Accessibility of the Built Environment for vulnerable populations

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STATEMENT OF ORIGINALITY:

Title: Accessibility of the Built Environment for vulnerable populations

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EXECUTIVE SUMMARY

The United Nations Convention on the Rights of Persons with Disabilities states that the disabled have equal rights with other members of society to access the Built Environment (BE). Lots of accessibility legislation has been enacted all over the world to protect the rights of disabilities.

Research Problem

But, what about the actual accessibility legislation compliance? It is important to evaluate to what extent the existing buildings have complied with the mandatory legislation, and how far the BE has met the needs of disabled groups to guarantee their equal human rights. This research focuses on manual wheelchair (MWC) users and BE accessibility in New Zealand.

Research Importance

There are about 65 million people worldwide who rely on a wheelchair in their daily lives, MWC users make up around 85% of all wheelchair users. And this number is growing. This study will significantly benefit this large amount of population. It will help people more deeply understand their expectations and boost the public to improve BE accessibility and protect MWC users' rights on the ground.

Research Objectives

There are six research objectives for this project:

1. Summarize the main accessibility features and the corresponding specifications of the accessibility legislation applied in NZ. Compare the NZ accessibility legislation with the American policy.
2. Conduct a practical accessibility assessment of 10 case shops in NZ to collect their actual measurements of accessible features, find out how far these existing public buildings comply with the NZ accessibility legislation, and identify key features that need to be improved.
3. Review the literature to learn the implementation of accessibility policy in various nations.
4. Identify the main challenges faced by MWC users when accessing BE.
5. Explore the underlying reasons leading to poor BE accessibility.
6. Make recommendations to improve the BE accessibility for MWC users.

Research Method

A systematic literature review was conducted, and a research gap was identified: there isn't a study to assess the accessibility legislation compliance of public buildings in NZ, and how well the current BE in NZ meets the MWC users' needs.

To fill this gap, an experiment of 10 case shops in NZ was conducted by measuring their practical dimensions of accessible features and comparing them with the NZ mandatory legislation. The compliance percentages were calculated by shop, by feature, and by sub-item of features. The experiment results were then compared with the findings of the literature review.

Research Results

1. Features and specifications of the accessibility legislation in NZ (NZS4121:2001) for MWC users are sorted and listed in a table. Compared with the 2010 ADA standards applied in America, most of the accessible requirements are similar, but there are still some differences that are better than one another.

2. The experiment of 10 case shops indicates a serious failure of BE accessibility legislation compliance in NZ. Only 10% of the case shops completely comply with the requirements of NZS4121:2001 for outdoor environments, while that is 0% in terms of indoor environments. Even except the influence of the checkout counter, the indoors of case shops are just partially accessible.

Regarding the compliance outcome by features, all the outside features present very poor accessibility compliance. Only 20% of the car parking,30% of the footpaths, and 25% of the kerb ramps comply with the legislation, while no ramps completely meet the regulations. Even though the indoor BE accessibility is much better than outdoors, there are no checkout counters that meet the accessible requirements (0%), and just part of the passing space and shelf is accessible for MWC users.

The Compliance Outcome by Sub-item of Features identifies the inaccessible items that need to be improved. In terms of the outdoors, it includes the short dimensions of car parking, steep transverse gradient and longitudinal gradient of footpaths and ramps, inaccessible kerb ramps gradients, obstacles in the path, etc. For the indoors, the narrow passing space, the high height of the shelves and checkouts are quite challenging for MWC users.

3. The literature review theme 1 indicates the generally poor accessibility policies implementation in various countries, and the accessibility compliance level differs significantly in different places. The experiment results of 10 case shops confirm this idea - weak accessibility legislation compliance in NZ, and their compliance level differs significantly.

4. The inaccessible features identified in the experiment are quite similar to the main challenges summarized in other nations (the literature review theme 2), including outdoor barriers, such as inaccessible parking, narrow pavement, lack of dropped curbs, steep slopes, obstructions in the path (like plant, columns), and indoor challenges, like high counters and shelves, cluttered aisles, etc.

5. Poor legislation implementation is a significant cause of poor BE accessibility in NZ. The literature review theme 3 also summarized other underlying reasons, including social exclusion, inadequate design, building practitioners' negative attitude, lack of cost, etc.

6. The potential solutions are suggested to improve BE accessibility for MWC users in NZ. For instance, stricter enforcement of accessible policies, improvement of public awareness and social inclusion to disabilities, engagement of MWC users in BE design, development of navigation tools, provision of training for staff to help MWC users, government-led activities, etc. The inaccessible features identified in the experiment, such as inaccessible parking, narrow pavement, lack of dropped curbs, steep slopes, etc., need to be paid more attention to improve.

Research Implications

This research will help the public better understand the practical accessibility policies implementation, the main challenges faced by MWC users, underlying causes of poor BE accessibility, and potential ways to improve the situation; it will encourage the government and the public in NZ to remove the existing barriers, address the underlying problems and finally provide an accessible BE for MWC users and protect their equal rights in practice. Other researchers can also use the data of this research, and conduct further investigations based on the findings of this study.

TABLE OF CONTENTS

LIST OF TABLES:

LIST OF FIGURES:

ABBREVIATIONS:

BE: Built Environment

MWC: manual wheelchair

1.0 INTRODUCTION

The large size of the disabled and MWC users

Vulnerable groups are an important part of the world's population. There are about 1.3 billion disabled individuals across the globe, which accounts for 16% of the whole population of the world (World Health Organisation, 2023). The disability includes many types, manual wheelchair (MWC) users, visually impaired people, the elderly, etc (Zeng et al., 2017). However, MWC users make up a significant part. About 1 percent of the population uses MWC in their daily life (Flemmer, 2022), and this number is growing due to the increasing number of old individuals (Bromley et al., 2007; Holloway & Tyler, 2013; World Health Organisation, 2023). Tannert et al. (2019) presented that there are about 65 million people worldwide who rely on a wheelchair in their daily lives, and MWC users make up around 85% of all wheelchair users. There are about 0.7% of the population aged no less than 15 years old in Canada using MWC daily (Smith, Giesbrecht, et al., 2016). This large amount of group faces lots of challenges when accessing the Built Environment (BE).

Accessibility rights of vulnerable populations

The United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) identifies the basic rights of vulnerable populations including personal mobility, participation in public activities, etc. (United Nations, 2006), as shown in Table 1. However, all these rights require the support of accessibility of the BE to achieve. Article 9 Accessibility of the UNCRPD states that vulnerable groups have equal rights with other members of the society to access the physical environment, transportation, built environment, such as work offices, schools, hospitals as well as other public services (United Nations, 2006). Tudzi et al. (2017) highlighted accessible teaching BE is required to protect the rights of inclusive education for disabled students. Pagán (2015) stated the BE accessibility problems have hindered disabled people's chance to participate in various social activities like tourism. Building inaccessibility prevents vulnerable groups from experiencing the ease of personal mobility (Page & Þorsteinsson, 2018). All these indicate the importance of BE accessibility.

Table 1 The achievement of disabilities' rights requires the support of BE accessibility.

Right	Article	Relationship	Right	Article
Living independently and being included in the community	19	Require the support of BE accessibility to achieve	Accessibility	9
Personal mobility	20			
Education	24			
Work and employment	27			
Adequate standard of living and social protection	28			
Participation in political and public life	29			
Participation in cultural life, recreation, leisure and sport	30			

(Source:United Nations, 2006)

Research problem and importance

Lots of accessibility policies have been enacted to protect these rights. Since the enactment of the 1990 Americans with Disabilities Act (ADA), which is the first version of legislation to consider BE accessibility for vulnerable populations, many countries have enacted similar legislation to protect disabilities' rights (Flemmer, 2022), such as the Guidance on the 2010 ADA Standards for Accessible Design (Department of Justice, 2010), NZS 4121:2001 Design for access and mobility – Buildings and associated facilities (Standards New Zealand, 2001), etc.

But, what about the practical implementation situation of these accessibility policies? Does the current BE meet the needs of the disabled? This research focuses on MWC users and aims to evaluate to what extent the existing buildings in NZ have complied with the mandatory legislation, and how far the BE has met the needs of disabled groups in reality to guarantee their equal human rights.

A systemic literature review was conducted to understand the background of the topic. A practical accessibility assessment of 10 case shops in NZ was performed to collect their actual measurements of accessible features, find out how far these existing public buildings comply with the NZ accessibility legislation, and identify key features that need to be improved. Finally, a comparison was conducted between the experiment findings and the findings of the literature review.

This study will significantly benefit the large MWC populations. It will help people more deeply understand their expectations and actual accessibility situation, encourage the public to remove the existing barriers, address the underlying problems, and finally provide an accessible BE for MWC users and protect their equal human rights on the ground.

The literature review is presented in section 2.0; then the research method is explained in section 3.0; the research results are stated and discussed in section 4.0; lastly, section 5.0 presents the conclusion and recommendations of this study.

2.0 LITERATURE REVIEW

2.1 Introduction

Many researchers from various countries have been investigating the BE accessibility for people with physical disabilities, including America (Rimmer et al., 2017), Canada (Stephens et al., 2017), South Africa (Vincent & Chiwandire, 2017), India (Alagappan et al., 2018), Malaysia (Bashiti & Rahim, 2016), etc. So, what did they find in their research?

Table 2 Main themes of literature review

	Research themes
1	Practical implementation situation of accessibility policies in various nations
2	Challenges faced by MWC users when accessing BE
3	The underlying causes of poor BE accessibility
4	Recommendations for improving the BE accessibility

A total of 68 relevant articles were reviewed, including 56 recent journal articles (within the last 10 years), 3 earlier journal articles, 4 recent conferences, 3 earlier government reports, 1 recent website, and 1 recent book. The content of these articles was arranged into some main themes, as shown in Table 2. These themes are in line with the project objectives.

Accessibility policies in different countries are the national standards to ensure the accessibility of buildings for vulnerable populations. Numerous studies have been conducted to investigate the practical implementation situation of these legislations, and the challenges faced by MWC users even with these regulations enacted. Moreover, according to the accessibility policies implementation across the world, the underlying causes of poor BE accessibility were concluded, and potential solutions were recommended to achieve better BE accessibility.

2.2 Review of literature

2.2.1 Practical implementation situation of accessibility policies in various nations

Since the enactment of the 1990 Americans with Disabilities Act (ADA), lots of accessibility policies have been enacted to protect the rights of vulnerable people in different nations (Table 3).

