Investigating Cycling Equity: Perceptions, Initiatives, and Barriers

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Abstract

Among transportation modes, active transportation, and in particular cycling, has become a priority for many countries to reduce single-occupant car usage. Despite some success, there exist many barriers to increasing bicycle usage, both environmental and societal, such as inequity in cycling. In cycling equity analysis, studies have primarily focussed on the fair distribution of cycling infrastructure among neighbourhoods, and the solution has necessarily been the provision of more or better infrastructure to disadvantaged population groups. However, it is important to ensure that equity is considered in the provision of all cycling initiatives. Consequently, the objectives of the research are to better understand how to achieve an equitable cycling environment, considering aspects of cycling such as population needs, usage behaviour, and perceptions of cycling infrastructure, and to identify cycling initiatives other than bicycle infrastructure, assess their effectiveness, and highlight barriers to implementing cycling equity policies in practice.

The thesis first explores a number of sociodemographic characteristics to determine their influence on bicycle usage in Auckland, New Zealand. The results indicate that sociocultural factors are the most important factors influencing bicycle usage. Then, the impact of cycling infrastructure provision on individual perceptions of cycling infrastructure in relation to sociodemographic characteristics is explored. The results show that cycling infrastructure provision perception is more affected by factors such as ethnicity, education, and bicycle user type than objective measures of bicycle infrastructure. Following the capabilities approach of justice, findings suggest that the equitable provision of cycling infrastructure may not lead to an equitable cycling environment. To achieve this, interpersonal and intrapersonal indicators such as ethnicity, sociocultural, and community-related factors need to also be considered in order to fairly encourage and empower all population groups to cycle.

The thesis proceeds to evaluate equity in cycling initiatives, and their operational challenges, by reviewing a wide range of cycling initiatives implemented in Auckland. The various target groups or resulting beneficiaries were discussed, along with potential additional initiatives, barriers to implementing cycling equity initiatives in practice, and possible solutions to address such barriers. Results suggest that some of the current initiatives implemented could be more equitably distributed geographically. In addition there are inequities in terms of social distribution. For example, there are limited initiatives focusing on the safety of female cyclists in Auckland, and no initiatives specifically aimed at Māori and Pacific people, population groups that are both considered disadvantaged with respect to cycling in Auckland. Finally, the effectiveness of cycling initiatives in encouraging bicycle usage and their relationship with sociodemographic characteristics is explored. The results indicate that people with different backgrounds have different perceptions about the level of effectiveness of the various cycling initiatives. Findings indicate that the current cycling initiatives in Auckland do not focus sufficiently on the elderly and women, two groups with lower bicycle usage rates, as well as non-cyclists. This indicates that, in the interests of equity, cycling initiatives should be equipped with more targeted plans for these groups.

The findings of this thesis can be used to provide better insights for policymakers and local governments for improving cycling policies, initiatives, and investment in order to help address inequity in cycling.

Dedication

To brave Iranian women and men

Acknowledgment

I would like to express my sincere gratitude to my main supervisor, Professor Seósamh Costello, for his excellent guidance, encouragement and patience that has led to the successful completion of this research. I would also like to thank my co-supervisor, Professor Bert van Wee for his continuous support, encouragement and wonderful guidance. Sincere thanks are also extended to my co-supervisor Dr Subeh Chowdhury and my advisor Professor Kim Dirks, for their encouragement and positive advice in undertaking this research.

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Chapter 1

Introduction

1.1 Background

Urbanization, population growth and, consequently, the ongoing development and expansion of cities are among the characteristics of our age. The urbanization rate is increasing in parallel with population growth, and it is important to note that this growing urban population needs proper control of resources, goods, and services (Browne et al., 2012), otherwise the increasing population density and spatial growth of cities will continue to adversely impact on human life.

Many cities have already experienced serious environmental damage, resulting in unacceptable conditions, such as air pollution, caused by the pursuit of development (Karki & Tao, 2016). It can be argued that the development process must be planned in a way not to endanger the environment and the needs of future generations, but it is important to note that a balance between development and a healthy environment is crucial. Given that our social and economic developments are currently causing harm to the environment (Song, 2011), cities should strive to provide healthy and sustainable life opportunities for all. On this basis, governments strive to improve the environmental health of its people.

A key contributor to the adverse environmental impacts is the overuse of cars. While using cars and personal vehicles is convenient, the growth and increase of their use will have devastating effects on land, energy, environment, urban traffic congestion and safety (Shaheen et al., 2011). Urban transportation systems should be designed to counteract the negative aspects of rapid urbanization and increased demand for transportation, while ensuring access for all. This can be addressed by providing alternative transportation modes for better access, economically and socially (Mateo-babiano, 2015). Achieving sustainable urban mobility is, therefore, one of the major challenges of rapid urbanization and its associated health, economic, social and environmental problems (Ahmad & Puppim de Oliveira, 2016).

Consequently, the provision of sustainable mobility in urban spaces has become a priority for many countries, in addition to developing reliable, comfortable and secure transportation modes. Bicycles can be considered as one of the most efficient methods of achieving sustainable urban mobility (Berloco & Colonna, 2012), given their minimal consumption of energy and resource (Shaheen et al., 2011). Bicycles are ideal vehicles for short distances, and can also be integrated with other transportation modes to cover medium and long distances. Cycling also has a lot of social aspects, as Mark Auge states in his book "La bicyclette du mythe a l'utopic" that from a social viewpoint, using bicycles means prioritizing human beings (Auge, 2010). The use of bicycles includes a range of health, environmental and socioeconomic advantages. Using bicycles instead of motor vehicles reduces air pollution, traffic, fuel consumption and transportation costs and also improve health (Gupta et al, 2014; Berloco & Colonna, 2012; Bernatchez et al., 2015; Karki & Tao, 2016; Midgley, 2011; Tran et al., 2015). Therefore, the promotion of cycling has become a key strategy adopted in many countries for reducing reliance on private vehicles for mobility. However, little attention has been given to how resources allocated to cycling infrastructure and other cycling initiatives can be distributed fairly and equitably in the sense that the benefits as well as costs are shared equitably across all members of society (Di Ciommo & Shiftan, 2017).

1.2 Research problem statement

Although it is crucial to take equity into consideration in transport project planning and to implement equitable systems and infrastructure for everyone, it is rarely a key objective of projects and is often lacking entirely (Di Ciommo & Shiftan, 2017). However, there is an increasing trend in the literature to evaluate, understand and provide solutions for transportation equity-related issues (Beyazit, 2011; Di Ciommo & Shiftan, 2017; Lee et al., 2017; Levinson, 2010; Nahmias-Biran et al., 2017; Neutens, 2015; Pereira et al., 2017). Equity in transportation has been defined as sharing of benefits and costs to all members of society in an fair way (Di Ciommo & Shiftan, 2017). Transport equity can be discussed through different approaches including social equity, spatial equity, or a combination of both, and from other aspects (R. J. Lee et al., 2017). As stated by Thomopoulos et al. (2009), equity can have different aims: providing equitable rights and benefits of a service or program for all, maximizing the whole welfare of a community, or improving the situation of more disadvantaged population groups. Critically, equity seeks fairness in society and this is the point of difference when compared with the concept of equality (Carleton & Porter, 2018; Pereira et al., 2017). Equal access to facilities and infrastructure varies from an equity perspective as equal access does not consider the specific needs of different population groups.

A key element of equity is the distribution of benefits and costs across population groups. How these benefits and costs are measured is a prerequisite to make a system more equitable. In transportation, equity is mainly discussed by considering accessibility. Discussing accessibility in transport equity typically relates to access to transport facilities/modes, or access to destinations by transportation modes (Di Ciommo & Shiftan, 2017). Studies used various measures for investigating accessibility, such as considering journey time, distance, travel cost, and travel destinations, as well as considering place-based or people-based accessibility (Bocarejo S. & Oviedo H., 2012; Di Ciommo & Lucas, 2014; Neutens et al., 2010; Pereira, 2019). Affordability is another factor considered in transport equity and directly relates to different income levels. If transport services are relatively cheap, more people can afford them and will use them, and affordable transportation is critical for low-income people, especially low-income workers (Falavigna & Hernandez, 2016; Guzman & Oviedo, 2018). Socio-demographic characteristics of the population, such as age, gender, income, employment status, educational level, and physical impairment differentiate population groups and can also affect transport equity. However, the influence of socio-demographic characteristics is not shaped by a single axis of social division and it is the "intersections of them" (the combination of multiple socio-demographic variables) that create differences among different population groups. It suggests that researchers should not characterize the population groups' behavior by considering one aspect of their identity (Hill Collins & Bilge, 2016). For example, it is not possible to describe "men's cycling behavior" and "women's cycling behavior" without taking into account other socio-demographic characteristics.

Among transportation modes, active transportation, and in particular cycling, has become a priority for many countries to reduce single-occupant car usage. Bicycles can provide cost effective and flexible access to destinations, and reduce air pollution, traffic, fuel consumption and transportation costs, as well as improve health outcomes (Shaheen et al., 2010). Equitable bicycle infrastructure, bicycle sharing systems (BSSs), and dock-less bicycle sharing systems (DBSSs) can be achieved when they are accessible by different population groups with minimal barriers. An equitable system also provides access to key destinations for all, by distributing quality infrastructure fairly in a region. Reviewing literature focused on active transport equity, Lee et al. (2017) highlighted that studies commonly assess social and spatial equity but do not consider factors such as safety, quality of facilities, project funding, procedural equity, and the consideration of potential users. The study also found that the main focus has been on pedestrian equity, with a paucity of research undertaken on bicycling equity.

The majority of studies investigating cycling equity have focused on access to bicycle infrastructure, or access to destinations by bicycle (Chen et al., 2019; Hosford & Winters, 2018;

Tucker & Manaugh, 2018; Winters et al., 2018). Such studies have shown that disadvantaged populations, those living in lower-income neighbourhoods, those from minority population groups, women, the elderly, and immigrants usually experience lower levels of access to bicycle infrastructure and facilities compared to other groups, and also experience lower rates of bicycle usage. Similarly, in the New Zealand context, studies have shown lower bicycle usage amongst minorities, women, the elderly, low-income population groups, and Māori (the indigenous population) (Ministry of Health, 2022; Jones et al., 2020; Russell et al., 2021; Shaw & Russell, 2017; Shaw et al., 2020; Thorne et al., 2020). However, understanding the reasons why this is the case has yet to be adequately addressed. Although many studies worldwide have focused on cycling perceptions or perceptions of bicycle-sharing systems (Caulfield et al., 2017; Fishman et al., 2014; Jahanshahi et al., 2020; Nikitas, 2018; Shaheen et al., 2011), applying an equity lens of cycling perceptions to a multicultural population has yet to be carried out.

In cycling equity analysis specifically, studies have primarily focussed on the fair distribution of cycling infrastructure among neighbourhoods, and the solution has necessarily been the provision of more or better infrastructure to disadvantaged population groups. However, due consideration is needed of aspects beyond traditional infrastructure provision such as education, level of awareness about the benefits of cycling, cycling skills, and other sociocultural factors. Examples include demands for social and family cycling and the need to access places of importance for specific communities (Jones et al., 2020; Vietinghoff, 2021; Maldonado-Hinarejos et al., 2014) to help address inequity. The capabilities approach of justice argues that focusing only on the distribution of resources to provide equity can be misleading (Sen, 2009; Pereira et al., 2017). In particular, cycling perceptions can vary amongst individuals, can be context-specific and can be influenced by multiple factors, such as differences in general income and development levels, as well as geographical, cultural, and religious factors (Jahanshahi et al., 2019), aspects that tend to be largely ignored (Maldonado-Hinarejos et al., 2014). Other sociodemographic characteristics can also influence people's perceptions about cycling. For example, young people tend to be more cost-aware than older groups, parents more influenced by the needs of their children, and women more risk-averse than men (Banister & Bowling 2004; Pucher & Buehler 2008; Wennberg et al., 2010; Ogilvie & Goodman 2012; Mackett & Thoreau 2015). Different communities can also face unique barriers to cycling related to their individual identity (Vietinghoff, 2021). Therefore, there is a need for policymakers to include cyclists' perceptions more explicitly in decision-making processes (Marquart et al., 2020).

As Levinson (2010) argued, a policy deemed equitable to researchers or policy-makers may not necessarily be recognised as equitable to those affected by the policy. The attitude and perceptions of people affected by a decision can influence the satisfaction and effectiveness of the decision outcome (Cropanzano et al., 2015). Therefore, it would be helpful to understand if policy-makers, decision-makers, planners, designers, and transportation professionals have different perceptions to the populations they serve, in terms of the effectiveness of cycling initiatives. Previous studies attempted to improve cycling policies in terms of equity in cycling. However, there could be potential barriers which prevent councils from implementing cycling equity policies in practice. The gap between cycling equity policies and implementing them in practice is largely ignored, and highlighting the barriers to implement these policies can help governments to improve the practicality of cycling equity policies. The general research gap in the academic literature is the lack of consideration of more individual aspects in cycling equity, other than the provision of cycling infrastructure, and the barriers to implement the cycling equity policies. In addition, there is an empirical gap in the literature where communities' unique needs and barriers, particularly those of minorities and indigenous peoples, are not evaluated.

1.3 Research aims and objectives

The overarching question addressed in this research is:

"What can be done to improve equity in cycling?"

The overall aim of this research is, therefore, to gain a more comprehensive understanding of equity in cycling and to evaluate equity in cycling in aspects beyond bicycle infrastructure. This, in turn, will help provide a better understanding of cycling equity for designers, planners, decision makers, and transport professionals. The specific research objectives are listed below:

Objective 1: To synthesize the key findings and knowledge gaps from studies focused on bicycling equity

Objective 2: To develop a psychological model which explains the influence of perceptions of cycling on bicycle usage in Auckland

Objective 3: To understand people's perceptions of cycling infrastructure provision, their relationships to the physical infrastructure provided, the ways in which socio-demographic characteristics influence those perceptions, and how these are influenced by individual experience in using the cycling infrastructure

Objective 4: To understand equity in cycling initiatives, barriers to implementing cycling equity policies, and strategies to address the barriers

Objective 5: To determine the effectiveness of cycling initiatives among different population groups and compare these against the intended target groups

1.4 Outline of research methodology adopted for this study

This study consists of seven chapters, including five chapters which address the research objectives outlined above, bookended by this introductory chapter and a concluding chapter. Referring to Figure 1.1, the overarching research question and objectives were derived from the first phase of this research, a comprehensive review of the literature. The objectives can be categorised into psychological and policy challenges.

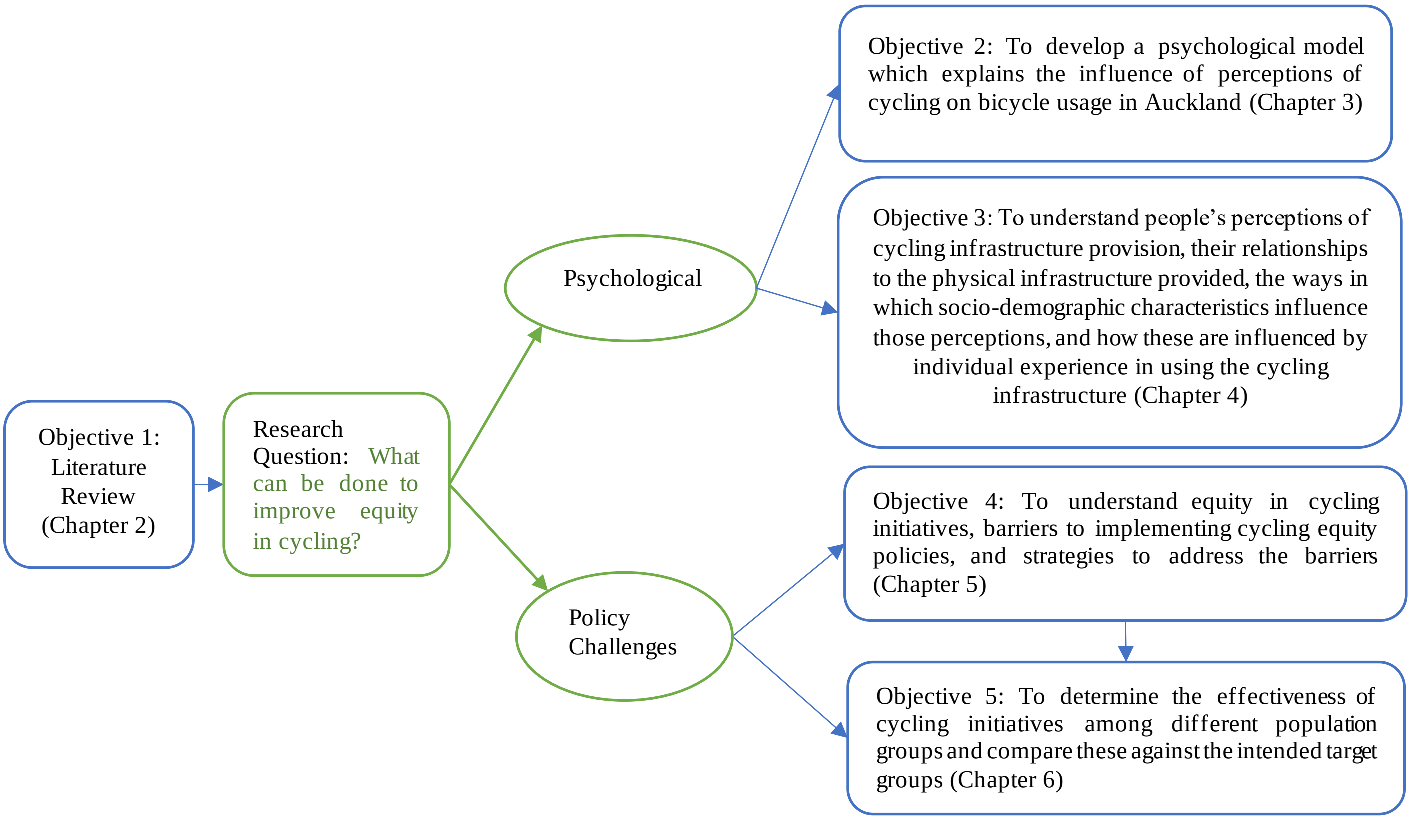

Figure 1.1: Links between the research question, objectives and chapters

As is shown in Figure 1.1, the psychological phase of the research is split into two chapters, Chapter 3 and 4. The policy phase of the research utilizes a mixed method study, a qualitative study in Chapter 5 followed by a quantitative study in Chapter 6.

