastal hazards and may be less aware of the impacts that coastal hazards will have due to being inland. Most of Woolston is classified as a flood management area in the Christchurch District Plan. The suburb also has a main road (Ferry Road) through the centre, with a small shopping centre and supermarket, potentially providing many services frequently needed. The section of road near the shopping village has recently been upgraded, and should have the latest standards of road design. The main road is also considered a strategic road, providing access to Sumner, Heathcote and Lyttelton.

The Heathcote Coastal Hazard Adaptation Area, containing Woolston, was chosen to focus on. Sumner was also chosen as a secondary area due to having transport links with Heathcote, one main bus route, and because it has a high aging population compared with the other Coastal Hazard Adaptation Areas.

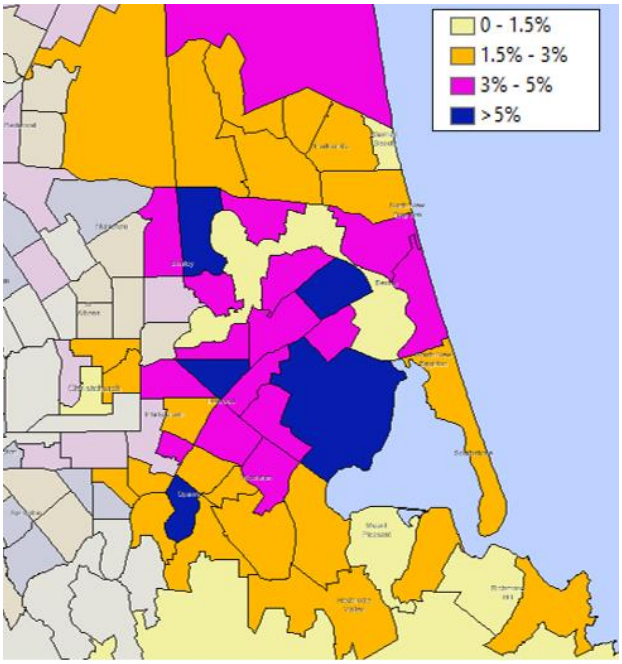


Figure 3. Percentage of population who have a lot of difficulty walking or cannot walk at all in Christchurch's flood prone areas (Stats NZ, 2013a)

3.2 Recruitment

A combination of eligibility criteria and snowball sampling was used to gather participants. Participants had to have a lived experience of having a physical impairment and live in the Christchurch Council District, with preference to those who lived in Eastern suburbs as they were more likely to have experienced surface flooding in their neighbourhoods compared to other parts of the city (Tolich & Davidson, 2018). Snowball sampling was chosen as there was no obvious list of people meeting the criteria, and to allow those who were enthusiastic to share their experiences and who were seeking change, to contribute to the research. This approach has an element of self-selection bias, which is difficult to avoid in interview-based research by the nature of seeking voluntary participation and was considered acceptable as the aim of this research was to seek examples of experiences rather than form a representative sample of the eligible demographic. The bias leaned toward people who were connected in their community, willing to share potentially vulnerable stories and who had time and energy to advocate for themselves, including being proactive to fill out the survey or contact the researcher. The approach to advertise to potential participants was chosen as balance between the time available to conduct the research compared with the time required to recruit a wide range of participants. The nature of the research topic meant that those who face the most travel barriers and resulting systemic barriers will have been excluded from this study, however, the interviews conducted are intended to be an initial exploration. It is hoped to be one of many studies in efforts address in accessibility (Robinson, 2014).

The organisations approached for referral were either Woolston-based, older persons oriented or disability advocacy oriented. Additionally, the poster was advertised in Woolston-based Facebook groups and posters were displayed in public areas, such as the Ferry Rd New World supermarket and community notice board. Although this study focused on nuisance flooding with its own definitions, the term 'surface flooding' was used in lieu of 'nuisance flooding' when engaging with externals, especially research participants, as surface flooding is a better known and relatable term.

The poster and each emailed organisation was given a unique web address to the survey to gain an indication of where referrals snowballed from. The poster was included in all recruitment emails as a simplified visual advertisement. Participants heard about the research from either the Disabled Persons Assembly, sharing of the poster or word of mouth from other participants.

A Qualtrics survey was used to assist with the recruitment of participants. The purpose of the survey was two-fold, firstly to simplify the recruitment process, allowing people to register their interest to be interviewed at a time that suited them, capturing all the required information about the participants. Secondly, if a large number of people expressed interest, the criteria of participants could be adjusted based on the scale of interest, such as residential location. The survey took 1 – 5 minutes to complete, and covered questions relating to ability to travel and independence, which gave indications of commonalities to determine suitability to pair or group participants into group interviews. The survey data was only used for organising the interviews and personal context ahead of the interviews.

3.3 Interview research design

The study group of people with physical impairments is incredibly diverse and it was important to gain rich contextual data. Semi-structured interviews enabled certain topics to be covered and also enabled the flexibility of people sharing their opinions and experiences in an order that was more natural to a conversation (Hay, 2016). An interview guide was used (Appendix B) and covered the themes of: destinations frequented and travel modes, experiences travelling in rainfall/wet streets, and mitigations to rainfall/wet streets as dictated by the research questions. This interview guide was adjusted after analysing each interview. This continual development had the advantage of reflecting and designing better and more targeted interview questions, resulting in some interviews building off each other.

The interviews were conducted in both public spaces and private homes, wherever the participant felt most comfortable, especially with the topic of study being travel barriers. Most participants chose to be interviewed individually, some in pairs with someone they were close with, and one interview took place as a group of five as they all lived at one residential facility. Interviews typically took one-hour and time was allowed for building a rapport; however, most participants were eager to describe their experiences about travelling in the rain, with surface flooding. Participants were given the opportunity to choose an alias to be represented by.

Prior to the interviews, participants were sent the information sheet and a list of themes that they would be asked about, to allow participants to have more time to recall their experiences and prepare what they most wanted to highlight. Fortunately, most interviews occurred within a month after July 2022, which was a month that with many days of heavy rain, making recall of experiences easier. Prompts were sometimes given as an aided recall technique to get fuller experiences, to help participants provide relevant responses from their memory (Tolich & Davidson, 2018). Questions were designed to focus on past experiences and elicit anecdotes to build a more personal picture. This also had the advantage of focusing on past events that were stories able to be re-told, as opposed to asking about future scenarios, which may be difficult for participants to forecast and may not happen.

Interviews were audio recorded on a personal communication device, and notes were taken during the interview. Written consent was gained prior to the interviews. A koha of $20 was offered as a gift for contributing to the research.

3.3.1 Interview analysis

After each interview, detailed notes were taken from the interviews and the audio recordings, using a framework based on the interview guide. The framework was organised by the themes from the interview guide and allowed for themes to be seen across each participant. Framework analysis has similarities to thematic analysis, in that it is used to find themes, but also has the advantage of having a systematic approach and provides some transparency of the development of the themes which thematic analysis is sometimes critiqued for (Parkinson et al., 2016). As more data was collected, sub-themes emerged and the interview guide was adapted to form Two-directional data analysis as described by Tolich & Davidson (2018), where sub-themes shaped prompts and questions for further interviews.

3.4 Spatial analysis design

Three spatial analyses were conducted following interviews. The spatial analysis was to add quantitative elements with the types of analysis based off a theme in the interviews. Firstly, the distribution of aging populations was assessed to understand where there may be greater populations of older people experiencing the barriers described by participants. Secondly, a common theme that came through in the interviews was the desire for more shelter along journeys. As bus patronage data and bus shelter data was relatively easy to access in Ōtautahi, an analysis was conducted to assess what impact rainfall has on bus patronage and whether there is any relationship to sheltered bus stops. Lastly, an analysis was conducted to assess how equitable the locations of bus shelters were and if they were located in areas where there is more likely to be disabled and older people, who may have less choice in transport option and are more significantly impacted by rain on their journey.

3.4.1 Aging dynamics

With Aotearoa's aging population, an increasing portion of the population may have age-related health concerns and difficulty walking, impacting ability to travel. Bulvic et al. (2018) demonstrate that American retirees are attracted to coastal areas, which are prone to issues caused by sea level rise and surface flooding. This research sought to understand the distribution of older population in Ōtautahi, including understanding where there has been the most recent growth of older populations, with focus on the adaptation areas.

The distribution of older population was assessed from the 2006 and 2018 census. This was defined as the percentage of population over 65 in each Statistical Area 2 (SA2) in Ōtautahi district (Bukvic et al., 2018). Data was categorised into the age structures defined in Table 1. In population statistics, an area is considered to be 'young' if it has lower amount of older populations and likewise, 'aged' if it has high amounts of older people (Xie et al., 2016).

Table 1. Age Structure Definitions

Age Structure	Distribution of older population
Young	<4%
Adult	4-7%
Aged	7-15%
Super-Aged	>15%

The growth rate was measured by comparing the distribution of older people between 2006 and 2018. The percentage change of the proportion of the population over 65 was calculated for each SA2 area.

3.4.2 Rainfall, bus shelters & bus patronage

This analysis aimed to quantify the impact of the availability of bus shelters on bus patronage on rainy days. The Greater Christchurch Public Transport Futures Combined Business Cases document was commissioned and endorsed by Environment Canterbury and the partnering district councils in December 2020, and guides Christchurch City Council's placement of shelters (Boffa Miskell, 2020). Patronage is a large factor in determining the location of bus shelters. Alternatively, shelters are commissioned by an advertising company, which drives shelters to be placed where advertisements can be seen, typically where there is a high flow of cars to maximise sightings, which is contradictory to encouraging pedestrian friendly streets and walking to bus stops.

The bus stops analysed were all in the Heathcote and Sumner adaptation areas. Heathcote has 16% (n=309) sheltered stops and Sumner has 12% (n=154) sheltered stops. Figure 4 shows the bus stops in the area and Table 2 provides details about the routes included.

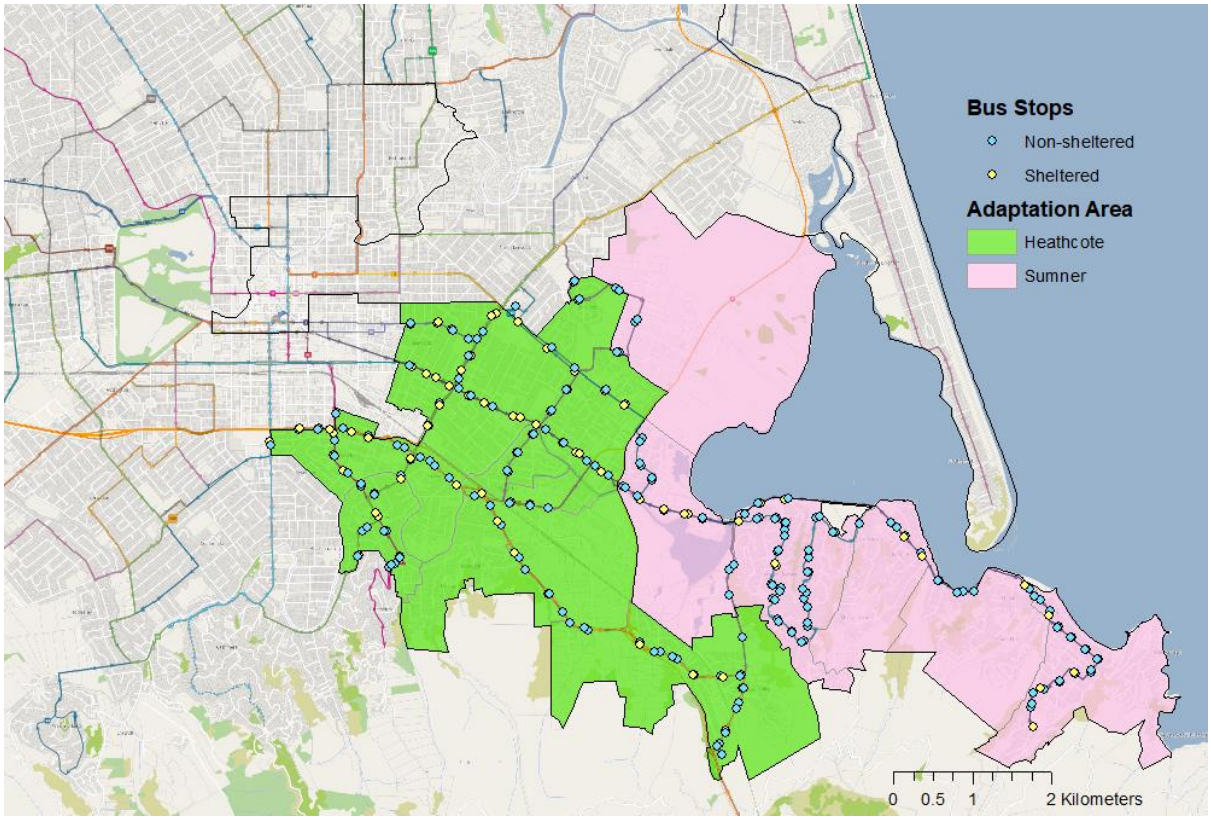


Figure 4. Heathcote and Sumner Area bus stops

Table 2. Bus Routes and Stops in the Heathcote & Sumner Area

	Core Route	Frequency	Sheltered	Non-sheltered
Route 3	Yes	10 – 15 mins	29	46
Route 140	No	30 minutes	21	53
Route 80	No	15 – 30 minutes	3	8
Route 155	No	Three times per day	8	44
Route 28	Yes	20 – 30 minutes	12	39
Route 17	No	20 – 30 minutes	5	13
Orbiter Route	No	15 minutes	12	11

Daily patronage for each stop was collected from Environment Canterbury, by route and fare type. The data available was from 01 July 2021 to 30 September (465 days). The bus stop data was sourced from Christchurch City Council (CCC) and included whether stops had a shelter and were on a core route. Shelter was used as a binary variable that equalled one if a bus shelter was present and zero otherwise. Bus shelter locations were confirmed by sighting the stops for the Heathcote and Sumner areas. Two bus stops[1] did not have bus shelter infrastructure, however, were considered to be sheltered due to the bus stops being outside a building with a seat providing a similar level of shelter that would be provided by a bus shelter. There were other stops that had shelter from the surrounding built environment but were not considered to have the same level of shelter, although this may have influenced the shelter variable.

Hourly rainfall data was collected from the National Institute of Water and Atmospheric Research (NIWA) for the Heathcote Rain Gauge[2] which was closest to the area of study. The rainfall from each was totalled for the hours between 6am – 6pm, the time that is expected to most influence daily travel. Days were then categorised into dry, rainy, and wet following meteorological definitions, below in Table 3 (Trenberth & Zhang, 2018). A categorical variable was used as it was predicted that bus users would not be able to feel the difference of rain in 0.2m measurements, however, a day with minimal rain may influence behaviour less than heavy rain.

Table 3. Categories of Rain Days (Trenberth & Zhang, 2018)

Rain Label	Rain Recorded
Dry	0mm
Rain	≥ 0.2mm and < 1mm
Wet	≥ 1mm

Weekends were factored for as the bus patronage was significantly less on the weekends, as well as rain is known to have greater impact on weekends when more people are undertaking trips for leisure and may have more flexibility in undertaking the journey (Chung et al., 2005). Similarly, over the study period, other factors that would have reduced patronage were considered, including public holidays and school holidays. Covid-19 lockdown periods (level 3 & 4) were excluded.

[1] Stop 42583 (Main Rd near Augusta St) and Stop 42554 (Wakefield Ave near Nayland St), from Sumner area.
[2] Site 325619 Tunnel Road, Heathcote (Latitude: -43.5551338, Longitude: 172.69169451)

Outliers were considered by reviewing box plots for each stop. Any patronage data point that was 1.5 times above the interquartile range was labelled an outlier considered for exclusion, however, no outliers were excluded.

The rainy-day ratio was the difference between average patronage on rainy days and dry days normalised by the average dry day patronage. Similarly, the wet-day ratio was measured in the same way, using average patronage on wet days. Relationships were sought for the shelter variable and the rainy-day and wet-day ratios and factored for weekends.

A variable was created to categorise stops by their patronage levels as busier stops are more likely to have shelter. The average patronage was calculated for each stop (regardless of route), then thresholds were created based off Jenks natural breaks classification method with categories listed in Table 4. Stops that had a busyness label of 'very low' were excluded as the stops had much greater variability in patronage and the low patronage caused the ratios to be disproportionate. Similarly, it was intended to repeat this process with patronage of gold card users, however, the overall low patronage of gold card users also skewed ratios and was not used.

Table 4. Categories of Stop Busyness

Busyness Category	Average Daily Patronage
Very Low	<3
Low	3 – 9.9
Medium	10 -24.9
High	25-59.9
Very High	≥60

3.4.3 Availability of Ōtautahi bus stops

The intention of this method was to study if there is inequity in the placement of bus shelters in Ōtautahi. It is expected that areas with a high deprivation index may be more reliant on public transport networks, with higher patronage and therefore to have an equitable network, there should be better infrastructure in those areas.

Christchurch City District bus stops were joined to statistical area 1 (SA1 area). A buffer radius of 200m around each bus stop point was used as the most appropriate distance for walking to a bus stop is typically considered to be 400m (El-Geneidy et al., 2014; Waka Kotahi NZ Transport Agency, n.d.-a). However, 400m is considered for the overall population, and people with mobility impairment typically cannot walk as far, so this number was halved to 200m. SA1 areas have a target population of 100 – 200 and the SA1 layer was chosen as the finest area to reduce over estimation of the population that can reach the bus stop.

Population data was sourced from the 2018 census data and deprivation index information was sourced from Environmental Health Intelligence New Zealand (EHINZ)(Salmond & Crampton, 2012). SA1 areas not classified to be in a "Major urban area" by the Statistics New Zealand urban rural classification 2018 were excluded (such as areas in Banks Peninsula) as they are likely harder to reach by the bus network and had large SA1 areas, which could distort population-based results. SA1 areas with population densities below 135 people per meters-squared based off a visual scan of the types of land uses in areas were also excluded for the same reason.