Table 3 Accessibility legislation in different countries

	Country	Accessibility Policy	Reference
1	America	2010 Americans with Disabilities Act (ADA) Standards for Accessible Design	(Department of Justice, 2010)
2	New Zealand	NZS 4121:2001 Design for access and mobility – Buildings and associated facilities	(Standards New Zealand, 2001)
3	South Africa	2008 National Building Regulations and Building Standards Act	(Vincent & Chiwandire, 2017)
4	Bangladesh	Bangladesh National Building Code (BNBC) 2008	(Farzana, 2018)
5	India	Handbook on Barrier-Free and Accessibility	(Alagappan et al., 2018)
6	Ghana	Ghanaian Disability Law (Act 716, 2006)	(Cosmos et al., 2017)
7	Malaysia	Malaysian Standards 1184:2014	(Mobasheri et al., 2017)
8	Turkey	TSE 12576 'Design Rules Regarding the Structural Measures for the Disabled and the Elderly in Streets, Roads, Squares and Ways'	(Meshur, 2013)

But, what about the practical implementation situation of these policies? Many researchers from various countries have been investigating the BE accessibility for people with physical disabilities, and the legislation compliance in different places is summarized in Table 4.

Table 4 Poor accessibility policies implementation in different countries

Country	Disabilities	Built Environment	Compliance Outcome	Reference
U.S.	people with disabilities	fitness facilities	high level of inaccessibility	(Dolbow & Figoni, 2015; Rimmer et al., 2017)
South African	wheelchair users	10 public universities	insufficient and unsuccessful	(Vincent & Chiwandire, 2017)
Bangladesh	wheelchair users	public buildings	6.7%	(Farzana, 2018)
India	wheelchair users	bus terminal BE.	42%	(Alagappan et al., 2018)

Ghana	Students with disabilities	university buildings	inaccessibility	(Tudzi et al., 2017)
Canada	disabled children	buildings	0%	(Stephens et al., 2017)
	wheelchair users	curb ramps	2.6%	(Bennett et al., 2009)
Malaysia	people with disabilities	3 public facilities	71.76%,75.29%,78.82%	(Bashiti & Rahim, 2016)
Saudi Arabia	wheelchair users	13 public buildings (shops, restaurants, etc.)	extremely limited (<50%)	(Mohammad & Al-Harbi, 2016)
Turkey	people with disabilities	city center	limited accessibility	(Meshur, 2013)
Botswana	wheelchair users	30 supermarkets	limited accessibility	(Mafatlane et al., 2015)

Rimmer et al. (2017) and Dolbow and Figoni (2015) presented a high level of inaccessibility of fitness facilities in different states of the U.S. where the first accessibility legislation in the world comes from. Vincent and Chiwandire (2017) also concluded that many universities in South Africa were failing to address access to buildings for disabled students, even the libraries which are fundamentally important to a student; the accessibility legislation has been applied insufficiently and unsuccessfully. Only 6.7% of public buildings surveyed were considered accessible for wheelchair users and complied with National legislation in Bangladesh (Farzana, 2018). A case study conducted in India by Alagappan et al. (2018) indicated the evidently poor accessibility guidelines implementation with a 42% accessibility level in a bus terminal BE. Research conducted by Tudzi et al. (2017) presented the inaccessibility of university buildings and the disability rights of students were violated in Ghana. None of the case buildings met Canada's accessibility obligation to ensure equity of disabled children's access and inclusion (Stephens et al., 2017). A survey of curb ramps in Canada indicated that only 2.6% of samples complied with the accessibility requirements (Bennett et al., 2009). Bashiti and Rahim (2016) presented a pretty high legislation compliance of 3 public facilities with a 70%-80% accessibility degree in Malaysia. An assessment of 13 public buildings showed extremely limited compliance degrees in Saudi Arabia (Mohammad & Al-Harbi, 2016). Meshur (2013) presented the limited accessibility of streets of a city center in Turkey. A study by Mafatlane et al. (2015) also showed limited accessibility of 30 supermarkets for wheelchair users.

It indicates that except for the survey in Malaysia (70%-80%), the accessibility policies implementation was generally poor, and the accessibility compliance level of different places differs significantly.

2.2.2 Challenges faced by MWC users when accessing BE.

Due to the poor accessibility policies implementation, the disabilities face lots of barriers in the BE. However, the MWC users are encountering the most challenges compared with other kinds of disabilities when they access the BE (Page & Þorsteinsson, 2018). The main challenges MWC users face when accessing buildings can be grouped into 3 categories, attitudinal barriers from society, individual impairment, and poor physical conditions of BE.

Table 5 Challenges faced by MWC users when accessing buildings.

Challenges	Disability	Reference

Attitudinal barriers from society	social model of disability	(Außermaier et al., 2016; Bromley et al., 2007; Coleman et al., 2015; Cosmos et al., 2017; Hara et al., 2016; Mohammad & Al-Harbi, 2016; Page & Þorsteinsson, 2018; Smith, Sakakibara, et al., 2016; Zahari et al., 2020)
Individual impairment	medical model of disability	(Akyuz et al., 2014; Außermaier et al., 2016; Crytzer et al., 2017; Flemmer, 2022; Mohammad & Al-Harbi, 2016; Smith, Sakakibara, et al., 2016)
Poor physical conditions of BE	social model of disability	(Außermaier et al., 2016; Bromley et al., 2007; Coleman et al., 2015; Flemmer, 2022; Jackson, 2018; Mohammad & Al-Harbi, 2016; Page & Þorsteinsson, 2018; Smith, Sakakibara, et al., 2016; Vale et al., 2017; Vincent & Chiwandire, 2017)

Many studies indicated that the attitude of the public and individual impairment significantly affect the exercising of accessibility right for MWC users. Physical barriers in the BE were identified as one of the most significant factors influencing wheelchair users' lives (Borisoff et al., 2018; Smith, Sakakibara, et al., 2016). A study conducted by Akyuz et al. (2014) showed the most common challenge faced by MWC users is physical barriers of BE, followed by the public attitude, and finally the individual's own health issues. This study focuses more on the physical conditions of BE. The detailed physical challenges include barriers outdoors, such as parking, ramps, and barriers indoors, like the height of counters, shelves, etc., as shown in Table 6.

Table 6 Detailed Challenges of physical conditions of BE

Challenges	Indoors or outdoors	Reference
Parking	Outdoors	(Agarwal & Agarwal, 2019; Bromley et al., 2007; Mafatlane et al., 2015; Mohammad & Al-Harbi, 2016; Vincent & Chiwandire, 2017)
Ramp		(Agarwal & Agarwal, 2019; Hartblay, 2017; Kavishe & Isibika, 2018; Martínez-Chao et al., 2023; Mohammad & Al-Harbi, 2016; Tudzi et al., 2017; Vale et al., 2017; Vincent & Chiwandire, 2017)
Pedestrian Crossing		(Agarwal & Agarwal, 2019; Martínez-Chao et al., 2023; Mohammad & Al-Harbi, 2016; Yu et al., 2023)
Narrow pavement		(Bromley et al., 2007; Gani et al., 2019; Martínez-Chao et al., 2023; Tannert et al., 2019; Vale et al., 2017; Vincent & Chiwandire, 2017)
Lack of dropped curb		(Bromley et al., 2007; Hara et al., 2016; Martínez-Chao et al., 2023; Mohammad & Al-Harbi, 2016; Page & Þorsteinsson, 2018; Vale et al., 2017; Vincent & Chiwandire, 2017)
Slope		(Agarwal & Agarwal, 2019; Choi et al., 2015; Gani et al., 2019; Martínez-Chao et al., 2023; Mohammad & Al-Harbi, 2016; Tannert et al., 2019)
Stairs		(Bromley et al., 2007; Hara et al., 2016; Martínez-Chao et al., 2023; Mohammad & Al-Harbi, 2016; Tudzi et al., 2017; Vale et al., 2017; Vincent & Chiwandire, 2017)
Uneven surface		(Bromley et al., 2007; Cooper et al., 2012; Hara et al., 2016; Kavishe & Isibika, 2018; Martínez-Chao et al., 2023; Page & Þorsteinsson, 2018; Tannert et al., 2019; Vale et al., 2017)
Obstructions in the path (like lighting, benches)		(Cooper et al., 2012; Gani et al., 2019; Martínez-Chao et al., 2023; Mohammad & Al-Harbi, 2016; Page & Þorsteinsson, 2018; Tannert et al., 2019; Vale et al., 2017)
Elevator (provision and use)	Indoors	(Bromley et al., 2007; Hara et al., 2016; Martínez-Chao et al., 2023; Mohammad & Al-Harbi, 2016; Tudzi et al., 2017; Vale et al., 2017)
Entrance doors		(Agarwal & Agarwal, 2019; Bromley et al., 2007; Kavishe & Isibika, 2018; Mohammad & Al-Harbi, 2016)
Toilet		(Agarwal & Agarwal, 2019; Bromley et al., 2007; Mohammad & Al-Harbi, 2016; Tannert et al., 2019; Tudzi et al., 2017)
Counter (height)		(Bromley et al., 2007; Mafatlane et al., 2015; Rashid-Kandvani et al., 2015; Vale et al., 2017)
Shelf (height)		(Bromley et al., 2007; Kavishe & Isibika, 2018; Mafatlane et al., 2015; Page & Þorsteinsson, 2018)
Cluttered aisles		(Agarwal & Agarwal, 2019; Bromley et al., 2007; Tannert & Schöning, 2018)

These factors are identified as the main barriers generally because they not only are very challenging for MWC users to overcome but also have a profound effect on their health and safety. For example:

Slope

A steep slope is one of the main challenges for MWC users and requires greater effort to navigate and overcome (Kim et al., 2014). Choi et al. (2015) stated that MWC users' pulse rate, blood pressure and performance times of pushing the wheelchair generally increase with increasing ramp slopes, which indicates the importance of appropriate slope.

The cross-slope negatively influences MWC users' propulsion, forcing them to propel harder and more frequently, rotating their seated posture to compensate for the slope, which increases the likelihood of strain injuries due to overloaded stress to arms (Cooper et al., 2012). Holloway and Tyler (2013) stated that cross slope is one of the most frequent barriers faced by MWC users because footpaths are often designed to slope toward the street to facilitate water drainage away from buildings.

Surface deformation

MWC users may fall out of their wheelchairs due to abrupt route surfaces, it also requires more attention to avoid these risks which pose more difficulties for MWC users to access buildings (Tannert et al., 2019). The pavement surface deterioration generates vibrations that are quite perceptible and uncomfortable to MWC users. A deteriorated surface can be caused by prolonged usage, inclement weather, poor management of road construction materials, etc., which creates architectural barriers to MWC users (de Abreu et al., 2022). Tannert et al. (2019) also stated that a rough surface is a potential hazard, it will increase the work required by an MWC user and cause harmful whole-body vibration leading to a long-term negative effect on their health.