Figure 1.2 below summarizes the relationship between the research objectives and the research methods adopted. As is shown in the figure, there are three questionnaire surveys used in this thesis. Questionnaire survey A is used to address two objectives of this thesis (in Chapter 3 and 4). Questionnaire survey B is a semi-structured survey used in Chapter 5. Finally, questionnaire survey C is used to address the last objective of this thesis in Chapter 6. The detailed information about conducting the surveys is explained in each relevant chapter.

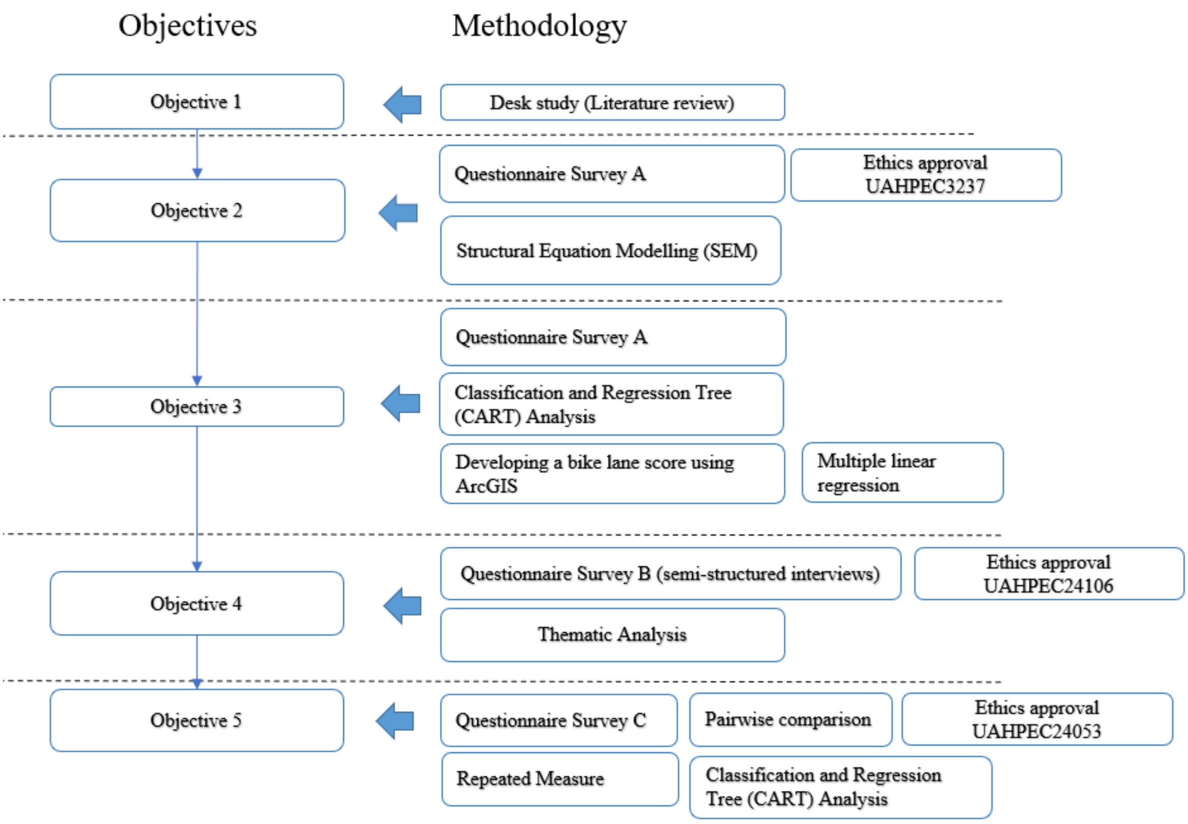

Figure 1.2: Research Methods corresponding with Research Objectives

1.4.1 Ethical Considerations

This research study was conducted with three ethics approvals obtained from the University of Auckland Human Participants Ethics Committee on the following dates and reference numbers:

- 26th February 2021 with the reference number UAHPEC3237
- 20th May 2022 with the reference number UAHPEC24053
- 3rd October 2022 with the reference number UAHPEC24106

The ethics approvals were granted for a period of three years. The ethics approval letters for this research are included in Appendix 5. It is a requirement of the ethics approval granted that participants are provided with a Participant Information Sheet (PIS) describing the nature and objectives of the research study, as well as the process of data collection. PISs used for this study are included in the Appendix.

1.5 Thesis outline

According to the University of Auckland PhD guidelines, the doctoral thesis can include a series of published and submitted research papers of which the PhD candidate is the lead or sole author. Following the University of Auckland PhD guidelines, the thesis must be a coherent whole, and publications included in the thesis must be integrated by the effective use of linking passages. Accordingly, this doctoral thesis consists of seven chapters including an introduction, which contains introductory and methodological discussion, a literature review chapter based on a published paper, four main chapters, and one final chapter covering the conclusions and recommendations of the thesis. The four main chapters are based on one published and three submitted papers. Additional material was added as required. The introduction section of the paper-based chapters has been modified to avoid repetition as much as possible, although some unavoidable repetition remains. In the current chapter, the background to the research, problem statement, research scope and objectives, outline of the research methodology, and thesis outline are discussed. The thesis further consists of the following chapters:

Chapter 2 details the literature review undertaken for this research and the knowledge gaps, to date, on cycling equity. Barriers to cycling from an equity perspective are examined from three perspectives: policy and planning, infrastructure and cycling facilities, and population groups. The review includes both peer-reviewed and grey literature.

Chapter 3 explores a number of sociodemographic characteristics to determine their influence on bicycle usage in Auckland, a multi-cultural city in New Zealand. A conceptual model of Bicycle Usership is proposed which includes the constructs Sociocultural Factors, Price Value, Perceived Safety and Security, Cycling Provision Perception, and Information and Communication. The conceptual model is then analysed using Structural Equation Modelling (SEM) to examine the effect of the constructs on various sociodemographic groups. The moderating effects of age, gender, ethnicity and income level on the relationship between these constructs and Bicycle Usership are also examined.

Chapter 4 explores the impact of cycling infrastructure provision on individual perceptions of cycling infrastructure in relation to sociodemographic characteristics. For this purpose a Bike Lane Score was calculated for Auckland. The study considered regular cyclists, potential cyclists, and non-cyclists.

Chapter 5 evaluates equity in cycling initiatives and their operational challenges by reviewing a wide range of cycling initiatives implemented in Auckland, through interviewing policymakers, decision-makers, planners, designers, and transportation professionals. The effectiveness of current initiatives with respect to various target groups or resulting beneficiaries were discussed, along with potential additional initiatives, barriers to implementing cycling equity initiatives in practice, and possible solutions to address such barriers.

Chapter 6 explores the effectiveness of cycling initiatives in encouraging bicycle usage and their relationship with sociodemographic characteristics in the multi-cultural city of Auckland, New Zealand. The study considered regular cyclists, potential cyclists, and non-cyclists, as well as sociodemographic groups to provide a holistic understanding of the association between the perceived effectiveness of cycling initiatives in encouraging bicycle usage and socio-demographic characteristics including age, gender, income level, educational level, ethnicity, and bicycle user type.

Finally, **Chapter 7** presents the conclusions and recommendations. The chapter outlines the achievement of the research objectives, thereby highlighting the value and significance of the research in the field of cycling equity. This is followed by a statement of the limitations of the research and, finally, recommendations for future research.

Chapter 2

Literature Review: Review of Key Findings and Future Directions for Assessing Equitable Cycling Usage

2.1 Introduction

This chapter provides a literature review on equity in cycling. Transport equity can be discussed through different approaches including social equity, spatial equity, or a combination of both, and from other aspects (R. J. Lee et al., 2017). There is an increasing trend in the literature to evaluate, understand and provide solutions for transportation equity-related issues (Beyazit, 2011; Di Ciommo & Shiftan, 2017; R. J. Lee et al., 2017; Levinson, 2010; Nahmias-Biran et al., 2017; Neutens, 2015; Pereira et al., 2017). The literature on transport equity mostly discussed equity in accessibility to public transportation and equity in active transportation is not properly considered (Di Ciommo & Shiftan, 2017). Among studies on equity in active transportation, the main focus has been on pedestrian equity, with a paucity of research undertaken on bicycling equity and studies commonly assess social and spatial equity but do not consider factors such as safety, quality of facilities, project funding, procedural equity, and the consideration of potential users Lee et al. (2017).

Consequently, an understanding of equity in relation to bicycle provisions is important to provide better insights for planning and policy-making for cycling. This chapter provides a review of recent literature on bicycling equity, which includes both peer-reviewed and grey papers, with the intention of synthesizing the key findings from studies focused on bicycling equity and identifying knowledge gaps and suggest avenues for future research.

The review considers cycling systems, including private bicycles, BSS, and DBSS, and both leisure and utility cycling. The key findings and knowledge gaps are provided in sub-categories for ease of summarization. The subcategories were not defined prior but based on the papers included in the review. Findings from this review are expected to help direct future research in cycling equity so that practitioners and transportation policy-makers can integrate equity into their planning procedures and policymaking.

2.2 Method

The procedure adopted for the structured exploratory literature review is explained step by step in this section. A mixed search strategy was used to combine database searches using keywords, forward snowballing (finding citations to papers), and backward snowballing (from the reference lists) similar to those used in previous studies (Jalali & Wohlin, 2012; Wee & Banister, 2016). Mixing these methods, according to Jalali and Wohlin (2012), results in a comprehensive list of relevant papers, although it is more time consuming. The process is illustrated in Figure 2.1 and the individual steps are described below. The papers were collected by the first author (steps 1-4) and then reviewed by all authors (steps 5-6).

1. The search process first involved identifying the keywords for database searches. Scopus, Google Scholar, and TRID (Transport Research International Documentation) were used as the target databases and only English language articles were considered for inclusion. The databases were searched using (combinations of) the following keywords: bike, bicycle, cycling, active, equity, equality, fairness, and justice. The terms equity, equality, fairness, and justice have been included because these terms are often used interchangeably. Restrictions were not applied to the year of publishing, but the oldest publication was found to originate in 2009.

2. Articles were evaluated for inclusion and exclusion. At this stage, all the titles found by searching the selected keywords through databases were checked for relevance. If the article title was relevant to equity/inequity in cycling, it was added to the extracted papers list (L). When it was not clear if the title was relevant to the scope of the study, it was included in the extracted papers list, to be looked at in detail at a later stage.

3. The next step involved forward and backward snowballing of each extracted paper. Initially, citations to all the papers including the papers published in the selected databases, grey papers, theses/dissertations, books, book reviews, reports, editorials, and conference abstracts were checked through using Google Scholar (L=59). Next, all the references lists were scanned and potential papers extracted based on the titles. Through this step, 19 new papers were selected (L=78). Forward snowballing and backward snowballing continued with each new paper identified

and ended when there were no suitable papers in the final citation lists. It should be noted that, based on this search methodology, the boundary of grey papers in this study is restricted to Google Scholar.

4. Alerts were set which included all the aforementioned search keywords using a Google Scholar profile. This step was added to the process to capture any papers published after the initial review. The procedure for checking alert emails was to scan the titles once received for relevance (as per Stage 2). There were 10 further inclusions to the final extracted papers list from this step.

5. After finalizing the paper search process through steps 1 to 4 and finding a wide range of papers (L=88), all the abstracts were read to check for relevance to the scope of the review. Scanning the abstracts by carefully checking the aim of the papers, methodologies, and results helped the authors to identify if the extracted papers discuss equity/inequity in cycling. For example, while there were papers with relevant titles, the content may have focused on equality in bicycle usage, rather than equity. Papers such as these were excluded from the final list, following a discussion between the authors. In this step, eight documents were excluded (seven documents due to lack of relevancy to the present investigation and one duplicate document).

6. In the final step, the full texts of the 80 remaining documents were read. The inclusion strategy for full texts was to retain all the documents which clearly investigated equity/inequity in cycling (not equality), discuss the reasons or outcomes of inequity/equity in cycling, or discuss bicycling equity policies. After this stage, 40 further documents were excluded and 40 documents remained (L=40).

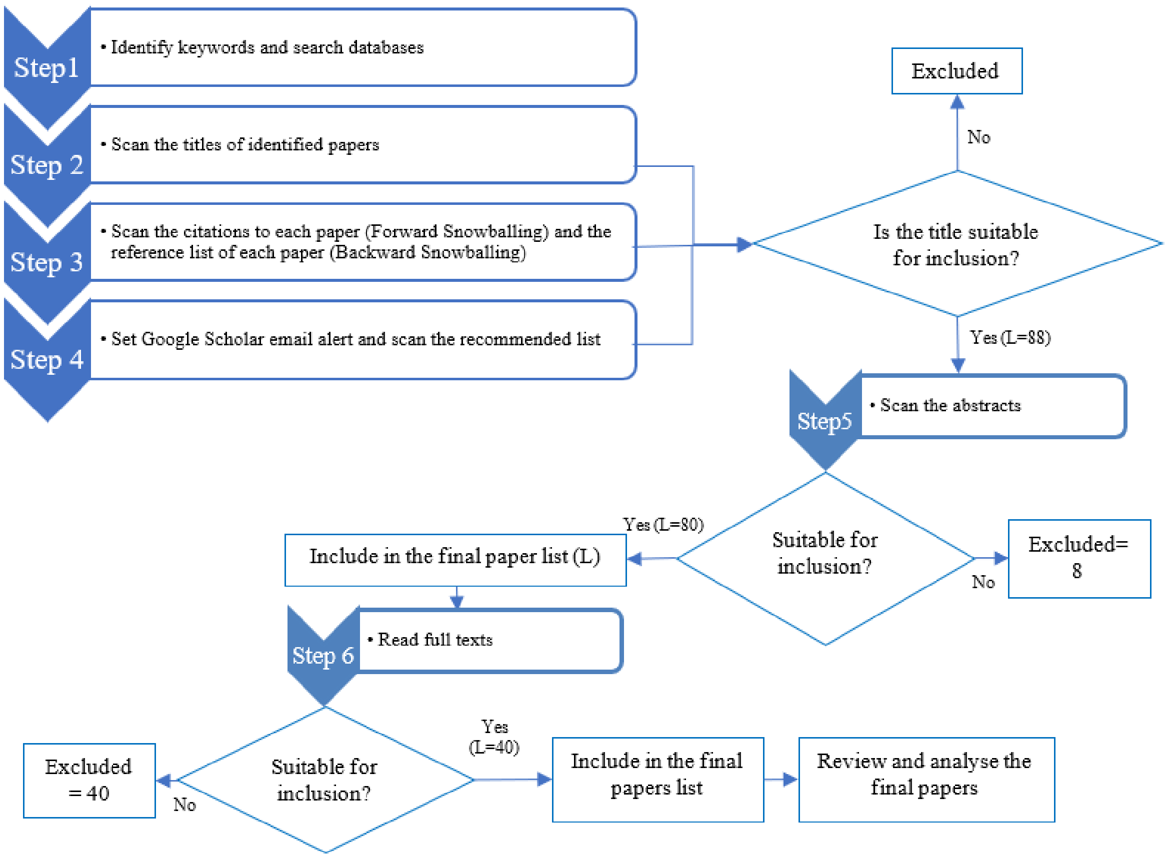

Figure 2.1: Flow chart of search strategy.

2.3 Key findings on bicycling equity

Most of the studies originate from the USA, Canada, and the UK. Typically, the case study included one city or neighborhood. Only nine studies evaluated and compared a few cases, and there are five studies that included many (more than 10) cases. Equity in cycling can be discussed from various perspectives. Findings of this review can be categorized to: (a) equitable access to bicycle infrastructure (Fuller & Winters, 2017; Houde et al., 2018; Mooney et al., 2019; Pistoll & Goodman, 2014), (b) equitable access to destinations by bicycle (Kent & Karner, 2019; Pritchard et al., 2019; Qian & Niemeier, 2019), and, (c) equity issues in cycling policies (Bernatchez et al., 2015; Howland et al., 2017; Lam, 2018; Piatkowski et al., 2017; Rebentisch et al., 2019). Studies mainly considered the relationships between equity and socioeconomic characteristics (mostly income and place of residence), cycling investments, infrastructure locations and accessibility, safety, and policymaking.

The 45 papers in the final list of papers for review were categorized based on their primary focus areas. Three clear sub-categories emerged. The sub-category “Equitable access to bicycle infrastructure" includes the selection of papers that discuss equity issues related to bicycle infrastructure, which included access to bicycle lanes and bicycle sharing stations by different sociodemographic groups. The second sub-category, "Equitable access to destinations by bicycle" includes papers that discuss equity issues related to accessibility of different destinations. Papers in this category considered the use of private bicycles, BSS, or bicycle lanes to access key destinations. The third category, "Equity issues in cycling policies" considered papers that discuss the influence of policymaking and equity consideration (at policy level and decision-making level) for cycling. The papers in this category are different from "access to bicycle infrastructure" and "access to destinations by bicycle" as they are related to policy, and explore equity issues at a higher level by using case studies in bicycle usage. These papers consider equity in investments in cycling projects, public awareness about cycling facilities, and policy views and equity considerations in BSS and infrastructure projects. Table 2.1 presents the three sub-categories and details (authors, study area, focus of study) for each of the 33 papers.