Stops with a daily average patronage greater than 30 were excluded, so that they did not disproportionally reflect higher patronage in different SA1 categories. The daily patronage of 30 was selected as it was 1.5 times above the interquartile range of all the stops. The high patronage stops are also more likely to have been bus transfers or be a cluster of return journeys.

The number of stops in each deprivation index was measured and normalised by the summation of the population for each deprivation index area. The total counts were split into three bus stop infrastructure types: shelter, seat, and stop only. A stop that intercepted two SA1 areas of the same category was only counted once, however, it was counted multiple times if it intercepted multiple SA1 areas of different categories.

The total patronage from all stops in the SA1 category was calculated and normalised by the total number of stops in the SA1 category.

4 Results

4.1 Interview results

A set of 10 interviews were conducted, all face-to-face, with a total of 16 participants as some interviews were conducted in pairs. Nine participants were female and seven were male, with six wheelchair users, two people who relied on crutches to walk, four were older participants, and two Māori males. Four participants lived alone, and six participants referred to being employed, as well as one person attending regular vocational training. There are extensive transport barriers for people with mobility impairments even when the streets are dry and on days without rain. Many of the results indicated that wet weather amplifies the challenges that urban inaccessibility has created. Due to typical barriers being more difficult on wet days, people have additional considerations when making journeys on wet days.

4.1.1 Barriers discouraging leaving (trips not made)

In this section, barriers that participants pointed out that discourage them from leaving the house are identified. The following section highlights in more detail the barriers that people described when out and about.

4.1.1.1 Journey planning & energy

For some people, especially non-car-based journeys, journey planning can be extensive and exhausting (two participants likened their journey planning to planning military operations). Planning may include things such as finding the times of buses, where accessible toilets are, if a building is accessible, expected capacity of energy, and so on. Participants all described the planning and executing of a journey in wet weather to be much harder. On rainy days, people with mobility impairments have additional planning burdens such as considering if there will there be shelter at the bus stop, whether the route will have surface flooding, what to do if they miss the bus because of the rain, where they can park, if they need to carry a raincoat, where the available accessible toilets are. For some participants, this increased load of journey planning prevented them leaving their home.

Disabled and older people may have reduced mental and physical energy capacity (sometimes referred to as spoons) than an average non-disabled person to carry out their everyday tasks. This is due to both additional environmental barriers and their own individual limitations. Participants described that they needed to plan the practical aspects of travel, as well as how much energy they can use on a journey without exhausting themselves. Becoming stranded or taking subsequent days to recover was a concern. The uncertainty and disruption that rain can cause requires more energy to be consumed in planning as well a greater margin allowed for if an unexpected event was to occur due to the rain. This uncertainty can compromise the activities planned, require more recovery time after a journey and reduce the likelihood of making the trip at all. Some people navigated this by seizing opportunities to go out when paths were dry if they had a flexible schedule.

Wet weather can be a nuisance for anyone, and can prevent journeys from happening. This is especially the case for those without access to a car where the impact of wet weather is much greater, resulting in a lower threshold to not make a journey. Participants who were able to drive, confirmed the convenience of the car as they appeared to cancel their journeys less often and travelled greater distances to their choice of activity.

Ramie is a wheelchair user who likes painting and horse riding and also uses the bus regularly. She will try to factor in possibilities of the bus being slightly delayed, but it is difficult to plan for all situations, and finds she has more chance of being delayed on rainy days. This can be from the bus being delayed due additional traffic congestion on rainy days, having to detour around surface flooding getting to the bus stop, or her inability to get off at a particular stop due to surface flooding. She hates the feeling of being unreliable and finds it difficult to commit to meeting friends or meeting at a particular time, with the problem exacerbated by less frequent buses.

4.1.1.2 Wanting to avoid getting wet

Some participants expressed reluctance to go out on wet days to avoid getting wet. Where others may be able to carry a change of clothes or move around to assist in the drying of damp clothes, participants didn't want to get wet as they would not be able to get themselves dry again. Reasons for not wanting to get wet also included requiring another person's help to change clothes, requiring special equipment that was only available at home, or it being impractical to find a place to change clothes. If they got wet, they would remain in wet clothes for the duration of their time away from home or until their next support worker's visit. Some participants also described not being able to hold an umbrella or wear a raincoat, feeling more exposed to wet weather.

For Mr B who has a strong sense of humour and uses a powerchair, getting to work on-time is important to him. He has designed his life to live a 10-minute wheel from his workplace where he works full-time. When it rains, puddles of water form in the drains, blocking some of his usual route, which means he needs to find alternative kerb cuts, making the journey longer, and potentially being exposed longer to the rain. He cannot get changed at work and described the discomfort of his seat cushion absorbing water, that he has to remain in for the rest of the day.

Participants felt that they were more prone to getting wet than non-disabled people, explaining they moved slower and therefore spent more time in the rain while others felt that in a seated position, they got wetter more quickly as water pooled on them. When wet, it dampened their enjoyment of the activity and sometimes had follow-on consequences such as fear of becoming sick.

> *"Because even just going into the mall while you're wet, it's uncomfortable. You know if you're nice and warm and dry, you can enjoy your time because it's socialisation, just going to the mall. It's like meeting people and being part of the community. But if you are wet, you're just a sad sack on a set of wheels. Just want to yell at the shopkeeper. The shopkeeper says good morning, you go, 'yea whatever!'"*
> *- Henri*

Henri, a wheelchair user and a good sense of humour, highlighted that older and disabled people often have lower immunity, and concern about getting sick from the cold was a factor in making a journey. Additionally, he pointed out that being wet and cold can make people need to urinate more. He considers if there will be accessible bathrooms available on his journey if he becomes desperate, however, he does not like to use accessible bathrooms as they are not always clean and his wheels collects the germs, transferring them to his hands, requiring extra cleaning of both. This is also a concern for him navigating the wet streets, with his wheels collecting more dirt on wet days.

People were aware that the equipment they are dependent on needed more maintenance when used in wet or muddy conditions. This didn't necessarily prevent them going out but caused them caution to how they used their equipment.

For Mr B, he cannot move around without his wheelchair, including at home. He highlighted that using his wheelchair on wet days, causes extra wear with the dirt and corrosion to the mechanics of his powerchair. This is a concern for him, as the wheelchair repairers he has used work business hours (they may be available after hours at an extra cost), and if his powerchair was to break down in a weekend, he may not be able to move until it was repaired.

4.1.1.3 Role and power of support workers

Poor weather makes it difficult for the main traveller(s) as well as anyone they are dependent on to get places. Participants described situations where an individual wanted to go out, however, the support person made the decision not to go due to weather, as they felt it would be too challenging, consume most of the time preparing for the rain and easier to go on a fine day (and possibly the support worker not wanting to be soaked the rest of their shift). Some of the additional planning burden for travelling is placed on the support workers or caregivers, which creates a barrier for individuals, and can be particularly problematic when there is typically a power dynamic between a support worker and the individual, where the support worker has the power to remove choice in making an outing. This can reduce autonomy and independence of individuals. Similarly, a participant described concern about how support workers can have the best intentions to protect individuals by preventing them doing activities such as going out into the cold and rain; however, this can also stop people learning the consequences (and the joy) of the rain or surface flooding, missing the opportunity to enhance autonomy and make decisions for themselves.

For Anna & Elsa, who are sisters who love the movie Frozen and lead very social lives, when travelling via taxi and private vehicle to their regular destinations (including: dance classes, church, vocational training, swimming and family events), they rely on support from others to enable them to do so. When it is wet or raining, planning becomes more difficult for their family and support workers, and it becomes easier to cancel activities. Increased information for journey planning and where surface flooding is, would be useful for them.

> *"I think you just don't go, because with a wheelchair, it has to be known, it has to be... you have to know where you're going and you have to know what your circumstances are, you have to know that the parking is okay. And that you're going to get inside without getting too wet and if there's too many uncertainties and unpredictability that makes it difficult." - Iduna*

One participant spoke proudly about their support worker's agency. He highlighted how much he enjoyed having one support worker assigned to him, rather than a rostered support worker. He has been able to build a good relationship with the chosen support worker and with the trust created, his support worker better understands his limits and can provide more tailored support to him. This strong relationship reduces some of the power imbalance between support worker and individuals, in deciding what's best for the individual.

> *"People have gotta listen to the user, because the user knows ae. They know what toilets they can use. They know how to get from this point over to that point. And when people try and change the user's mind, it's like, a mother telling a child what to do." – Henri*

A lifetime of having others decide what is achievable for you can take a toll.

> *"So there's a lot of education people out there that people don't know about and like me, I didn't. I haven't even been able to drive until this year. I'm 49. That's because,*

well, growing up being a teenager and that, everyone's like, nah you can't drive and then put in there that you can't do it so you don't go looking for avenues that can help you because everyone's told you that you can't. So, you start just to believe it and then it's just hard to get away from it." - Lee

4.1.1.4 Fear of falling or injury

Participants had an increased fear of falling when there was water on the streets, whether it was from slippery surfaces, water directing them to walk on uneven or less sturdy surfaces such as wet grass, or not being able to see where the edge of the kerb was beneath water which was a particular concern for wheelchair users.

McAuley, is a retired gentleman, who moved to Ōtautahi to be closer to his grandkids. He uses the activity of walking to keep healthy and recently had knee surgery. Prior to the surgery, he found himself prone to tripping due to his knee having reduced agility and was aware that if he did fall, his recovery may be slow. It didn't prevent him going places, but he's much more reassured post-surgery.

Some participants had a disability that made them prone to being more easily injured if they were to fall. They described the more difficult decision of whether to make a journey on wet streets when there was a greater risk to them if they fell, knowing that if they became injured, they would likely become more isolated when less mobile. Others also had worsened their permanent disability from a fall on the streets and were personally very aware of the consequences of another injury. Wheelchair users also highlighted the inaccessibility of ambulances, fearing that if they were to need emergency healthcare transport from a fall on the streets, the ambulance may not be able to take their wheelchair/power chair reducing their mobility while in hospital, or needing to make their own way to a hospital. The fear of the consequences of an injury from falling is another consideration of whether to make a journey on wet streets.

For Amy and Mr B, who both use wheelchairs, if one of them needs an ambulance, the other cannot go with them due to the ambulance not being accessible to their chairs and would have to plan to transport themselves independently. They do not have a vehicle, wheelchair taxis are typically unavailable impromptuly, especially out of business hours, leaving them to find a bus to the hospital or asking a favour from a friend who has a wheelchair van.

When a participant was asked if there is a connection between social anxiety and wet weather, they highlighted that there is a greater fear of loss of dignity from a fall.

"It does because you're falling over, and you don't want to fall over and hurt yourself in public. That's just humiliating … I'm very weary if I do have to go out in the wet weather, or any sort of weather but yeah you don't want to just fall in public and sort of make a scene, we like to stay under the radar sort of."- Lee

4.1.1.5 Unexpected barriers

People described events where the presence of water on streets created unexpected events which significantly disrupted their journey. Surface water meant a detour, resulting in becoming wet or having to return home. These unexpected disruptions have a dampening effect on the desire to go out. People highlighted if there were major barriers last time, they were reluctant to make a similar journey in similar conditions. The not-knowing what barriers they may come across, which are more sporadic on a wet day, can sometimes discourage them from making a journey.

4.1.2 Barriers when out

Many of the barriers described in this section are as a result of other non-weather-related barriers, where wet streets and poor weather worsen the barriers. Examples included potholes in footpaths, limited kerb cuts, footpath obstacles, lack of taxi availability and lack of mobility parking with appropriate kerb cuts. This section describes the barriers related to ground surfaces, using the bus and driving or using taxis.

4.1.2.1 Ground related

The presence of water on the streets in the form of puddles and full drains was a barrier for all participants. Participants highlighted that the excess water tends to make the potholes worse, making the trip hazard worse in dry conditions. Footpaths are commonly cluttered with obstacles, such as rubbish bins, sandwich boards, and e-scooters. Puddles add to the cumulative footpath barriers as shown in Figure 5 and Figure 6. Deep puddles are particularly a problem, as people are unsure of their depth, and for power chairs and mobility scooters, the water depth has the potential to be greater than the height of the electronics, causing doubt whether to transverse through the water. Water tends to be a journey barrier that is unforeseen, unless the route is very familiar.

> *"I like to use them [the electronics of his wheelchair] for mobility, not electrical punishment." – Mr B*

Figure 5. Example of cumulative barriers at a designated crossing point, puddles and rubbish bins.

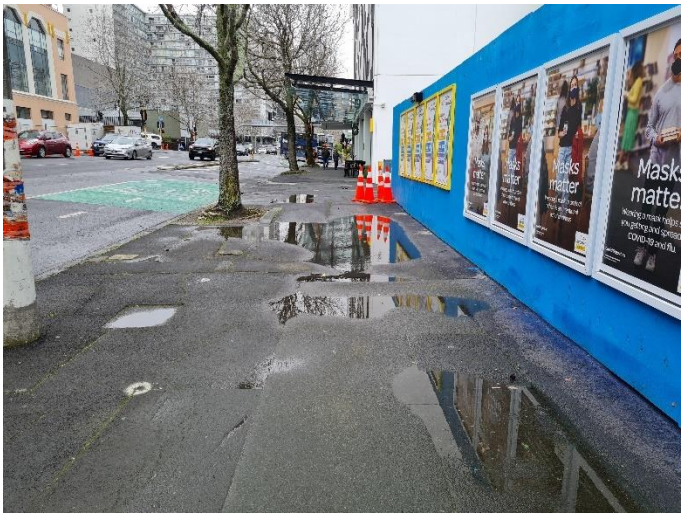


Figure 6. An uneven surface that has cumulated water.

When drains overflow, some participants described being unable to make larger steps over the water in the drain, which made crossing the road more difficult. A wheelchair user highlighted that when a kerb cut fills with water, it limits their options for choosing where to cross a street and may cause them to detour an extra few hundred metres in order to cross the road, which on a rainy day adds more time spent in the wet and cold. Additionally, sometimes the kerb cuts at the designated crossings with median waiting points become blocked and people need to cross at less safe points when they may be slower or have less control of their speed than the average person. Other participants shared their dislike for puddles because of the splashes created by cars onto pedestrian areas. Being less mobile, they have time to spring out of the way.

Henri, using a manual wheelchair, described concern about being unable to see the edge of the footpath in a puddle, and concern for falling off the edge. When this happened previously, he was reliant on a stranger's help to get up and used humour to cover up his loss of dignity.

The impact of water stretches beyond footpaths as a number of participants expressed concern for the slipperiness of busy entrances, such as at malls and supermarkets (and later discussed bus entrances). The high traffic of people bringing in water creates slippery surfaces.

A singular puddle may seem insignificant, but for participants, there were barriers that would sometimes cause long detours. If they did not have capacity to cope with the disruption to their journey, it would cause them to return home. Figure 7 shows an example of surface flooding would be daunting for most disabled and older people.

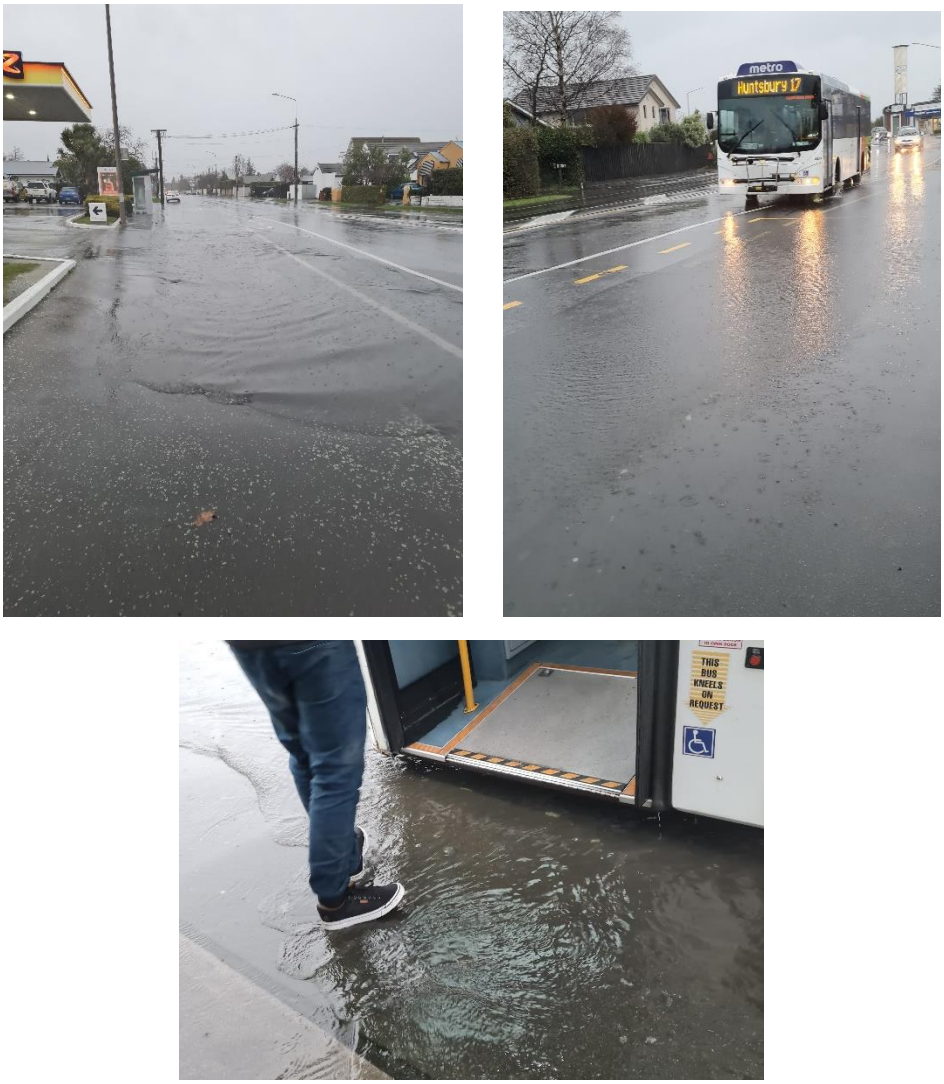


Figure 7. Example of surface flooding at a bus stop that a bus can drive through but a pedestrian may find it difficult to walk through or get on and off the bus, from July 2022 Ōtautahi flooding

4.1.2.2 Bus related

Even with lots of attempts to improve, buses tend to be known for their inaccessibility. Participants described why they do not catch the bus in general including because of the steep ramp angle, inability to secure a wheelchair, and the vibrations of the bus. However, this section focuses on the barriers related to using the bus in wet weather.