Lack of dropped curb.

The route can be passed by dropping down which is indeed dangerous(Hara et al., 2016). So, the lack of a dropped curb means inaccessible for MWC users to buildings.

Stairs

Obviously, stairs are generally impassable for MWC users (Martínez-Chao et al., 2023; Tannert et al., 2019; Tudzi et al., 2017).

Narrow pavement

If the pavement outdoors is not wide enough or is obstructed by something, like lighting, benches, then the MWC users may have to use the road lane which is dangerous as they may get hurt by cars on the road (Mohammad & Al-Harbi, 2016).

2.2.3 The underlying reasons leading to poor BE accessibility.

It is obvious that the accessibility policies implementation is weak in many countries, which means poor BE accessibility. So, what are the reasons? Apparently, limited implementation of disability legislation is an important cause, but what about others? Table 7 illustrates the main reasons, including social exclusion, limited implementation, inadequate design, cost, etc.

Table 7 Reasons for poor BE accessibility

Reasons	Aspect	Reference
Limited implementation of disability legislation	Legislation	(Alagappan et al., 2018; Flemmer, 2022; Jackson, 2018; Kportufe, 2015; Mohammad & Al-Harbi, 2016; Page & Þorsteinsson, 2018)
Societal attitudes/Social exclusion	Public	(Alagappan et al., 2018; Bromley et al., 2007; Chan et al., 2023; Jackson, 2018; Kadir & Jamaludin, 2013; Mohammad & Al-Harbi, 2016; Page & Þorsteinsson, 2018)
Building practitioners' negative ideology	Professional	(Außermaier et al., 2016; Bromley et al., 2007; Kadir & Jamaludin, 2013; Mohammad & Al-Harbi, 2016; Page & Þorsteinsson, 2018)
Building practitioners' poor knowledge of BE accessibility		(Chiluba, 2019; Henke, 2019; Kadir et al., 2018; Mohammad & Al-Harbi, 2016; Rashid-Kandvani et al., 2015; Simonson et al., 2013)
Inadequacy of accessibility design		(Fleck, 2019; Meshur, 2013; Mohammad & Al-Harbi, 2016; Page & Þorsteinsson, 2018; Tutuncu, 2017; Vale et al., 2017; Wauters et al., 2014; Zallio & Clarkson, 2021)
Cost for better BE accessibility	Economy	(Flemmer, 2022; Mohammad & Al-Harbi, 2016; Page & Þorsteinsson, 2018; Vincent & Chiwandire, 2017; Zahari et al., 2020; Zeng et al., 2017)

Poor legislation implementation as a main cause has been discussed in section 2.2.1.

The lack of public awareness and social exclusion of disabilities is a significant public aspect to consider (Kadir & Jamaludin, 2013). If the individuals express negative attitudes to the MWC users, they will feel bad and tend to go to the public buildings less which prevents their accessibility rights (Bromley et al., 2007).

Inclusive design and building practitioners' attitudes is another key aspect. A case study in Turkey conducted by Meshur (2013) presented that the design standards for the disabled were not considered in case buildings, and the accessible design was limited. Some researchers also pointed out the effect of building practitioners' lack of knowledge about BE accessibility. Page and Þorsteinsson (2018) discovered that designers' attitudes to inclusive design differ, and both designers and property developers tend to meet the minimum requirements of accessibility regulations due to profit reduction which is the biggest problem to design accessible BE for MWC users.

Vincent and Chiwandire (2017) also presented that money needed to satisfy BE accessibility requirements for MWC users is a significant issue to be addressed. Conserving existing buildings is costly, and the provision of accessible ramps, elevators, platforms, etc. for wheelchair users, will incur extra costs, especially for old buildings (Zahari et al., 2020).

Chiluba (2019) indicated the factors leading to poor accessibility implementation in Figure 1, which is consistent with the reasons summarised above.

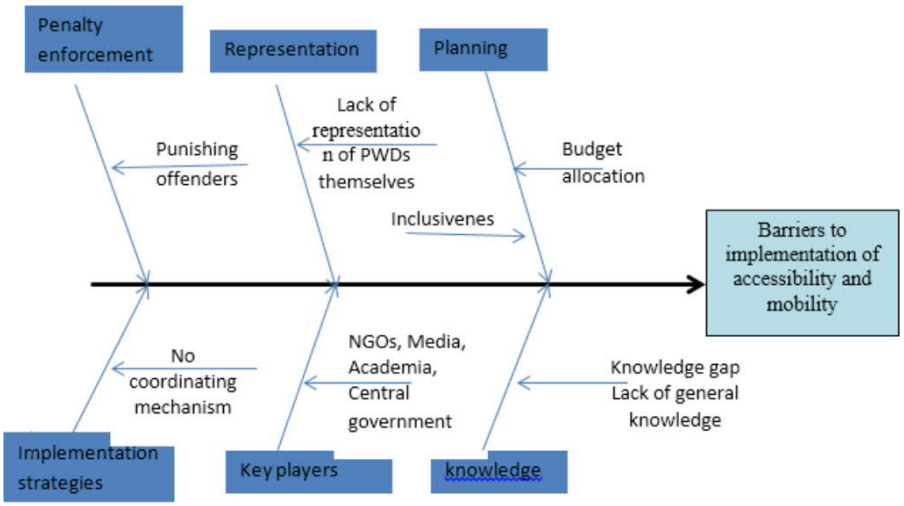

Figure 1 Factors leading to poor accessibility implementation

(Chiluba, 2019)

2.2.4 Recommendation for improving the BE accessibility.

There are lots of potential ways to improve the BE accessibility for MWC users, as shown in Table 8.

Table 8 Recommendations

Recommendations	References
Stricter enforcement of accessible policies	(Abu Tariah et al., 2018; Alagappan et al., 2018; Chiluba, 2019; Cosmos et al., 2017; Fleck, 2019; Rashid-Kandvani et al., 2015)
Improvement of public awareness and social inclusion for disabilities	(Bromley et al., 2007; Coleman et al., 2015; Cosmos et al., 2017; Jackson, 2018; Kadir & Jamaludin, 2013; Mohammad & Al-Harbi, 2016; Pagán, 2015; Page & Þorsteinsson, 2018; Vincent & Chiwandire, 2017)
Better understanding of existing BE conditions	(Agarwal & Agarwal, 2019; Außermaier et al., 2016; Flemmer, 2022; Jackson, 2018; Stephens et al., 2017)
Engagement of MWC users in BE design	(Außermaier et al., 2016; Bromley et al., 2007; Cosmos et al., 2017; Flemmer, 2022; Jackson, 2018; Mohammad & Al-Harbi, 2016; Vale et al., 2017; Vincent & Chiwandire, 2017)
Gain Building practitioners' knowledge and understanding of BE accessibility. (Like: designers, government staff)	(Abu Tariah et al., 2018; Evcil, 2018; Fleck, 2019; Gamache et al., 2016; GÜRSOY et al., 2017; Meshur, 2013; Mohammad & Al-Harbi, 2016; Ubani et al., 2013)
Provide more accurate BE accessibility information for MWC users. (Like: Navigation tools)	(Evcil, 2018; Gani et al., 2019; Gharebaghi et al., 2017; Mobasheri et al., 2017; Mourcou et al., 2013; Tannert et al., 2019; Zeng et al., 2017)
Provide training for staff to assist the disabilities	(Dolbow & Figoni, 2015; Frost et al., 2015; Kadir & Jamaludin, 2013; Kavishe & Isibika, 2018; Mafatlane et al., 2015; Rashid-Kandvani et al., 2015; Tutuncu, 2017)

Stricter enforcement of accessible policies is a must. Alagappan et al. (2018) and Cosmos et al. (2017) suggested that accessible requirements must be met before the issuing of completion certificates, and periodical access audits shall be conducted to ensure the implementation of mandatory accessibility legislation. Meshur (2013) and (Chiluba, 2019) recommended there must be a further sanction mechanism to enforce the regulation implementation.

Public awareness and social attitudes is another aspect to be changed. A thorough study is needed to explore the opinions of various social groups to wheelchair users, such as the government, the general

public, and retail clerks, to appeal to them to help minimize the social model of disability to MWC users and support their experience of BE accessibility (Page & Þorsteinsson, 2018). Coleman et al. (2015) suggested relevant organizations can organize activities to encourage the abled to sit in a MWC to gain personal experience, to better understand and promote awareness of accessibility issues faced by MWC users. Vincent and Chiwandire (2017) highlighted that social activities involving both abled and disabled people to interact with each other are recommended to promote public awareness and social inclusion for disabilities. Moreover, the reasons for impairment include conditions of birth, sickness, traffic accidents, old age, etc., anybody may suffer these situations unpredictably, so it's crucial to increase public awareness and enhance social inclusion for MWC users (Ubani et al., 2013). Pagán (2015) indicates that holiday trips are an essential part of social life, and policymakers and the tourism industry should take action to eliminate BE barriers and engage the disabled in inclusive leisure BE to exercise their rights.

Reliable research data about BE accessibility lays the foundation to develop informed related actions (Stephens et al., 2017). It is necessary to investigate and better understand the existing BE conditions. For example, the BE accessible conditions change regularly due to constant usage and weather circumstances, such as deteriorated surfaces, obstacles introduced, etc. (Martínez-Chao et al., 2023). Monitoring is a must so as to conduct timely maintenance and corrective action to keep the BE conditions to meet the MWC users' accessible needs (de Abreu et al., 2022).

Regarding the design, many researchers suggested engaging the MWC users in the design stage, expressing their expectations and promoting the inclusive design to meet their needs in practice. Badawy et al. (2020) illustrated the process of inclusive designs (Figure 2). It is essential to involve the MWC users who are an important part of the whole end-users to listen to their expectations (Cosmos et al., 2017), and adapt effective ways to meet their needs and protect their rights on the ground (Vincent & Chiwandire, 2017).

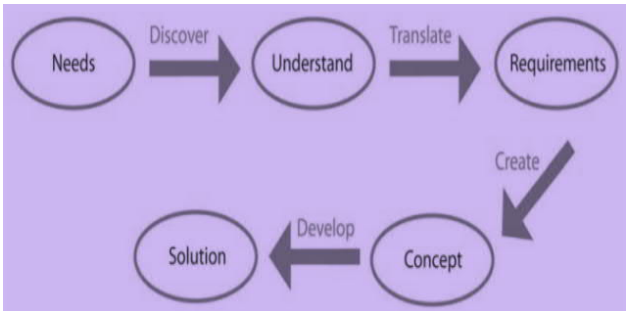

Figure 2 The process of inclusive designs

(Badawy et al., 2020)

Building practitioners play a key role in BE accessibility performance. The local government should encourage the designers and other building practitioners to increase their knowledge of BE accessibility (Ubani et al., 2013). Competitions can be organized, and awards can be provided for the projects with the best accessibility design to promote them (Evcil, 2018). The government can also lead the development of inclusive design and accessibility by example with infrastructure and other public programs, then the private sector will follow (Fleck, 2019).