Table 2.1: An overview of literature on bicycling equity

Sub-categories	**Authors**	**Study Area**	**Focus of Study**
(a) Equitable access to bicycle infrastructure	Dill & Haggerty, 2009	Portland, USA	Association along socioeconomic lines and access to bicycle lanes
	Deka & Connelly, 2011	New Jersey, USA	Association along socioeconomic lines and access to bicycle infrastructure
	Pistoll & Goodman, 2014	Melbourne, Australia	Association between socioeconomic characteristics and access to cycling infrastructure and investment
	Flanagan et al., 2016	Chicago and Portland, USA	Equity in investments in cycling infrastructure over 20 years
	Clark & Curl, 2016	Glasgow, UK	Equity in access to BSS stations
	Wang & Lindsey, 2017	Minnesota, USA	Association between socioeconomic characteristics and access to bicycle network

Sub-categories	**Authors**	**Study Area**	**Focus of Study**
	Fuller & Winters, 2017	Calgary, Halifax, Moncton, Montreal, Saskatoon, Toronto, Vancouver, and Victoria, Canada	Association along socioeconomic lines and access to bicycle lanes.
	Tucker & Manaugh, 2018	Rio de Janeiro and Curitiba, Brazil	Association along socioeconomic lines and access to bicycle lanes
	Braun, 2018	22 large U.S cities	Association along socioeconomic lines and access to bicycle lanes and equity in investments in cycling infrastructure over 25 years
	Parra et al., 2018	Bogotá, Colombia	Association along socioeconomic lines and access to bicycle lanes
	Winters et al., 2018	Victoria, Kelowna, and Halifax, Canada	Association along socioeconomic lines and access to bicycle lanes
	Houde et al., 2018	Montreal, Longueuil, and Laval, Canada	The effect of bicycle lane expansions on accessibility inequities over 25 years
	Conrow et al., 2018	Phoenix, Arizona, USA	Equitable locating of BSS stations
	Barajas, 2018	29 BSSs in USA	Equity in access to BSS stations
	Duran et al., 2018	Porto Alegre, Recife, Salvador, Sao Paulo, and Rio de Janeiro, Brazil	Equity in access to BSS stations

Sub-categories	Authors	Study Area	Focus of Study
	Hosford & Winters, 2018	Vancouver, Hamilton, Toronto, Ottawa-Gatineau, and Montréal, Canada	Equity in access to BSS stations
	Meng, 2018	Chicago, USA	Equity in access to BSS stations
	Babagoli et al., 2019	New York, USA	Equity in access to BSS stations over two years.
	Qian & Niemeier, 2019	Chicago & Philadelphia, USA	Equity in access to BSS stations
	Braun et al., 2019	22 large U.S cities	Association along socioeconomic lines and access to bicycle lanes over four years
	Mooney et al., 2019	Seattle, USA	Equity of access to bicycles in a DBSS along sociodemographic and economic lines, bicycle locations, bicycle idle time, and rebalancing patterns
	Couch & Smalley, 2019	73 BSSs and DBSSs in the USA	Comparing spatial equity of 73 DBSSs and BSSs
	Aman et al., 2021	Austin, Texas, USA	Equity in access to BSS and DBSS stations
	Padeiro, 2022	Lisbon, Portugal	Association between deprivation index and access to cycling network
	Tortosa et al., 2021	England	Association along socioeconomic lines and access to bicycle lanes
	Mora et al., 2021	Santiago de Chile	Association along socioeconomic lines and access to bicycle lanes
(b) Equitable access to destinations by bicycle	Tucker & Manaugh, 2018	Rio de Janeiro and Curitiba, Brazil	The impact of bicycle lanes on accessibility of different income level population groups to key destinations
	Barajas, 2018	29 BSSs in the USA	Equity in access to key destinations by using a BSS

Sub-categories	**Authors**	**Study Area**	**Focus of Study**
	Kent & Karner, 2019	Baltimore, USA	Prioritization of bicycle network projects in terms of equity and investigating the impact of reductions in level of stress experienced by cyclists on improvement of accessibility to some key destinations
	Qian & Niemeier, 2019	Chicago & Philadelphia, USA	Equity in access to key destinations by using a BSS
	Chen et al., 2019	Southern Tampa, USA	Equity in access to key destinations by using a BSS
	Hamidi et al., 2019	Malmo, Sweden	Equity in access to key destinations by using a BSS or private bicycles
(c) Equity issues in cycling policies	Bernatchez et al., 2015	Montréal, Canada	Changes in awareness of people about a BSS during a period of two years, considering their educational levels and proximity to BSS stations.
	Piatkowski et al., 2017	Chicago, Cincinnati, Philadelphia, Portland, USA	The effect of web-based community engagement in equitable distribution of the BSS stations
	Howland et al., 2017	56 BSSs in the USA	Equity considerations in BSS projects
	Lam, 2018	Hackney, UK	Equity considerations in cycling policies
	Rebentisch et al., 2019	New York, USA	Equity in safety investments considering reported bicycle crash rates
	Q. Zhao & Manaugh, 2023	Montreal, Canada	Introducing a framework for cycling investment prioritization considering equity
	Cunha & Silva, 2023	Lisbon, Portugal	Introducing a planning support tool for assessing the relative equity impact of bicycle planning
	Keall et al., 2022	New Plymouth and Hastings, New Zealand	Equity impact of a program to promote and normalise active travel

2.3.1 Equitable access to bicycle infrastructure

The majority of studies on equity of bicycle infrastructure focused on socioeconomic levels and income levels, to assess if disadvantaged groups have the required accessibility to bicycle networks and BSSs/DBSSs. A common finding from these studies is that bicycle infrastructure is not equitably distributed among different population groups. It is typically reported that there is lower access to bicycle infrastructure for disadvantaged populations. As shown in Table 2.1, studies considered different criteria and methods including the associations between socio-demographic characteristics and the availability of cycling infrastructure (Fuller & Winters, 2017; Pereira et al., 2017; Rodriguez et al., 2018; Deka & Connelly, 2012; Dill and Haggerty, 2009), the density of cycling routes (Pistoll & Goodman, 2014), availability, coverage, and connectivity of bicycle lanes (Braun et al., 2019), associations between accessibility to cycling infrastructure and socio-demographic characteristics using the deprivation index[1] (Padeiro, 2022), the Gini coefficient[2] (Wang & Lindsey, 2017), the Lorenz curve[3] (Aman et al., 2021), Palma Ratio[4] (Rosas-Satizábal et al., 2020), and the Theil index[5] (Hamidi, 2019). The studies considered various types of bicycle infrastructure and socio-demographic characteristics, including education, age, employment status, occupation, car ownership, ethnicity, and race. This shows some evidence of inequitable investment by governments and a lack of equity consideration by policymakers.

In contrast, a limited number of studies discussed better access for low-income populations and disadvantaged populations (Deka & Connelly, 2012; Vanderslice et al., 2009b; Winters et al., 2018). Deka and Connelly (2012) suggested that low-income and minority populations' lower participation in physical activities could be caused by other external factors, such as cultural norms. Winters et al. (2018) reported that neighborhoods with higher density populations were prioritized for bicycle infrastructure investment in Victoria and Kelowna (Canada) cycling policies. Therefore, the urban form of these cities influenced greater access

[1] A statistical measure that quantifies and ranks the level of socio-economic disadvantage within a specific area or population based on various indicators such as income, education, employment, and housing conditions.
[2] "The Gini coefficient is calculated from Lorenz curves and may take values ranging from 0, which represents perfect equality, to 1, which represents perfect inequality".
[3] A Lorenz curve is a graphical representation of the distribution of income or wealth within a population. Lorenz curves graph percentiles of the population against the cumulative income or wealth of people at or below that percentile.
[4] The Palma ratio is an alternative to the Gini coefficient and focuses on the differences between those in the top and bottom income brackets.
[5] The Theil index measures an entropic "distance" the population is away from the "ideal" egalitarian state of everyone having the same income. The numerical result is in terms of negative entropy so that a higher number indicates more order that is further away from the "ideal" of maximum disorder.

for lower income population groups, since the higher income areas were more suburban in nature with lower density populations.

Some studies evaluated equity in investments over a period of time and reported that bicycle infrastructure improvements were not undertaken in an equitable way, so that investments benefitted people of European ethnicity and those living in gentrified neighborhoods (Flanagan et al., 2016) or provided lower accessibility to bicycle lanes for non-European, African-Americans, those without a vehicle, and those with low income (Braun et al., 2019; Houde et al., 2018; Wang & Lindsey, 2017). In contrast, Houde et al. (2018) noted that accessibility for recent immigrants and the elderly did improve over a 25 year period of bicycle lane expansion in Montreal, Longueuil, and Laval in Canada. Also in a recent study, Keall et al. (2022) examined the long-term effects of an active mode promotion program, five years after the initial assessment, focusing on the changes in active travel patterns for Māori individuals and those with lower incomes. They conducted a series of in-person interviews with 2,500 participants and included two comparable cities without intervention as control groups. The intervention resulted in sustained increases in active travel rates in the intervention cities compared to the control groups. Notably, Māori individuals and households with below median income demonstrated even greater increases in active travel rates. The program effectively tackled certain inequities within a transportation system heavily reliant on cars.

Regarding equity in the distribution of BSS stations, the majority of studies have attempted to investigate whether the distribution of BSS stations is equitable. A study, by Conrow et al. (2018), tried to identify suitable locations for BSS stations considering both social and spatial equity, as well as budgetary limitations and realities.

In contrast to BSS, DBSSs are free-floating systems working without any stations, and bicycles are moved based on user destinations and rebalances are based on demand. As the system is not dependent on stations, the equity consideration is different to BSSs. Evidence indicates that DBSSs appear to be more equitable than BSSs in terms of accessibility (Couch & Smalley, 2019) and, for example, in Seattle, Mooney et al. (Mooney et al., 2019) found that no neighborhoods were disadvantaged and inequity of access to bicycles was notably low, as the number of available bicycles remained high in all neighborhoods. However, it was noted that slightly more bicycles were available in neighborhoods with more local community resources and higher incomes.

In summary, studies in this topic mainly reported lower access for disadvantaged populations. For instance, slightly more access to BSS stations for the employed (Clark & Curl, 2016), more access for residents with European ethnicity and lower accessibility for those residing in lower socioeconomic areas (Barajas, 2017; Qian & Niemeier, 2019), and for minorities (Aman et al., 2021), more access for higher income areas (Duran et al., 2018), and better access for advantaged and wealthier areas (Babagoli et al., 2019; Hosford & Winters, 2018; Meng & Welch, 2018; Qian & Niemeier, 2019).

2.3.2 Equitable access to destinations by bicycle

This section includes studies which explored equity in terms of accessibility to destinations by bicycle, made possible by the provision of bicycle infrastructure or BSSs. These studies mainly considered access to various key destinations including job destinations (Barajas, 2017; Qian & Niemeier, 2019), grocery stores, hospitals, and schools (Qian & Niemeier, 2019), shopping opportunities (Kent & Karner, 2019; Tucker & Manaugh, 2018), pharmacies, banks, and libraries (Kent & Karner, 2019). They mainly reported more access to key destinations for the affluent, people of European ethnicity, or neighborhoods within and around the downtown area (Barajas, 2017; Chen et al., 2019; Qian & Niemeier, 2019; Tucker & Manaugh, 2018). Only a limited number of studies focused on disadvantaged population groups and they reported that these population groups experience more inequities relating to access to destinations by bicycle.

There are also some studies that focused on specific key destinations. Hamidi et al. (2019) examined accessibility by bicycle to major public transport key destinations, including bus and train stations and found no significant difference in access to transport hubs between Swedish and immigrant populations. Also, a study by Kent and Karner (2019) discussed prioritized bicycle network projects in Baltimore to improve equity, and investigated the impact of reductions in level of stress experienced by cyclists due to improved accessibility to some key destinations including supermarkets, pharmacies, banks, and libraries.

2.3.3 Equity issues in cycling policies

As detailed above, most of the studies in the field of cycling equity focused on “accessibility”. However, a limited number of studies have examined equity and cycling from a different perspective, including equity in safety investments, public awareness about cycling facilities, and policy views and equity considerations in transport projects. Similar to previous sections, disadvantaged population groups, such as those with lower income and educational levels, usually experienced greater inequity.

For instance, a recent study (Rebentisch et al., 2019) relating to crash rates in cycling and walking in New York revealed that crash rates in lower-income neighborhoods were higher. This study also found that safety investments were lower in the areas with higher crash rates. Bernatchez et al. (2015) found that lower educational levels and lack of a BSS station within walkable distance led to lower awareness of the system. In spite of an increase in the level of awareness, those with lower levels of education were most unaware of BSS. This study concluded that differences between the levels of awareness did not change even after improvements in accessibility to BSS stations, and that it therefore appears to be a multi-faceted issue. A study in four US Cities (Chicago, Cincinnati, Philadelphia, Portland) revealed that locating stations based solely on public participation through a web-based engagement led to inequitable distribution of stations. The outreach of this participatory planning was not fair for minority population groups (Piatkowski et al., 2017).

A number of studies focused on policy views and equity considerations based on case studies. Howland et al. (2017) assessed equity considerations of 56 BSSs in the USA through a survey circulated to each service provider, for the attention of staff capable of responding about their equity policies. They found that around 25% of studied BSSs and 50% of the schemes with more than 500 bicycles had written equity policies which affect their station locating, cost and pricing principles, marketing, and operations. They also found that accessibility and affordability of the systems are the biggest barriers for implementing equitable BSSs. Hosford and Winters (2018) showed that inequity in access to BSS stations is associated with the type of organization, in that greater equity was evident in systems operated by non-profit organizations, and greater inequity was evident in privately operated systems. A qualitative study in the London Borough of Hackney showed that despite the fact that Hackney has a good reputation for bicycle usage rates, the cycling policies did not consider equity for race and gender and that they needed to incorporate the social justice approach more in their planning and policies (Lam, 2018).

There are two recent studies that introduced frameworks and tools to help better planning and investment in the field of cycling equity. Zhao and Manaugh (2023) presented a quantitative framework to prioritize future bicycle improvement projects within budget limitations. This "equity-based" approach prioritizes projects that increase bicycle accessibility for disadvantaged populations, aiming to address disparities in access to bicycle facilities. Cunha and Silva (2023) introduced an innovative planning support tool which enables the assessment of the equity impact of bicycle planning at a micro-scale level. Their tool evaluates how the allocation of cycling networks affects the accessibility of different socioeconomic groups, allowing for a detailed analysis of equity. They test the tool in a practical context by assessing the cycling strategy implemented in Lisbon, Portugal. They identified areas in the city where the distribution of cycling networks is equitable, as well as areas where disadvantaged groups have below-average accessibility levels, highlighting the need for special attention during the bicycle planning process. Furthermore, the tool assisted local planning practitioners in identifying target areas and developing equity-oriented strategies, fostering awareness about the equity impacts of allocating cycling infrastructure.

2.4 Knowledge gaps and research challenges

This review has identified some key knowledge gaps and directions for future research. Bicycling equity is a relatively new topic, given that the first paper to address bicycling equity was published in 2009 (Vanderslice et al., 2009b). The significance of bicycling equity is rising due to increasing social consciousness and it is increasingly receiving attention in both academia and in practice. The gaps in the literature and research challenges will be discussed within the context of three layers, as shown in Figure 2.2.

The first layer is related to demand and focuses on the differences between population groups, in terms of socioeconomic characteristics. Bicycling equity is influenced by socioeconomic differences among population groups, such as age, gender, income, ethnicity, and education, and also with respect to their place of residence and destination choices (employment location, places of shopping, etc.). As explained above, this influence of socio-demographic characteristics is not shaped by a single axis of social division and it is the “intersections of them” (the combination of multiple socio-demographic variables) that create differences among different population groups (Hill Collins & Bilge, 2016). Such differences induce different needs with respect to the importance of cycling-related access to destinations, as well as safety concerns. The second layer focuses on the supply side: the provision of more equitable bicycle infrastructure and facilities (because the concept of equity is strongly, but not exclusively, related to the spatial distribution of cycling facilities) and, more importantly, the beneficial effects of these facilities on population groups. It includes bicycle infrastructure, such as bicycle networks, and facilities, such as BSSs, DBSSs, bike shops and bike repair workshops. Because the population, infrastructure, and facilities are spatially distributed in a non-homogeneous way, cycling infrastructure and facilities influence bicycle equity levels. Finally, the third layer focuses on policy and planning with respect to the first two layers. They can influence the first and second layer, through land use planning (location of houses, employment, retail, schools, medical services, etc.), housing policies, and the provision of cycling infrastructure and facilities. Note that the provision of facilities is not entirely in the hands of the public sector, as the private sector also offers such facilities. For example, the private sector mainly operate BSS and DBSS, bike parking facilities, shops, repair facilities, and employers sometimes provide bicycle storage and showers.

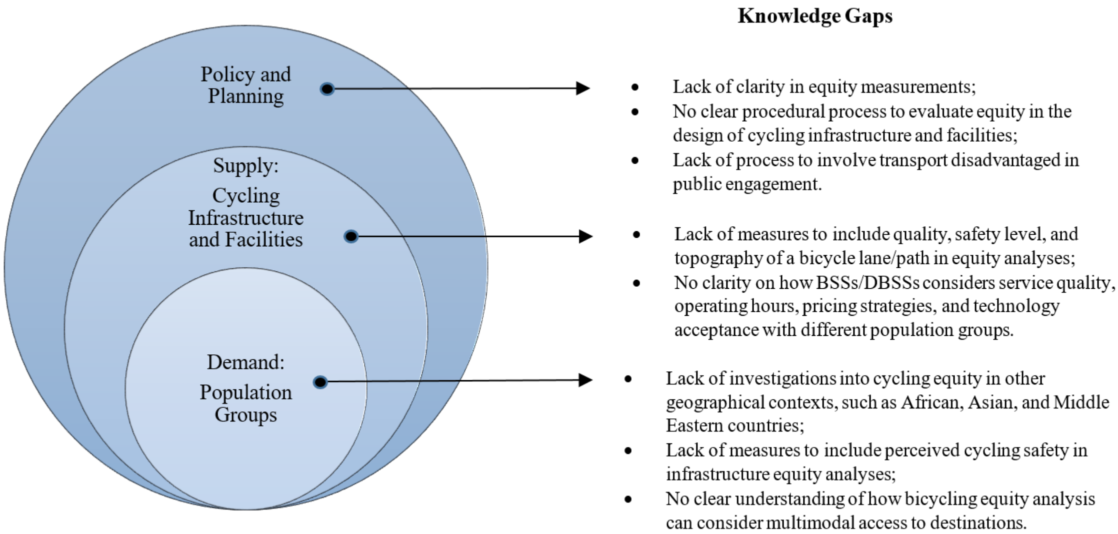

Figure 2.2: Onion model for bicycling equity.