4.1.2.2.1 Lack of shelter

Availability of sheltered bus stops was mentioned by nearly all bus users as a factor determining whether they would take the bus on a rainy day. If their required route didn't have a shelter on a day with rain, they were more likely to forgo the trip. Alternatively, if they had choice in a route, they would walk slightly longer to a route with a bus shelter. This preference was also apparent because of uncertainty if the bus was going to arrive on time, and shelter would make the wait more tolerable.

> *"That'd be a luxury while you're waiting [to have a sheltered bus stop], and especially when you're in a chair, you get more wet because you're sitting down." - Ramie*

4.1.2.2.2 Floor slipperiness

Participants described the bus floors as being very slippery on wet days. The floor becomes wet through others walking in with wet shoes as shown in Figure 8. Example of a bus with a slippery floor. Slipping on the bus was a big concern for someone who uses crutches for stability, and another participant highlighted that their powerchair sometimes struggled to make the ninety degree right turn when getting on the bus after paying.

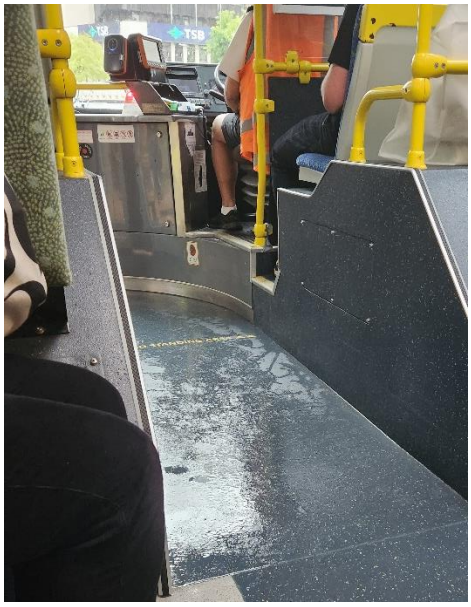


Figure 8. Example of a bus with a slippery floor

4.1.2.2.3 Signalling the driver

The requirement to signal (wave down) is a barrier for some participants on any day, however, in the presence of poor weather, people felt they were less likely to be seen with the bus drivers having reduced visibility. Numerous participants named times that the bus they needed drove past them, leaving them waiting for the next bus, often 30 minutes later, making for an uncomfortable wait in poor weather.

4.1.2.2.4 Stigma from bus drivers

Participants had lots of positive things to say about Canterbury's bus drivers, including being helpful and taking time to assist with their needs. However, participants also had stories about feeling they were a burden and being misunderstood in their needs. On wet days, participants were sometimes more likely to need assistance, such as needing a ramp to avoid a big step over a puddle. People who have invisible (or less obvious) disabilities had been quickly dismissed when seeking assistance. Sometimes participants didn't make the effort ask for help so they didn't feel they were a burden, even if it caused the journey to be more painful. One participant described having limited energy most days, and that they regularly face decisions between advocating for themselves or spending that energy elsewhere in the day. Discomfort leads to asking for accommodations less, making journeys more effortful, and eventually not making the journey.

> *"It's hard to have to explain when you've got invisible disabilities. Having to explain yourself is a drag. So, I just put myself through pain just to avoid the confrontation." - Ang*

4.1.2.3 Driving related including taxis

For those who can afford a taxi, taxis may mitigate some of the additional challenges created by rain, however, participants described a number of challenges using taxis or driving themselves as well.

4.1.2.3.1 Taxis not available on demand

Taxis have the advantage of taking passengers more directly between destinations. When asked about using taxis on rainy days, participants described difficulty in booking a wheelchair taxi unless it was booked at least a few days prior, removing taxis as a backup option or because of a change in circumstance, such as weather or lower energy. Some participants were able to sometimes negotiate some flexibility in a pickup time, if they were unsure how long they wanted to be out, such as when at a social occasion, but not having this flexibility results in a loss of autonomy.

Participants sometimes overcame this challenge by building personal relationship with drivers of wheelchair vans (including taxi drivers) or contacting them directly. Requesting a taxi to go to work at a similar time to a school commute was described as near impossible. This was also the case in evenings, which is also when the buses become less frequent, making social events hard to attend.

Due to the limited availability of wheelchair taxis, Mr B wakes early to check the weather forecast, and calls upon the taxi drivers he has built relationships with to see if they can take him to work. Taxi companies also tend to reduce the priority of his trip because it is a short trip, disregarding how important the trip is to him. He can work remotely if desired, however, he prefers to separate work from home, and is also in a customer facing role, and finds customers are more pleasant when face-to-face.

4.1.2.3.2 Shelter & transfer time

Unless parking in a large underground or multi-storey carpark, carparks (mobility or otherwise), rarely have shelter. For wheelchair users especially, participants described how transferring in and out of a vehicle often takes longer than a non-disabled person, resulting in more stationary time in direct rain. Many wheelchair vans have hoists which lower and raise wheelchairs in and out. One participant timed themselves with the transfer taking them approximately two minutes to get in and out of a rear hoist van, compared with a non-disabled person that would take less than ten seconds. They expressed gratitude to the taxi drivers that get the hoist ready while they are under shelter, resulting in less time in the rain. However, sometimes people have support workers who operate the vehicles, and if they are more likely to spend time in direct rain, they may also have the decision-making ability to discourage making the trip. This was one of the reasons that malls are attractive to participants, reducing the number of vehicle transfers due to the co-location of shops, and having the large carparks with shelter.

> *"Because as a wheelchair user you're a bit more vulnerable because you haven't any protection. You've either got to wear lots of gear or you've got to, you can't carry an umbrella really and as she's getting into the vehicle, and that takes time, it's raining." - Iduna*

4.1.2.3.3 Poor availability of mobility parking

Finding a mobility park can be difficult as they are not at all destinations and if taxiing, participants described using loading bays or parking illegally on rainy days to be dropped off (and picked up) close to their destination, hoping not to be fined while doing so. Additionally, not all mobility carparks are suitable for all wheelchair accessible vehicles, further limiting the availability of mobility parking.

Rebel Wilson loves jet-skiing, drinking wine, spending time with friends and family and uses a wheelchair. She owns her own vehicle that she can drive and is often driving people to destinations for her work. She points out that even if mobility parking is present (and not being abused), not all mobility parks are suitable for all wheelchair accessible vehicles as some use side entry (left and right) and some have rear entry, i.e., a parallel park is not suitable for rear entry vehicles. The lack of options for carparking means that she spends more time searching for a carpark, sometimes having to park much further away from the entrance to their destination or giving up looking, spending more time in the rain when out of the vehicle.

One participant expressed concern at the rise of other designated carparks such as parks for electric vehicles and parent/caregiver parks, feeling that they were being placed close to entrances, potentially competing for mobility parks.

Adding to the lack of usable mobility parking, many participants also described at least one carpark situation where there was not a suitable kerb cut near the carpark. This meant that if they exited their vehicle onto the road, they had to travel an excessive distance on the road to get on the footpath. Not only is this a safety risk but it lengthens the time spent in the rain.

4.1.2.3.4 Reactions times and visibility

An older driver expressed some avoidance for driving in the rain because of reduced visibility, especially at night, where important aspects such as street markings became harder to see. He also knew his reaction times weren't as quick as his younger self and was worried that if he needed to stop quickly, the slipperiness of the road would reduce his stopping time even further. Conversely, many participants who are regularly pedestrians, expressed concern being on the road side on rainy days, feeling that they were less visible, that drivers would be less able to stop quickly and potentially distracted by driving in the rain, especially if there was more traffic, creating more chaotic driving patterns and a greater chance of being hit.

4.1.3 Impacts of wet weather barriers

4.1.3.1 Loss of independence

Some of the barriers listed above may be easier when accompanied by another person or create a need for assistance, such as having someone else drive somewhere, assistance using the slippery bus, or avoiding puddles, however, this creates a loss of independence, something that is important to all participants. The way that participants described various barriers, demonstrated that in their lives they are constantly adapting to the world around them, and many had an element of acceptance of the reality of living with regular barriers.

Participants highlighted that poor experiences shaped their choice of future journeys.

Amy is a wheelchair user who loves her two dogs and used to own a wheelchair accessible vehicle. She sold the vehicle because it was too cumbersome organising someone else to drive it (she either needed to go with someone somewhere or have them drop her off and pick her up later) and the ownership costs outweighed the benefit of having it. She now uses taxis mostly but is starting to gain more confidence in the buses. It had been years in between of not taking the bus after some bad experiences. She was not aware of improvements in accessibility of the bus until a friend encouraged her to try again. She remarked how she could have saved so much money knowing that the bus had improved its accessibility and wants to see the return of open days that allow people to try and explore the bus without pressure.

4.1.3.2 Implication to mental health

The increased barriers faced mean that more people may choose to not go out or may be restricted to be isolated at home. These restrictions, especially with trips related to wellbeing not being undertaken reduces people's livelihoods and is detrimental to mental health. People described the frustration of being stuck at home as unpleasant and lonely, and acknowledged it becomes harder to reach out to others when in a low mental state.

Castle stated walking as his favourite hobby and regularly goes for walks with a friend. Walking is a way of keeping healthy for him, and a management technique for his diabetes. Therefore, not going for walks not only impacts his mental health, but also his physical health.

Participants described being less likely to go out on rainy days, and for some participants they choose to stay inside because it was easier.

Lee, who regularly bakes bread, enjoys spending time with his children and uses crutches to walk, described how home can become a place of comfort, and for them, they sometime prefer to stay home because it's easier and not anxiety inducing. However, they also described that the more they stay in their comfort zone, the harder it is to leave, and sometimes risk falling into a spiral of comfort, and the number of places they feel comfortable going shrinks. They described the anxiety threshold to make a new trip becomes even harder.

A number of people had support systems helping them with their daily lives, such as support workers regularly visiting homes or living in residential care facilities. This indicated that these individuals would likely have support to get their essential needs if they were unable to leave the home (acknowledging striving for independence is always a strong aim). While this reduces the impact of not being able to leave the home, it does not address the fact that people need to leave the home in order to maintain good mental health and wellbeing.

There were mixed levels of community resilience surrounding the participants. Those who lived on their own preferred to make-do than feel like a burden asking for help. One participant was disappointed that during the heavy rains of July 2022 no one knocked on his door to see if he needed anything, even though he knew his neighbours. Heart-warmingly, another participant who lived within walking distance of a supermarket, had been noticed by a supermarket employee. The employee gave their phone number instructing to call if they needed anything and the participant indicated preference to ask for that help over family connections.

> *"I'm afraid of this flooding. Like, two weeks ago, I think we had a lot quite a bit of flooding and rain. Yeah. And everyone was looking after themselves. I didn't have one knock on the door to ask if I was alright or needed something. No, no one came, no one at all." - Henri*

4.1.4 Important destinations

4.1.4.1 Social and recreation

Trips that supported wellbeing were important to participants. When asked which destinations they frequented, people most commonly described places where they could connect with the natural environment or socialise. Nature-based destinations included visiting Ihutai (Avon-Heathcote estuary), horse riding, the New Brighton Coast and walking in the red zone. Several participants also described the enjoyment of taking the bus to explore the city, some highlighting that it was very cheap to be able to go so far.

Most participants emphasised the importance to them of getting out of the house and interacting with others. Some social activities were very organised, such as dance classes, vocational training, and painting classes, while others were more casual such as going for walks with friends, meeting for coffee and busing to Kaiapoi to deliver baking.

These nature-based and social events are essential to people, even though they may be considered less essential compared with access to food. Several participants mentioned an avoidance of the red-zone and parks because of the recent heavy rain. The muddiness, slipperiness, puddles and unpredictability made the paths and grassy areas daunting to navigate with an example in Figure 9.

Figure 9. Example of a park path with a puddle days after rain

One participant also described that it was easier when rain was very heavy as it meant that events were typically cancelled. This meant that they didn't have to make a decision about whether to make the journey and it reduced the negative feelings of missing out if others were able to attend.

4.1.4.2 Malls

Malls were a popular choice of frequent destination by participants. People enjoyed malls for various reasons: they are predictable environments, where supermarkets and other shops are co-located in close proximity, as well as guaranteeing shelter and having a consistent standard of accessibility to meet. The frequent core bus routes that go to the malls also made mall trips easier.

4.1.4.3 Healthcare

It was predicted that disabled and older people have more frequent healthcare journeys. For some participants, this was true but what was surprising was that people often chose to use a GP that was not in close proximity to them, making the healthcare journey harder. People chose their doctors on existing relationships, recommendations from others, and availability of service. One participant was not registered with an Ōtautahi GP as they couldn't find one accepting new registrations that was suitable for them.

4.1.5 Communication and engagement of surface flooding

Some participants were asked how they learned of the surface flooding and if they had a preferred way. Most people learned of flooding through word of mouth or discovering it for themselves although they had an idea of it from seeing the amount of rain and receiving news (tv, radio, internet news articles) of the heaving rain and flooding in Ōtautahi.

Some people who were travelling for leisure trips didn't mind finding out about detours at the bus stop, but others who were on a time schedule or had limited daily energy, wanted to know about travel disruptions before they left the house. Sometimes, when visiting friends, people could ask others if there was flooding at their destination, but other times they took the gamble if the rain was going to block their journey. Participants emphasised that if information was at the bus stop, it needed to also be accessible.

> *"To know that [a bus was detouring for flooding] in advance, well then, you know, if you can't cope with it, well, then you'd know not to go." - Ramie*

When asked for a suggested method of notification of surface flooding or bus detours, multiple participants who are regular bus users, suggested information could be on the metro bus website, not knowing that already occurs. Seeking preferred style of notification that has a hypothetical focus was difficult to get a quick and simple answer for. The enquiry would likely get better results in a workshop, with more detailed questions. People tended to try give answers that represented their community rather than just speaking for themselves and their own situation, stating that there probably is not a singular solution. The suggestion of an app was most common which could send notifications relevant to the user. An opt-in text service, similar to what already is offered to deaf people for emergencies was suggested, but people struggled to visualise it and worried that it would cost organisations too much to manage. What was implicitly recognised, is that there is no hub of information to find out travel information when heavy rain or another disruption occurs. Two participants highlighted concern that people would not want to be over-notified, and discouraged the use of the alert system that has been recently used for notifying people of tsunamis and Covid alert level changes, feeling it was too invasive for the purpose of surface flooding. It is also worth recognising that people were thinking about alert systems that are used for major emergencies, which perhaps shows the level of distress that surface flooding or travel disruptions can cause on them.

Ramie is sometimes unable to get off the bus due to surface flooding. Sometimes the bus driver can pull in close to the stop to let her off, however, one time she stayed on the bus until the next stop, and waited for 20 minutes for a bus to come in the other direction and drop her closer to the location she needed.

This lack of consensus was even more prevalent when asked how they would like to be engaged with in regard to adaptation planning in the future. Most said there was no specific way, while other described diverse methods including wanting workshops in groups with others in their community or one-to-discussions with email invites.

4.1.6 Severity of surface flooding to some

When asked about barriers from surface flooding, people sometimes answered with the lens that was closer to severe flooding compared with surface flooding, such as the choice of method to notify people of surface flooding. This could have been from using the term surface flooding that references the word flooding which is more commonly used in the form of major/hazardous flooding, spurring thoughts of emergency situations. More likely, the additional barriers that are created by water have a severe impact upon disabled people's ability to travel, and that in their circumstances, surface flooding is closer to an emergency situation than a non-disabled person. This was also backed-up by most participants wanting to know more about what the Council was doing to address regular excess water on streets, showing that the water regularly has an impact on their journeys.

4.2 Spatial analysis results

4.2.1 Ageing dynamics

The spatial distribution maps of population aging in Ōtautahi (Figure 10) shows that most areas outside of the central city have high percentages of older populations with many SA2 areas in the coastal adaptation areas moving from the 'aged' area in 2006 to 'super aged' in 2018. This means that many areas that need coastal adaptation in the future, already have a high portion of the population over 65 who may face a higher consequence of early signs of coastal hazards in regard to travelling, especially if they do not have the ability to drive.