Many wheelchair users can't adequately exercise their basic rights because of the lack of accurate BE accessibility information for them to arrange their route. The development of navigation tools is an

innovative direction to provide significant support to MWC users when accessing BE and substantially promote their exercise (Gharebaghi et al., 2017; Mourcou et al., 2013). In fact, various navigation systems have been investigated to assess and gather more accurate accessible information to support the disabled (Außermaier et al., 2016). More apps or routing tools contributing to BE accessibility information are encouraged to help MWC users achieve free-barrier travel in BE (Gani et al., 2019; Tannert et al., 2019; Zeng et al., 2017).

No staff had been trained to help meet the specific needs of the disabilities and this is an important aspect to be improved (Dolbow & Figoni, 2015). Kadir and Jamaludin (2013) also highlighted the crucial role of staff assistance in BE accessibility. It is significantly needed to train the managers and staff about assisting the disabled to facilitate BE accessibility, such as healthcare clinics (Frost et al., 2015; Rashid-Kandvani et al., 2015), libraries (Kavishe & Isibika, 2018), etc.

Also, the government should play a leading position and set a prioritization about national planning, budget allocation, and national programs(Chiluba, 2019) to promote BE accessibility.

2.3 Gaps in the literature

The literature review indicates the limited accessibility policies implementation and poor BE accessibility. The current accessibility conditions of existing BE in many countries don't comply with the mandatory accessibility regulations adequately and can't meet the needs of MWC users.

However, there isn't a study to assess the practical compliance of existing buildings in NZ with the relevant NZ accessibility standards, to evaluate how well the BE in NZ meets the MWC users' needs and protects their rights. To fill this gap, an experiment of 10 case shops was conducted, trying to identify to what degree the NZ public buildings meet the mandatory regulations, the key features that need to be improved, and potential solutions to create a more accessible BE for MWC users to protect their basic human rights on an equal basis with other general populations.

2.4 Summary

Through a critical review of the latest good scholarly articles, a basic understanding of the project topic was gained, and the main themes other researchers have been investigating were discussed. Furthermore, by looking at what has been done about BE accessibility by other researchers, a clear research gap was identified: the practical compliance of existing buildings in NZ with the mandatory accessibility legislation. This research will fill this gap and achieve other project objectives to improve BE accessibility for MWC users and protect their equal rights.

3.0 METHODS

3.1 Research method and design

There are six research objectives for this project:

1. Summarize the main accessibility features and the corresponding specifications of the accessibility legislation applied in NZ. Compare the NZ accessibility legislation with the American policy.

2. Conduct a practical accessibility assessment of 10 case shops in NZ to collect their actual measurements of accessible features, find out how far these existing public buildings comply with the NZ accessibility legislation, and identify key features that need to be improved.
3. Review the literature to learn the implementation of accessibility policy in various nations.
4. Identify the main challenges faced by MWC users when accessing BE.
5. Explore the underlying reasons leading to poor BE accessibility.
6. Make recommendations to improve the BE accessibility for MWC users.

3.1.1 Research Steps:

Several steps were taken to achieve these research objectives:

1. Literature review

A systematic literature review was conducted to gain a basic understanding of the project topic, to see what other researchers have done, and what the common themes are.

2. Ethics application

This research was identified as low risk category: Low Risk Notification: # 4000027973 received on 23/8/2023. The potential ethical issues were considered, including risks to the participants, the researcher, the institutions involved. The main research risks were the inconvenience to others, the safety problems while measuring the case shops, etc. The corresponding solutions were performed to minimise these risks. The full ethics application is presented in Appendix A.

3. Practical accessibility assessment of case shops

Conduct a practical accessibility assessment of 10 case shops in NZ to collect the actual dimensions of accessible features of these case buildings, find out how far these existing public buildings comply with the NZ accessibility legislation, and identify key features that need to be improved in the NZ built environment.

4. Comparison and recommendations

A comparison was performed between the findings of this research and the findings of the reviewed articles. The potential solutions were recommended to improve BE accessibility and ensure the equal human rights of MWC populations with others.

3.1.2 Reasons for choosing this method.

The research method for this project is mixed.

Literature review is a qualitative method. It helps learn other researchers' findings, typical research methods, main themes of this topic, and identify the unanswered research gaps.

Measurement of random case shops means quantitative method and represents good data reality and reliability. For example, the slopes of the ramps and the width of the pavements provide numerical data, and numbers represent fact-based, repeatable, provable, and unbiased. This way is more reliable than interviews which collect personal opinions. The comments of participants are subjective and may be biased and negatively affect the research findings.

The comparison helps to identify any similarities or differences between this research findings and other researchers' findings and puts this research into the overall context of the topic.

This mixed method efficiently contributes to achieving the research objectives.

3.1.3 Study plan

Figure 3 shows the study plan.

	Task	Due Date	Jul-23		Aug-23				Sep-23				Oct-23				Nov-23				Dec-23				Jan-24	
			w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2
1	Literature review																									
2	Complete A1 : Ethics application form	7/08/2023																								
3	List accessibility features and specifications of NZ legislation																									
4	Compare NZ accessibility legislation with other countries' policies																									
5	List 10 case shops to be measured																									
6	Complete A2 : Research Proposal Presentation	30/08/2023																								
7	Measurement of accessible features of case buildings																									
8	Compare the measured data with NZ mandatory regulations																									
9	Complete A3 : Research Findings Presentation	27/11/2023																								
10	Complete A4 : Written Report on Research Project	12/02/2024																								
																		Note: week(w)								

Figure 3 Study plan

3.2 Data collection method

The research data comes from two sources, literature review and measurement of 10 case shops.

3.2.1 Literature review

68 relevant academic articles were reviewed to support the achievement of the project objectives. Keywords including wheelchair, accessibility, built environment, disability, accessibility standard, etc, were applied to search the relevant articles in some search engines, such as Google Scholar, Scopus, Discovery, etc. Google Scholar was chosen as the main data source, because firstly it is one of the largest academic databases, moreover, it has a higher indexing rate and a broader publication coverage compared with many other databases. It has been strongly recommended because of its criticalness to incorporate popular keywords to enhance the data validity and reliability. Discovery and Scopus were used as supplementary databases. A few crucial screening criteria were adopted to select good scholarly articles:

1. Publication year: Most of the articles are the latest publications within the past 10 years. The project is about the BE accessibility for the disabled, as everything is changing fast in modern times, not only the BE but also the relevant policies. So, it is better to select up-to-date publications.

2. Language: Papers in English were chosen in this study which is the most widely used language in the world.

3. Citation: tended to choose articles with more citations which means good references.

After that, the abstract of each article was reviewed and evaluated to get the most relevant and good scholarly articles.

3.2.2 Practical accessibility assessment of case shops

After a preliminary visit, shops were chosen as the type of public buildings to evaluate BE accessibility in NZ. 10 random shops near Massey University were chosen including large grocery shops and small dairy. The features and specifications of the accessibility legislation in NZ (NZS 4121:2001) were sorted and listed in a table to detail the accessibility features for MWC users and the mandatory specifications. The practical dimensions of indoor and outdoor features of case shops were measured and recorded in accordance with this table to ensure data validity, and the same scales were also applied to ensure data reliability. These raw data were compared with the corresponding specifications of NZS 4121:2001, and the accessibility compliance degrees by shops, by feature and by sub-item of features were calculated to assess the BE accessibility in NZ.

The experiment results were then compared with the findings of the literature review.

Measurement tools

Different types of tools were used to measure. For example, a tape measure was used to measure the width of pavements, the height of checkout, etc., and the slope was measured with a high-quality digital angle finder protractor to ensure data accuracy.

Validity and Reliability of Data

A typical width (1200mm) and slope (1.20 degrees) were measured 30 times, and a statistical analysis was conducted to assess the accuracy and repeatability of the measurements. The result is shown in Table 9. As the p-values are both above 0.05, the data is normally distributed with a standard deviation of 1.380mm and 0.072 degrees.

Table 9 Statistical analysis

Item	Width	Slope
Mean	1199.6	1.187
Standard Deviation	1.380	0.072
Sig.	0.073	0.069

Pictures of typical inaccessible features

Additionally, pictures were taken during the measuring to prove typical building inaccessibility features, which are difficult for MWC users to overcome and need to be improved.

3.3 Data analysing techniques

1. Content analysis

The content of the reviewed articles was analysed and arranged into the 4 main themes of the topic. Features and specifications of the NZ accessibility legislation (NZS 4121:2001) were sorted and listed in a table to detail the accessibility features and mandatory specifications.

2. Tables and graphs

For practical measurements of case shops, tables were applied to compare each feature with the corresponding specifications of NZS 4121:2001. The compliance percentage by shop, by feature, and by sub-item of features were calculated and presented using tables and histograms.

3. Comparison

Comparison was conducted between the experiment findings and other researchers' findings, to find out similarities or differences.

4 RESULTS AND DISCUSSION

This section presents the experiment results about the outdoor and indoor accessibility of 10 case shops, and then compares and discusses the results with the four literature review themes.

4.1 Features and specifications of the accessibility legislation in NZ

It is clear that accessibility policies are compiled weakly in other countries, but what about that in New Zealand? New Zealand Standard NZS4121:2001 Design for access and mobility – Buildings and associated facilities (NZS4121:2001) is the mandatory accessibility legislation applied in NZ stating the minimum accessibility requirements indoors and outdoors to protect the disabilities' rights. It claims that to cater to the accessible needs of the disabled, accessible routes are required, including car parks to park their cars, footpaths and ramps to allow them to approach the buildings from parking, public entrance, and other indoor facilities. The key features and corresponding specifications for MWC users are summarized in Table 10.