Note: BSS = bicycle sharing system; DBSS = dock-less bicycle sharing system

2.4.1 Demand: Population groups

An initial gap observed is that there is limited understanding of demand from the perspective of certain population groups. All the studies to date have been undertaken in western contexts, predominantly in North America. Consequently, there is a lack of knowledge in respect to bicycling equity in other geographical contexts, such as African and Asian countries. The demand for cycling can be context specific because of differences in income, and due to cultural and religious reasons. For example, in Mashhad city in Iran, women are not allowed to use BSS programs (Jahanshahi et al., 2019).

The impact of the geographical context is not limited to the demand side. The supply side, as well as policy and planning, can also be context specific. For example, some developing countries may have limited funding for the provision of cycling infrastructure. In addition, safety levels for cyclists can significantly differ between countries and regions. To put it more generally, the extent to which policy makers and planners pay attention to inequity in transportation, and in particular cycling, can influence these context-specific issues. Therefore, studying cycling equity in different geographical contexts presents an opportunity for future research.

Secondly, there are a limited number of studies on safety concerns related to bicycling inequity. Studies to date have focused on the equitable distribution of safe cycling infrastructure (Rebentisch et al., 2019). In addition, it is necessary to understand different population groups' perceived cycling safety in order to provide equitable cycling facilities. This is because low levels of perceived safety can be a barrier to cycling for many, and a reason not to allow their children to cycle. Consequently, research into perceived cycling safety should include all population groups, even those who currently do not cycle. A new approach to study perceived cycling safety could be to make use of virtual and augmented reality. Previous studies have shown that it can be successfully implemented in the transport context to evaluate travel behavior (Farooq et al., 2018; Moussa et al., 2012). It could also be used to evaluate perceived levels of safety and the results used to assess the equitable distribution of safe cycling infrastructure among different population groups.

Thirdly, most studies have focused on access to bicycle facilities and infrastructure, or accessibility by bicycle from origin to destination. However, only a limited number of studies have focused on cycling as an access and egress mode, to and from public transport hubs. A promising direction for future research, therefore, is to study multimodal access to destinations, combining bicycle and public transport. Finally, studies on access to some destination types, in particular in the areas of health, education and recreation, are very limited, and future research in these areas is recommended.

2.4.2 Supply: Cycling infrastructure and facilities

Although half of the literature on bicycling equity focuses on bicycle infrastructure, these studies were limited to access to infrastructure, and did not consider the specific characteristics of the infrastructure itself (Pistoll & Goodman, 2014; Winters et al., 2018). However, characteristics such as quality, (perceived) safety level, and topography of a bicycle lane or path can also influence a population groups' willingness to ride a bicycle (Hezaveh et al., 2018; Tran et al., 2015). The perceptions of different population groups regarding these characteristics are not clearly understood. For instance, women and the elderly can be more risk-averse and sensitive to the difficulty of riding a bicycle up steep inclines and down steep descents. Therefore, further research is recommended to take into account different population groups' sensitivity and perceptions of safety and topography in the context of bicycling equity. Secondly, BSSs and DBSSs are often operated by the private sector. The literature on BSS and DBSS is limited to spatial analyses of stations (in BSS) and bicycles (in DBSS). However, apart from providing equitably distributed BSS stations and bicycles geographically, these systems should also provide BSS services and bicycles that are compatible with different groups of the population in terms of design and service quality. Further research on BSSs/DBSSs is recommended to focus on equity in service quality, operating hours, pricing strategies, and technology acceptance issues, in an attempt to solve service inequity in BSSs and DBSSs. Both the location of such facilities, as well as their payment options, could be considered as barriers to accessing BSSs and are potential topics to investigate in future research.

2.4.3 Policy and planning

Equity measurement indicators such as levels of access to destinations, or facilities, play an important role in policy decision making. Literature on bicycling equity mainly focused on the importance of providing improved accessibility for disadvantaged populations. Some of these studies used measures, such as the Gini coefficient, as indicators of inequity (Chen et al., 2019; Pritchard et al., 2019; J. Wang & Lindsey, 2017). However, to the best of our knowledge, the literature does not provide a tool or methodology to systematically evaluate the distribution of cycling benefits across population groups. This is important because cities have limited financial resources, and generally work within constrained budgets. Therefore, research is required to develop methods capable of systematically analyzing the impact of policy interventions and the spatial allocation of infrastructure on the distribution of benefits. Such research should explicitly include the specific needs of population groups. A first step could be a trial of multiple indicators (such as the Gini coefficient, the Theil index, or the Palma Ratio) using case studies, and the evaluation of their advantages and disadvantages. Then, based on the results, methodologies for wider application could be developed.

Considering equity at the early stages of policy making and planning should result in a more equitable cycling environment by helping to avoid inequity issues at a later stage. The literature mainly focuses on the evaluation of equity considerations in the development of cycling policies by governments and BSS service provision by companies (Howland et al., 2017; Lam, 2018). However, there is a lack of understanding on the design of such policies.

For example, the barriers to including equity in the design process of cycling infrastructure and facilities are not yet clearly understood. Such research is considered an important step forward, to provide guidance for practitioners on how to better include equity in planning activities. Lee et al. (R. J. Lee et al., 2017) stated that procedural equity (which refers to the fairness of decision-making) is not yet appropriately considered in bicycling equity research. Procedural equity in transport planning processes aims for all population groups' demands to be equally heard by policymakers (Pereira et al., 2017). While improvement of equity in bicycle infrastructure is commonly undertaken by spatial analysis techniques, addressing procedural equity seems to be more complicated (Kent & Karner, 2019). The literature on bicycling equity showed that minorities in a community are relatively worse off. It is, therefore, essential that these population groups have a spokesperson in planning and policy decision-making. Therefore, local governments are advised to design procedural equity policies that explicitly target minority population groups. In addition, with regards to 'Black Lives Matter' and other movements, specific attention could also be given to cycling equity policies to improve anti-racism.

Public engagement in cycling policymaking and planning is one of the ways to explore the needs of different population groups. Piatkowshi et al. (2017) discovered that planning solely based on this method might result in inequity. This can stem from the fact that not all population groups participate. Some people might not participate because of cultural norms, a lack of information and communication technology resources, because of their remote place of residence, being historically underrepresented or dismissed in participatory processes, time constraints on participating in meetings or outreach events, or family/childcare responsibilities. However, knowing the needs of all population groups is important to provide an equitable cycling environment. Although public participation attempts to address this, challenges with representative participation can result in biases in the outcomes. This can be particularly evident in disadvantaged populations. Consequently, further research is required to understand how the population groups that are underrepresented can be persuaded to participate and influence policy making, which in turn will contribute to improved policy and planning. In addition, in order to better gather feedback from disadvantaged neighborhoods, strategies such as offering virtual meetings, providing consultancy opportunity directly to disadvantaged communities instead of expecting meeting attendance, providing childcare, ensuring the availability of materials (translated into appropriate languages), and ensuring diverse hiring practices so that planners reflect the communities they serve.

2.5 Conclusion

This chapter provides a review of current and relevant literature on bicycling equity, highlighting the gaps in knowledge, providing recommendations for future studies, and implications for policy. It shows that the literature mainly considered accessibility, focusing on bicycle infrastructure and BSS. There are also a limited number of studies relating to other aspects of bicycling equity, such as safety and policy. The review revealed that, typically, disadvantaged population groups who live in lower income neighborhoods, often minority population groups, experience more inequity in cycling.

Providing a comprehensive equitable cycling environment, representing the needs of all population groups might be problematic due to financial constraints. Therefore, from a policy perspective, it is important to prioritize cycling projects, considering both equity and investment limitations. In addition, services and facilities should preferably be flexible, so that they can adapt to future changes. Finally, policy makers and planners need to better understand the needs of population groups, to facilitate the design of more equitable cycling policies. Therefore, involving all population groups in participatory planning processes is key. The outcomes can be helpful to design and evaluate options for policies including multiple policy instruments, such as infrastructure and service investments, traffic regulations, and urban planning. Preferably, different governmental levels, ranging from (sub) local, to regional and national, as well as private companies, should collaborate to help develop comprehensive equitable cycling outcomes.

Overall, through a review of the literature on bicycling equity and subsequent identification of the gaps in the literature, it can be concluded that future researchers should focus on the following key topics:

- Developing a better understanding of an equitable cycling environment, by exploring various aspects of cycling such as population needs, usage behavior, and perceptions of cycling infrastructure.
- Identifying cycling initiatives other than bicycle infrastructure, assessing their effectiveness, and highlighting barriers to implementing cycling equity policies in practice.
- Developing equity measures for policymaking that incorporate various aspects of bicycling equity and evaluating their effectiveness.

This chapter addressed the first objective of this research, as outlined in Section 1.3. The aim of the research work presented in the subsequent chapters is to address the first and second research gaps identified above. The third research gap will not be addressed in this thesis. The next chapter, Chapter 3, and Chapter 4 attempt to better understand an equitable cycling environment by exploring aspects of cycling such as population needs, usage behaviour, and perceptions of cycling infrastructure to address the second and third objectives, respectively. Then, in Chapters 5 and 6, cycling initiatives will be identified and barriers to implementing cycling equity policies in practice will be discussed to address the fourth and fifth objectives, respectively.

Chapter 3

Understanding the influence of sociodemographic characteristics on perceptions of cycling and bicycle usage in Auckland

3.1 Introduction

Chapter 2 comprehensively reviewed cycling equity and, from the review, a number of research gaps were identified. This chapter aims to partially address the first research gap by understanding the factors affecting people's perceptions of cycling and their bicycle usage in Auckland, considering age, gender, ethnicity, and income levels.

This chapter is structured as follows. First, the chapter provides some relevant background. Then, the research methodology adopted for this chapter is explained, followed by the results and analysis of the model to investigate the factors influencing people's perceptions of cycling and their bicycle usage. Finally, the results are discussed and conclusions are drawn.

3.2 Background

Active and sustainable mobility modes, such as cycling and walking, are being promoted in many countries worldwide to help achieve health, environmental and societal goals through a reduction in reliance on private motorized vehicles. However, travel behaviour varies significantly between groups depending on socioeconomic characteristics, accessibility to resources, tastes, desires, needs, and many other factors. Thus, inequities in the uptake of active modes start from these differences amongst population groups.

A recent study investigating the health benefits of active transport in New Zealand suggested that such benefits are not evenly distributed across the population. Specifically, while Māori receive significantly fewer health benefits from cycling generally (Bassett et al., 2020) , the relative benefits are higher when they partake (Jones et al., 2020). Amongst the various ethnic groups, European New Zealanders and males are the most likely to use a bicycle in New Zealand, while Pacific peoples are the least likely (Shaw & Russell, 2017). Given the inequalities in bicycle usage that exist, and the unequal levels of general health amongst population groups, there is benefit in investigating bicycle usage and bicycling inequity in New Zealand in order to assist policymakers in understanding the nature of the inequities in cycling that exist, and to help develop the solutions required to address such inequities.

Although providing cycling infrastructure in more disadvantaged neighbourhoods could improve cycling equity, bicycle usage could also be related to populations' perceptions and behavioural perspectives. In other words, apart from the many factors related to the built environment, deciding to ride a bicycle arises from a perception-related process. However, the literature has largely emphasised the role of infrastructure while neglecting to consider the role of perceptions (Maldonado-Hinarejos et al., 2014). This is an important omission given that cycling perceptions can be expected to vary amongst groups within the population. For example, young people tend to be more cost-dependent, parents influence their children, and women are generally thought to be more risk-averse (Banister & Bowling, 2004; Ogilvie & Goodman, 2012; Pucher & Buehler, 2009; Mackett & Thoreau 2015). Thus, providing the same level of services for all without considering people's cycling perceptions cannot be expected to result in equity in cycling.

The majority of studies investigating cycling equity have focused on access to bicycle infrastructure, or access to destinations by bicycle (Chen et al., 2019; Hosford & Winters, 2018; Tucker & Manaugh, 2018; Winters et al., 2018). Such studies have shown that disadvantaged populations, those living in lower-income neighbourhoods, those from minority population groups, women, the elderly, and immigrants usually experience lower levels of access to bicycle infrastructure and facilities compared to other groups, and experience lower rates of bicycle usage (see Chapter 2). Similarly, in the New Zealand context, studies have shown lower bicycle usage amongst minorities, women, the elderly, low-income population groups, and Māori (the indigenous population) (Ministry of Health, 2022; Jones et al., 2020; Russell et al., 2021; Shaw & Russell, 2017; Shaw et al., 2020; Thorne et al., 2020). However, understanding the reasons why has yet to be adequately addressed. Although many studies worldwide have focused on cycling perceptions or perceptions of bicycle-sharing systems (Caulfield et al., 2017; Fishman et al., 2014; Jahanshahi et al., 2020; Nikitas, 2018; Shaheen et al., 2011), applying an equity lens of cycling perceptions to a multicultural population has yet to be carried out.

Consequently, this chapter attempts to fill this gap by understanding the factors affecting people's perceptions of cycling and their bicycle usage in Auckland, considering age, gender, ethnicity, and income levels. Moreover, Auckland is a multicultural city consisting of a high proportion of Māori (indigenous people) and more than 220 ethnic groups. Thus, the study adopts an intersectionality approach to considering the effects of moderators on the model. The approach takes into account the fact that the influence of sociodemographic characteristics is not shaped by a single axis of social division but by their ''intersection'' (a combination of multiple sociodemographic variables) that create differences among different population groups. Thus researchers should not characterize the behaviour of a group by considering only one aspect of their identity (Hill Collins & Bilge, 2016). For example, it is not possible to describe ‘‘men’s cycling behaviour’’ and ‘‘women’s cycling behaviour’’ without also taking into account other sociodemographic characteristics.

3.3 Methodology

3.3.1 Participants and questionnaire

Auckland is the most populous city in New Zealand with approximately 1,695,200 residents and a land area of 4,941.16 km^2 (www.stats.govt.nz, 2022). It is also one of the most culturally diverse cities in the world. However, the city has the lowest cycling rates amongst the large cities in New Zealand, with 1% and 1.5% cycling for travel to work and education, respectively (www.stats.govt.nz, 2022).

Due to the COVID-19 pandemic, in person data collection through paper questionnaires was not feasible. In this regard, participants were recruited from across the Auckland Region using a university affiliated survey company. The selected survey company’s privacy policy is aligned with the ethical aspects of our research. Proportional quota sampling was used in this study in an attempt to reproduce the characteristics of Auckland’s population in the sample. Specifically, quotas were set for selected subgroups of interest to the study, including age, gender, ethnicity, and income, based on their proportions in the overall population, thereby retaining the population’s group proportions. Referring to Table 3.1, the distribution of subgroups in age, gender, ethnicity, and income levels closely resemble the overall percentages in Auckland (www.stats.govt.nz, 2022), shown in parenthesis. However, it is important to note that it is not feasible to achieve a truly representative sample using non-probability sampling methods, in the same way that probability random sampling methods can. Although quota sampling provides more control over who is selected compared to other non-probability methods, such as convenience or opportunity sampling, there is still an element of convenience in the sampling. In this case, the convenience was provided by using a pre-existing database of volunteers, belonging to the survey company.Based on the research objectives of this study, data also needed to be collected from areas with different levels of cycling infrastructure. Therefore, after consulting these criteria with the survey distribution company and considering their available database, 27 postcodes were chosen for this purpose. The distribution of the questionnaire was random since there are no inclusion or exclusion criteria except for age (over 18 years old). The survey company has a very large list of participants in their database who have volunteered to receive survey questionnaires. Respondents receive reward points for each survey they complete, and it is credited to their member account, the value of which is determined by the length of the survey. These reward points have a monetary value and when they accumulate enough points, then they can redeem them for gift cards which they can use at different retail outlets. People voluntarily sign up to the survey company’s propriety panels through a variety of online/web-based portals and provide their details for opting in to receiving survey invitations. The participants received an invitation email from the company and could voluntarily accept or reject participating in the study. The number of required participants was planned based on the authors’ request, and the company sent random emails through their databases to reach the required completed surveys. This method of data collection has limitations, including solely taking into account individuals who are registered in the company's database. However, this method was the prevailing approach during the pandemic.

The population that this study aims to address are participants 18 years of age and older. Consequently, the elderly and disabled, for whom cycling may not be an option, were potentially included. The questionnaire was only provided in English, and therefore only those with a sufficiently high command of the English language were able to complete it. The questionnaire was administered during the period of May to July 2021. In total, 697 approaches were made, and 683 responses were collected. After removing incomplete questionnaires, as well as those that had been answering with patterns, such as providing the same answer to all of the questions and providing very unlikely answers, 491 were retained for data analysis, resulting in a response rate of 70%. The response rates in cycling related studies could be various, range from about 20% to 80% and depends on the nature of data collection and case studies (Høye et al., 2020; Schepers et al., 2020; Howland et al., 2017; McTigue et al., 2018; Dill & McNeil, 2013; C. F. Lee & Huang, 2014; Zhao & Zhang, 2019). Therefore, the response rate in this study is considered as a high response rate, but it is consistent with the literature.

The first section of the questionnaire related to participant demographics, including age, ethnicity, gender, education, employment status, income, and access to a car. A summary of the demographic characteristics of the participants is presented in Table 3.1.