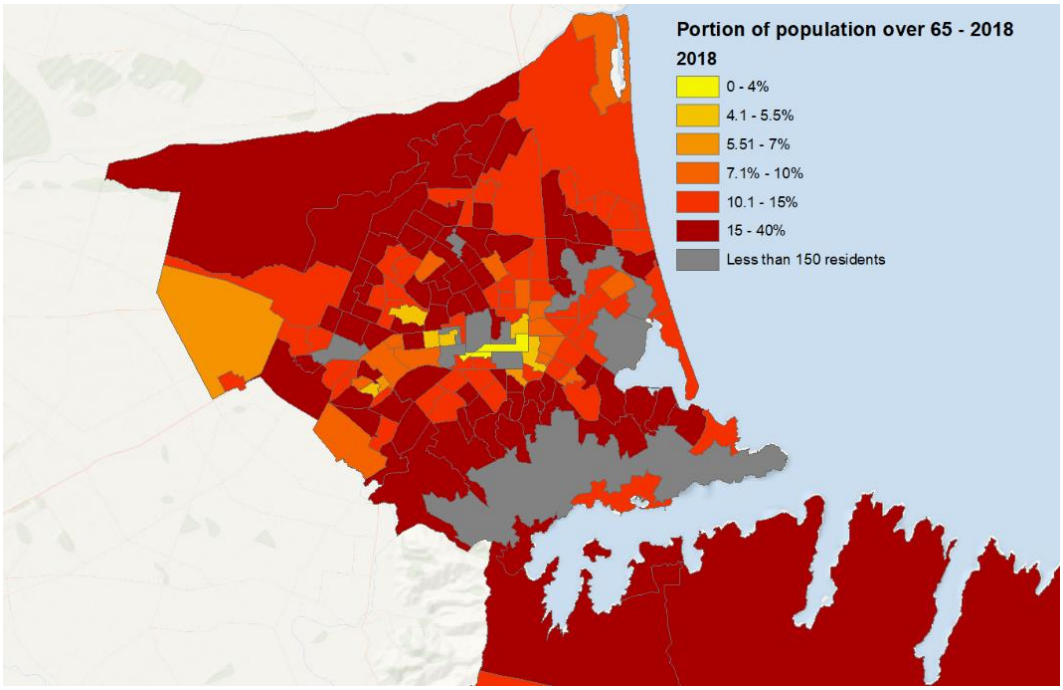


Figure 10. Age Structures of Ōtautahi in 2018

The growth rate of the SA2 areas was measured as the percentage change in the portion of over 65 years population between 2006 and 2018.

The growth rate of older populations may be due to some people aging in place as the comparison of years is only over 12 years. Whether it is from older people moving to the areas or aging into the over 65 age bracket, the portion of older populations in the areas: Ferrymead, Heathcote Valley and Woolston South, Clifton Hill, Waimairi Beach, Waitikiri and Travis Wetlands have grown the most across the adaptation areas shown in Figure 11, which are mostly in the Sumner adaptation area.

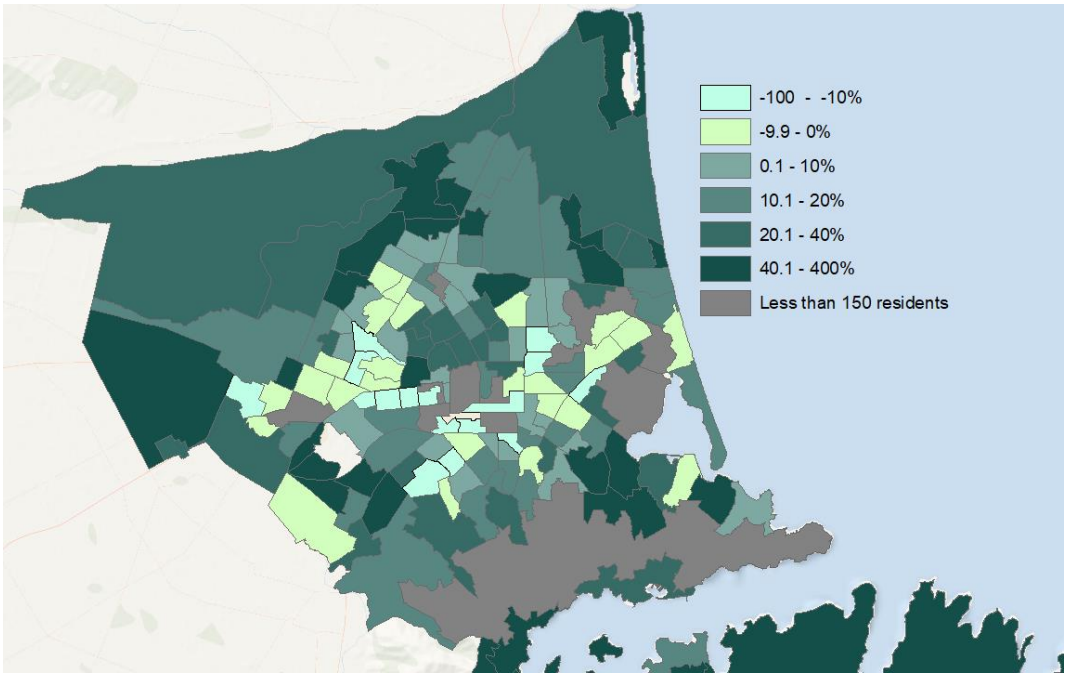


Figure 11. Growth rate of over 65s in Ōtautahi between 2006 and 2018.

4.2.2 Rainfall correlation

Overall, rain tended to have a negative relationship with bus patronage with a summary of results shown in Table 5 and more detailed results in Appendix C – Rainfall Correlation Data. On wet weekdays, the average patronage was almost always less than the average patronage on dry days for the same stop, indicating the travel mode of busing is less attractive on wet days. Weekends had greater variance for rain and wet ratios than weekdays, indicating that people may be less bothered by rain in the weekends for some trips. The nature of the destination beside the stop was also related to patronage, for example, one of the stops with the greatest reduction of patronage on wet days, was stop 45925 at the Christchurch Gondola, a major Christchurch tourist attraction, aligning to people not wanting to visit the Gondola and miss the stunning views.

For bus stops in the Heathcote area, there was a weak-medium relationship of bus shelters to the wet-day ratio, that was statistically significant, $r(81) = .37$, $p < .001$. This indicates that the presence of a bus shelter may be a factor for weekday bus users, whether to make the journey by bus on a wet day. On rainy days, this relationship was not present, rather a weak negative relationship that was not statistically significant, which is likely due to the higher variance of the rain-day ratio for non-sheltered stops. Sumner bus stops had no relationship between shelters and rain-day ratios or wet-day ratios.

When stops on core routes across both areas were compared, statistically significant relationships were found. Shelters had a positive relationship on wet-day ratios (both weekdays and weekends) and the weekend rain-day ratio, all statistically significant. However, a negative relationship on the rain-day ratio on weekdays was found that was not statistically significant. No relationship was found for busyness of stops.

Table 5. Summary of ratios for Heathcote stops and stops on core-routes

	Rainy_day ratio				Wet_day ratio			
	Heathcote		Core Routes		Heathcote		Core Routes	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Shelter Correlation	-0.19	0.30	-0.14	0.20	0.37	0.15	0.38	0.19
p value	0.155	0.023*	0.160	0.041*	0.001***	0.304	0.000***	0.055
Average Sheltered	-9.2%	0.6%	-10.3%	-2.9%	-12.8%	-3.4%	-13.7%	-5.6%
Average Non-Sheltered	-6.2%	-8.3%	-8.0%	-10.0%	-19.5%	-10.7%	-20.8%	-14.2%

*Note. * p < .05, ** p < .01, *** p < .001*

4.2.3 Availability of stops

Most SA1 areas were found to have 1 – 10 stops within the 200m buffer and there is no visible correlation between number of stops available and deprivation index shown in Figure 12 and Figure 13. Sheltered stops were more likely to cross over multiple deprivation areas than seated stops.

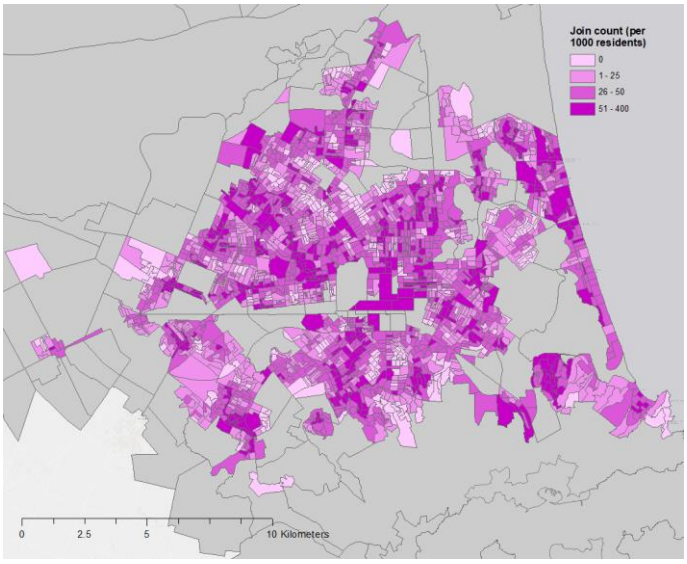


Figure 12. Bus stops within 200m per 1000 residents

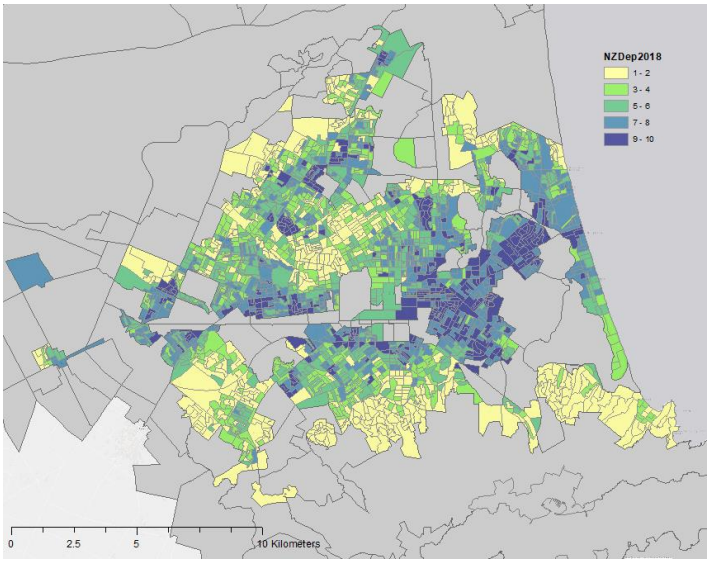


Figure 13. Dep Index 2018

Overall, the highest count of shelters and seats can be seen in areas of middle deprivation, not providing the infrastructure to those who may be most dependent on public transport. Figure 14 below shows as deprivation index increases, the portion of stops that are sheltered increases, while the portion of seated stops serving each deprivation index category remains the same. However, it is worth noting that deprivation index extremes have the least of number of stops as shown in Table 6.

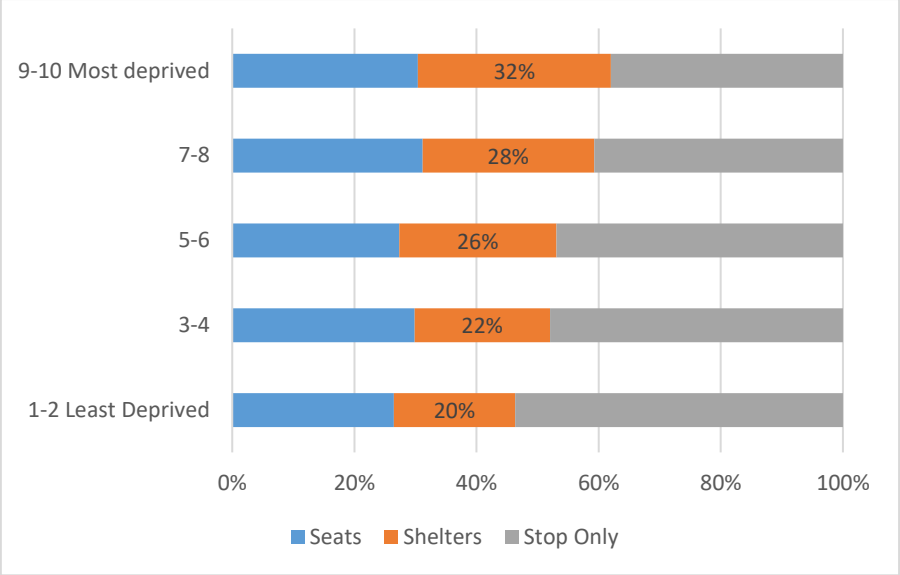


Figure 14. Type of infrastructure of stops per deprivation index.

Table 6. Summary of Stops per Deprivation Index Category

Deprivation Index	Seats	Shelters	Stop Only	Total Count of Bus Stops	Total Population
1-2 (Least Deprived)	181	136	367	684	300804
3-4	261	194	419	874	280086
5-6	294	277	504	1075	342141
7-8	306	276	400	982	373716
9-10 (Most deprived)	179	195	236	610	233277

When all stops on the bus network were considered, people living in range of the bus network and deprivation index 5 to 8 are likely to have access to the most shelters and seats, with 64% of the network's bus shelters available to the two SA1 categories.

Bus stops (of any infrastructure type) in Deprivations Index areas 5 and 6 serve the greatest number of people with highest number of stops per population while there are the least number of stops per resident population in wealthier areas. Deprivation Index areas 7 to 10 have similar shelters per population served as shown Figure 15. Seats per population have a similar pattern to shelters, although deprivation areas 3 and 4 have similar counts to the highest deprivation areas.

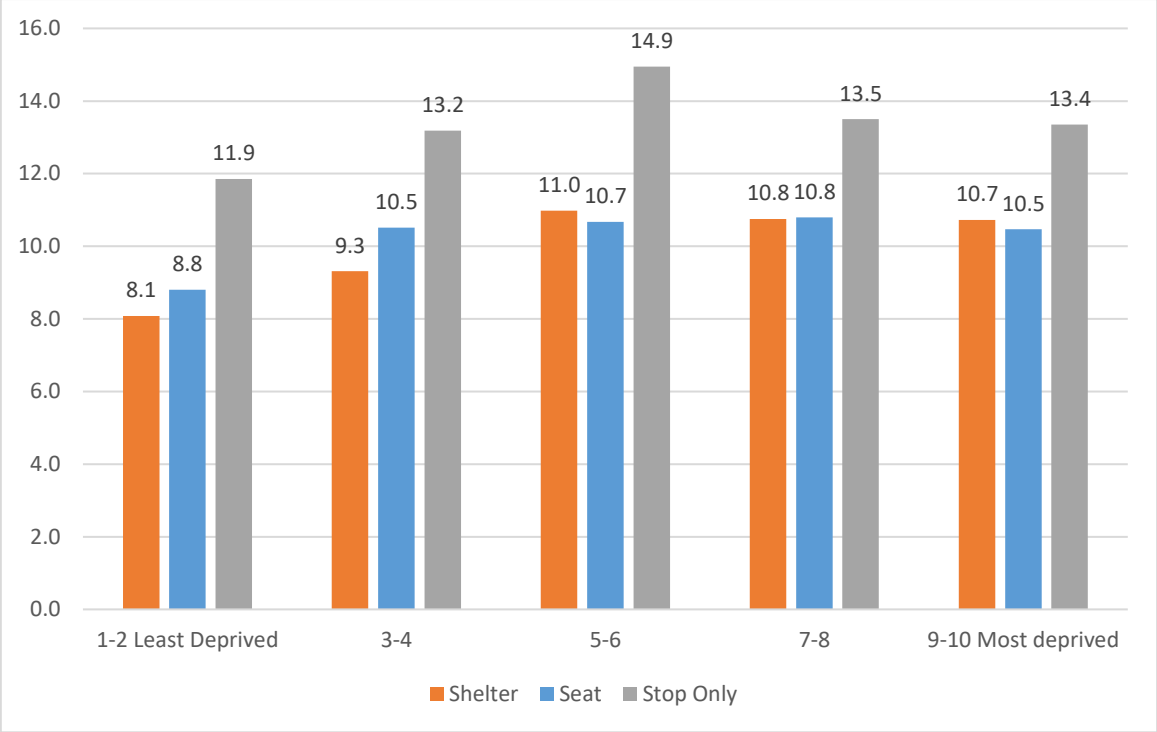


Figure 15. Bus Stop Infrastructure per 1000 people by Deprivation Index

Stops in areas of higher deprivation tend to have a higher average patronage across all types of infrastructure as shown in Figure 16. Gold card patronage follows the same pattern. When stops only on core routes are considered, differences across deprivation indexes are widened.

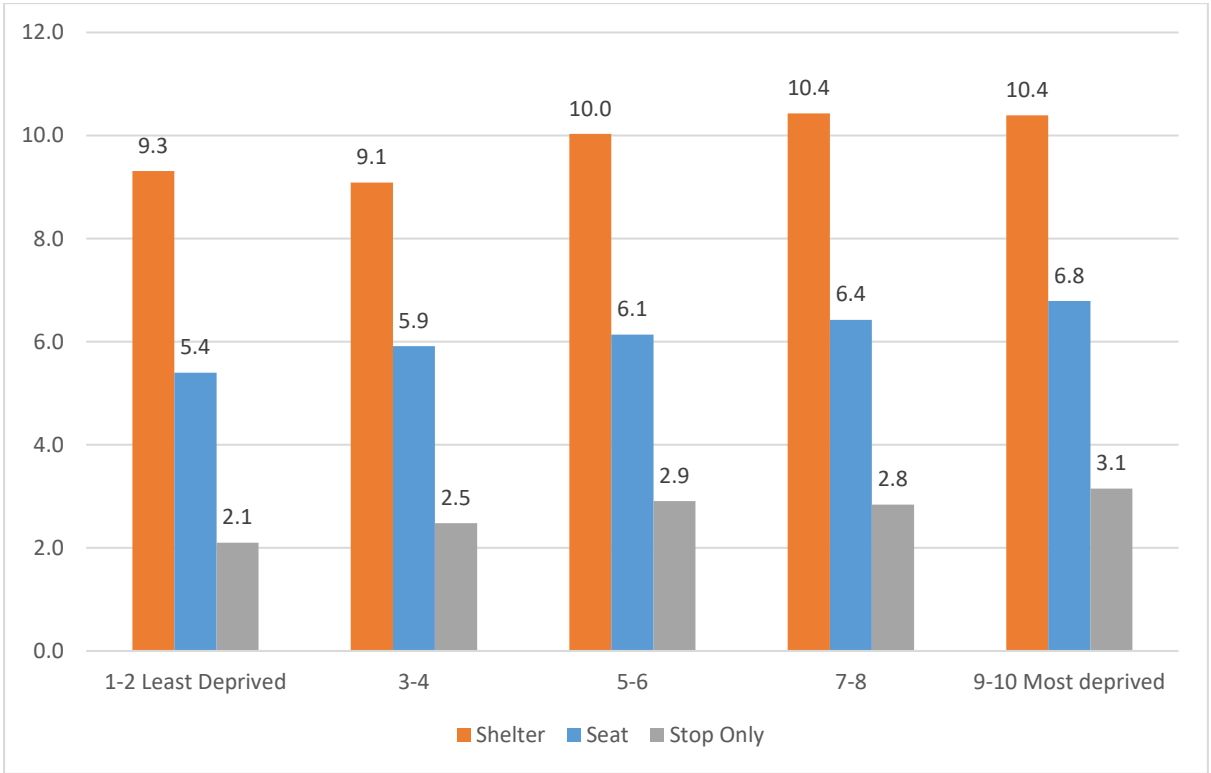


Figure 16. Average patronage per infrastructure type per deprivation index.