Table 10 Specification of accessible features in NZS4121:2001

Feature	**Sub-item**		**Specification**
			NZS4121:2001
Outdoors			
Car parks	C1	location	on the accessible route to a building
	C2	signs	fixed on a wall ,1400-1700 mm above floor level to lower edge of sign plate; have ground marking
	C3	numbers	accessible parks ≥1/Total 1-20; accessible parks ≥2/Total 21-50; ≥1accessible parks added/ for every additional 50 car parks (Total)
	C4	dimensions	Width(W) ≥ 3500mm, Length(L) ≥ 5000mm
	C5	surface	a stable, firm, slip resistant flat surface
Footpaths	F1	clear width	W≥1200mm
	F2	transverse gradient	≤1:50(1.15 degrees)
	F3	longitudinal gradient	1:33(1.72 degrees) <longitudinal gradient≤1:20 (2.86 degrees)
Ramp	R1	clear width	W≥1200mm
	R2	transverse gradient	≤1:50(1.15 degrees)
	R3	longitudinal gradient	1:20 (2.86 degrees) <longitudinal gradient≤1:12 (4.76 degrees)
	R4	edge-rail	Height (H) ≤ 75 mm
	R5	Safety rail	provided mid-height between the upstand and the handrail
	R6	Handrails	H: 840-900 mm on both sides of the ramp
	R7	Landings (Level platforms)	W≥ 1200mm, L≥ 1200mm; Distance ≤ 9000 mm between two landings; Landings needed at the top and bottom, wherever direction changes.
Kerb ramps	K1	gradient	One side≤1:8 (7.13 degrees), the other side≤1:20 (2.86 degrees)
	K2	dimensions	L≤ 1500 mm, W≥1000mm
	K3	obstruction	space ≥800 mm between the top of the ramp and any obstruction
Indoors			

Entrances	E1	Level approach space	≥1200 mm x 1200 mm both inside and outside the entrance door
	E2	Thresholds	level thresholds, or
			stepped thresholds: change in level ≤ 20 mm, no ramp is required, or
			ramped thresholds (change in level > 20 mm), gradient ≤1: 8 (7.13 degrees), a going ≤450 mm
Doorways	D1	Clear opening	clear width ≥ 760 mm
	D2	automatic door	remain open ≥ 5 seconds
Passing space	P	clear width	W≥1200mm
Shelf	S	height	230mm < side reach limits < 1350mm
Checkout counter	CH1	height	675mm < H< 775mm
	CH2	aisle width	W > 850 mm
Lifts	L	not required	When buildings are two stories high and have a gross floor area of the upper floor of less than 400 m2
Toilets	T1	dimensions	a compartment ≥1900 mm x 1600 mm
	T2	toilet doors	clear opening ≥ 760 mm
	T3	washbasin	depth ≤ 400 mm, center line of a washbasin ≥ 400 mm from a wall forming a return to the wall on which it is fixed,
	T4		clearance ≥ 675 mm on the underside, clear space ≥760 mm wide *1200 mm deep in front of the basin

4.2 A comparison of accessibility regulations between NZ and American

2010 Americans with Disabilities Act (ADA) Standards for Accessible Design is the accessibility Act implied in America where the first disability strategy policy was enacted. Comparing the NZS4121:2001 with 2010 ADA standards, most of the accessible requirements for wheelchair users are similar, but there are still some differences.

Table 11 Comparison between 2010 ADA standards and NZS4121:2001

Feature	**Sub-item**	**Specification**	
		USA	**NZ**
Footpaths and ramps	clear width	≥ 915mm	≥1200mm
	cross slope	≤1:48	≤1:50
Ramp	height of the ramp handrail	865–965 mm	840-900 mm
	height of the ramp edge-rail	≤100 mm	≤75mm
Landing	clear width	the same as the widest ramp run connecting to it (W ≥ 915mm)	≥1200mm
	clear length	≥1525 mm	≥1200mm
Door opening	clear width	≥ 915mm	≥760 mm
Thresholds	height	≤13 mm	≤ 20 mm

Footpaths and ramps

The clear width of footpaths and ramps in 2010 ADA standards shall be no less than 915mm, while that is 1200mm minimum in NZS4121:2001; the specification of 2010 ADA standards is narrower than that in NZS4121:2001.

The maximum cross slope of footpaths and ramps is 1:48 in 2010 ADA standards, slightly steeper than that in NZS4121:2001 which is 1:50.

Ramp

The height of the handrail from its top surface to the ground floor in 2010 ADA standards shall be 865–965 mm on both sides of the ramp, instead of 840-900 mm in NZS4121: 2001. The height of the ramp edge-rail must be within 100 mm from the ground surface, higher than that in NZS4121: 2001 (within 75mm).

Landing

The 2010 ADA standards state the landing clear width shall be the same as the widest ramp run connecting to it (W≥ 915mm), and the clear length shall be more than 1525 mm. However, both the width and length of the landing must be not less than 1200 mm in NZS4121:2001.

Door opening

The clear width of the door opening is 915mm minimum in 2010 ADA standards, wider than that in NZS4121:2001 (760 mm minimum).

Thresholds

The height of thresholds in doorways in 2010 ADA standards is lower, which shall be no more than 13 mm high instead of the 20 mm maximum in NZS4121:2001.

According to these differences, some specifications of 2010 ADA standards are better than those in NZS4121:2001, providing more convenience for MWC users, such as the thresholds, door opening, etc. However, there are still some requirements of accessible features in NZS4121:2001 that are more friendly, like the clear width and cross slope of footpaths and ramps.

4.3 Accessibility compliance degree of case shops in NZ and features need to be improved.

An experiment was conducted in NZ, and 10 case shops near Massey University were measured to collect their practical dimensions of accessible features according to Table 10 in section 4.1. The case shops include large grocery shops (shop 2,3,6-7) and small dairy (shop 1,4,5,8-10).

The measurements of each item were compared with the standards of NZS4121:2001. If the measurements comply with the legislation, it is presented with C, N represents non-compliance with the legislation, P: partial compliance with the legislation, and “---" means “not applicable”. One feature may have several sub-item specifications, if one of these sub-items isn’t in line with the standards, this feature is considered non-compliance. For example, the feature of car parks contains 5 sub-items, including location, signs, numbers, dimensions, and surface. If only one sub-item, such as the dimension of the car park doesn't satisfy the requirement of NZS4121:2001, the feature of car parks is deemed non-

compliance with the mandatory legislation. If there are two routes for one shop, such as shop 2, and the features of one route comply with the standards, this shop is considered accessible.

Compliance Outcome of case shops

The compliance results of the 10 case shops are shown in Table 12.

The results indicate that only 1 case shop completely complied with the requirements of NZS4121:2001 for outdoor environments, which means only 10% of the accessibility compliance degree. In terms of indoor environments, no shop entirely meets the standards (0%). If except for the feature of the checkout counter, 9 out of the 10 case shops are partially compliant with NZS4121:2001.

The measurement outcome of the 10 case shops presents the serious failure of BE accessibility legislation compliance in NZ.

Table 12 Compliance Outcome of case shops

Feature	Compliance Outcome of case shops (S)										AN	CN	CP
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10			
Outdoors													
Car parks	N	C	N	N	N	C	N	N	N	N	10	2	20%
Footpaths	C	C	N	N	N	C	N	N	N	N	10	3	30%
Ramp	N	N	---	---	N	---	---	---	---	---	3	0	0%
Kerb ramps	N	---	N	C	---	C	N	N	N	N	8	2	25%
Compliance outcome	**N**	**N**	**N**	**N**	**N**	**C**	**N**	**N**	**N**	**N**	**10**	**1**	**10%**
Indoors													
Entrances	C	C	N	C	C	C	C	C	C	C	10	9	90%
Doorways	C	C	C	C	C	C	C	C	C	C	10	10	100%
Passing space	P	P	P	C	P	P	C	P	P	P	10	2	20%
Shelf	P	P	P	P	P	P	P	P	P	P	10	0	0%
Checkout counter	N	N	N	N	N	N	N	N	N	N	10	0	0%
Lifts	---	---	---	C	C	---	---	---	---	---	2	2	100%
Toilets	---	C	---	---	---	C	C	---	---	---	3	3	100%
Compliance outcome	**N (/P)**	**N (/P)**	**N**	**N (/P)**	**N (/P)**	**N (/P)**	**N (/P)**	**N (/P)**	**N (/P)**	**N (/P)**	**10**	**0**	**0%**

(Note: S1-10: case shop1-10, AN: Available Number, CN: Compliance Number, CP: Compliance Percentage)

Compliance Outcome by Features

Regarding the accessible features, all the outside features indicate very poor accessibility compliance. 20% of the car parking and 30% of the footpaths comply with the legislation, while no ramps completely meet the regulations. 2 out of 8 kerb ramps satisfy with the mandatory accessibility requirements, which means just a 25% compliance degree. The indoor BE accessibility is much better than outdoors. Almost all the entrances comply with the regulations (90%), and doorways, lifts and toilets indicate complete compliance (100%). However, none of the checkout counters of the 10 case shops meet the accessible counter requirements (0%), and just part of the passing space and shelf is accessible for MWC users.

Compliance Outcome by Sub-item of Features

A more detailed look at the compliance of accessible features is presented in Table 13 and Figure 4.

Table 13 Compliance Outcome by Sub-item of Features

Feature	Sub-item		Compliance Outcome of case shops (S)										AN	CN	CP
			S1	S2		S3	S4	S5	S6	S7	S8	S9	S10			
Outdoors																
				ro1	ro2											
Car parks	C1	location	C	C	C	C	C	C	C	C	C	C	C	11	11	100%
	C2	signs	C	C	C	C	C	C	C	C	C	C	C	11	11	100%
	C3	numbers	C	C	C	C	C	C	C	C	C	C	C	11	11	100%
	C4	dimensions	N	N	C	N	N	N	C	N	N	N	N	11	2	18%
	C5	surface	C	C	C	C	C	C	C	C	C	C	C	11	11	100%
Footpaths	F1	clear width	C	C	C	C	C	C	C	C	C	C	C	11	11	100%
	F2	transverse gradient	C	C	C	N	N	N	C	N	N	N	N	11	4	36%
	F3	longitudinal gradient	C	N	C	N	N	C	C	N	N	C	N	11	5	45%
Ramp	R1	clear width	C	---	C	---	---	C	---	---	---	---	---	3	3	100%
	R2	transverse gradient	C	---	N	---	---	N	---	---	---	---	---	3	1	33%
	R3	longitudinal gradient	N	---	N	---	---	N	---	---	---	---	---	3	0	0%
	R4	edge-rail	N	---	---	---	---	N	---	---	---	---	---	2	0	0%
	R5	Safety rail	N	---	---	---	---	C	---	---	---	---	---	2	1	50%
	R6	Handrails	N	---	C	---	---	N	---	---	---	---	---	3	1	33%
	R7	Landings	---	---	C	---	---	C	---	---	---	---	---	2	2	100%
Kerb ramps	K1	gradient	N	---	---	N	C	---	C	N	N	N	N	8	2	25%
	K2	dimensions	N	---	---	N	C	---	C	N	C	N	C	8	4	50%
	K3	obstruction	N	---	---	N	C	---	C	C	C	N	C	8	5	63%
Indoors																
Entrances	E1	level approach space	C	C		C	C	C	C	C	C	C	C	10	10	100%
	E2	Thresholds	C	C		N	C	C	C	C	C	C	C	10	9	90%
Doorways	D1	Clear opening	C	C		C	C	C	C	C	C	C	C	10	10	100%
	D2	automatic door	C	C		C	C	C	C	C	C	C	C	10	10	100%
Passing space	P	clear width	P	P		P	C	P	P	C	P	P	P	10	2	20%
Shelf	S	height	P	P		P	P	P	P	P	P	P	P	10	0	0%
Checkout counter	CH1	height	N	N		N	N	N	N	N	N	N	N	10	0	0%
	CH2	aisle width	C	C		C	C	C	C	C	C	C	C	10	10	100%
Lifts	L	not required	---	---		---	C	C	---	---	---	---	---	2	2	100%
Toilets	T1	dimensions	---	C		---	---	---	C	C	---	---	---	3	3	100%
	T2	toilet doors	---	C		---	---	---	C	C	---	---	---	3	3	100%
	T3	washbasin	---	C		---	---	---	C	C	---	---	---	3	3	100%
	T4	clearance	---	C		---	---	---	C	C	---	---	---	3	3	100%