Table 3.1: Sociodemographic characteristics including age, gender, ethnicity, highest completed degree, personal annual income, employment situation, and access to car in the household

Characteristics	% (Auckland%)	Characteristics	% (Auckland%)
Age (in years)		**Ethnicity**	
18-20	7.6 (not reported)	Māori	7.1 (11.5)
21-30	19.8 (20.5)	Pacific peoples	9.4 (15.5)
31-40	20.4 (18.8)	Asian	19.1 (28.2)
41-50	20.4 (17)	MELAA*	1.8 (2.3)
51-60	13.5 (15.7)	Indian	10.4 (not reported)
>60	18.4 (23)	European/NZ European	50.3 (53.5)
Gender		Other ethnicities	1.8 (1.1)
Men	44.1 (49)		
Women	54.9 (51)		
Diverse	1 (not reported)	**Personal annual income (NZD)**	
Highest completed degree		No income	9 (8.7)
High School or below	31.6	<30K	23.8 (36.8)
Undergrad degree	52.4	30K-70K	35.7 (34.1)
Master's degree/ Postgraduate	16	70K-100K	17.2 (10.3)
		>100K	14.3 (9.5)
Employment situation		**Car access in the household**	
Not employed	16	Yes	92.6
Part-time employed	14.3	No	7.4
Full-time employed	52.4		
Homemaker	6.1		
Retired	11.2		

* MELAA: Middle Eastern/Latin American/African

A summary of the cycling profile of the participants is presented in Table 3.2, including whether they have access to a bicycle at home, the extent of bicycle usage, the bicycle user types of the participants, and their purpose for cycling if they do indeed cycle. Both cyclists and non-cyclists were included in the data collection. Those categorised as 'cyclists' were split into two groups: 'regular cyclists' and 'potential cyclists', following the categorisation proposed by (Félix et al., 2017). Regular Cyclists are those who indicated having cycled in the past month for any purpose; Potential Cyclists are those who had cycled at least once in the past 12 months and Non-Cyclists are those who had not cycled in the past 12 months. The classification method for bicycle user type in this study was based the method proposed by Félix et al. (2017) and, subsequently, adopted in other studies (Wang & Akar, 2018; Félix et al., 2019). This method has a weakness in terms of clear identification of potential cyclists and non-cyclists as assigning people to these two categories based on one usage in last 12 months could not be a robust reason. For example, Someone who rode 11 months ago, and will not ride again unless infrastructure is dramatically improved is presumably classified as a 'potential cyclist' while someone who would like to ride, but has never learned how to ride, is classified as a 'non-cyclist' rather than a 'potential cyclist' because they have not ridden in the last year. However, considering different classification methods, the simplicity of the chosen method was attractive given the length of the questionnaire for this study as well as considering bicycle usage frequency. There is a four-way classification of bicycle user type that could have been used, introduced by Dill & McNeil (2013), Another reason to avoid using the four-way classification was the fact that this classification is made upon the preferences of the participants only and is determined by a person's comfort riding a bicycle on different types of bikeways. Therefore, the actual frequency of bicycle usage is ignored in this classification method. For example, Dill & McNeil (2013) find that 34% of the "strong and fearless" type of cyclists in their classification actually do not use bicycles. The frequency of bicycle usage is a crucial factor for categorizing cyclists (Damant-Sirois et al., 2014), and it is required due to the nature of research questions in this study.

In addition, in total, 35 participants (6.9%) reported having disabilities but ones that do not prevent them from cycling. Also, 29.1% of participants reported that they had experienced injuries because of cycling, one of the factors considered to influence people's perceptions of cycling infrastructure.

Table 3.2: Cycling profile of the respondents

Characteristics	%	Characteristics	%
Access to a bicycle at home		**Cycling purpose**	
Yes	46.7	Commuting	9.5
No	53.3	Short trips	25.5
Average bicycle usage (per week)		Recreation/exercise	65
0 times	32.9	**Average daily bicycle usage** (time)	
1-3 times	60.8	<15 mins	31.7
3-5 times	4.1	15-30 mins	47.2
>5 times	2.3	30-60 mins	18.3
Bicycle user type		>60 mins	2.8
Non-cyclists	51.2	**Cycling injuries**	
Regular cyclists	25.5	Yes	30
Potential cyclists	23.3	No	70

The second section of the questionnaire was designed to elicit the perceptions of cycling amongst Aucklanders (22 items). The questions designed based on a five-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. Referring to Table 3.3, the questions were divided into five categories: Sociocultural Factors, Price Value, Cycling Provision Perception, Perceived Safety and Security, and Information and Communication. However, this division was not visible to the respondents in order to avoid any possible bias arising due to the label used.

Figure 3.1 shows the conceptual model proposed in the study. The questions and categories were generated based on the available cycling literature which discussed the factors that influence bicycle usage (Aldred et al., 2016; Chataway et al., 2014; Dill & McNeil, 2013; Fuller & Winters, 2017; Goodman & Aldred, 2018; Hezaveh et al., 2018; Jahanshahi et al., 2019; Jahanshahi et al., 2020; Tompkins, 2017). The model structure was inspired by models such as Theory of Planned Behavior (TPB), Theory of Reasoned Action (TRA) and Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003; Venkatesh et al., 2008), similar to that used by Jahanshahi et al. (2020), which analysed intention to use, and usage of, bicycles. Sociocultural Factors, Perceived Safety and Security, and Price Value were then added to the model, based on the literature. Also, a construct which focuses on Cycling

Provision Perception (Vallejo-Borda et al., 2020; Ng et al., 2017) was added, along with a new cycling perception construct titled "Information and Communication". This construct focusses on the extent to which having access to information, awareness about cycling events, and the ease with which cycling issues can be reported to council influence bicycle usage.

Table 3.3: Questionnaire items for cycling perception constructs

Categories	Items
Sociocultural Factors	
	SC1: I am not embarrassed to be seen riding a bicycle
	SC2: My friends and family encourage me to ride a bicycle
	SC3: People who I know (family and friends) cycle often
	SC4: Cycling is becoming more popular as a transport mode in Auckland
Price Value	
	PV1: I find the cost of purchasing a bicycle reasonable
	PV2: I find the cost of purchasing bicycle equipment reasonable
	PV3: I can securely store my bicycle at home and my destination
	PV4: I find the overall cost of commuting with a bicycle cheaper than other transport modes
	PV5: I find the cost of maintaining a bicycle affordable
Cycling Provision Perception	
	PP1: There are sufficient cycling facilities such as bicycle lanes and/or dedicated cycleways in my residential neighbourhood
	PP2: There are sufficient cycling facilities to my common destination(s)
	PP3: There are sufficient street lighting and traffic signals in intersections in my journeys
	PP4: There are appropriate road marking and bicycle signage in bicycle lanes
	PP5: It is easy for me to carry my bicycle inside public transport vehicles
	PP6: I can securely park my bicycle at the station
Perceived Safety and Security	
	PS1: I am not concerned about becoming a victim of crime or harassment while riding a bicycle
	PS2: I feel safe cycling on-road
	PS3: Streets and footpaths in my neighbourhood feel safe to ride on
	PS4: I feel that children in my neighbourhood can safely cycle to school
Information and Communication	
	IC1: I can easily find cycling promotional events and attend them
	IC2: I can easily access information about traffic regulations for cyclists
	IC3: I can easily report issues to the council about cycling facilities and enforcement

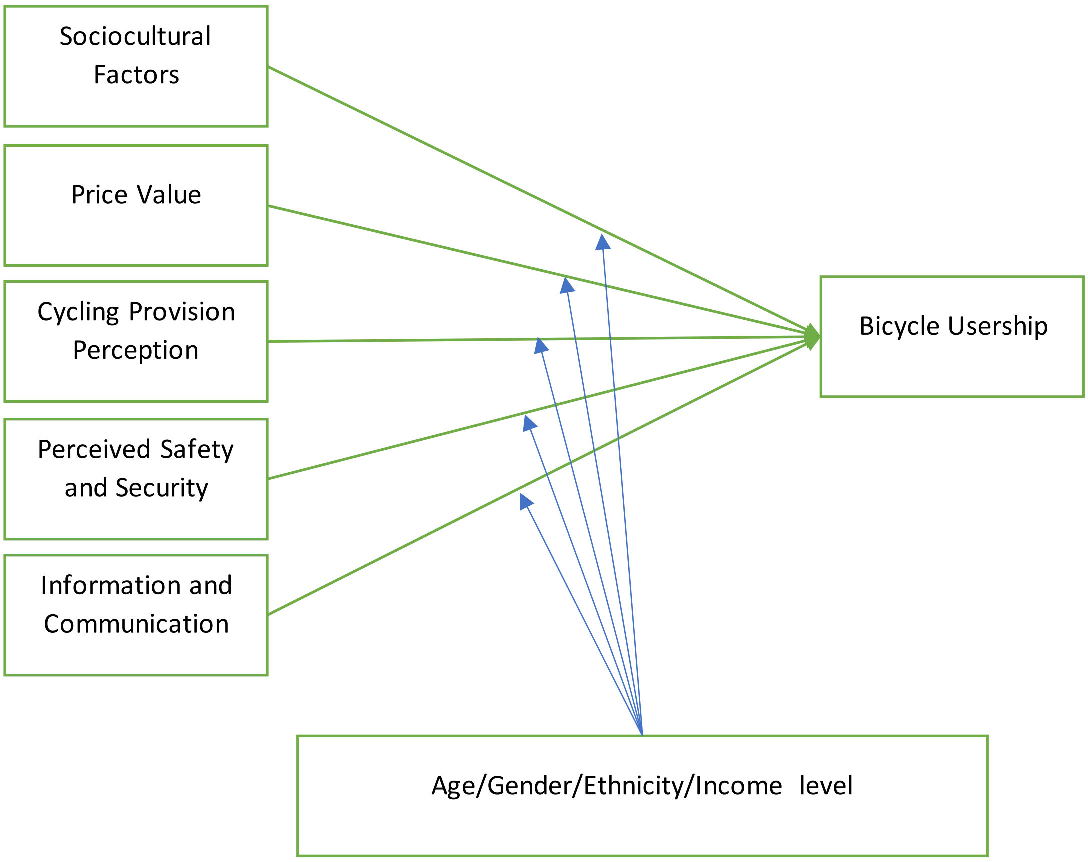

Figure 3.1: Conceptual model of study

3.3.2 Reliability tests

Assessing the reliability of a research instrument is a vital step for studies exploring factors that influence behaviour, as it illustrates to what extent the study is able to be replicated. (Rosenthal and Rosnow, 1991; Drost, 2011). To confirm the convergent and discriminant validity of the items, a Confirmatory Factor Analysis (CFA) (Churchill, 1979; Byrne, 2012) is required to determine whether the hypothesized structure provides a good fit to the data (Diana, 2014) and to confirm the relationships between a set of observed variables and a set of common items (Muthen and Muthen, 2010). It is recommended that items with loading factors of less than 0.5 be excluded (Hair et al., 2010). In addition, Cronbach's alpha values over 0.6 confirm the reliability of the model's constructs and illustrate acceptable internal consistency for each construct (Hair et al., 2010). The computed composite reliability (CR) assesses whether the model fitting is acceptable for the constructs and indicates its acceptance in fitting the model. CR values of greater than 0.6 are considered acceptable (Fornell and Larcker, 1981; Hair et al., 2010). The Average Variance Extracted (AVE) computes the discriminant validity and appraises the amount of variance produced by each construct according to its components (Bagozzi et al., 1991; Chen, 2016). AVE is acceptable if values are greater than 0.5 (Fornell and Larcker, 1981; Hair et al., 2010). The Variance Inflation Factor (VIF) is used to investigate multi-collinearity. In a reliable model, the VIF is less than 4 for each item, indicating that the constructs are designed appropriately for that item (Hair et al., 2021).

3.3.3 Analysis of the model

The correlation coefficients between the constructs in the conceptual model and Bicycle Usership were analysed to determine if a relationship exists between each of the studied constructs. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess the normality of the distribution of the data, a necessary criterion for many statistical tests and analyses of power and reliability. The hypothesized statistical model was then compared against the actual data set using a number of 'goodness-of-fit' statistical parameters ($0.1<GOF<0.38$ (weak to strong), $0.25<R^2<0.75$ (weak to strong), $0.02<Q^2<0.35$ (weak to strong)) (Hair et al., 2011; Hair et al., 2022). This is a common process to, first, evaluate a number of goodness-of-fit statistical parameters in order to improve or change the model in case of weak outcomes and, second, to analyze the mode using a Structural Equation Modelling (SEM) when the model is strong enough for the prediction. In this study, there was no need to change/improve the model due to the reported goodness-of-fit statistical parameters in Table 3.7.

After assessing model fit, the conceptual model was analysed and the prediction of Bicycle Usership by model constructs was assessed using Structural Equation Modelling (SEM) using Smart PLS software. The significance and the direction of the effects between the constructs were then analysed. Subsequently, the effects of the moderators on the relationships between Bicycle Usership and the studied constructs were analysed using two methods. First, the moderators' effects were analysed separately. These include age, gender, income level, and ethnicity. Then, following the intersectionality approach, groups were created based on ethnicities (Māori and Pacific peoples, and All Other Ethnicities), income levels (lower, average, and higher), and gender (male and female). In the groups, age was not considered because the amount of data in each group was insufficient for reliable analyses. The literature (Ministry of Health, 2022; Bassett et al., 2020; Shaw & Russell, 2017) emphasised that Māori and Pacific peoples bicycle usage and perceptions differ from those of other groups. Therefore, respondents were sorted by ethnicity into two broad groups (Māori and Pacific peoples, and All Other Ethnicities).

3.4 Results

3.4.1 Descriptive analysis of questionnaire items

Table 3.4 shows the mean, standard deviation (SD), and percentage of each response category for each item in Section 2 of the questionnaire. There are some noticeable findings in the responses. For example, a substantial number of respondents (strongly) disagreed with the influence of their friends and family on their cycling, suggesting that the majority do not receive specific encouragement from family and friends to use a bicycle. In addition, a large number of participants had concerns about becoming a victim of crime or harassment while riding a bicycle, and did not feel safe cycling on the road. In contrast, most of the respondents were not embarrassed to be seen riding a bicycle. This shows that cycling is considered to be culturally acceptable in Auckland. In addition, most of the respondents gave a high score to the items related to cost, including affordable travel with respect to travel by bicycle and affordable cost with respect to maintenance. Among the categories, Price Value produced the highest mean, suggesting that respondents mainly agree that the costs associated with a bicycle, equipment, maintenance, and travelling by bicycle are reasonable. Perceived Safety and Security produced the lowest mean, suggesting that safety and security is perceived as an issue when travelling by bicycle or is a reason not to travel by bicycle.

Table 3.4: Descriptive statistics for indicators and categories (overall)

Categories/Questions	Mean	SD	1	2	3	4	5
			Stronglydisagree%			Strongly agree%	
Sociocultural Factors	**3.12**	**0.742**					
SC1: Not embarrassed biking	3.59	1.143	4.9	14	22.1	34.6	24.3
SC2: Friends and family	2.63	1.104	18.6	26.5	32.2	18.8	4.0
SC3: People who I know	2.88	1.163	13.1	28.1	23.6	28.3	6.9
SC4: Cycling is becoming popular	2.87	1.158	13.4	27.9	23.6	28.7	6.3
Price Value	**3.34**	**0.678**					
PV1: Reasonably priced	3.09	0.975	6.3	20.6	35.2	34.0	4.0
PV2: Cost of equipment	3.06	0.962	6.1	21.3	37.0	31.8	3.8
PV3: Securely store bicycle	3.56	1.004	3.8	11.9	23.9	45.7	14.8
PV4: Cheaper form of travel	3.54	0.962	4.2	8.1	30.8	43.7	13.2
PV5: Affordable maintaining	3.45	0.844	1.8	10.1	37.0	43.4	7.7
Cycling Provision Perception	**3.07**	**0.691**					
PP1: Cycling facilities	3.10	1.080	6.9	24.1	30.0	30.0	8.9
PP2: Cycling to destination(s)	3.03	1.044	8.7	21.3	34.4	29.8	5.7
PP3: Street lighting/signals	3.32	0.984	5.1	14.2	31.4	41.5	7.7
PP4: Road marking/signage	3.37	0.918	2.6	15.0	33.2	41.5	7.7
PP5: Public transport integration	2.72	1.001	11.9	28.9	37.9	18.0	3.4
PP6: Secure parking	2.86	0.895	6.5	25.5	47.0	17.8	3.2
Perceived Safetyand Security	**2.77**	**0.832**					
PS1: Victim/harassment	2.75	1.096	14.8	26.3	32.2	22.1	4.5
PS2: Safe cycling on-road	2.42	1.079	22.7	32.2	28.3	13.6	3.2
PS3: Safe streets and footpaths	2.97	1.113	11.5	21.9	32.0	27.5	7.1
PS4: Safe cycling to school	2.93	1.076	10.3	25.1	31.4	27.7	5.5
Information and Communication	**2.99**	**0.758**					
IC1: Access cycling events	2.83	0.963	9.9	22.7	45.1	18.8	3.6
IC2: Access information	3.09	0.916	4.9	18.6	42.7	29.6	4.2
IC3: Report issues	3.05	0.913	5.5	17.8	47.4	24.5	4.7

3.4.2 Reliability results

Table 3.5 shows the loading factors and VIF for each item used in the questionnaire, and Cronbach's alpha coefficients, CR and AVEs for each construct. The table shows that all of the items had loading factors of greater than 0.4, which is considered acceptable. The convergent validity of the constructs was assessed using the average variance extracted (AVE). All AVEs were considered acceptable with values of greater than 0.5, except for the Sociocultural Factors and Cycling Provision Perception constructs, returning AVEs of 0.461 and 0.475, respectively. Consequently, we removed SC4 and PP3 from their respective constructs as they returned the lowest loading factors of 0.471 and 0.58, respectively. That produced a valid AVE for the Sociocultural Factors and Cycling Provision Perception constructs, returning values of 0.508 and 0.556, respectively. Also, the computed composite reliability (CR) was greater than 0.6 for each construct, indicating its acceptance for fitting the model. Cronbach's alpha coefficients of constructs were found to be between 0.6 and 0.765, within the ranges of acceptable to very good reliability. VIF was checked for each item, as previously discussed. The values of VIF being less than 4 for all of the items shows that each item is a good choice for its construct. On the basis of reliability, 20 items within five constructs were retained for analysis in the conceptual model.