5 Discussion

This research has set out how disabled and older people's travel patterns are impacted by wet weather and surface flooding. Key results of interviews primarily highlighted that physical barriers are exacerbated by rain and surface flooding. This makes the planning and execution of journeys harder, which in turn increases isolation and contributes to poorer wellbeing. The desire for more bus shelters was a common theme in interviews, and a moderating effect of bus shelters on bus ridership was found for days with heavy rain, with a medium relationship on weekdays. Areas of middle deprivation have access to the most shelters on the network and have access to the most sheltered and seated stops per population, yet stops in areas of higher deprivation, where there are higher rates of disabled people, tend to have a higher use across all types of infrastructure.

The results are discussed below following the sub-research questions, with focus on the experiences described by participants, coastal planning considerations, and mitigations for enhancing urban mobility in times of wet weather and surface flooding.

5.1 Barriers described arising from surface water & wet weather

5.1.1 Many barriers already, existing barriers worsen

Journeys of disabled people have been described as fragile due to the numerous interruptions they face (Doran et al., 2022). This research has shown that on days with or following wet weather, journeys become even more fragile. Water can become a physical blockage, create additional risk or can bring on anxiety from past experiences. This amplification of barriers exacerbates transport inequity and can create a steeper negative spiral of journeys not made, which then decreases wellbeing and further reduces confidence to make a journey. In wet weather limited accessible options available can become inaccessible while others (non-disabled) continue to have many options. Not only is this unfair, but it also relates to the concept of redundancy, commonly found in resilience frameworks (Gonçalves & Ribeiro, 2020). If on the minimum accessible options are provided in the street environment, when a disruptor such as rain and water is present, the journey fails.

One of the built environment barriers that arose most frequently was problems with kerb ramps (also known as kerb cuts) which are common causes of complaints even in dry conditions (Doran et al., 2022). Kerb ramps can collect stagnated water on path designed to be accessible as shown in Figure 17. The outcome of this was typically additional travelling effort to another kerb cut or walking or wheeling on the road, however, it could be another tipping point for early termination of the journey. This is a prime example of inaccessibility being worsened with rainfall or surface flooding, where if there were more kerb cuts and correctly implemented kerb cuts with good drainage, there would be less negative impact from excess water.

Figure 17. Examples of kerb cut blocked by water days after a heavy rain.

Encouraging people to report barriers to Councils could be an obvious solution. However, not everyone is aware of processes or even the possibility to seek a correction. Unfortunately, the people who face the most transport inequity have reduced opportunity for education and employment, and therefore may not have the experience or access to reporting (Spray et al., 2020). Disabled people have little voice in decision making and often cannot afford to spend excessive energy on advocating for themselves (Boberg & Sherwood-O'Regan, 2021).

5.1.2 Considerations preventing leaving

All participants mentioned that wet weather sometimes prevents them leaving the house and it was surprising to see the range of considerations for deciding to embark on a journey. Not only is this additional contemplation not factored in to transport planning, but travel data also typically focuses on the journeys that have occurred, not the journeys not made because they were too risky or hard (Doran et al., 2022). Participants who drove were also less likely to cancel trips which agrees with other research stating older people forgo trips when without a vehicle (Shirgaokar et al., 2020).

5.1.2.1 Emotional barriers

Participants described preference to stay in areas that were familiar and were less likely to make trips on days where there was potential flooding if the journey was unknown at it heightened their anxiety. This aligns to research stating anxieties are often worsened in unfamiliar environments, especially when there is poor paving and confusing spaces (Phillips et al., 2013).

It is important to also note that the participants sought for this study were to have a physical impairment with a walking limitation. However, many of the participants described challenges with mental health in some way, mostly relating to anxiety. If anxiety came up in the interview, it was often in the context of describing challenges of living in an inaccessible world, and indicated that challenges from rain and wet streets has a negative relationship to mental health.

Four themes of emotions (humiliation, frustration, loss, and humility) that arose in research by Barlew et al., (2013) when studying stand-out experiences of people new to using wheelchairs resonate with the experiences described in this research. Although not everyone explicitly expressed all of the feelings, almost all interviews touched on each of the themes. Humiliation came about when describing experiences of falling and was conveyed as a reason for wanting to avoid falling in the future. The emotion was also seen when feeling ostracised from inaccessible areas such as the beach and having people staring regularly because they were different. Frustration was frequently described when coming across unexpected water that caused a disruption or cessation of a journey.

Loss was mentioned when describing reduced independence on days with poor weather, either from not being confident to go out or needing additional help along the journey. A few participants also described a loss of ability, comparing their more-able past selves while some were looking ahead and describing concern for reduced ability in the future. Humility was strongest in interviews with people that were lesser able. Participants demonstrated an attitude of patience and acceptance of reality regarding the wet weather barriers, and reflected strong ability to adapt to the world they lived in albeit often unequitable. These range of negative emotions are not only hard to measure, but also overlooked when looking at quantitative journey data, such as number of trips.

5.1.2.2 Fear of falling

Participants' reluctance to make journeys due to fear of falling aligns with previous research stating that wet conditions and poor neighbourhood conditions increase a fear of falling (Curl et al., 2016; Phillips et al., 2013). Most participants had fallen in the last 12 months perhaps heightening their fear of falling, and perhaps reflective of their higher likelihood of falling due to poor and inaccessible neighbourhood conditions. Wetter conditions have the potential to create a negative feedback loop, where the potential of a fall increases from the poor conditions and the absence of journeys exacerbates the fear of falling. Additionally, a remedied section of footpath that previously flooded regularly may not be seen be someone avoiding going out. A similar result of physical barriers creating health and safety concerns which increases isolation and psychological challenges was found in a study about experiences of disabled youth in winter. This increased likelihood of isolation and negative mental health means that there should be more knowledge sharing of the relevant resources available during winter or periods of poor weather conditions (Lindsay & Yantzi, 2014).

Fear of falling may prevent engaging in other activities that are positive for wellbeing and assist the management of the fear of falling. It is agreed that more information is needed about this cycle of anxiety as often walking outside is promoted as an activity to increase wellbeing, when for some people it may be creating or worsening a fear of falling (Curl, Fitt, et al., 2020; Li et al., 2006). This is particularly relevant for disabled people who may have anxieties due to negative experiences from journeys being unwelcoming or suitable, beyond issues with water. Alternatively, people less active not making journeys, will have less physical ability due to inactivity, especially at an older age, and making a journey in the future will have another layer of difficulty (Devarajan et al., 2020). This research highlights that past experiences shape a person's choice in a journey, both the route and whether to make the journey at all. This is difficult to capture in checklists to make cities more accessible, however, increasing accessibility reduces the likelihood of a negative experience and in turn enables more journeys.

Professionals experience the built environment differently to older fallers and disabled people (Curl et al., 2016; Lid & Solvang, 2016). This is concerning when New Zealand transport professionals have limited contact with disabled and older people in a work capacity, with 25% having none in the previous 12 months and only 50% knowing someone in their organisation who had made contact but had not made the contact themselves (Burdett et al., 2021). To prevent falls, the need to connect urban designers and engineers with professionals who work directly with people with higher risk of falling has been highlighted (Curl et al., 2016). This will become even more necessary with increased water on streets, with more need to design streets in a way that does not worsen the condition of pedestrian pavements.

5.2 Coastal adaptation planning considerations

This section details four key considerations for coastal hazard planning. These include: ensuring that disabled and older people are included in risk based planning; ensuring that older people are aware of future coastal hazards if moving to coastal areas, utilising good practices in land use planning; and the co-benefits of nature based solutions.

5.2.1 Risk based planning – risk for whom?

Christchurch City Council (CCC) has adopted a risk-based approach to planning for coastal hazards from climate change (in line with central government advice). Councils need to be cautious using general flood risk assessments as they may not account for different needs in communities, especially when the needs of disabled people are commonly overlooked or made a lower priority. A disabled persons risk (physically, community connections, availability of evacuation etc) is greater than an average person (Ton et al., 2020). Surface flooding may cause someone to be isolated at home, while the same level of flooding may be only a nuisance to others.

5.2.2 Attraction of coastal areas by retirees

Coastal areas can be magnets for retirement, and the sea level rise impacts in coastal areas with high older populations should be considered (Bukvic et al., 2018). Higher proportions of older people lived in Ōtautahi coastal areas, with some of the largest increase in proportions in the Ferrymead and Heathcote Valley regions. With increases in older populations across Ōtautahi and Aotearoa, it is difficult to conclude that older people are attracted to coastal areas. Attraction to live near the coast may also be changing with increasing awareness of coastal hazards, and property risks being noted on Land Information Memorandum (LIM) reports (a property report). As sea level rise predictions typically are decades from now, it would have been ideal to generate population estimates with dates in line with sea level rise forecasts. Rather than attempt complicated population predictions, the past available census data was used. It is also worth noting that the 2018 Census had a lower-than-expected response rate (90% compared with the 2013 response rate of 94.5%). A large reason for this has been attributed to the census having 'digital first' approach, where data collection was primarily online (Jack & Graziadei, 2019). Older and disabled populations were likely affected and the 2018 census data may have lower trust in data quality for these groups.

5.2.3 Accessible housing and the role of land use planning

The participants who were interviewed tended to live in flood prone areas and this is likely an outcome of the snowball style of recruitment, where people with surface flood experiences and challenges came forward to interview. Systemic factors such a low income, reduced education, poor access to food and healthcare may cause people to live in flood prone areas, however it is those same factors that reduce an individual's resilience to flooding (Mason et al., 2021). Majority of participants had a living arrangement with a location that they did not have control over, limiting their choice to reduce their flood risk. There is a tendency for flood prone areas to have lower property values, attracting large residential facilities, social housing and more affordable housing (Logan & Guikema, 2020). Given that people in low-income neighbourhoods often have high rates of disability, placing residential facilities and social housing in these areas would be exacerbating the inequalities. The interwoven systemic barriers mean that increasing a household's resilience factors at outlined by Mason et al. (2021) may be more challenging than reducing exposure to surface flooding. Currently, a high number of (24 out of 117) Ōtautahi Community Housing Trust (social housing) sites are located in the Heathcote adaptation area. More research is needed to find

solutions that enable people with mobility impairments to live in less flood prone areas that have good standards of walkability to adapt cities in a more just way.

Aotearoa also has poor levels of accessible housing stock. This means that even if people had the choice of where to live, their only option may be to live in a flood prone area if an accessible house is required. Building or modifying more accessible homes in areas with low risk to flooding could help address this issue.

In the same way accessible streets often benefit everyone, designing cities away from car dependence, utilising the increasingly popular concepts like ‘x – minute' cities assist to make journeys easier by making everything in closer proximity (Handy, 2020). A journey taken by a disabled persons takes longer than a non-disabled person, and increasing proximity makes it easier to use active transport modes and reduces the difference in travel times. Shorter journeys have the potential to reduce the likelihood of surface flooding being a barrier at some point on the journey. The movement towards accessible streets and x-minute cities seeks to encourage active transport and the numerous benefits that come with a more local approach. However, for disabled and older people, malls have an advantage. Malls offer full weather protection, have more capacity to offer sheltered parking than what streets can provide. The tenants of malls collectively share the costs of the accessibility to achieve the consistency and predictability of the accessibility experience. Whole journey accessibility is much more difficult to achieve with individual properties than a singularly owned mall.

Related to this, the proximity of the closest General Practice (GP) is often used as an urban access measure (Hartley et al., 2021; Vannier et al., 2020). However, participants did not typically go to the closest GP to their residence, even with limited transport options. This result compares well with a study that examined primary healthcare records from enrolments in the Waikato area, that found that 68% of people were not enrolled in their closest medical clinic (Whitehead et al., 2019). According to Levesque et al., (2013) there are multiple factors at play when people choose a healthcare provider including the five dimensions: 1) Approachability; 2) Acceptability; 3) Availability and accommodation; 4) Affordability; 5) Appropriateness. Given that older and disabled people often have more specific healthcare needs, both needing healthcare more frequently and with more accessibility, it makes sense that there are stronger drivers than proximity.

5.2.4 Co-benefits of greening the city

There is a movement to shift away from the hard engineering of flood management to cities that are more embracing of water, using nature-based solutions as a climate change adaptation strategy (Kabisch et al., 2016). Wetlands and forests allow water to be absorbed and then the water is released slowly, preventing surges of water to low-lying areas and reducing surface flooding. They are also often cited as having many co-benefits, such as biodiversity, carbon absorbing, community connection, mental health. Ōtautahi has been embracing this view, opening up a number of stormwater basins for flood mitigation in the Heathcote catchment (Christchurch City Council, n.d.; Murphy & Hyde, 2018).

Majority of participants mentioned that recreation was important to them with most people regularly walking through their local park such as the red zone. Nature-based solutions provide both flood mitigation and recreation, however, the design of urban green spaces do not consider the needs of older and disabled people, often having lower accessibility, including slippery and uneven surfaces (Zuniga-Teran & Gerlak, 2019). Participants talked about the red zone being less enjoyable in the wet with many potholes attracting water. This presents an opportunity to better understand

how wetlands and nature spaces can be accessible so that the benefits can be available to everyone. There is limited research on accessibility of parks and outdoor tracks (McIntosh et al., 2017). Hoggin and other similar sand/gravel surfaces can be difficult depending on roughness to maintain balance (Curl et al., 2016). In wider Aotearoa, none of the 21 public parks and playgrounds in the Greater Wellington Region met the national accessibility standards. There is currently no mandatory legal framework for councils to meet when designing public environments (Perry et al., 2018). Impaired people should not miss out the restorative powers that nature can provide due to lack of accessibility, especially when flood mitigations such as storm water basins are often restored and curated by humans. Additionally, by enabling greater access to nature-based recreation, it enables greater participation in Māori values and allows people to connect to their cultural identity (Walker et al., 2019).

5.3 Mitigations to reduce negative impacts of wet weather and surface flooding

This section discusses some mitigations that would assist active transport systems in adapting to wet weather and surface flooding. Some of these interventions are directly targeted to support people with walking difficulties, while others are more improvements that support active transport modes and therefore improve overall transport equity. The mitigations are: a) Improving the experience of the journey and increasing the provision of shelter; b) Improving the accessibility of buses for wet weather days; c) Utilising the co-benefits of streets for people; d) Enhancing information sharing for journey planning; and e) Seeking and using more specific data towards accessibility.

Many of these mitigations are similar to the interventions recommended in the systems approach which are labelled in Figure 18 from the recent extensive research regarding disabled people's transport experiences in Aotearoa. To achieve more accessible journeys and address systemic barriers, a systems approach is needed rather than considering transport aspects in isolation (Doran et al., 2022).

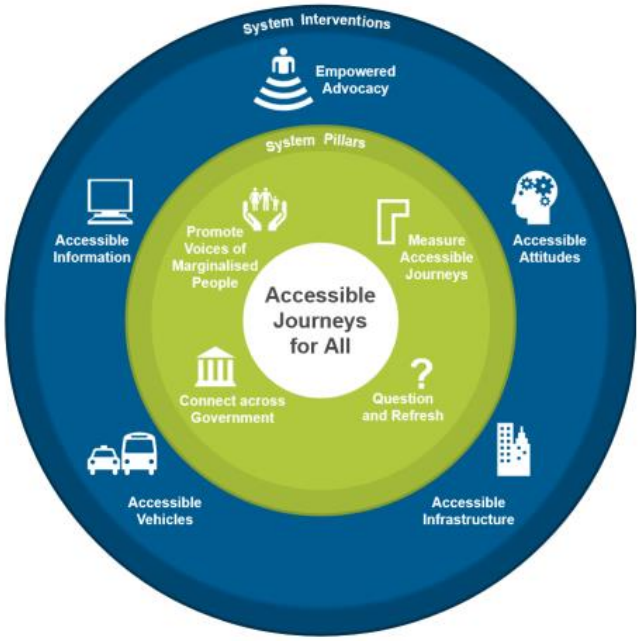


Figure 18. Accessible Journeys for All: A Systems Approach (Doran et al., 2022)

5.3.1 Improving the experience of the journey and increasing the provision of shelter

Good transport infrastructure such as shelters can enhance wellbeing and make for a more joyful journey (Meher et al., 2021). Unsurprisingly, the built environment also plays a role in motivation to make journeys and participate in spaces and activities (Handy et al., 2002; Wang et al., 2016). Without shelter, a person's active transport journey experience can be undignified, especially if people do not have choice in transport mode (Devarajan et al., 2020). Waiting for a bus in the rain while others remain dry in their cars is a strong visual representation of transport inequity. Making the journey a better experience for all weather and street conditions attracts and retains people using active transport modes (Iseki & Taylor, 2010). Bus stops are public spaces and their quality and condition should be prioritised, especially in low income areas which are typically underserved by bus networks (Moran, 2022).

Few people enjoy being wet while out, which is why the provision of shelter is important for encouraging journeys on wet days. People who travel without shelter from a vehicle are reliant on shelter from the urban form. Intentional design of buildings can significantly influence pedestrian comfort quality (Yasa, 2023). Building verandas offers protection for pedestrians with less need to wear extra clothing or carry an umbrella. Shelter along pedestrian paths is particularly important for disabled and older people as they have pointed out that they may have more consequences of getting wet such as having a weaker immune system, or the inability to get changed. Older and disabled people often move at a slower pace than non-disabled walkers and are not able to spring into a run between gaps in shelters, so continuous shelter is even better.