(Note: ro1, ro2: route1, route2)

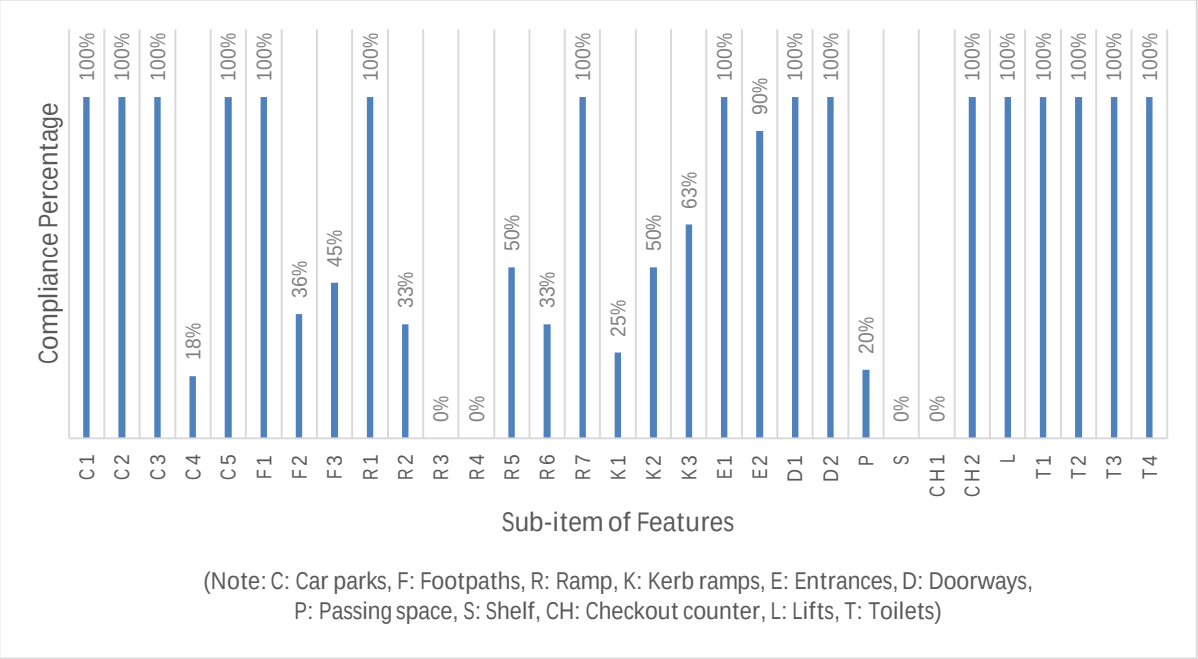

Figure 4 Compliance Outcome by Sub-item of Features

Outdoors

Car parks

The dimension of the accessible car parking (C4) doesn't meet the legislation, with only 18% compliance. Mostly the widths of the parking fulfill the requirement (more than 3500mm), but the lengths don't, 7 out of the 11 available case parking are less than 5000mm in length, and, on average their length is about 4000mm. This may be to save space. Also, some accessibility parking is occupied by cars that do not display a handicapped sticker, as shown in Figure 5.

Figure 5 Cars without a displayed handicapped sticker occupying accessible parking.

Footpaths

The clear width of footpaths all complies with the specification of NZS4121:2001. However, the transverse gradient (F2) and longitudinal gradient (F3) don't, with just 36% and 45% compliance percentage. The longitudinal gradients of footways always are above the required slope and sometimes more than the biggest gradient of a ramp (4.76 degrees). The transverse gradient compliance is quite

low, and some slopes (6.51,8.90 degrees) are quite steep and tend to be steeper than their longitudinal gradient, which is a serious challenge to MWC users.

Ramp

The situation is similar for ramps. Only 33% of the transverse gradients (R2) meet the accessibility criteria, and none of the longitudinal gradients (R3) satisfy. The edge-rail, safety rail, and handrails also present a quite low compliance degree.

Kerb ramps

The results for Kerb ramps are worrying too. One case shop lacks a curb ramp. Regarding the gradient (K1), only 2 out of 8 available kerb ramps comply with the regulations. It is noticeable that 2 of the gradients are very steep, one is 13.60 degrees and the other is 17.81 degrees, which are very difficult and dangerous for MWC users to overcome. Another problem for curb ramps is obstructions in front. Figure 6 shows the plant and columns which are barriers to access the case shops.

Figure 6 Obstructions in front of Kerb Ramps

Indoors

Entrances, Doorways, Lifts and Toilets

All the sub-items of Entrances, Doorways, lifts and Toilets completely comply with the regulations, with 100% legislation compliance degrees, except the threshold which is 90% (1 stepped threshold out of the 10 data is 24mm, higher than the requirement of 20mm).

Passing space

The clear width of the passing space varies in each shop. In only 2 of the 10 case shops (20%), all the passing space is wider than the minimum clear width (1200mm). The other 8 shops all have narrow passages which are not accessible to MWC users. Another common phenomenon is that there are always obstacles in the passing space that hinder MWC users' passage (Figure 7).

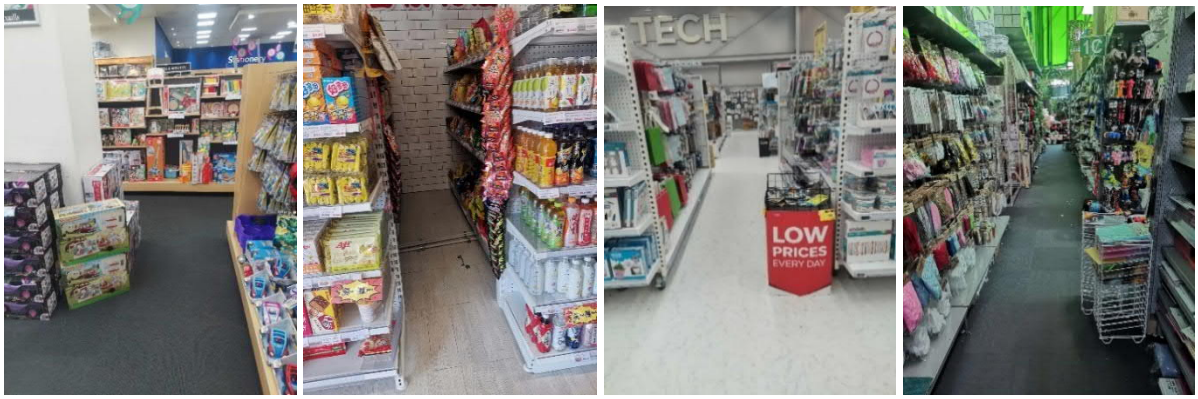

Figure 7 Obstacles in the passing space

Shelf

In NZS4121:2001, it states the side reach limit for wheelchair users is 230 mm-1350 mm. However, the shelf heights in different case shops are ranging from 980mm to 2300mm. So only part of the shelf is accessible for MWC users, and no shop completely meets the MWC users' accessible needs in terms of shelf (0%).

Checkout counter

The aisle width (CH2) in front of the checkout counter indicates a 100% standards compliance level. On the contrary, the compliance degree of the counter height (CH1) is 0%. In fact, there is no special checkout counter for MWC users in all case shops.

In summary, the experiment result indicates the failure of accessibility legislation compliance and the poor BE accessibility in NZ. Only 10% of the case shops completely comply with the requirements of NZS4121:2001 for outdoor environments, while that is 0% in terms of indoor environments. Even except for the influence of the checkout counter, the indoors of case shops are just partially accessible for MWC users.

Regarding the compliance outcome by features, all the outside features present very poor accessibility compliance. Only 20% of the car parking,30% of the footpaths, and 25% of the kerb ramps comply with the legislation, while no ramps completely meet the regulations. Even though the indoor BE accessibility is much better than outdoors, there is no checkout counters that meet the accessible requirements (0%), and just part of the passing space and shelf is accessible for MWC users.

Some features outdoors show serious non-compliance, including the dimensions of car parking, transverse gradient and longitudinal gradient of footpaths and ramps, the Kerb ramps gradients, obstacles in the path, etc. For the indoors, the narrow passing space, and the high height of shelves and checkouts are also challenging for MWC users. These inaccessible features will significantly prevent MWC users from exercising their basic human rights and need to be improved.

4.4 Comparison with the literature review themes.

The literature review theme 1 indicates the generally poor accessibility policies implementation in various countries, and the accessibility compliance level differs significantly in different places. The

experiment of 10 case shops presents weak accessibility legislation compliance and poor BE accessibility in NZ, which is in line with the general accessibility policies implementation situation worldwide. Compared with the study of 13 public buildings (shops, restaurants, etc.) in Saudi Arabia showing less than 50% compliance percentage, it confirms that the accessibility policies compliance differs significantly in different places (between NZ and Saudi Arabia about shops). This finding is consistent with the opinion of Tannert and Schöning (2018) who expressed a similar idea.

The literature review theme 2 summarizes physical challenges indoors and outdoors faced by MWC users when accessing buildings. These main challenges are consistent with the barriers identified in the experiment above, including outdoor barriers, such as inaccessible parking, narrow pavement, lack of dropped curbs, steep slopes, obstructions in the path (like plant, columns), and indoor challenges, like high counters and shelves, cluttered aisles, etc. The research assessing the accessibility of 30 supermarkets for wheelchair users also presents similar barriers, such as parking, high shelves and counters (Mafatlane et al., 2015).