Table 3.5: Loading Factors, Cronbach's alpha coefficients of the constructs, CR and AVEs

Categories	Items	Loading Factors	VIF	AVE	Cronbach's alpha	CR
Sociocultural Factors				**0.55**	**0.598**	**0.78**
	SC1	0.483	1.09			
	SC2	0.885	1.42			
	SC3	0.807	1.36			
Perceived Value				**0.50**	**0.75**	**0.83**
	PV1	0.775	2.32			
	PV2	0.776	2.26			
	PV3	0.657	1.20			
	PV4	0.633	1.44			
	PV5	0.704	1.62			
Cycling Provision Perception				**0.50**	**0.76**	**0.83**
	PP1	0.685	1.72			
	PP2	0.763	1.77			
	PP4	0.633	1.37			
	PP5	0.734	1.34			
	PP6	0.739	1.38			
Perceived Safety and Security				**0.58**	**0.76**	**0.85**
	PS1	0.624	1.31			
	PS2	0.840	1.69			
	PS3	0.834	1.80			
	PS4	0.752	1.57			
Information and Communication				**0.65**	**0.74**	**0.85**
	IC1	0.855	1.43			
	IC2	0.828	1.64			
	IC3	0.745	1.46			

3.4.3 Analysis of constructs and items

3.4.3.1 Relationships between the constructs and with bicycle usage

In this section, the correlation coefficients between the constructs and bicycle usage are analysed to determine if a substantial relationship exists between them. The correlation coefficients, provided in Table 3.6, show a positive relationship among the constructs. The strongest correlation was found between Cycling Provision Perceptions and Perceived Safety and Security. The positive correlation coefficient suggests that, typically, those who perceive bicycle safety as high also have higher perceptions about cycling provision. This was followed by the constructs Information and Communication, Price Value, and Sociocultural Factors.

Bicycle usage is substantially correlated with all of the constructs. The strongest correlation was found between bicycle usage and the Sociocultural Factors construct. The positive correlation suggests that people who cycle more would, typically, receive more support from family and friends to use a bicycle.

Table 3.6: Correlations between the constructs and Bicycle Usership

Categories	A	B	C	D	E	F	G
A. Sociocultural Factors	1						
B. Price Value	.411**	1					
C. Provision Perception	.262**	.343**	1				
D. Perceived Safety	.301**	.267**	.584**	1			
E. Information	.371**	.388**	.474**	.450**	1		
F. Bicycle Usership	.450**	.242**	.188**	.296**	.283**	1	

**. Correlation is significant at the 0.01 level (2-tailed).

3.4.3.2 Structural equation modelling

Using the Kolmogorov-Smirnov and Shapiro-Wilk tests, the data were found to be normally distributed. In Figure 3.2, the constructs (latent variables) are presented as circles, and items (observed indicators) are presented as rectangles. The structural model consists of five constructs (Sociocultural Factors, Price Value, Cycling Provision Perception, Perceived Safety and Security, and Information and Communication). Loading factors between the constructs and items are represented by the coefficients on the paths.

The results show that the fitness of the structure is acceptable based on the assessment of fit of the conceptual model presented in Table 3.7. As can be seen, GOF is 0.367 and Q^2 is 0.324, suggesting the model is very strong for the prediction of Bicycle Usership. The R^2 value is 34.1%, indicating an acceptable fit.

Analysis of the conceptual model, using SEM, shows that the five constructs have direct paths to Bicycle Usership. Table 3.8 reveals data about the significance and direction of the effects between each construct and Bicycle Usership. The results show that, after examination of the model, three paths are supported. Sociocultural Factors had a positive strong direct effect on Bicycle Usership and Perceived Safety as well as Security, and Information and Communication have a milder positive direct effect on Bicycle Usership. As shown in Figure 3.2, all of the coefficients linking the constructs and Bicycle Usership are positive.

Table 3.7: The fit statistics

GOF	R^2	Q^2
0.367	34.1%	0.324

Table 3.8: Results of structural model

Categories	Effect direction	Coefficient	p-value	Result
Sociocultural to BU	+	**0.472****	**0.000**	**Supported**
Price Value to BU	+	0.009	0.802	Not Supported
Cycling Provision Perception to BU	+	0.007	0.863	Not Supported
Perceived Safety/Security to BU	+	**0.147****	**0.001**	**Supported**
Information and Communication to BU	+	**0.080***	**0.046**	**Supported**

+: a positive effect, −: a negative effect; BU: Bicycle Usership; * shows the significant influence.

* $P < 0.05$. ** $P < 0.01$

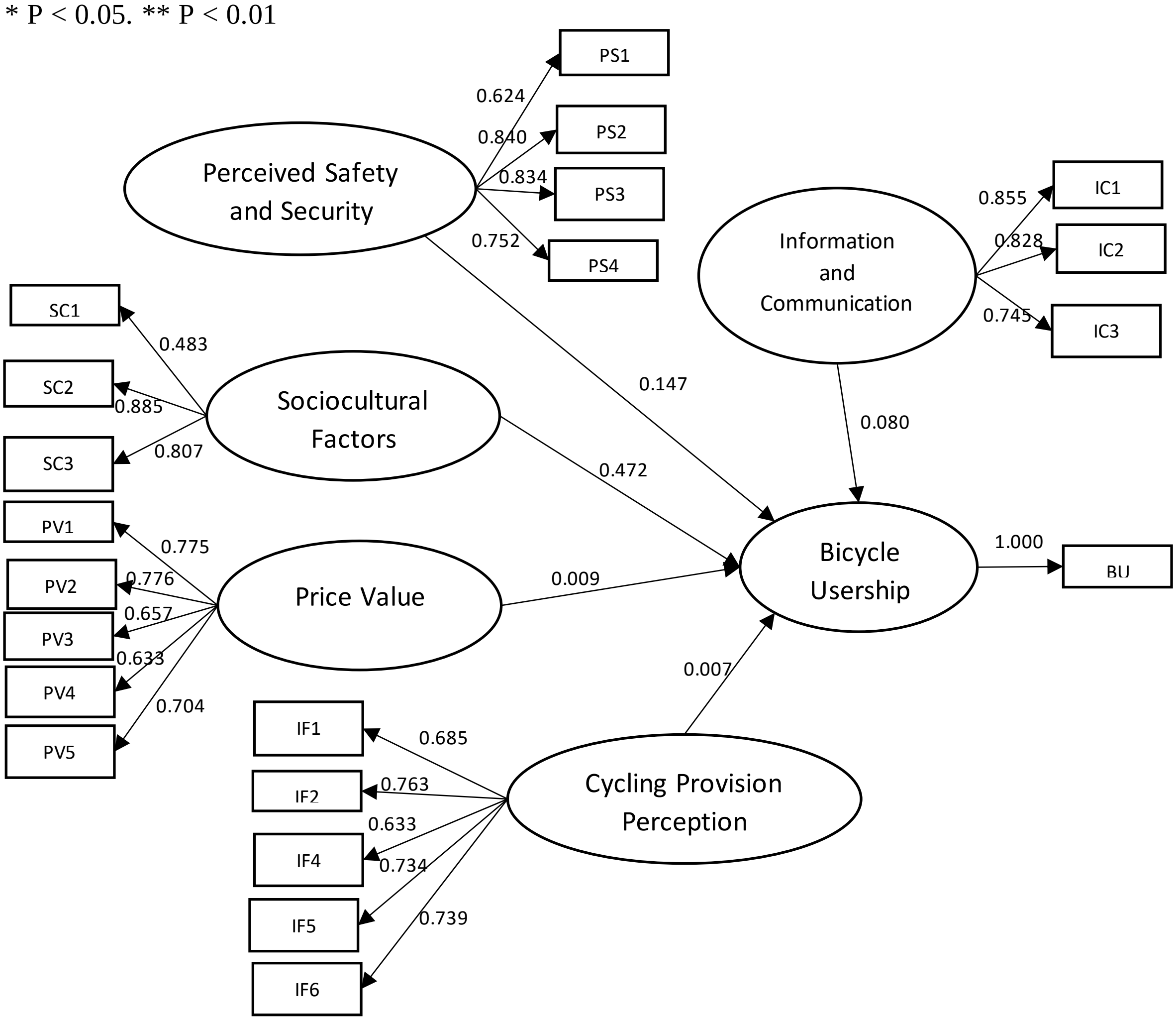

Figure 3.2: Results of the SEM

3.4.3.2.1 Impact of moderators in the model

Moderators were included in the model to examine their effects on the relationship between Bicycle Usership and Sociocultural Factors, Price Value, Cycling Provision Perception, Perceived Safety and Security, and Information and Communication.

Ethnicity

Ethnicities in this study included Māori and Pacific peoples, NZ European, Indian, Asian, and European. For MELAA and Other Ethnicities, the sample numbers were insufficient for a reliable analysis, therefore these two groups were excluded from the analyses. Results show that none of the ethnicities had any moderating effect on the relationship between Cycling Provision Perception and Bicycle Usership. This means that the relationship between Cycling Provision Perception and Bicycle Usership is not influenced by ethnicity. The same was found for the relationship between Price Value and Bicycle Usership. The influence of Information and Communication on Bicycle Usership is meaningful only for the Indian population. Also, the results show that the influence of Perceived Safety and Security on Bicycle Usership is meaningful only for NZ European. Regarding the relationship between Sociocultural Factors and Bicycle Usership, the P-value for all the ethnic groups is reported as less than 0.05 which means there are potential meaningful differences among these groups in terms of the influence of Sociocultural Factors on Bicycle Usership. Table 3.9 shows the moderating effect for each ethnic group for each path in the model.

Table 3.9: The moderating effect of each ethnic group for each path in the model

Group	path	Coefficient	Standard Deviation	T Statistics	p-Values
Māori & Pacific peoples	IC -> BU	0.081	0.102	0.790	0.430
NZ European	IC -> BU	-0.034	0.060	0.568	0.570
Indian	IC -> BU	0.321	0.160	2.008	**0.045**
Asian	IC -> BU	0.147	0.109	1.347	0.178
European	IC -> BU	-0.006	0.130	0.050	0.961
Māori & Pacific peoples	PP -> BU	0.026	0.185	0.139	0.890
NZ European	PP -> BU	0.021	0.061	0.340	0.734
Indian	PP -> BU	-0.126	0.223	0.563	0.574
Asian	PP -> BU	0.121	0.106	1.139	0.255
European	PP -> BU	0.110	0.141	0.776	0.438
Māori & Pacific peoples	PP -> BU	0.144	0.166	0.869	0.385
NZ European	PS -> BU	0.151	0.064	2.375	**0.018**
Indian	PS -> BU	0.115	0.181	0.632	0.528
Asian	PS -> BU	0.191	0.117	1.637	0.102
European	PS -> BU	0.200	0.121	1.660	0.098
Māori & Pacific peoples	PV -> BU	0.087	0.094	0.921	0.358
NZ European	PV -> BU	0.090	0.054	1.680	0.094
Indian	PV -> BU	-0.070	0.150	0.464	0.643
Asian	PV -> BU	0.027	0.118	0.230	0.818
European	PV -> BU	0.124	0.245	0.507	0.613
Māori & Pacific peoples	SC -> BU	0.335	0.090	3.710	**0.000**
NZ European	SC -> BU	0.558	0.049	11.377	**0.000**
Indian	SC -> BU	0.502	0.118	4.259	**0.000**
Asian	SC -> BU	0.266	0.086	3.081	**0.002**
European	SC -> BU	0.482	0.124	3.896	**0.000**

Note: Shaded cells with bold p-values (<0.05) indicate significant moderating relationships.

In order to compare the ethnic groups in terms of the relationship between Sociocultural Factors and Bicycle Usership, one-by-one comparisons were made (see Appendix 3.1). There were only two significant differences found between ethnicities, namely Māori and Pacific peoples showed significantly less sensitivity to Sociocultural factors compared with NZ European (p-value=0.03). Also, Asian people showed significantly less sensitivity to Sociocultural Factors compared with NZ European, with a p-value of 0.004.

Age

Results show that none of the age groups had any effect on the relationship between Price Value and Bicycle Usership. The 31-40 age group was the only group that significantly moderated the effect of Information and Communication and Perceived Safety and Security on Bicycle Usership. The effect of Cycling Provision Perception on Bicycle Usership was only meaningful for the 41-50 years old group. Interestingly, all of the age groups were found to be sensitive to the relationship between Sociocultural Factors and Bicycle Usership. Table 3.10 shows the moderating effect for each age group, for each path in the model.

Table 3.10: The moderating effect of each age group for each path in the model

Age group	Path	Coefficient	Standard Deviation	T Statistic	p-Values
18-20	IC -> BU	0.085	0.161	0.530	0.596
21-30	IC -> BU	-0.018	0.114	0.155	0.877
31-40	IC -> BU	0.253	0.117	2.165	**0.031**
41-50	IC -> BU	0.139	0.091	1.535	0.125
51-60	IC -> BU	-0.088	0.155	0.566	0.572
>60	IC -> BU	0.001	0.108	0.006	0.995
18-20	PP -> BU	-0.377	0.198	1.904	0.058
21-30	PP -> BU	0.032	0.152	0.212	0.833
31-40	PP -> BU	-0.027	0.128	0.213	0.831
41-50	PP -> BU	0.211	0.098	2.144	**0.033**
51-60	PP -> BU	-0.144	0.133	1.079	0.281
>60	PP -> BU	0.127	0.095	1.336	0.182
18-20	PS -> BU	-0.010	0.197	0.050	0.960
21-30	PS -> BU	0.116	0.105	1.110	0.267
31-40	PS -> BU	0.370	0.121	3.045	**0.002**
41-50	PS -> BU	-0.026	0.110	0.240	0.811
51-60	PS -> BU	0.173	0.201	0.862	0.389
>60	PS -> BU	0.084	0.109	0.773	0.440
18-20	PV -> BU	0.143	0.187	0.762	0.447
21-30	PV -> BU	-0.050	0.088	0.571	0.568
31-40	PV -> BU	-0.060	0.135	0.448	0.654
41-50	PV -> BU	0.048	0.097	0.500	0.617
51-60	PV -> BU	0.132	0.116	1.137	0.256
>60	PV -> BU	0.051	0.107	0.475	0.635
18-20	SC -> BU	0.493	0.168	2.940	**0.003**
21-30	SC -> BU	0.623	0.084	7.417	**0.000**
31-40	SC -> BU	0.225	0.089	2.529	**0.012**
41-50	SC -> BU	0.373	0.087	4.266	**0.000**
51-60	SC -> BU	0.468	0.099	4.707	**0.000**
>60	SC -> BU	0.507	0.095	5.362	**0.000**

Note: Shaded cells with bold p-values (<0.05) indicate significant moderating relationships.

In order to compare the effect of age groups on the relationship between Sociocultural Factors and Bicycle Usership, one-by-one comparisons were made (see Appendix 3.2). Significant differences were found for only three age groups, with 21-30 year olds showing significantly higher sensitivity to Sociocultural Factors compared with 31-40 year olds and 41-50 year olds, with p-values of 0.001 and 0.035, respectively. Also, 31-40 year olds showed significantly less sensitivity to Sociocultural factors compared with >60 year olds, with a p-value of 0.029. Regarding Perceived Safety and Security, 31-40 year olds were found to be more sensitive to the relationship with Bicycle Usership compared with 41-50 year olds.

Gender

Results show that none of the gender groups had any effect on the relationship between Price Value and Bicycle Usership. This is the same situation for Cycling Provision Perception and Information and Communication. Only women are sensitive to the effect of Perceived Safety and Security on Bicycle Usership. Interestingly, both men and women are sensitive to the relationship between Sociocultural Factors and Bicycle Usership. Table 3.11 shows the moderating effect for each gender group, for each path in the model. Comparison between men and women in terms of the relationship between Sociocultural Factors and Bicycle Usership does not show any significant difference (see Appendix 3.3).

Table 3.11: The moderating effect of each gender group for each path in the model

group	Path	Coefficient	Standard Deviation	T Statistics	p-Values
Male	IC -> BU	0.052	0.068	0.766	0.444
Female	IC -> BU	0.112	0.059	1.909	0.057
Male	PP -> BU	0.090	0.067	1.343	0.180
Female	PP -> BU	-0.053	0.063	0.832	0.406
Male	PS -> BU	0.102	0.070	1.451	0.148
Female	PS -> BU	0.142	0.067	2.124	**0.034**
Male	PV -> BU	0.011	0.069	0.154	0.878
Female	PV -> BU	0.008	0.051	0.161	0.872
Male	SC -> BU	0.482	0.062	7.827	**0.000**
Female	SC -> BU	0.485	0.052	9.289	**0.000**

Note: Shaded cells with bold p-values (<0.05) indicate significant moderating relationships.

Income level

Results show that income group did not have any effect on the relationship between Price Value and Bicycle Usership for any of the income groups. This is the same for Cycling Provision Perception and Information and Communication. Only people with an income level of 70k-100k (high income level) were found to be sensitive to the effect of Information and Communication on Bicycle Usership, as well as the effect of Perceived Safety and Security on Bicycle Usership. Interestingly, all income groups are sensitive to the relationship between Sociocultural Factors and Bicycle Usership. Table 3.12 shows the moderating effect for each income level group for each path in the model. Comparison between the income groups in terms of the relationship between the constructs and Bicycle Usership shows that people with an income level of 70k-100k are more sensitive to the effect of Information and Communication compared with people with an income level of 30k-70k.

Table 3.12: The moderating effect of each income level group for each path in the model

Group	Path	Coefficient	Standard Deviation	T Statistics	p-Values
No income	IC -> BU	0.120	0.176	0.685	0.494
<30k	IC -> BU	-0.002	0.082	0.028	0.978
30k-70k	IC -> BU	-0.021	0.067	0.308	0.758
70k-100k	IC -> BU	0.222	0.093	2.390	**0.017**
>100k	IC -> BU	0.034	0.125	0.271	0.787
No income	PP -> BU	-0.076	0.191	0.399	0.690
<30k	PP -> BU	-0.049	0.086	0.570	0.569
30k-70k	PP -> BU	0.086	0.067	1.288	0.199
70k-100k	PP -> BU	-0.020	0.100	0.201	0.840
>100k	PP -> BU	0.054	0.138	0.393	0.694
No income	PS -> BU	0.196	0.290	0.676	0.499
<30k	PS -> BU	0.121	0.094	1.289	0.198
30k-70k	PS -> BU	0.086	0.071	1.202	0.230
70k-100k	PS -> BU	0.298	0.103	2.886	**0.004**
>100k	PS -> BU	0.198	0.132	1.497	0.135
No income	PV -> BU	-0.271	0.203	1.335	0.182
<30k	PV -> BU	0.114	0.073	1.572	0.116
30k-70k	PV -> BU	0.081	0.084	0.970	0.332
70k-100k	PV -> BU	0.031	0.073	0.425	0.671
>100k	PV -> BU	0.057	0.138	0.411	0.682
No income	SC -> BU	0.368	0.145	2.530	**0.012**
<30k	SC -> BU	0.559	0.065	8.630	**0.000**
30k-70k	SC -> BU	0.494	0.056	8.753	**0.000**
70k-100k	SC -> BU	0.436	0.089	4.894	**0.000**
>100k	SC -> BU	0.315	0.126	2.503	**0.013**

Note: Shaded cells with bold p-values (<0.05) indicate significant moderating relationships.