Participants described challenges of not having shelter while transferring out of vehicles, with transferring out taking a lot longer than for non-disabled people. Participants described wanting to see more shelters at the entrances of large buildings or over mobility parks to make a more equitable experience of the rain. It is important to note that close proximity of mobility and parent parks to entrances not only reduces energy required to get to the entrance but also improves safety for shorter people (including children and wheelchair users) who may not be as easily seen by cars (Schwartz et al., 2022).

Te Whanganui-a-Tara (Wellington, New Zealand) has embraced the need for more shelter to improve the pedestrian experience in poor weather. Wellington City Council has installed shelters for pedestrians waiting at intersections, shown in Figure 19. This makes the experience of walking through the central city on a rainy day easier and more comfortable, especially when the weather changes frequently and people may not have initiated their journey with individual wet weather protection. These shelters have been built intentionally to be proud of their presence(Architecture Plus Ltd, n.d.). Sometimes bus shelters are built to blend into the background and not stand out, however, bus shelters also provide an opportunity to visually display that investing in and supporting active transport is a priority in the city (Waka Kotahi NZ Transport Agency, 2009).

Figure 19. Examples street shelters at signalled intersections

5.3.1.1 Bus shelter influence on ridership on rainy days

A positive correlation was found between shelters and wet days on weekdays. This may indicate that shelters are more favoured by commuters and agrees with results from Miao et al. (2019). The result of Sumner bus stops having no relationships between shelters and rain-day ratios, or wet-day ratios is likely due to the area being a coastal region. The combination of weather and destination was likely a stronger driver than the presence of shelters. Those stops had large reductions of bus riders on wet days regardless of being sheltered or not. This is a similar finding to a coastal Spanish study, that found higher temperatures increased ridership on weekends. Pleasant conditions encourage outdoor recreation activities while wind and rain decrease trips (Arana et al., 2014).

The greater variance rain-day ratios could be that levels of precipitation were less bothersome, and less likely to prevent a bus journey occurring. There could have been little or no rain at the time of the journey. The amount of rain at the time of the first leg of the trip is likely a greater factor in determining if the bus is taken. Participants talked about not enjoying being wet on their journey, however, once out they may have less choice and it may be more manageable for the ride home to become wet.

The reason for reduced patronage on wet days compared with rainy or dry days was not determined. Passengers could be not making a journey at all, using a different transport mode, or choosing a different stop. For disabled and older people, it is most likely that the journey does not occur, or that the journey happens on a finer day or when another person's help is available (typically with a vehicle) as they typically do not have the choice of other modes.

This relates to the finding that shelter has more significance on weekdays rather than weekends. A commuter may have disincentives to use other transport modes going to work, however, likely has transport options in the weekends, especially with 93% of Ōtautahi households having access to at least one car (Miao et al., 2019; Stats NZ, 2020a). This is a limitation of using total patronage to assess the influence of shelters on ridership, as the majority of passengers will be non-disabled, and their travel behaviour could have diluted the preference for sheltered stops as mentioned in interviews. The comparison of ridership on days with different weather has measured those who have choice (in transport mode, choice of stop, or choice to make the journey), but the discomfort people experience for those who have no choice in making the journey has not been captured. For disabled and older people, if they need to go out, or don't want the shame of reneging on a promise, for example, to a doctor's appointment or to a special social occasion, they will likely take the bus regardless of weather. This may be at the cost to themselves as they typically travel with more pain and take more risk (Doran et al., 2022). Installing bus shelters improves the experience of journeys

on wet days for anyone but is particularly valuable to those who have limited choice in transport mode.

Waiting time for a bus is likely a large factor in preventing bus journeys on wet days. Being able to shelter from rain or sun is important for transit stops, but safety and frequency/reliability is more important (Iseki & Taylor, 2010). Reliability allows people to plan better and avoid barriers, and high frequency services can mitigate issues with wait times and uncertainty. Currently, Ōtautahi has only five core routes with high frequency buses (ranging from every 10 to 15 mins) which may be one of the reasons underpinning a strong desire for more bus shelters. Shelter has greater influence of maintaining ridership in poor weather on low frequency routes (Miao et al., 2019).

5.3.1.2 Location of bus shelters

This research found that shelters are more likely to be in areas of middle deprivation, however, shelters in high deprivation areas had more patronage per stop. This reflects the importance of looking beyond total patronage as a main factor to install shelters. Areas of higher deprivation would benefit from more shelters, as typically these areas cannot afford car-related costs and have less choice to take the bus. Communities in these areas are more likely to relate to the transport barriers described in this research, such as having a lower threshold when choosing not to make a journey due to weather. Areas that were not near bus stops were not included in the analysis. Low-income neighbourhoods are typically underserved by bus networks, therefore, there is a higher likelihood that some high deprivation areas do not have a bus stop at all (Azolin et al., 2020).

Work commuters tend to be a large portion of bus users and are easiest to plan for with their regular travel patterns and ease of travelling to central business hubs. Only considering total patronage overlooks the range of needs of individuals and the different types of trips that may be taken including people using the bus system for journeys that are not for commuting to work or school, such a leisure trip to the beach or park, or a parent taking children to a caretaker before work. Is it for this reason that it was intentionally chosen to not factor in the direction of a bus stops.

Prioritising installing sheltered stops on core routes with high patronage ignores the relationship that good infrastructure has the potential to attract riders. Participants stated that they wouldn't catch the bus without shelter on rainy days but would have if they knew there was a shelter nearby. By investing in bus shelters where there is existing high patronage, it serves people who are already taking the bus frequently. This has similarities to survivorship bias, which is when erroneous results are shown from data that has passed selection criteria and filters the data that did not pass the selection criteria (Czeisler et al., 2021; Elston, 2021). In the case of bus stop patronage, bus stops with high patronage are seen as performing positively but ignores the potential bus users who were not able to use the bus, which could be for a variety of reasons including the lack of shelter. Low patronage stops should be reviewed for why they may not have the same patronage as other stops including considering who would benefit from using the bus but finds it too difficult.

This is not to say the needs of commuters should be ignored when considering placement of shelters as there is a need to encourage high numbers of commuters to active transport. Shelters can assist in moderating reduced ridership on rainy days and results indicate a preference for shelters on weekdays. A balance should be found in providing shelters to encourage active transport and provide better experiences for people who do not have choice in transport modes. This will enable both a transition to environmentally friendly transport and a just-transition.

Travel patterns have been changing post pandemic lockdowns with more employers offering flexibility and options to work remotely. This may provide some people opportunity to adapt their

workday on poor weather days, however, people with lower incomes may not have this same flexibility as they are more likely to be employed in roles that require being physically present such as supermarket workers, drivers, factory workers, etc (K. Park et al., 2022; Patel et al., 2020). This provides even more reason to design a bus network that caters beyond the office worker. Additionally, even if people can work from home and essential needs are met with delivery services, the company of others and engaging with the natural environment is just as important.

The need to publicly consult to install bus shelters is an implementation barrier on top of the cost of shelters. Communities can have polarised attitudes of buses and active transport, providing resistance to shelter installations. This also applies to placing shelters on private properties, which would enable larger shelters and allow for pedestrian throughfare. It is positive to see the consultation requirements in the Local Government Act 2002 are being reviewed by Waka Kotahi to make it easier for Councils (Waka Kotahi NZ Transport Agency, 2022).

5.3.2 Improving the accessibility of buses for wet weather days

Training to increase bus drivers understanding additional needs such as bus floors being slippery puddles being a challenge, signs of distress from someone with invisible disability, would improve journeys and mitigate having negative experiences that discourages future journeys. This research has highlighted that there are more barriers on poor weather days, so by the time someone reaches a bus stop, they may not only need more help with the bus but be in a more exhausted state than other days. Participants often said it was difficult to ask for help for various reasons, including not wanting to lose independence, being exhausted and having poor past experiences. Therefore, it would be valuable for bus drivers to have an understanding of how to offer assistance proactively in way that is not condescending or de-humanising.

Additionally, participants said that some days were harder than others due to factors like their own fluctuations in health. Some participants talked about the journey being easier with company and it is recommended to further explore the concept of free fares for a buddy as concessions typically only apply to card holders. This could be a support worker or a friend, where that person understands their abilities better than a stranger. Having company on the journey made it more enjoyable and social, and although the company may or may not have explicitly been there to assist (physically or mentally), having company helped. A discount on an additional fare would be less costly than a taxi fare subsidy, making travel also more affordable if the individual is then able to use the bus.

5.3.3 Utilising the co-benefits of streets for people

There is currently a major shift happening, making people higher priority in cities and street design above cars. With pressure from climate change, transport initiatives are being implemented with the goal of encouraging active transport and increasing safety (Mandic et al., 2019). A number of initiatives that are implemented under the lens of ‘streets for people’ will alleviate some of the journey barriers that are worsened by rain and surface water, providing even more justification for implementation.

5.3.3.1 Reduced speeds

There are more vehicle collisions and a higher likelihood of more severe outcomes on rainy days (Chung et al., 2005; Zhai et al., 2019). Reduced speeds are known to increase the survivability of a crash, especially for more vulnerable street users: pedestrians and cyclists. In cities around Aotearoa including Ōtautahi, urban street speeds are reducing speeds limits from 50km/h to 30km/h with the aim of increasing safety and encouraging active transport. Disabled and older people benefit a lot

from this change, as this group of people typically take more time to cross a street and cannot burst into a run if a car is approaching. A wheelchair user is at a more vulnerable height and may be less able to be seen from large vehicles (Schwartz et al., 2022). These safety concerns cause more anxiety about being on the streets which slower speeds helps to mitigate. In this study, participants who walked raised concerns of being less visible on rainy days, and therefore slower speeds both gives more time to be seen and provides shorter stopping distance which would be longer on wet days. Similarly, participants who drove expressed concern of less control of the car in wet conditions and felt they had less visibility. Slower speeds have additional benefits for rainy days and disabled and older people.

5.3.3.2 Raised pedestrian crossings

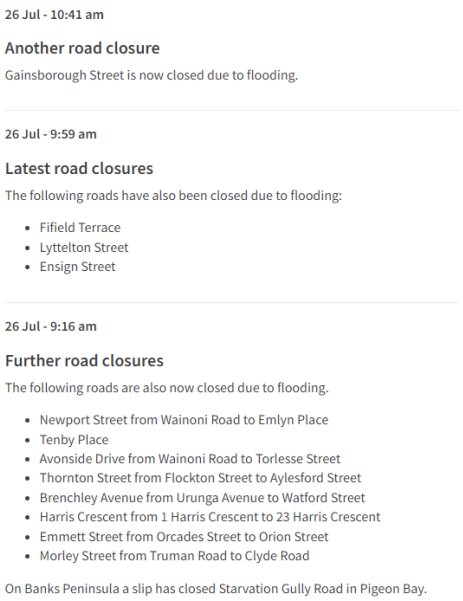
Raised pedestrian crossings have many safety advantages including reducing likelihood of injury in a motor vehicle accident and making the crossing more visible to all road users as a safer place to cross (Loprencipe et al., 2019; Waka Kotahi NZ Transport Agency, n.d.-c). They can be a mitigation to reducing surface flooding as they can also eliminate the need for kerb cuts that can collect water. Raising pedestrians out of street drainage systems, raises the visibility of pedestrians and symbolises the increased priority of pedestrians.

5.3.3.3 Co-benefits

Placing additional investment into small projects like raised pedestrian crossing can require additional justification. The concept of raised pedestrian crossings is often sold as a safety initiative, but there is also opportunity to sell the co-benefits of streets for people initiatives, that they can also enable journeys to occur in wetter environments as cities adapt for a changing climate. Currently the Waka Kotahi website highlights a benefit of raised pedestrian crossings to be the eliminated gradient on the pedestrian path, but misses the opportunity to mention preventing water pooling on the pedestrian path (Waka Kotahi NZ Transport Agency, n.d.-c).

5.3.4 Enhancing information sharing for journey planning

Trips for people with mobility impairments and non-car-based journeys require a lot of planning, and the presence of rain makes journey planning even harder. The level of effort required to plan journeys becomes a deterrent to making a trip and reinforces the idea described by J. Park & Chowdhury (2021) that journeys start at the information planning stage. Participants described needing to plan multiple scenarios for days that had the possibility of rain. Good provision of public information can enable people to choose a route that may be easier and more manageable in the rain, or has the possibility to warn of disruptions to journeys, reducing the likelihood of a poor experience on journey or a journey that is unable to be completed altogether. Information about locations of flooding was shared on the Christchurch City Council webpage, listing the street names as shown in Figure 20. It was not easy to know if the flooding streets would affect any bus routes and people needed to be familiar with the street names to know if the flooding would impact them.



26 Jul - 10:41 am

Another road closure

Gainsborough Street is now closed due to flooding.

26 Jul - 9:59 am

Latest road closures

The following roads have also been closed due to flooding:

- Fifield Terrace
- Lyttelton Street
- Ensign Street

26 Jul - 9:16 am

Further road closures

The following roads are also now closed due to flooding.

- Newport Street from Wainoni Road to Emlyn Place
- Tenby Place
- Avonside Drive from Wainoni Road to Torlesse Street
- Thornton Street from Flockton Street to Aylesford Street
- Brenchley Avenue from Urunga Avenue to Watford Street
- Harris Crescent from 1 Harris Crescent to 23 Harris Crescent
- Emmett Street from Orcades Street to Orion Street
- Morley Street from Truman Road to Clyde Road

On Banks Peninsula a slip has closed Starvation Gully Road in Pigeon Bay.

Figure 20. July 2022 flooding locations on the Council's website

Additionally, information related to journey planning to enable unfamiliar journeys should be made more available and accessible (Moran, 2022). Examples of information include: location of bus shelters, provisions of accessibility on buses, accessible toilets, and availability of mobility parking (and the vehicle suitability). This type of information could assist journeys that are less familiar, providing more certainty, reducing anxieties and reducing need for planning for so many possibilities on route. Simple things like placing increased signage in areas has been reducing anxiety for older people in unfamiliar neighbourhoods (Phillips et al., 2013).

Public transport authorities should also be aware of the routes that have flood risk (including down to nuisance flooding). Passengers can be aided by knowing ahead of flooding what will happen if a bus is disrupted on its route. The timetabled service and limited ability for a bus to change routes erodes perceived reliability of the service, but could be mitigated with good communications. A number of participants did not know that route changes were listed on the Metro website (Canterbury's bus operator) indicating this style of communication is not sufficient. Planning to have redundancy in routes for rainy days provides flexibility, a key factor for improving resilience of transport systems (Gonçalves & Ribeiro, 2020).

5.3.5 Seeking and using more accessibility related data

Commonly in transport planning, outcomes that are easily measured, such as cost and level of service, are more easily achieved. However, measuring accessibility is often more complex, requiring the measurement of the ease of a journey, journeys not being taken or the comfort of a journey (Burdett et al., 2021; Handy, 2020). More innovation is needed to embed accessibility measures into policy, and this also includes better collection of transport data that captures data about people with limited walking ability (DeRobertis & Renard, 2022). A balance of both quantitative and qualitative data is needed as quantitative data provides the measurable aspects, while qualitative data provides more explanation and depth and may highlight people's needs that have been overlooked (Hay, 2016). Some aspects of disabled and older people's journeys are difficult to capture but are just as important, such as that they often travel longer with more risk and pain (Doran et al., 2022).

Census data provides a foundation of data for decision-makers on disability matters. Analyses in this research did not include disability data because it was not considered reliable. It is positive to see Statistics New Zealand seek feedback on the questions that are asked about disability matters ahead of the 2023 census with communication in accessible formats (Stats NZ, 2013b).

There have been intentions for New Zealand to have concessions for community services card holders that have been delayed due to nationwide half price discounts for everyone (Ministry of Transport, 2022). Targeted concessions make transport more affordable for those who benefit most and create opportunity to collect more granular data on public transport travel patterns underserved by the bus network which opens more possibilities to better design public transport.

5.4 Limitations

5.4.1.1 Built environment lens

This research was approached with a lens of interactions with the built environment alongside a desire to better understand travel patterns. This lens came from the research having a non-disabled viewpoint, life experiences to-date and a background in engineering. It meant that there was a missed opportunity to understand psychological challenges that were described in the interviews, as they were not analysed in depth. I hypothesise that this is more common than not in transportation research. Following the strong critique of the medical model of disability, moving into the social model, a lot of accessibility-related research focuses on identifying the root cause of barriers within a disabling society. Society also tends to consider people to be disabled if they have visual disability (Calder-Dawe et al., 2020; J. Park & Chowdhury, 2021). It is no surprise to see focus on barriers that are visible, definable and measurable, which often leads to audit tools and checklists. This problem-solving approach helps us to understand the causes of poor experiences but undermines the feelings and personal hurdles in making journeys, and the role that past experiences play. There is a need for more research in understanding the psychological impacts and solutions to journey barriers.

5.4.1.2 Disabled vs older people – not the same

Older people and disabled people were both sought for this study because of some of the similarities of physical challenges in the built environment they face. However, not only does everyone experience the challenges in different ways, but there are also important differences between the two groups of studied people. Some disabled people face systemic barriers their whole lives and are not afforded the same opportunities as non-disabled disabled people, while older people may have had more opportunities growing up non-disabled, and transition to being less able later in life. Disabled people may have more adaptation resilience than older people, built out of lifetime of repeated barriers and creating a stronger sense of disability pride or connection to a disabled community. Older people may not be accepting of the loss of their ability, may go through a cessation of driving after being accustomed to the convenience of the car their whole lives, and may have more temporary impairments such as a limited movement post-surgery. Older people may have additional resources such as friends or family that can offer rides, and without the challenges of transporting some of the larger mobility aids such as wheelchairs. Older people as a whole tend to be in financially better situations, which can sometimes mitigate transport inequities. Although there are differences, both communities find difficulties in an inaccessible world and the result of this study aims to benefit both communities.