The literature review theme 3 presents various reasons leading to poor BE accessibility, such as poor accessibility legislation implementation, social exclusion, inadequate design, building practitioners' negative attitude, lack of cost, etc. Obviously, poor accessibility legislation implementation is a significant cause in NZ. Further research is needed to explore other potential reasons for poor BE accessibility in NZ.

4.5 Recommendations for improving BE accessibility in NZ.

The literature review theme 4 lists lots of recommendations for improving BE accessibility. According to the problems identified, some solutions are suggested to be considered in NZ.

Firstly, stricter enforcement of accessible policies is a must due to the limited accessibility policy compliance results of the experiment. The NZ government can require that completion certificates will be issued only if all accessibility legislation requirements have been met. Also, periodical access audits shall be conducted, and a further sanction mechanism is suggested to enforce the regulation implementation. The inaccessible features identified in the experiment, such as inaccessible parking, narrow pavement, lack of dropped curbs, steep slopes, etc., need to be paid more attention.

Secondly, for public awareness and social attitudes, relevant public organizations can organize activities to encourage the abled to sit in an MWC to gain personal experience, to better understand accessibility issues faced by MWC users; or social activities involving both abled and disabled people to interact together are recommended to promote social inclusion for disabilities.

Then, the NZ government should encourage the inclusion of MWC users in the design stage and the achievement of inclusive design by designers and other building practitioners. The government can lead by example with infrastructure and other public programs to promote the following of the private sector. Competitions can also be organized with awards for projects with the best accessibility design to encourage people. The universities can take similar actions to promote students' BE accessibility awareness and knowledge to facilitate the achievement of BE accessibility when they go to work.

Advanced technology, such as navigation tools, is recommended to facilitate mobility for MWC users. In addition, according to the experiment, it is essential to provide training for staff to help MWC users deal with indoor challenges, like the high height of the shelves and checkouts, etc.

All these recommendations will significantly help improve BE accessibility in NZ for MWC populations. It requires the contribution of the government, building practitioners as well as the general public. The NZ government should play a leading position in supporting the achievement of better BE accessibility for MWC users.

5 CONCLUSION AND RECOMMENDATIONS

After carrying out a critical literature review and the experiment of 10 case shops in NZ, all the research objectives have been achieved. This research reveals the poor BE accessibility and limited accessibility legislation compliance of shops in NZ and makes recommendations for improving the BE accessibility for MWC populations and protecting their equal human rights in practice.

5.1 Review of research findings

There are several research findings which tie in well with the research objectives:

1. Features and specifications of the accessibility legislation in NZ (NZS4121:2001) for MWC users are sorted and listed in a table. Compared with the 2010 ADA standards applied in America, most of the accessible requirements are similar, but there are still some differences that are better than one another.

2. The experiment of 10 case shops indicates a serious failure of BE accessibility legislation compliance in NZ. Only 10% of the case shops completely comply with the requirements of NZS4121:2001 for outdoor environments, while that is 0% in terms of indoor environments. Even except the influence of the checkout counter, the indoors of case shops are just partially accessible.

Regarding the compliance outcome by features, all the outside features present very poor accessibility compliance. Only 20% of the car parking,30% of the footpaths, and 25% of the kerb ramps comply with the legislation, while no ramps completely meet the regulations. Even though the indoor BE accessibility is much better than outdoors, there are no checkout counters that meet the accessible requirements (0%), and just part of the passing space and shelf is accessible for MWC users.

The Compliance Outcome by Sub-item of Features identifies the inaccessible items that need to be improved. In terms of the outdoors, it includes the short dimensions of car parking, steep transverse gradient and longitudinal gradient of footpaths and ramps, inaccessible kerb ramps gradients, obstacles in the path, etc. For the indoors, the narrow passing space, the high height of the shelves and checkouts are quite challenging for MWC users.

3. The literature review theme 1 indicates the generally poor accessibility policies implementation in various countries, and the accessibility compliance level differs significantly in different places. The experiment results of 10 case shops confirm this idea - weak accessibility legislation compliance in NZ, and their compliance level differs significantly.

4. The inaccessible features identified in the experiment are quite similar to the main challenges summarized in other nations (the literature review theme 2), including outdoor barriers, such as inaccessible parking, narrow pavement, lack of dropped curbs, steep slopes, obstructions in the path (like plant, columns), and indoor challenges, like high counters and shelves, cluttered aisles, etc.

5. Poor legislation implementation is a significant cause of poor BE accessibility in NZ. The literature review theme 3 also summarized other underlying reasons, including social exclusion, inadequate

design, building practitioners' negative attitude, lack of cost, etc. Further research is needed to explore other potential reasons for poor BE accessibility in NZ.

6. The potential solutions are suggested to improve BE accessibility for MWC users in NZ. For instance, stricter enforcement of accessible policies, improvement of public awareness and social inclusion to disabilities, engagement of MWC users in BE design, development of navigation tools, provision of training for staff to help MWC users, government-led activities, etc. The inaccessible features identified in the experiment, such as inaccessible parking, narrow pavement, lack of dropped curbs, steep slopes, etc., need to be paid more attention to improve.

5.2 Implications/Significance of research findings (including any limitations)

5.2.1 Project significance

These findings will increase the awareness of both professionals and plain people about MWC users' actual accessibility situation. The compliance outcome of the 10 case shops will help the government to deeply realize the poor accessibility legislation implementation of shops in NZ, get an idea about the inaccessible features, and encourage them to take action to address these problems. This research will help the public better understand the accessibility policies implementation, the main challenges faced by MWC users, and potential ways to improve the situation; it will encourage the public to remove the existing barriers, address the underlying problems, and finally provide an accessible BE for MWC populations.

As mentioned earlier, there is a large group of populations who rely on an MWC in their daily life across the world, and this number is growing. This research will benefit this large vulnerable group and help them exercise their equal human rights by promoting the achievement of a better accessible BE. Also, other researchers can use the data of this research, and conduct further investigations based on the findings of this study.

5.2.2 Project limitations

This study only evaluated the accessible features of shops using 10 case buildings, the results may be not convincing enough; larger size samples and many other types of public buildings, like restaurants, hospitals, entertainment venues, etc. need to be further assessed.

This research only focuses on MWC users. By the experiment, several features were identified and suggested to be improved to increase the BE accessibility. However, there are many other types of disabilities, they annotate different, and even conflicting constraints on accessible routes (Zeng et al., 2017). The improvements of these suggested features for MWC users may pose obstacles to other kinds of disabled users. So, more comprehensive research is recommended to investigate as many types of disabilities as possible to figure out better universal design solutions to meet the needs of more kinds of vulnerable populations.

The measurement of case shops is only valid at the time of the measurement, as the building situation is changing, and a passage may be blocked at another time. Also, for the published studies, some do not consider the opinions of MWC users.

5.3 Recommendations

Based on the findings and limitations of this research, more comprehensive research considering larger

size case samples, more types of public buildings, and disabilities is recommended to further investigate the BE accessibility for vulnerable populations.

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APPENDICES

Appendix A Ethics Application

Human Ethics Application Risk Assessment Form

Student Name: Dongdong Li

Supervisor Name: Claire Flemmer

Project Details

1. **Project Title:** Accessibility of the Built Environment for vulnerable populations

2. **Recruitment/data collection start date:** *2/09/2023*

3. **Expected end of project date:** *15/04/2024*

4. **Project Type:** Postgraduate Student Research

5. **Aim of the project:**
   To evaluate the basic rights of vulnerable groups when they access the built environment, to identify building accessibility features and specifications presented in relevant legislation to protect these rights, and to assess the extent to which the built environment meets the needs of vulnerable groups in real life. By doing this, it provides a better understanding of the accessibility of buildings to vulnerable groups and encourages people to improve the actual built environment to better protect the rights of vulnerable populations to access buildings.

6. **Project Summary**

   I will take a few steps to do this research, as below:

   (1) Literature review:

   I will review about 60-80 articles to get an in-depth understanding of the topic and gather supporting materials to achieve the project objectives, including:

   1) Identifying deserved rights of the vulnerable groups regarding the accessibility of the Built Environment with a focus on manual wheelchair (MWC) users.

   2) Clarifying the population of this particular type of disability and their share of the total population in different countries.

   3) Identifying the challenges faced by the MWC users when assessing the public buildings.

   4) Listing a table on the accessibility features of public buildings and the compliance specifications related to these features in the legislation of NZ and other countries.

   (2) Practical assessment:

   1) A type of public building will be selected from a range of building types, such as shops, restaurants in NZ, etc.

   2) I will then assess about 10 case buildings of the selected type by measuring the actual dimensions of features identified in the literature review process and compare these collected data with the mandatory regulations listed before to see how well these buildings comply with the specifications in New Zealand legislation.

   3) I might interview some building managers to get their experience with MWC users on building accessibility.

   (3) Comparison and recommendations:

Finally, I will make a comparison between my findings and the findings from reviewed articles, suggest potential methods to improve public building accessibility, and ensure the basic rights of MWC populations.

This project will be conducted with my supervisor, Claire Flemmer. She will guide, supervise, and help me to do this research. There is a group of 8 students who are doing the same project but focusing on different building types.

7. **Describe the peer review process that has been used to discuss and analyze the ethical issues present in this project.**

During the peer review process, I took the following steps:

(1) Downloaded and went through the resources of "Research methods, ethics and communication" provided by the supervisor to get a basic understanding of what ethics is.

(2) Read the instructions, Ethics application form, and marking sheet to get familiar with what is required for ethics application.

(3) Went through the Research Outline of the research topic, made it clear about the project objectives, what should be conducted to achieve the project goals, possible research methods and participants involved in the research, etc.

(4) Studied the slide of "Research Methods Ethics and Communication" again to think and record what aspects of ethical issues need to be considered and addressed for this research, such as the participant, the researcher, the institutions involved, etc.

(5) Read Ethics Notes - Privacy in relation to research involving human subjects and Code of Ethical Conduct for Research, Teaching and Evaluations Involving Human Participants to realize Massey's ethics requirements.

(6) Reviewed some relevant articles provided in the research outline of the project, got more information about the topic, and better understood the potential ethical problems when doing the research, recorded questions faced when reviewing.

(7) Read the relevant pages of the study slides about ethics and filled out the Ethics application form, recorded the problems that confused me.

(8) Emailed the supervisor my questions and the completed form, discussed and got sound advice.

(9) Made some corrections according to the feedback and submitted my signed Ethics application form on stream.

(10) Once I got permission from the supervisor, I will submit the online ethics application using the words in assignment one.