3.4.3.2.2 Impact of the moderators in the model; an intersectionality approach

As mentioned previously, we also assessed the moderating effect of the combined groups to investigate intersectionality, as well as to identify any differences between these groups and single sociodemographic characteristics. The number of participants was such that gender, income level, and ethnicity were all able to be considered for most combinations. Specifically, ethnicities were split into two main groups (Māori and Pacific peoples, and All Other Ethnicities), income levels were split into three main groups (lower: no income and income <30k, average: income between 30k and 100k, and higher: income >100k), and gender was split into two groups (male and female), resulting in 12 group combinations. Two of the groups were eliminated because of low numbers (G5:high income Māori and Pacific males and G11:high income Māori and Pacific females). The remaining groups are shown in Table 3.13.

Table 3.13: Intersectional demographic groups based on ethnicity, income level, and gender

Groups	Gender	Income level	Ethnicity
G1	Male	Low	Māori and Pacific
G2	Male	Low	All Other Ethnicities
G3	Male	Average	Māori and Pacific
G4	Male	Average	All Other Ethnicities
G6	Male	High	All Other Ethnicities
G7	Female	Low	Māori and Pacific
G8	Female	Low	All Other Ethnicities
G9	Female	Average	Māori and Pacific
G10	Female	Average	All Other Ethnicities
G12	Female	High	All Other Ethnicities

The results suggest that none of the groups were sensitive to the influence of Cycling Provision Perception, Information and Communication, and Price Value on Bicycle Usership (see Appendix 3.5). G10 (average income, All Other Ethnicities, women) was sensitive to the influence of Perceived Safety and Security on Bicycle Usership. This means that G12 (All Other Ethnicities, high income, women) was the only group where their Perceived safety and Security influences Bicycle Usership. Also, G2 (low income, All Other Ethnicities, men), G4 (average income, All Other Ethnicities, men), G6 (high income, All Other Ethnicities, men), and G10 (average income, All Other Ethnicities, women), were sensitive to the influence of Sociocultural Factors on Bicycle Usership.

The results of comparisons between the groups suggest that G10 (average income, All Other Ethnicities, women) and G8 (low income, All Other Ethnicities, women) were more sensitive compared with G12 (high income, All Other Ethnicities, women) in terms of the relationship between Sociocultural Factors and Bicycle Usership. Also, G12 (high income, All Other Ethnicities, women) were more sensitive compared with G10 (average income, All Other Ethnicities, women) in terms of the relationship between Price Value and Bicycle Usership (see Appendix 3.6).

3.5 Discussion and conclusion

This research aimed to understand the factors influencing Aucklanders' bicycle usage and, in addition, the sensitivities of different population groups to those factors. For this purpose, age, income levels, gender, and ethnicity were investigated separately, as well as combined, through the use of an intersectionality approach. The particular aim of the chapter was to examine whether the constructs Sociocultural Factors, Price Value, Perceived Safety and Security, Cycling Provision Perception, and Information and Communication could explain bicycle usage in Auckland, and whether age, gender, ethnicity, and income level moderate such relationships. This chapter expanded the theoretical horizon of cycling perceptions by introducing a new construct, Information and Communication, and investigating the factors influencing bicycle usage in the multicultural city of Auckland.

The outputs of the structural equation modelling reveal that Sociocultural Factors, Perceived Safety and Security, and Information and Communication have a significant positive impact on bicycle usage in Auckland. Sociocultural Factors showed the strongest relationship with bicycle usage. This relates to the impact of people around the participants, such as family and friends, on their bicycle usage and the image of bicycles in society. People who perceived that others (for example, their family and friends) believe that they should use a bicycle showed a relatively higher bicycle usage rate. Also, people who were not embarrassed to be seen riding a bicycle showed a higher bicycle usage rate. This is consistent with the notion that in travel behaviour, social influence impacts people's opinions on an individual's acceptance or rejection of a behaviour (Venkatesh et al., 2003; Yuan et al., 2005; Axhausen, 2008; Carrasco and Miller, 2009; Goetzke and Rave, 2010; Sherwin et al., 2014).

Descriptive analyses indicate a low level of social influence from others (people, friends, family, etc.) affecting the respondents with respect to their cycling, either positively or negatively. As Sherwin et al. (2014) suggested, the effectiveness of cycling promotion programmes can be improved in a city by controlling and harnessing social processes. Therefore, investment into the social environment in Auckland with respect to cycling, including encouraging and facilitating family cycling, permanent cycling challenges initiatives (e.g. Auckland's annual February Bike Challenge), and creating more active local cycling communities could lead to significant improvements in people's perceptions about cycling and help raise bicycle usage rates.

Perceived Safety and Security was another factor with a positive impact on bicycle usage. Individuals feeling safe while bicycling cycled more. The result supports the views of Chataway et al. (2014) and Dill and McNeil (2013) that negatively Perceived Safety and Security may constitute a barrier to the use of a bicycle. In this study, Perceived Safety and Security was the construct with the lowest level of perception, suggesting people in Auckland have concerns about their safety while cycling. In addition, the results of the correlation analysis indicate that the strongest significant relationship is between Perceived Safety and Security, and Cycling Provision Perception. In addition, there was also a strong concern about becoming a victim of crime or harassment while riding a bicycle in Auckland. This suggests that cycling policymakers and planners should also consider social safety and security, in addition to improving road safety, in their planning and policies.

Finally, the newly introduced construct, Information and Communication, was found to be an important factor which influences Bicycle Usership. Information and Communication focused on the promotion of cycling, awareness of traffic regulations, and having access to the reporting of cycling issues in the city. People who perceived that they have better access to information have a higher rate of bicycle usage.

In this study, the effect of moderators on the relationships between the constructs were investigated. As reported in the results section, all of the items (age, gender, income level, and ethnicity) moderate the influence of Sociocultural Factors on Bicycle Usership. This finding shows that differences among population groups can strongly influence their sensitivities to Sociocultural Factors. An interesting finding, was that Māori and Pacific peoples are significantly less sensitive to Sociocultural Factors, compared with NZ European. This means that the impact of family and friends, in terms of influencing bicycle usage, is more important for NZ European than Māori and Pacific peoples. When the intersectional groups were assessed, the results showed that lower income women from All Other Ethnicities are more sensitive than higher income women from All Other Ethnicities, indicating that there is a relationship between income and sensitivities to Sociocultural Factors among women. Overall, we can conclude that younger people are more sensitive to Sociocultural Factors with respect to using a bicycle.

The influence of Information and Communication on Bicycle Usership is significant for people who identify as Indian and people with a high income (70k-100k). People with income levels of 70k-100k are more sensitive to the effect of Information and Communication compared with people with an income level of 30k-70k. Information and Communication was also important for those aged 31-40 years. These findings could open new avenues for research, to investigate why some population groups are more sensitive to the level of information provided. Women and high-income people (70k-100k) are sensitive to the effect of Perceived Safety and Security on Bicycle Usership. This is in line with the fact that women are generally more risk averse compared with men (Ogilvie & Goodman 2012).

The findings of this chapter can be used to provide better insights for policymakers and local governments for improving cycling policies, initiatives, and investment in order to decrease the gap between bicycle usage among different population groups. Following the capabilities approach of justice (Sen, 2009; Pereira et al., 2017), focusing only on the provision of cycling resources, such as bicycle lanes, can be misleading; socio-cultural factors should also be considered in order to fairly encourage and empower all population groups to use bicycles. Initiatives which target particular barriers for specific groups could help improve unequal usage of bicycles and equity in cycling. Establishing policies which focus more on sociocultural factors than infrastructure can increase bicycle usage for those who are more sensitive to these factors. Also, providing better information and communication systems for population groups could help improve their awareness about cycling, resulting in an increase in bicycle usage.

This chapter has shown that bicycle usage is more affected by Sociocultural Factors than other constructs. It has also shown that an individual's sociodemographic characteristics can result in different perceptions about cycling. However, there is still a need for policymakers to include cyclists' perceptions more explicitly in decision-making processes (Marquart et al., 2020) related to equity. Therefore, to supplement the findings of this chapter and to finish addressing the first research gap in Chapter 2, the next step is to understand perceptions of cycling infrastructure provision and highlight its role in cycling equity. The next chapter will address this by evaluating people's perceptions of cycling infrastructure provision, their relationships to the physical infrastructure provided, the ways in which socio-demographic characteristics influence those perceptions, and how these are influenced by individual experience in using the cycling infrastructure.

Chapter 4

Understanding perceptions of cycling infrastructure provision and its role in cycling equity

4.1 Introduction

The previous chapter identified that an individual's sociodemographic characteristics can result in different perceptions about cycling and that focusing only on the provision of cycling resources, such as bicycle lanes, can be misleading. The purpose of this chapter is to supplement these findings by evaluating people's perceptions of cycling infrastructure provision and their relationships to the physical infrastructure provided, to highlight the extent to which bicycle infrastructure plays a role in cycling equity.

This chapter is structured as follows. First, the chapter provides some relevant background to the study. Then, the research methodology adopted for this chapter is explained including the study area, participants and questionnaire, development of a Bike Lane Score for Auckland, and data analysis strategy. This is followed by the results and analysis of the data to answer the research questions. Finally, the results are discussed, and conclusions are drawn.

4.2 Background

Cycling brings with it a range of health, environmental and societal advantages over other modes of transport (Bernatchez et al., 2015; Götschi et al., 2016; Jahanshahi et al., 2019; Macmillan et al., 2014). As a result, the promotion of cycling has become a key strategy adopted in many countries for reducing reliance on private vehicles for mobility. However, little attention has been given to how resources allocated to cycling infrastructure and other cycling initiatives can be distributed fairly and equitably in the sense that the benefits as well as costs are shared equally across all members of society (Di Ciommo & Shiftan, 2017).

In cycling equity analysis specifically, studies have been carried out on the interaction between the provision of bicycle infrastructure, the place of residence and employment, and the income levels of both advantaged and disadvantaged population groups (Fuller & Winters, 2017; Houde et al., 2018; Kent & Karner, 2019; Mooney et al., 2019; Pistoll & Goodman, 2014; Qian & Niemeier, 2019). The majority of such studies have focused on access to bicycle infrastructure or cycling facilities, including bicycle sharing systems (BSS) and dock-less bicycle sharing systems (DBSS), or access to destinations by bicycle (Chen et al., 2019; Hosford & Winters, 2018; Tucker & Manaugh, 2018; Winters et al., 2018). Such studies have shown that disadvantaged populations, those living in lower-income neighbourhoods, those from minority population groups, women, the elderly, and immigrants, usually have lower access to bicycle infrastructure and facilities, and experience lower bicycle usage rates. Because studies have primarily focussed on the fair distribution of cycling infrastructure among neighbourhoods, the solution has necessarily been the provision of more or better infrastructure to disadvantaged population groups. However, more consideration is needed of aspects beyond traditional infrastructure provision to include education, level of awareness about the benefits of cycling, cycling skills, and other sociocultural factors, for example, demands for social and family cycling and the need to access places of importance for specific communities (Jones et al., 2020; Maldonado-Hinarejos et al., 2014; Vietinghoff, 2021) to help address inequity.

The capabilities approach of justice argues that focusing only on the distribution of resources to provide equity can be misleading (Sen, 2009; Pereira et al., 2017). In particular, cycling perceptions can vary amongst individuals, can be context-specific and can be influenced by multiple factors, such as differences in general income and development levels, as well as geographical, cultural, and religious factors (Jahanshahi et al., 2019), aspects that tend to be largely ignored (Maldonado-Hinarejos et al., 2014). Other sociodemographic characteristics can also influence people's perceptions about cycling. For example, young people tend to be more cost-aware than older groups, parents more influenced by the needs of their children, and women more risk-averse than men (Wennberg and Hyden, 2010; Mackett and Thoreau, 2015; Banister and Bowling, 2004; Pucher and Buehler, 2009; Ogilvie and Goodman, 2012). Different communities can also face unique barriers to cycling related to their individual identity (Vietinghoff, 2021). Therefore, there is a need for policymakers to include cyclists' perceptions more explicitly in decision-making processes (Marquart et al., 2020).

4.3 Cycling equity analysis in Aotearoa New Zealand

The literature on cycling equity is discussed in detail in Chapter 2. Consequently, this section only reports on the cycling equity literature relevant to New Zealand – the location of our case study.

In New Zealand, bicycle usage rates in cities are quite low compared to other cities in developed countries. The lack of popularity of cycling as a mode of transport in New Zealand can be explained, at least in part, by the topography. Evidence suggests that the rates of bicycle usage are even lower amongst low-income and minority populations, groups who also experience higher rates of obesity compared with the general population (Ministry of Health, 2021). Māori (the indigenous peoples of Aotearoa New Zealand) have also been found to experience reduced health benefits from cycling due to lower bicycle usage rates (Bassett et al., 2020). European New Zealanders are most likely to be cyclists in New Zealand, while Pacific peoples are less likely to use bicycles than other ethnicities (Shaw & Russell, 2017). There is also a considerable gender gap in cycling in New Zealand with three-quarters of regular cyclists being male (Shaw et al., 2020).

In New Zealand's Future Streets Programme, Thorne et al focussed on one suburb in Auckland (Mangere Central) to explore perceptions of cycling using a mixture of community key informant interviews and focus groups (Thorne et al., 2020). Using thematic analysis, the authors identified a number of factors which influence people's perceptions, including local cycling norms, socioeconomic barriers, appreciation of the new community walking and cycling trail, a desire for connectivity beyond the neighbourhood, concerns about on-road bicycle lanes, support for local cycling champions, and tensions between views of the project as "experimentation" rather than "investment".

Jones et al. (2020) in a narrative literature review, investigated cycling patterns, barriers, and possible solutions for Māori specifically. The study showed that the barriers to cycling for Māori are largely similar to those of New Zealand European. However, there are some that are particularly relevant to Māori, including inflexible employment conditions, concerns about neighbourhood safety, inadequate provisions to enable social cycling (i.e., opportunities to cycle with friends and family), and a lack of adequate infrastructure to allow access to places of importance to them. Thus, there is an opportunity to provide solutions for this specific group to make cycling more appealing.

Finally, based on the observed gender inequality in bicycle usage in New Zealand, Russell et al. (2021) using a feminist intersectional approach, found that perceptions of traffic danger and personal safety, and the need to be safety-conscious because of responsibilities for others, influence women's cycling preferences. The results also showed that while Māori women are significantly less likely to have access to a bicycle compared with non-Maori women, Māori women are significantly more likely to be willing to cycle with others compared with non-Māori women, reflecting differences in cultural perspectives with respect to cycling.

4.4 Methodology

4.4.1 Study Area: Auckland, Aotearoa New Zealand

Auckland is the most populous city in New Zealand with approximately 1,695,200 residents and a land area of 4,941.16 km^2 (www.stats.govt.nz, 2022). It is one of the most culturally diverse cities in the world, spanning more than 220 ethnic groups and with four in ten Aucklanders having been born overseas. Auckland and its surrounding areas are home to 60 percent of the country's indigenous population, Māori, and boasts the largest Polynesian population in the world (World Population Review, 2021). The city has the lowest overall cycling rates amongst the large cities in New Zealand at 0.4%. In comparison, cycling rates are 3.6% for Christchurch, 1.9% for Tauranga, 1.4% for Wellington, 1.3% for Dunedin, and 1.1% for Hamilton (Shaw & Russell, 2017). The differences in cycling rates can be partly attributed to differences in topography, but also the geographical size of the city.

In this chapter, participants were recruited from across the Auckland Region, spanning 27 different postal codes, as shown in Figure 4.1, and representing a distribution of age, gender, ethnicity, income, and levels of bicycle infrastructure typical of Auckland. This chapter used the same questionnaire survey as used in Chapter 3, and the reader is referred to Chapter 3 for details of the data collection methods and procedures. The bicycle lanes that exist in each of these areas are highlighted in Figure 4.1. Note that these are bike lanes that exist currently, rather than planned bike lanes. As can be seen, some areas in Auckland are devoid of any bicycle infrastructure whereas other areas are well served.