5.4.1.3 Intersectionality in recruitment

A limitation of the qualitative aspects of this research was that participants from this research were not super diverse and are not representative of all people with who have limited walking ability.

People recruited were well connected to society and were able to travel independently. They tended to be advocates in their community, many had access to employment previously if not in current employment. This research aimed to provide some examples of considerations for strategic planning of public transport in the context of climate change, rather than provide a checklist or a list of all barriers faced. Disabled and older people who face further systemic barriers likely face the barriers described and additional barriers. This was not mitigated against due to time and scope limitations, and ensuring the ability to travel independently assisted keeping the research in scope.

5.4.1.4 Patronage data

This research used bus patronage data over a period where there were plenty of reasons for travel patterns to be disrupted including COVID-19. Post-pandemic have remained cautious to use public transport (Awad-Núñez et al., 2021; Conrow et al., 2021). Additionally, nationwide discounts on public transport have been in place since 01 April 22 and a spike in petrol prices could have encouraged the bus to be a more attractive option. Although this time period of patronage data may have some uniqueness, this likely did not significantly impact results as comparisons were not comparing patronage over time, rather against weather and geographical locations.

Similar to the study by (Miao et al., 2019), the ridership analysis on rainy days primarily focused on people's exposure to rain and only considered the rainfall on the day. It did not assess the impact that a multi-day storm may have. The event of a heavy rainfall period would likely also deter people from making journeys, especially if there was increased likelihood of surface flooding or flooding of greater severity. Additionally, people experience weather differently, and weather has different impacts between seasons which has not been considered in this study (Böcker et al., 2016). It is likely that the rainfall results within this research is limited in applicability to urban areas that have a similar climate to Ōtautahi, and cities with different climates will have different tolerances and adaptive mechanisms.

5.4.1.5 Multi-hazard assessments

This study has solely considered the impacts of surface flooding and poor weather on travel patterns. Weather events that have the heavy rain and cause the surface flooding also have the potential to cause multiple hazards, for example, a power cut resulting from a large storm knocking power lines over. Traditionally, disaster risk assessments consider hazards discretely, which often produce different results to multi-hazard assessments, which analyse cascading hazards with combined effects (Hart et al., 2020). Ōtautahi remains exposed to hazards that may cause or exacerbate impacts of nuisance flooding, especially coastal communities, with various coastal hazards such as coastal inundation, ground water rising, tsunami and pluvial/fluvial flooding. The detailed descriptions of the decisions that people with physical impairments consider before making a journey may assist in becoming a foundation in other hazard planning, however, further engagement with the disability community is recommended for building wider multi-hazard assessments.

6 Conclusion

Nuisance flooding and wet weather makes journeys a lot more difficult for people without the choice of a vehicle, increasing the likelihood of isolation and a journey not being able to be made. The wet environment exacerbates accessibility challenges for disabled and older people. This results in increased safety risk on a journey, heightened fear of falling or conditions that prevent successful journeys. While nuisance flooding may be a nuisance to vehicle drivers, rain and low-level flooding impacts disabled people disproportionally to non-disabled. People's past experiences were a strong factor in deciding whether to make a journey and how it was taken, which is difficult to capture in checklists and design guides. Wetter conditions have the potential to create a negative feedback loop, where the potential of a fall increases from the poor conditions and the absence of journeys decreases wellbeing and further reduces confidence to make another journey. When planning for the future of cities, the impacts of nuisance flooding must be considered with effective engagement of disabled and older people.

The desire for increased shelter along active journeys was a key finding, especially at bus stops and over mobility parking. Bus shelters in high deprivation areas of Ōtautahi have higher patronage per stop, yet the majority of shelters are found in the middle deprivation areas. Lack of a reliable, accessible and affordable door-to-door service also contributes to journeys not being made and disabled people cannot rely on organising a timely driver for wet weather days that would be too difficult to make a journey on or if caught out by rain.

Improving the comfort quality of the journey for rainy conditions increases transport equity by providing a more dignifying experience for people who have little choice in their transport mode. Capturing and using more information about disabled and older people's journeys is essential to enhancing urban mobility. The movement to prioritise people above cars will assist in mitigating inaccessible streets and the compounding effect of nuisance flooding, with many co-benefits. Improving the journey experience for those with the greatest mobility needs and non-car users, improves the experience for everyone. This will make public transport and other active transport modes more attractive and resilient to future predicted climatic changes of more intense rainfall events.

6.1 Further study

There are four key aspects that would benefit from more research, building off this research. Firstly, to better understand and prevent the cycle of poor street conditions leading to isolation and poor mental health. Solutions are needed beyond the recommendation of walking for increased mental health as it is part of the problem. Secondly, as disabled people disproportionately face the negative impacts of climate change, this research has only begun to explore how the adaptation of a city to climate change can provide opportunity to increase accessibility and address systemic barriers that disabled people face. In particular, more research is needed to understand the barriers of disabled and older people engaging in with wetland and nature spaces, as they are often seen as both a flood mitigation and wellbeing solution that disabled people should not miss out on. Thirdly, related to the above, more research is need to further understand why accessibility measures are difficult to implement, in transport in particular. There is extensive research on the physical barriers that disabled people face, yet disabled people remain over represented in negative statistics regarding access to transport. Lastly, if cost and measurable outcomes are incentives for accessibly and increased resilience of a transport network, more research is needed to understand the economic aspects of improving public transport infrastructure, especially in relation to ridership and also wider public health aspects.

7 References

Anderson, M. J., Kiddle, D. A. F., & Logan, T. M. (2022). The underestimated role of the transportation network: Improving disaster & community resilience. *Transportation Research Part D: Transport and Environment*, *106*, 103218. https://doi.org/10.1016/J.TRD.2022.103218

Arana, P., Cabezudo, S., & Peñalba, M. (2014). Influence of weather conditions on transit ridership: A statistical study using data from Smartcards. *Transportation Research Part A: Policy and Practice*, *59*, 1–12. https://doi.org/10.1016/j.tra.2013.10.019

Architecture Plus Ltd. (n.d.). *Street Corner Canopies | Wellington 2000 -2003*. Architecture Plus Ltd. Retrieved February 11, 2023, from https://architectureplus.co.nz/public/streetcornercanopies/

Auliagisni, W., Wilkinson, S., & Elkharboutly, M. (2022). Using community-based flood maps to explain flood hazards in Northland, New Zealand. *Progress in Disaster Science*, *14*, 100229. https://doi.org/10.1016/j.pdisas.2022.100229

Awad-Núñez, S., Julio, R., Gomez, J., Moya-Gómez, B., & González, J. S. (2021). Post-COVID-19 travel behaviour patterns: Impact on the willingness to pay of users of public transport and shared mobility services in Spain. *European Transport Research Review*, *13*(1), 20. https://doi.org/10.1186/s12544-021-00476-4

Azolin, L. G., Rodrigues da Silva, A. N., & Pinto, N. (2020). Incorporating public transport in a methodology for assessing resilience in urban mobility. *Transportation Research Part D: Transport and Environment*, *85*(June), 102386. https://doi.org/10.1016/j.trd.2020.102386

Barlew, L., Secrest, J., Guo, Z., Fell, N., & Haban, G. (2013). The Experience of Being Grounded: A Phenomenological Study of Living with a Wheelchair. *Rehabilitation Nursing*, *38*(4), 193–201.

Boberg, J., & Sherwood-O'Regan, K. (2021). Nothing about us without us: Climate change and disability justice. In H. Clark (Ed.), *Climate Aotearoa: What's happening & what we can do about it*.

Böcker, L., Dijst, M., & Faber, J. (2016). Weather, transport mode choices and emotional travel experiences. *Transportation Research Part A: Policy and Practice*, *94*, 360–373. https://doi.org/10.1016/j.tra.2016.09.021

Böcker, L., Dijst, M., & Prillwitz, J. (2013). Impact of Everyday Weather on Individual Daily Travel Behaviours in Perspective: A Literature Review. *Transport Reviews*, *33*(1), 71–91. https://doi.org/10.1080/01441647.2012.747114

Boffa Miskell. (2020). *Greater Christchurch Public Transport Futures Combined Business Cases: Non Technical Summary*. https://www.ecan.govt.nz/document/download?uri=4012459

Bukvic, A., Gohlke, J., Borate, A., & Suggs, J. (2018). Aging in Flood-Prone Coastal Areas: Discerning the Health and Well-Being Risk for Older Residents. *International Journal of Environmental Research and Public Health 2018, Vol. 15, Page 2900*, *15*(12), 2900. https://doi.org/10.3390/IJERPH15122900

Burdett, B. R. D., Witten, K., Willing, E., & Ameratunga, S. (2021). Inclusive access in transport policy and practice: Views of New Zealand transport practitioners. *Case Studies on Transport Policy*, *9*(4), 1593–1599. https://doi.org/10.1016/j.cstp.2021.08.008

Calder-Dawe, O., Witten, K., & Carroll, P. (2020). Being the body in question: Young people's accounts of everyday ableism, visibility and disability. *Disability & Society*, *35*(1), 132–155. https://doi.org/10.1080/09687599.2019.1621742

Christchurch City Council. (n.d.). *Heathcote catchment*. Christchurch City Council. Retrieved February 11, 2023, from https://ccc.govt.nz/services/water-and-drainage/stormwater-and-

drainage/stormwater-projects/whats-happening-in-your-neighbourhood/heathcote-catchment/

Chung, E., Ohtani, O., Warita, H., Kuwahara, M., & Morita, H. (2005). Effect of rain on travel demand and traffic accidents. *Proceedings. 2005 IEEE Intelligent Transportation Systems, 2005.*, 1080–1083. https://doi.org/10.1109/ITSC.2005.1520201

Conrow, L., Campbell, M., & Kingham, S. (2021). Transport changes and COVID-19: From present impacts to future possibilities. *New Zealand Geographer*, *77*(3), 185–190. https://doi.org/10.1111/nzg.12315

Curl, A., Fitt, H., & Tomintz, M. (2020). Experiences of the Built Environment, Falls and Fear of Falling Outdoors among Older Adults: An Exploratory Study and Future Directions. *International Journal of Environmental Research and Public Health*, *17*(4). https://doi.org/10.3390/IJERPH17041224

Curl, A., Ward Thompson, C., Aspinall, P., & Ormerod, M. (2016). Developing an audit checklist to assess outdoor falls risk. *Proceedings of the Institution of Civil Engineers - Urban Design and Planning*, *169*(3), 138–153. https://doi.org/10.1680/udap.14.00056

Curl, A., Watkins, A., McKerchar, C., Exeter, D., & Macmillan, A. (2020). *Research Report 666 Social impact assessment of mode shift*. www.nzta.govt.nz

Czeisler, M. É., Wiley, J. F., Czeisler, C. A., Rajaratnam, S. M. W., & Howard, M. E. (2021). Uncovering survivorship bias in longitudinal mental health surveys during the COVID-19 pandemic. *Epidemiology and Psychiatric Sciences*, *30*, e45. https://doi.org/10.1017/S204579602100038X

DeRobertis, M., & Renard, A. (2022). Beyond Multimodal Metrics: Adapting Streets for People and Our Evolving Environment. *Institute of Transportation Engineers. ITE Journal*, *92*(6), 44–50.

Devarajan, R., Prabhakaran, D., & Goenka, S. (2020). Built environment for physical activity—An urban barometer, surveillance, and monitoring. *Obesity Reviews*, *21*(1), e12938. https://doi.org/10.1111/obr.12938

Doran, B., Crossland, K., Brown, P., & Stafford, L. (2022). *Transport experiences of disabled people in Aotearoa New Zealand*.

El-Geneidy, A., Grimsrud, M., Wasfi, R., Tétreault, P., & Surprenant-Legault, J. (2014). New evidence on walking distances to transit stops: Identifying redundancies and gaps using variable service areas. *Transportation*, *41*(1), 193–210. https://doi.org/10.1007/s11116-013-9508-z

Elston, D. M. (2021). Survivorship bias. *Journal of the American Academy of Dermatology*. https://doi.org/10.1016/j.jaad.2021.06.845

Fant, C., Jacobs, J. M., Chinowsky, P., Sweet, W., Weiss, N., Sias, J. E., Martinich, J., & Neumann, J. E. (2021). Mere Nuisance or Growing Threat? The Physical and Economic Impact of High Tide Flooding on US Road Networks. *Journal of Infrastructure Systems*, *27*(4), 04021044. https://doi.org/10.1061/(ASCE)IS.1943-555X.0000652

Gaskin, C. J., Taylor, D., Kinnear, S., Mann, J., Hillman, W., & Moran, M. (2017). Factors Associated with the Climate Change Vulnerability and the Adaptive Capacity of People with Disability: A Systematic Review. *Weather, Climate, and Society*, *9*(4), 801–814. https://doi.org/10.1175/WCAS-D-16-0126.1

Gonçalves, L. A. P. J., & Ribeiro, P. J. G. (2020). Resilience of urban transportation systems. Concept, characteristics, and methods. *Journal of Transport Geography*, *85*, 102727. https://doi.org/10.1016/j.jtrangeo.2020.102727

Handy, S. (2020). Is accessibility an idea whose time has finally come? *Transportation Research Part D: Transport and Environment*, *83*, 102319. https://doi.org/10.1016/j.trd.2020.102319

Handy, S., Boarnet, M. G., Ewing, R., & Killingsworth, R. E. (2002). How the built environment affects physical activity: Views from urban planning. *American Journal of Preventive Medicine*, *23*(2, Supplement 1), 64–73. https://doi.org/10.1016/S0749-3797(02)00475-0

Hart, D. E., Pitman, S. J., & Byun, D.-S. (2020). Earthquakes, Coasts... and Climate Change? Multi-hazard Opportunities, Challenges and Approaches for Coastal Cities. *Journal of Coastal Research*, *95*, 819–823. https://doi.org/10.2112/SI95-159.1

Hartley, M., Curl, A., Crossin, R., & Mckerchar, C. (2021). Access to Primary Care services using Public Transport in Ōtautahi Christchurch. *The New Zealand Medical Journal*, *134*.

Hay, I. (2016). *Qualitative research methods in human geography* (Fourth). Oxford University Press. https://go.exlibris.link/DpG0ncv0

Injury Prevent Research Unit, University of Otago. (2019). *IPRU Factsheet 45* (ISSN 1172-8388).

Iseki, H., & Taylor, B. (2010). Style versus Service? An Analysis of User Perceptions of Transit Stops and Stations. *Journal of Public Transportation*, *13*(3). https://doi.org/10.5038/2375-0901.13.3.2

Jack, M., & Graziadei, C. (2019). *Report of the Independent Review of New Zealand's 2018 Census* (p. 96). https://www.stats.govt.nz/assets/Uploads/Report-of-the-Independent-Review-of-New-Zealands-2018-Census/independent-review-report.pdf

Jacobs, J. M., Cattaneo, L. R., Sweet, W., & Mansfield, T. (2018). Recent and Future Outlooks for Nuisance Flooding Impacts on Roadways on the U.S. East Coast: *Https://Doi.Org/10.1177/0361198118756366*, *2672*(2), 1–10. https://doi.org/10.1177/0361198118756366

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., & Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and Society*, *21*(2). https://www.jstor.org/stable/26270403

Lättman, K., Olsson, L. E., & Friman, M. (2018). A new approach to accessibility – Examining perceived accessibility in contrast to objectively measured accessibility in daily travel. *Research in Transportation Economics*, *69*, 501–511. https://doi.org/10.1016/j.retrec.2018.06.002

Levesque, J.-F., Harris, M. F., & Russell, G. (2013). Patient-centred access to health care: Conceptualising access at the interface of health systems and populations. *International Journal for Equity in Health*, *12*(1), 18. https://doi.org/10.1186/1475-9276-12-18

Li, W., Keegan, T. H. M., Sternfeld, B., Sidney, S., Quesenberry, C. P., & Kelsey, J. L. (2006). Outdoor Falls Among Middle-Aged and Older Adults: A Neglected Public Health Problem. *American Journal of Public Health*, *96*(7), 1192–1200. https://doi.org/10.2105/AJPH.2005.083055

Lid, I. M., & Solvang, P. K. (2016). (Dis)ability and the experience of accessibility in the urban environment. *Alter*, *10*(2), 181–194. https://doi.org/10.1016/j.alter.2015.11.003

Lin, P., Weng, J., Brands, D. K., Qian, H., & Yin, B. (2020). Analysing the relationship between weather, built environment, and public transport ridership. *IET Intelligent Transport Systems*, *14*(14), 1946–1954. https://doi.org/10.1049/iet-its.2020.0469

Lindsay, S., & Yantzi, N. (2014). Weather, disability, vulnerability, and resilience: Exploring how youth with physical disabilities experience winter. *Disability and Rehabilitation*, *36*(26), 2195–2204. https://doi.org/10.3109/09638288.2014.892158

Local Government New Zealand. (2014). *Managing natural hazard risk in New Zealand-towards more resilient communities A think piece for local and central government and others with a role in managing natural hazards*.

Logan, T. M., & Guikema, S. D. (2020). Reframing Resilience: Equitable Access to Essential Services. *Risk Analysis*, *40*(8), 1538–1553. https://doi.org/10.1111/RISA.13492

Loprencipe, G., Moretti, L., Pantuso, A., & Banfi, E. (2019). Raised Pedestrian Crossings: Analysis of Their Characteristics on a Road Network and Geometric Sizing Proposal. *Applied Sciences*, *9*(14), Article 14. https://doi.org/10.3390/app9142844

Mandic, S., Jackson, A., Lieswyn, J., Mindell, J. S., Bengoechea, E. G., Spence, J. C., Wooliscroft, B., Wade-Brown, C., Coppell, K. J., & Hinckson, E. (2019). *Turning the tide-from cars to active transport*.