8. **Summarise the ethical issues considered and explain how each has been addressed.**

(1) To participants

1) When reviewing a literature, it's important to cite the source clearly, not copy or pretend other's work is mine and accurately state the findings complying with academic integrity rules to prevent plagiarism. The researchers can study these standards and discuss them with the supervisor to clarify any doubts.

2) Measuring the dimensions of disabled access may cause inconvenience to other users and impede their passage. Measurements need to be taken at a proper time when fewer people are using the access.

3) Measuring a public place, such as a shop, may interfere with the normal operation of the store or invade its privacy. So, consent from the managers or staff must be obtained. Who the researcher is, the research aims, the way to measure, and how these collected data will be used should be informed to them.

4) If building managers are unwilling to cooperate with the research, their decisions must be respected, and the assessment shouldn't be forced. Other managers can be found to cooperate with data collection.

5) Retrieve all measuring tools without leaving any traces to protect the case building's environment and take adequate care to prevent any damage to public facilities.

(2) To researchers

1) When researchers collect data, for instance, to measure slopes of accessible ramps, they need to pay attention to their surroundings, whether the pedestrians, scooters, or wheelchairs may accidentally hit them, resulting in bodily injuries, etc. They can ask a classmate to join them to ensure their safety while measuring.

2) Do the research complying with Student Academic Integrity Policy, any breaches may lead to penalties for misconduct.

(3) To Massey

1) Be honest, responsible, and apply the Plagiarism prevention checklist on stream to avoid plagiarism and protect Massey's reputation for high academic standards.

2) Do the research complying with the MUHEC Code to avoid damaging Massey's reputation due to improper behaviors.

9. **With whom did you peer review the ethical aspects of your research?**

I got in touch with my supervisor, Claire Flemmer, every week to get advice about the ethics of my research. Also, I discussed with my classmates the ethical risks to the participants, researchers and Massey University, and the possible ways to mitigate them.

Applicant Details

1. **Applicant Department:** *School of Built Environment*
2. **Ethics Category:** *Human*
3. **Campus of Chief Applicant:** *Albany*
4. **Internal Personnel:** *Claire Flemmer*
5. **External Personnel:** *No*

Health and Disability Ethics Committee

Is Health and Disability Ethics Committee (HDEC) review required for this study?

No

Declaration: *(By the applicant)*

I declare that the information in this form is accurate for my research project in course 218.810.

Signed:

Date: *1/8/2023*

Declaration:

I declare that I have reviewed the information in this form and that it is correct for this research project.

Signed: Claire Flemmer

Date: 1/8/23

Risk Assessment

Does your research include:

a	Situations where the researcher may be at risk of harm	No	
b	Use of a questionnaire or interview, whether or not it is anonymous, which might reasonably be expected to cause discomfort, embarrassment or psychological or spiritual harm to the participants.	No	
c	Processes that are potentially disadvantageous to a person or group, such as the collection of information which may expose a person / group to discrimination.	No	
d	Collection of information of illegal behavior(s) gained during the research which could place the participants at risk of criminal or civil liability or be damaging to their financial standing, employability, professional or personal relationships.	No	
e	Collection of blood, body fluid, tissue samples or other samples.	No	
f	Any form of exercise regime, or deprivation. (e.g. sleep or dietary)	No	
g	Any form of physical examination (e.g. physical, radiation, ultrasound).	No	
h	The administration of any form of drug, medicine (other than in the course of standard medical procedure), or placebo.	No	
i	Physical pain, beyond mild discomfort.	No	
j	Any Massey University teaching which involves the participation of Massey University students for a demonstration of procedures or phenomena which have potential for harm.	No	
k	Participants whose identities are known to the researcher giving oral consent rather than written consent, other than for cultural reasons .	No	
l	Participants who are unable to give informed consent.	No	
m	Research on your own students / pupils. For Massey Staff - refer to the Decision Chart in section 2 of the Code.	No	
n	The participation of children (seven (7) years old or younger).	No	
o	The participation of children under sixteen (16) years old where active parental consent is not being sought.	No	
p	Participants who are in a dependant situation, such as nursing home or prison, or patients highly dependent on medical care.	No	
q	Participants who are vulnerable.	No	
r	The use of previously collected identifiable personal information or research data for which there was no explicit consent for this research.	No	
s	The use of previously collected biological samples for which there was no explicit consent for this research.	No	
t	Any evaluation of organisational services or practices where information of a personal nature may be collected and where participants or the organisation may be identified.	No	
u	Deception of the participants, including concealment or covert observations.	No	
v	Conflict of interest situation for the researcher.	No	

w	Payments or other financial inducements (other than reasonable reimbursement of travel expenses or time) to participants.	No	
x	A requirement by an outside organisation (e.g. a funding organisation or a journal in which you wish to publish) for Massey University Human Ethics Committee approval.	No	
y	I wish to submit a full application for Training / Education purposes	No	

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

23/08/2023

Dear: Dongdong Li

Re: Low Risk Notification - 4000027973 - Accessibility of the Built Environment for vulnerable populations

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our database for inclusion in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

If situations subsequently occur which cause you to reconsider your ethical analysis, please contact a Research Ethics Administrator.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director - Ethics, telephone 06 3569099 ext 85271, email humanethics@massey.ac.nz."

Please note, if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to complete the application form again, answering "yes" to the publication question to provide more information for one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

Feature	Sub-item		Measurement										
			Shop 1	Shop 2		Shop 3	Shop 4	Shop 5	Shop 6	Shop 7	Shop 8	Shop 9	Shop 10
Outdoors													
				route 1	route 2								
Car parks	C1	location	√	√	√	√	√	√	√	√	√	√	√
	C2	signs	ground marking	ground marking	ground marking	ground marking	ground marking	ground marking	sign on a cloumn:1645mm,ground marking	sign on a cloumn:815mm,ground marking	sign on a cloumn:>2m,ground marking	ground marking	ground marking
	C3	numbers	1/Total<20	3/Total<100	5/Total<200	2/Total<50	2/Total<50	2/Total<50	8/Total<300	4/Total<200	10//Total<400	2/Total<50	1/Total<20
	C4	dimensions	W*L:3673*4010	3708*4001	4423*5092	3892*4730	3945*3954	3002*5304	3533*5200	3450*3910	3462*5210	5104*4002	5030*4010
	C5	surface	√	√	√	√	√	√	√	√	√	√	√
Footpaths	F1	clear width	2054mm	1935mm	3052mm	1432mm	1743mm	1672mm	2207mm	2584mm	3654mm	2512mm	2400mm
	F2	transverse gradient	0.92	0.61	0.21	1.73	4.20	3.31	0.20	6.51	8.90	3.20	2.62
	F3	longitudinal gradient	2.71	5.12	2.63	3.24	5.30	1.20	2.74	5.30	7.62	2.53	5.80
Ramp	R1	clear width	1935mm	---	1965mm	---	---	1633mm	---	---	---	---	---
	R2	transverse gradient	0.61	---	2.23	---	---	1.30	---	---	---	---	---
	R3	longitudinal gradient	5.22	---	10.30	---	---	4.90	---	---	---	---	---
	R4	edge-rail	no edge-rail	---	---	---	---	79mm	---	---	---	---	---
	R5	Safety rail	no Safety rail	---	---	---	---	√	---	---	---	---	---
	R6	Handrails	no Handrails	---	850mm	---	---	920mm	---	---	---	---	---
	R7	Landings	---	---	4080*1973mm//distance:7820mm	---	---	1633*2142mm/distance:8540mm	---	---	---	---	---
Kerb ramps	K1	gradient	Lack kerb ramps	---	---	one side: 9.20;the other: 1.42	one side: 7.12;the other: 0.60	---	one side: 5.60;the other: 2.61	one side: 8.92;the other: 1.70	one side: 13.60;the other: 2.81	one side: 17.81;the other: 0.50	one side: 12.43;the other: 1.21
	K2	dimensions		---	---	L*W:1230*925mm	L*W:1450*1051mm	---	L*W:1124*1120mm	L*W:1900*1453mm	L:1237mm, W:spacious	L*W:1552*533mm	L*W:1420*1772mm
	K3	obstruction		---	---	670mm	no	---	no	no	no	plant	no

Indoors												
Entrances	E1	level approach space	W:1953mm,L:1530mm	spacious	spacious	spacious	spacious	spacious	spacious	spacious	spacious	spacious
	E2	Thresholds	step:16mm	level	step:24mm	level	level	level	level	level	step:17mm	level
Doorways	D1	Clear opening	795mm	2350mm	1950mm	2000mm	2700mm	1600mm	1235mm	1700mm	2000mm	1480mm
	D2	automatic door	no doors	automatic without 'Push to open' buttons,Open≥ 5 s	automatic without 'Push to open' buttons,Open≥ 5 s	automatic without 'Push to open' buttons,Open≥ 5 s	no doors	no doors	no doors	automatic without 'Push to open' buttons,Open≥ 5 s	no doors	automatic without 'Push to open' buttons,Open≥ 5 s
Passing space	P	clear width	various, 723mm(min), 795,1334…	various, 872mm(min), 1051,1452…	various, 835mm(min), 1002,1300…	various, 1237mm(min), 1375…	various, 791mm(min), 1183,2000…	various, 835mm(min), 1375…	various, 1320mm(min), 1575,3012…	various, 720mm(min), 1240…	various, 863mm(min), 1193,1230…	various, 642mm(min), 1120,1304…
Shelf	S	height	2237mm	mostly about 2m	≥1600mm	≥2m	≤2300mm	about 2m	about 2m	980mm,1160mm	about1.6m	1933mm
Checkout counter	CH1	height	945mm	980mm	1020mm	953mm	900mm	950mm	920mm	951mm	942mm	900mm
	CH2	aisle width	1324mm	1473mm	1507mm	1940mm	2054mm	2753mm	1126mm	spacious	1163mm	1538mm
lifts	L	not required	---	---	---	no lifts, 2nd floor about 200m2	no lifts, 2nd floor < 400m2	---	---	---	---	---
Toilets	T1	dimensions	---	2930*1875mm	---	---	---	1900*1600 mm	1900*1600 mm	---	---	---
	T2	toilet doors	---	870mm	---	---	---	844mm	860mm	---	---	---
	T3	washbasin	---	depth =392 mm, center line of a washbasin=1035 mm	---	---	---	depth =350 mm, center line of a washbasin =676 mm	depth =350 mm, center line of a washbasin =711 mm	---	---	---
	T4	clearance	---	713mm underside;1425*2340mm in front of the basin	---	---	---	716mm underside; 1210*1253 mm in front of the basin	700mm underside; 1300*1250 mm in front of the basin	---	---	---

Appendix C Other Supporting Documents