Mason, K., Lindberg, K., Haenfling, C., Schori, A., Marsters, H., Read, D., Borman, B., Miner, R., Jain, S., & Lausier, A. (2021). Social Vulnerability Indicators for Flooding in Aotearoa New Zealand. *International Journal of Environmental Research and Public Health 2021, Vol. 18, Page 3952*, *18*(8), 3952.

McClymont, K., Morrison, D., Beevers, L., & Carmen, E. (2020). Flood resilience: A systematic review. *Journal of Environmental Planning and Management*, *63*(7), 1151–1176. https://doi.org/10.1080/09640568.2019.1641474

McIntosh, J., Marques, B., & McKone, M. (2017). *Removing disability: The restorative powers of landscape*.

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, *147*, 38–49. https://doi.org/10.1016/j.landurbplan.2015.11.011

Meher, M., Spray, J., Wiles, J., Anderson, A., Willing, E., Witten, K., 'Ofanoa, M., & Ameratunga, S. (2021). Locating transport sector responsibilities for the wellbeing of mobility-challenged people in Aotearoa New Zealand. *Wellbeing, Space and Society*, *2*, 100034. https://doi.org/10.1016/j.wss.2021.100034

Miao, Q., Welch, E. W., & Sriraj, P. S. (2019). Extreme weather, public transport ridership and moderating effect of bus stop shelters. *Journal of Transport Geography*, *74*, 125–133. https://doi.org/10.1016/j.jtrangeo.2018.11.007

Ministry of Transport. (2022). *Community Connect*. Ministry of Transport. https://www.transport.govt.nz/area-of-interest/public-transport/community-connect/

Moftakhari, H. R., AghaKouchak, A., Sanders, B. F., Allaire, M., & Matthew, R. A. (2018). What Is Nuisance Flooding? Defining and Monitoring an Emerging Challenge. *Water Resources Research*, *54*(7), 4218–4227. https://doi.org/10.1029/2018WR022828

Moran, M. E. (2022). Are shelters in place? Mapping the distribution of transit amenities via a bus-stop census of San Francisco. *Journal of Public Transportation*, *24*, 100023. https://doi.org/10.1016/j.jpubtr.2022.100023

Murphy, A., & Hyde, K. (2018). *Flooded with opportunities—Turning flood mitigation schemes into community assets*. Water New Zealand's 2018 Stormwater Conference.

Ngo, N. S. (2019). Urban bus ridership, income, and extreme weather events. *Transportation Research Part D: Transport and Environment*, *77*, 464–475. https://doi.org/10.1016/j.trd.2019.03.009

Office for Disability Issues. (2017). *An Explanation of the Washington Group Short Set of Questions on Disability*. Office for Disability Issues. https://www.odi.govt.nz/guidance-and-resources/an-explanation-of-the-washington-group-short-set-of-questions-on-disability/

Park, J., & Chowdhury, S. (2018). Investigating the barriers in a typical journey by public transport users with disabilities. *Journal of Transport & Health*, *10*, 361–368. https://doi.org/10.1016/J.JTH.2018.05.008

Park, J., & Chowdhury, S. (2021). Towards an enabled journey: Barriers encountered by public transport riders with disabilities for the whole journey chain. *Https://Doi-*

Org.Ezproxy.Canterbury.Ac.Nz/10.1080/01441647.2021.1955035. https://doi.org/10.1080/01441647.2021.1955035

Park, K., Chamberlain, B., Song, Z., Nasr Esfahani, H., Sheen, J., Larsen, T., Long Novack, V., Licon, C., & Christensen, K. (2022). A double jeopardy: COVID-19 impacts on the travel behavior and community living of people with disabilities. *Transportation Research Part A: Policy and Practice*, *156*, 24–35. https://doi.org/10.1016/J.TRA.2021.12.008

Parkinson, S., Eatough, V., Holmes, J., Stapley, E., & Midgley, N. (2016). Framework analysis: A worked example of a study exploring young people's experiences of depression. *Qualitative Research in Psychology*, *13*(2), 109–129. https://doi.org/10.1080/14780887.2015.1119228

Parr-Brownlie, L. C., Waters, D. L., Neville, S., Neha, T., Muramatsu, N., & Meeks, S. (2020). Aging in New Zealand: Ka haere ki te ao pakeketanga. *The Gerontologist*, *60*(5), 812–820. https://doi.org/10.1093/GERONT/GNAA032

Patel, J. A., Nielsen, F. B. H., Badiani, A. A., Assi, S., Unadkat, V. A., Patel, B., Ravindrane, R., & Wardle, H. (2020). Poverty, inequality and COVID-19: The forgotten vulnerable. *Public Health*, *183*, 110–111. https://doi.org/10.1016/j.puhe.2020.05.006

Perry, M. A., Devan, H., Fitzgerald, H., Han, K., Liu, L.-T., & Rouse, J. (2018). Accessibility and usability of parks and playgrounds. *Disability and Health Journal*, *11*(2), 221–229. https://doi.org/10.1016/j.dhjo.2017.08.011

Phillips, J., Walford, N., Hockey, A., Foreman, N., & Lewis, M. (2013). Older people and outdoor environments: Pedestrian anxieties and barriers in the use of familiar and unfamiliar spaces. *Geoforum*, *47*, 113–124. https://doi.org/10.1016/j.geoforum.2013.04.002

Robinson, O. C. (2014). Sampling in Interview-Based Qualitative Research: A Theoretical and Practical Guide. *Qualitative Research in Psychology*, *11*(1), 25–41. https://doi.org/10.1080/14780887.2013.801543

Salmond, C. E., & Crampton, P. (2012). Development of New Zealand's Deprivation Index (NZDep) and Its Uptake as a National Policy Tool. *Canadian Journal of Public Health / Revue Canadienne de Sante'e Publique*, *103*, S7–S11.

Sanderson, W. C., & Scherbov, S. (2013). The Characteristics Approach to the Measurement of Population Aging. *Population and Development Review*, *39*(4), 673–685.

Schwartz, N., Buliung, R., Daniel, A., & Rothman, L. (2022). Disability and pedestrian road traffic injury: A scoping review. *Health & Place*, *77*, 102896. https://doi.org/10.1016/j.healthplace.2022.102896

Shirgaokar, M., Dobbs, B., Anderson, L., & Hussey, E. (2020). Do rural older adults take fewer trips than their urban counterparts for lack of a ride? *Journal of Transport Geography*, *87*, 102819. https://doi.org/10.1016/j.jtrangeo.2020.102819

Skirbekk, V. F., Staudinger, U. M., & Cohen, J. E. (2019). How to Measure Population Aging? The Answer Is Less than Obvious: A Review. *Gerontology*, *65*(2), 136–144. https://doi.org/10.1159/000494025

Spray, J., Witten, K., Wiles, J., Anderson, A., Paul, D., Wade, J., & Ameratunga, S. (2020). *Inequitable mobilities: Intersections of diversity with urban infrastructure influence mobility, health and wellbeing*. 1–15. https://doi.org/10.1080/23748834.2020.1827881

Stats NZ. (2013a). *Disability Survey: 2013 New Zealand Disability Survey*. http://www.stats.govt.nz/browse_for_stats/health/disabilities/DisabilitySurvey_HOTP2013.aspx

Stats NZ. (2013b). *Household Disability Survey 2023: Final content*. www.stats.govt.nz

Stats NZ. (2018). *Activity limitations*. https://datainfoplus.stats.govt.nz/Item/nz.govt.stats/83ca312b-bd72-4a13-bdcf-14c570710700?_ga=2.129924300.1392222516.1651519804-417328218.1650583100

Stats NZ. (2020a). *2018 Census – NZ.Stat tables*. Stats NZ. https://www.stats.govt.nz/information-releases/2018-census-nz-stat-tables/

Stats NZ. (2020b). *National population projections: 2020(base)–2073 | Stats NZ*. Stats NZ Tatauranga Aotearoa. https://www.stats.govt.nz/information-releases/national-population-projections-2020base2073

Tolich, M., & Davidson, C. (2018). Collecting and Analysing Qualitative Data. In *Social Science Research in New Zealand*. Auckland University Press.

Ton, D., Duives, D. C., Cats, O., Hoogendoorn-Lanser, S., & Hoogendoorn, S. P. (2019). Cycling or walking? Determinants of mode choice in the Netherlands. *Transportation Research Part A: Policy and Practice*, *123*, 7–23. https://doi.org/10.1016/j.tra.2018.08.023

Trenberth, K. E., & Zhang, Y. (2018). How Often Does It Really Rain? *Bulletin of the American Meteorological Society*, *99*(2), 289–298. https://doi.org/10.1175/BAMS-D-17-0107.1

Vannier, C., Campbell, M., & Kingham, S. (2020). Pathways to urban health and well-being: Measuring and modelling of community services' in a medium size city. *Geospatial Health*, *15*(1). https://doi.org/10.4081/gh.2020.808

Vella-Brodrick, D. A., & Stanley, J. (2013). The significance of transport mobility in predicting well-being. *Transport Policy*, *29*, 236–242. https://doi.org/10.1016/j.tranpol.2013.06.005

Waka Kotahi & The Research Agency. (2022). *2021 Understanding attitudes and perceptions of cycling & walking*. https://www.nzta.govt.nz/assets/resources/understanding-attitudes-and-perceptions-of-cycling-and-walking/Waka-Kotahi-Attitudes-to-cycling-and-walking-final-report-2021.pdf

Waka Kotahi NZ Transport Agency. (n.d.-a). *Bus stop spacing*. Retrieved January 28, 2023, from https://www.nzta.govt.nz/walking-cycling-and-public-transport/public-transport/public-transport-design-guidance/bus-stop/bus-stop-location-planning/location-fundamentals/bus-stop-spacing/

Waka Kotahi NZ Transport Agency. (n.d.-b). *Falls—Slips, trips and stumbles*. Waka Kotahi NZ Transport Agency. Retrieved December 22, 2022, from https://www.nzta.govt.nz/walking-cycling-and-public-transport/walking/walking-standards-and-guidelines/pedestrian-network-guidance/walking-in-new-zealand/falls-slips-trips-and-stumbles/#_ftn3

Waka Kotahi NZ Transport Agency. (n.d.-c). *Raised zebra crossings*. Waka Kotahi NZ Transport Agency. Retrieved January 6, 2023, from https://www.nzta.govt.nz/walking-cycling-and-public-transport/walking/walking-standards-and-guidelines/pedestrian-network-guidance/design/crossings/priority-crossings/raised-zebra-crossings/

Waka Kotahi NZ Transport Agency. (2009). *Pedestrian planning and design guide* (p. 188). https://www.nzta.govt.nz/resources/pedestrian-planning-guide/

Waka Kotahi NZ Transport Agency. (2022). *Reshaping Streets regulatory changes: Consultation document* (p. 38). https://www.nzta.govt.nz/assets/consultation/reshaping-streets/reshaping-streets-regulatory-changes-consultation-document.pdf

Walker, E. T., Wehi, P. M., Nelson, N. J., Beggs, J. R., & Whaanga, H. (2019). Kaitiakitanga, place and the urban restoration agenda. *New Zealand Journal of Ecology*, *43*(3), 1–8.

Wang, Y., Chau, C. K., Ng, W. Y., & Leung, T. M. (2016). A review on the effects of physical built environment attributes on enhancing walking and cycling activity levels within residential neighborhoods. *Cities*, *50*, 1–15. https://doi.org/10.1016/j.cities.2015.08.004

Whitehead, J., Pearson, A. L., Lawrenson, R., & Atatoa-Carr, P. (2019, October 18). *Spatial equity and realised access to healthcare – a geospatial analysis of general practitioner enrolments in Waikato, New Zealand*. https://doi.org/10.22605/RRH5349

Xie, B., Zhou, J., & Luo, X. (2016). Mapping spatial variation of population aging in China's mega cities. *Journal of Maps*, *12*(1), 181–192. https://doi.org/10.1080/17445647.2014.1000984

Yasa, E. (2023). *Pedestrian Level Relationship Between Building Forms and Streets Effects on the Condition of Comfort in Historical Context*. IntechOpen. https://doi.org/10.5772/intechopen.108735

Zhai, X., Huang, H., Sze, N. N., Song, Z., & Hon, K. K. (2019). Diagnostic analysis of the effects of weather condition on pedestrian crash severity. *Accident Analysis & Prevention*, *122*, 318–324. https://doi.org/10.1016/j.aap.2018.10.017

Zuniga-Teran, A. A., & Gerlak, A. K. (2019). A Multidisciplinary Approach to Analyzing Questions of Justice Issues in Urban Greenspace. *Sustainability*, *11*(11), Article 11. https://doi.org/10.3390/su11113055

8 Appendices

8.1 Appendix A - Vulnerability Factors

The demographic factors in Table A1 were reviewed when choosing a study area based off social vulnerability factor for flooding (Mason et al., 2021). SA2 areas with the most extreme vulnerability factors were shortlisted and weighed up against flood risk.

Table A1. Demographic factors of shortlisted areas

SA2 name	Usual resident population	Population over 65 (%)	Māori among over 60 (%)	Some walking difficulty (%)	A lot of walking difficulty (%)	Households with no car	Households with an older adult (65+ years) living alone	One Person Household	NZDep2018
Rawhiti	2769	15.5	3.6	17%	4%	7.9	14.7	31.1	8
New Brighton	3330	13.4	5.0	14%	3%	9.5	14.0	35.0	8
Opawa	1365	25.1	2.1	19%	7%	6.3	14.0	29.3	4
Woolston East	3225	19.6	5.6	20%	4%	12.2	17.3	34.5	8
Woolston South	507	13.0	6.9	15%	2%	9.2	10.0	40.0	8
Shirley East	2679	24.4	1.9	21%	7%	12.2	17.3	27.0	4
Dallington	2361	16.8	4.1	15%	4%	7.6	12.7	27.4	7
Aranui	4200	8.4	12.6	20%	5.4%	15.6	7.8	24.4	10

8.2 Appendix B – Interview Guide

Interview Section	Subtheme	Likely Question	Probes
Introductions/ Whanaun-gatanga	Thanks for agreeing, further introduce myself and the research. Introduction of group, offer of refreshments. Step through the consent form, emphasising on ability to withdraw and putting at ease for recording. Offer to open with a karakia		
Introductory Questions	Preferred terminology Enjoyed activities	What terminology do you prefer? What are some activities you enjoy?	(disabled, walking etc) Hobbies
Destinations and Mapping	Places frequented Mode of travel Delivery services/Reliance on others	Where are the places you visit frequently? Where do you go for (and how frequently)? Why those locations? How do you usually travel to these destinations? Do you use any delivery services or ask others to bring things?	Healthcare Shopping Employment Food Social Exercise Cultural Bus use (and barriers to PT use) Car use
Flood experiences	Past flood experience Barriers (or advantages) revealed with rain or water on the streets Tolerance for water on streets Access solutions	Can you tell me about any experiences you've had of flooding/heavy rain that disrupted your daily routine? How does rain or water on the streets make 'walking' more difficult for you? Are there any advantages? What was your biggest worry about the rain/excess water on the streets? What would make going out when there are wet streets easier?	June 2021 rain More recent rain? Earthquakes Fear of falling Events when couldn't reach essentials Asking for help because of rain Fear of rain Sheltered bus stops Tactile pavement
Flood resilience	Consequences of not reaching essential destinations Support needed from others Connection to neighbours Supplies at home Enhancing community resilience Previous contact from organisations in flooding and other emergencies	What did you do when you were unable to reach your regular destinations? What support did you require (or would you like to see) if you were unable to reach a destination? How well do you know your neighbours? Do you feel prepared at home if it was to happen again? What community initiative would you like to see? Were you contacted by anyone during last year's flooding?	Access to food, ability to work, essential health visits Support from friends, food delivered (like COVID 19)

Council engagement	Prior/current engagement (with council, advocacy groups) Desire to be involved in city planning processes Preferred engagement style	Have you been involved with informing Council about your experiences before? Would you like to be more involved? If Council was making decisions relevant to you, how would you like to be informed or engaged?	 Town halls, submissions, online, disability groups
Conclusion	Thanks for time and perspective, offering of notes or summary of results, any last questions or remarks? Closing karakia if opened with karakia		

8.3 Appendix C – Rainfall Correlation Data

Table C1. Summary of Rainfall Correlation Data

	Heathcote				Sumner				Core Routes			
	Weekday		Weekend		Weekday		Weekend		Weekday		Weekend	
	Rainy day	Wet day	Rainy day	Wet day	Rainy day	Wet day	Rainy day	Wet day	Rainy day	Wet day	Rainy day	Wet day
Shelter Correlation with ratio	-0.19	0.37	0.30	0.15	0.10	0.11	-0.02	0.00	-0.14	0.38	0.20	0.19
p value	0.16	0.00	0.02	0.30	0.91	0.60	0.70	0.69	0.16	0.00	0.04	0.05
Average Sheltered	-9.2%	-12.8%	0.6%	-3.4%	-11.4%	-16.5%	-12.6%	-12.8%	-10.3%	-13.7%	-2.9%	-5.6%
Average Non-Sheltered	-6.2%	-19.5%	-8.3%	-10.7%	-13.2%	-19.7%	-11.8%	-13.1%	-8.0%	-20.8%	-10.0%	-14.2%
Max	14.3%	0.3%	31.2%	42.7%	20.1%	5.3%	68.3%	79.5%	20.1%	0.3%	55.9%	42.7%
Min	-35.4%	-36.5%	-41.7%	-60.0%	-29.6%	-53.5%	-53.8%	-76.5%	-35.4%	-53.5%	-53.8%	-76.5%
n	81	81	81	81	36	36	36	36	101	101	101	101
t value	1.44	3.61	2.33	1.03	0.12	0.53	0.39	0.41	1.42	4.14	2.07	1.95
Standard Deviation	0.08	0.08	0.15	0.20	0.09	0.12	0.26	0.28	0.08	0.09	0.15	0.21