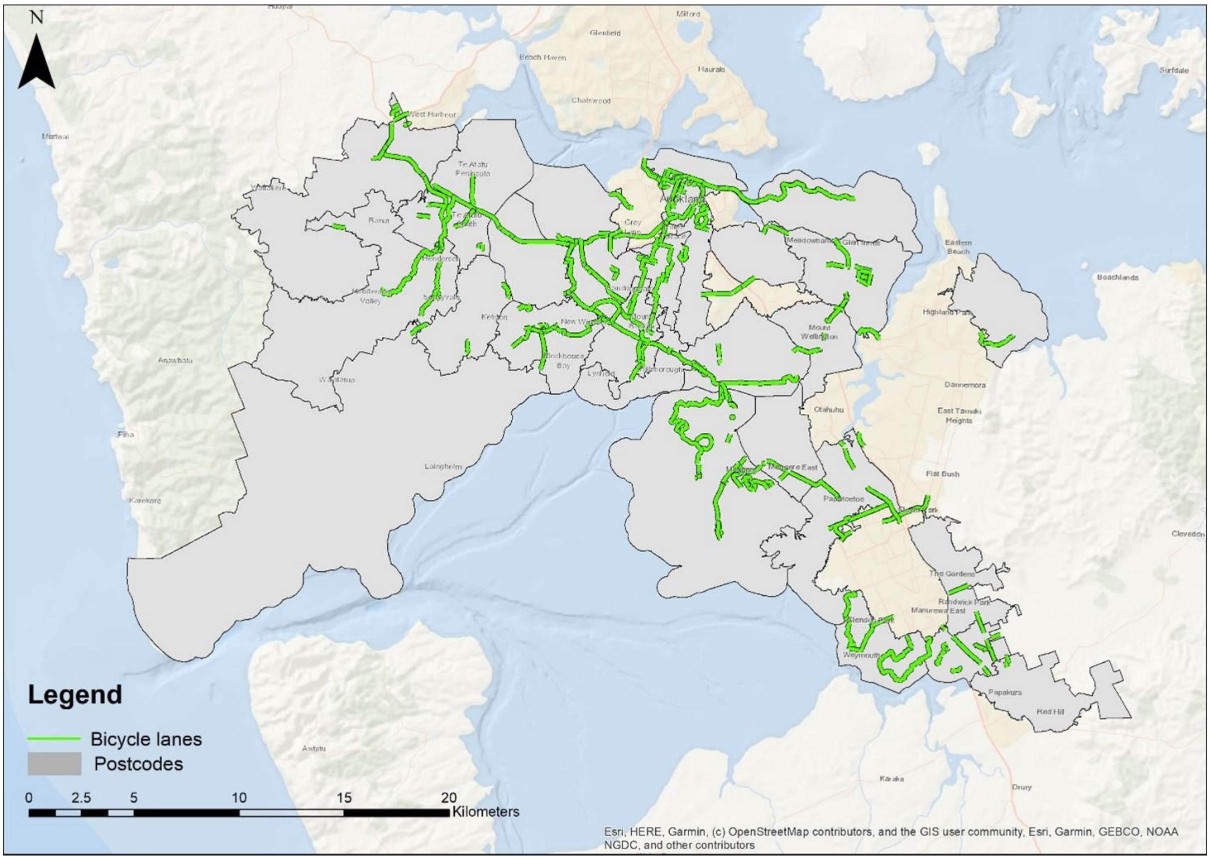

Figure 4.1: Spatial distribution of bicycle lanes in Auckland

4.4.2 Participants and questionnaire

The number of participants surveyed per postal code varied based on population size, and ranged from 9 to 35. While there were no exclusion criteria, participation was restricted to those aged 18 years and over. Consequently, the elderly and disabled, for whom cycling may not be an option, were not excluded. The questionnaire was only provided in English and was therefore limited to those with a sufficiently high command of the English language to be able to complete it. The questionnaire was administered during the period of May to July 2021. In total, 697 approaches were made, and 683 responses were collected. After removing incomplete questionnaires, as well as those that had been answering with patterns, such as providing the same answer to all of the questions and providing very unlikely answers, 506 were retained for data analysis, resulting in a response rate of 72% The response rates in cycling related studies varies, ranging from about 20% to 80% and depends on the nature of data collection and case studies (Høye et al., 2020; Schepers et al., 2020; Howland et al., 2017; McTigue et al., 2018; Dill & McNeil, 2013; C. F. Lee & Huang, 2014; Zhao & Zhang, 2019). Therefore, the response rate in this study is considered as a high response rate, but it is consistent with the literature. The first section of the questionnaire was related to participant demographics (21 items), including age, ethnicity, gender, education, employment status, income, and access to a car. A summary of the demographic characteristics of the participants is presented in Table 4.1. The collected data are very similar to Auckland with respect to distributions of age, gender, ethnicity, and income levels (Statistics New Zealand, 2021), as shown in parenthesis in Table 4.1.

A summary of the cycling profile of the participants is presented in Table 4.2, including whether they have access to a bicycle at home, the extent of bicycle usage, the bicycle user types of the participants, and their purpose for cycling if they do indeed cycle. Both cyclists and non-cyclists were included in the data collection. Those categorised as 'cyclists' were split into two groups: 'regular cyclists' and 'potential cyclists', following the categorisation proposed by (Félix et al., 2017): Regular Cyclists are those who indicated having cycled in the past month for any purpose; Potential Cyclists are those who had cycled at least once in the past 12 months; and Non-Cyclists are those who had not cycled in the past 12 months. In addition, in total, 35 participants (6.9%) reported having disabilities, but ones that do not prevent them from cycling. Also, 30% of participants reported that they had experienced injuries because of cycling, one of the factors considered to influence people's perceptions of cycling infrastructure.

Table 4.1: Socio-demographic characteristics of the respondents (completed responses)

Characteristics	% (Auckland%)	Characteristics	% (Auckland%)
Age (in years)		**Ethnicity**	
18-20	7.5% (not reported)	Māori	7.1% (11.5%)
21-30	19.8% (20.5%)	Pacific Islanders	9.1% (15.5%)
31-40	20.4% (18.8%)	Asian	19.8% (28.2%)
41-50	20.4% (17%)	MELAA*	2.2% (2.3%)
51-60	13.5% (15.7%)	Indian	10.1% (not reported)
>60	18.4% (23%)	European/NZ European	50% (53.5%)
Gender		Other ethnicities	1.8% (1.1%)
Men	44.1% (49%)		
Women	54.9% (51%)		
Diverse	1% (not reported)	**Personal annual income (NZD)**	
Highest finished degree		No income	8.7% (8.7%)
High School or below	31.7%	<30K	23.9% (36.8%)
Undergrad degree	52.3%	30K-70K	35.6% (34.1%)
Master's degree/	16%	70K-100K	17.7% (10.3%)
Postgraduate		>100K	14.1% (9.5%)
Employment situation		**Car access in the household**	
Not employed	15.5%	Yes	92.1%
Part-time employed	14.7%	No	7.3%
Full-time employed	52.3%		
Homemaker	6.2%		
Retired	11.3%		

* MELAA: Middle Eastern/African/Latin American

Table 4.2: Cycling profile of the respondents

Characteristics	%	Characteristics	%
Access to a bicycle at home		**Cycling purpose**	
Yes	46.7%	Commuting	9.3%
No	53.3%	Short trips	25.8%
Average bicycle usage (per week)		Recreation/exercise	64.9%
0 times	33%	**Average daily bicycle usage** (time)	
1-3 times	60.4%	<15 mins	32.3%
3-5 times	4.4%	15-30 mins	46.6%
>5 times	2.2%	30-60 mins	18.4%
Bicycle user type		>60 mins	2.7%
Non-cyclists	51.6%	**Cycling injuries**	
Regular cyclists	23.7%	Yes	30%
Potential cyclists	21.1%	No	70%

The second section of the questionnaire was designed to determine the perceptions of cycling infrastructure. Questions were designed based on a five-point Likert scale (‘strongly disagree’, ‘disagree’, ‘neutral’, ‘agree’, and ‘strongly agree’) and asked about the availability of bicycle lanes in the respondents’ neighbourhood and at their destinations, as well as the quality of road marking and signage. Responses to the three statements below were collected, and then used, to compute a scale variable for the perceptions of cycling provision:

- There are sufficient cycling facilities such as bicycle lanes and/or dedicated cycleways in my residential neighbourhood
- There are sufficient cycling facilities to my common destination(s)
- There are appropriate road marking and bicycle signage in bicycle lanes

Table 4.3 presents the distribution of the aforementioned variables.

Table 4.3: Descriptive statistics for indicators

Categories/Questions	Mean	SD	1	2	3	4	5
			Stronglydisagree%			Strongly agree%	
Cycling provision perception	**3.16**	**0.836**					
Cycling facilities	3.10	1.080	6.9	24.1	30.0	30.0	8.9
Cycling to destination(s)	3.03	1.044	8.7	21.3	34.4	29.8	5.7
Road marking/signage	3.37	0.918	2.6	15.0	33.2	41.5	7.7

4.4.3 Developing a Bicycle Lane Score for Auckland

In this section, in order to evaluate the availability of bicycle lanes in Auckland, a Bike Lane Score is developed. Based on the computed score, participants of this study will be assigned a level of access to bicycle lanes. The development of a Bicycle Lane Score involves establishing evaluation criteria, collecting data on bicycle lane types, assigning weights to each criterion, scoring based on collected data, calculating an overall score, and visualizing and reporting the results. This systematic approach allows for a standardized and objective assessment of the availability of bicycle lanes. The following paragraphs explain the background, calculation method, and categorization of the scores in detail.

The Bike Score index and its components are frequently used in the literature to measure the availability of bicycle infrastructure within a neighbourhood (Fuller & Winters, 2017; Winters et al., 2016; Winters et al., 2018; Yang et al., 2019; Zuo & Wei, 2019). The Bike Score index is a weighted sum of components, including the Bike Lane Score, Hill Score, Destinations and Connectivity Score, and the recently added Bike Commuting Mode Share Score. In order to analyse the availability of bicycle lanes, the Bike Lane Score was applied in this analysis, following its use in recent evaluations of bicycle infrastructure availability (Branion-Calles et al., 2019).

The Bike Lane Score is a normalised index of a location’s proximity to bicycle lanes. Based on the Bike Lane Score (Walkscore.com, 2010; Winters et al., 2016; Branion-Calles et al., 2018), the weighting system takes the sum of the lengths of all nearby bicycle lanes and is calculated based on a distance decay function to each segment, where no value is given to segments further than 1,000 meters from the origin. Distance decay is the idea that the farther away people are from services, the less likely they are to make use of them. A linear relationship between distance and service accessibility is assumed, for distances up to 1,000 meters. The weight given for bike paths is 2x that of bicycle lanes, and bike paths are given scores 3x those with shared infrastructure. The weights are assigned to each bicycle lane to compute the Bike Lane Score. The final weighted lengths are then normalised to a score of between 0 and 100, with higher Bike Lane Scores indicating greater availability of bicycle infrastructure and a Bike Lane Score of 0 indicating no infrastructure within 1 km. The Bike Lane Score for each postcode is the density of bicycle lanes calculated as the sum of the scores of bicycle lanes for each area postcode divided by the area (km2) of each postcode.

In this study, the standard calculation method for the Bike Lane Score, as detailed above, is used to analyse the availability of bicycle lanes in Auckland. Auckland has seven types of bicycle lanes, as presented in Table 4.4. In order to weight these appropriately, each is grouped into one of three standard categories: bike paths, bicycle lanes, and shared infrastructure. Figure 4.2 shows the spatial distribution of the Bike Lane Scores for the study area calculated using a Geographical Information System (GIS). On this basis, participants are assigned a score for the availability of bicycle infrastructure (range 0–100) based on their residential postal code. The Bike Lane Score for each participant is then categorised as 'poor', 'average', or 'excellent' on the basis of this score using Jenk's natural breaks classification method (JENKS) (Jenks, 1967), by selecting the ordered number of classes with a goodness of variance fit (Gili et al., 2017).

Table 4.4: Weights for bicycle lanes in Auckland to calculate Bike Lane Score

Weights	Bike lanes category based on Bike Lane Score index	Auckland Bicycle lanes
3x	Bike path	On-road protected cycle lanes (two-ways)
		Off-road cycle path (only bicycle)
		On-road protected cycle lanes (one-way)
1.5x	Bicycle lane	On-road unbuffered cycle lanes
		On-road buffered cycle lanes
1x	Shared infrastructure	Off-road shared paths (with pedestrians)
		Quiet routes

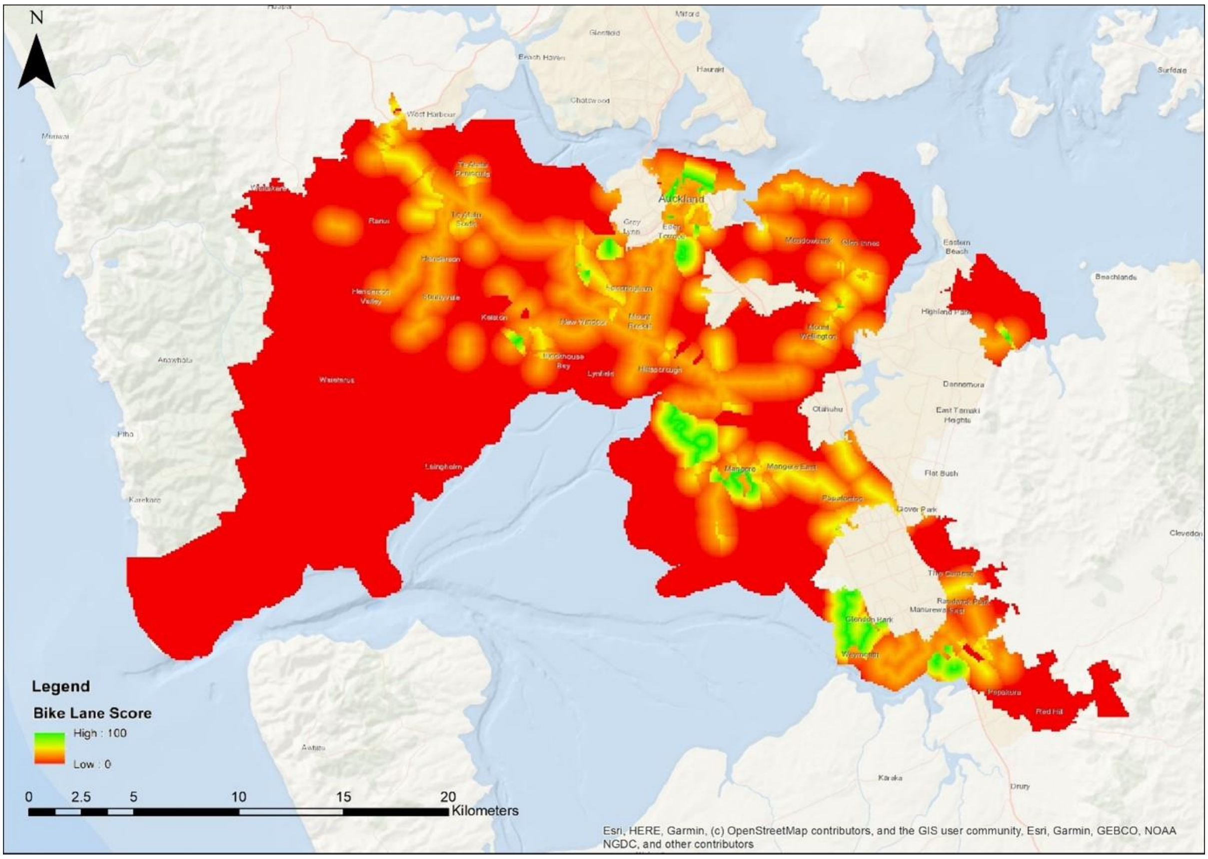

Figure 4.2: Spatial distribution of bicycle infrastructure, using the Bike Lane Score as a proxy

4.4.4 Data analysis strategy

This section provides a comprehensive explanation of the data analysis process undertaken in this study. It encompasses several crucial steps, starting with the evaluation of variable reliability. An assessment of the variables used in the analysis was conducted to ensure their accuracy. Furthermore, the section delves into the statistical methods employed in the study. Details are provided to shed light on the specific techniques implemented to analyze the data and derive meaningful insights. These statistical methods including Classification and Regression Tree (CART) Analysis and multiple linear regression were carefully selected based on their appropriateness for the research objectives and the nature of the data collected. This section aims to provide a clear understanding of the analytical procedures.

The first step of the data analysis was to confirm the reliability of the variables used in the study. Carrying out Confirmatory Factor Analysis (CFA) is crucial for determining whether the hypothesised structure of the items and constructs provide an acceptable fit to the data (Diana, 2014), and confirming the relationships between a set of observed variables and a set of common items (Muthen and Muthen, 2010). Thus, to confirm the convergent and discriminant validity of the questions, CFA was carried out (Churchill, 1979; Byrne, 2012) with items with loading factors of less than 0.5 excluded (Hair et al., 2010). The results indicate loading factors of above 0.5 for all of the questions (0.79, 0.78, and 0.54 for Questions 1 to 3 respectively). Cronbach's alpha was also analysed to confirm the reliability of the questions with coefficients found to be above 0.7, thus within the acceptable reliability range.

Statistical analyses were conducted using SPSS (Version 25.0). Descriptive statistics were first undertaken with respect to bicycle user types (regular cyclists, non-cyclists, and potential cyclists). At this stage, we also assessed and reported the results of Chi-Square tests for each sociodemographic variable, to evaluate the significance of their relationships with respect to bicycle user types. Then, to identify the factors that influence people's perceptions of cycling infrastructure, a Classification and Regression Tree (CART) Analysis was used to classify the participants into different groups based on their perceptions of cycling provision. A multiple linear regression was then carried out to analyse the influence of the availability of cycling infrastructure and sociodemographic characteristics on cycling provision perception for each group of bicycle users. Finally, the influence of sociodemographic characteristics and bicycle usage on cycling provision perception was evaluated for each level of infrastructure (poor, average, and excellent) using a series of multiple linear regressions. Note that analysing the influence of the availability of cycling infrastructure and sociodemographic characteristics on cycling provision perception for cycling purpose groups (commuting and recreation) was investigated. However, because the relationships were not significant nor notable, these results are not presented.

4.5 Results

4.5.1 Descriptive analysis of bicycle user types

This section presents the socio-demographic characteristics of the participants by bicycle user group, as shown in Table 4.5, and the results of Chi-Square tests, in order to determine whether any of the relationships are significant. The results of the Chi-Square test show a significant relationship between age and bicycle user types ($X^2(10, 446)=63.181$, $p=0.000<0.005$). As evident in Table 4.5, as the age category of the participants increased, the percentage of non-cyclists also increased. The highest percentage of regular cyclists was for the 21-30 age category. Interestingly, there is a considerable percentage of potential cyclists among the youngest group of participants (18-20 years old). The results of the Chi-Square test show a significant relationship between gender and bicycle user types ($X^2(2, 447)=9.816$, $p=0.007<0.05$). A lower proportion of women are regular cyclists, compared with men, however, women do account for more potential cyclists. The results of the Chi-Square test show a significant relationship between ethnicity and bicycle user types ($X^2(10, 447)=17.753$, $p=0.049<0.05$). The lowest percentage of regular cyclists was for European and Pacific Islanders, and a considerable percentage of Pacific Islanders are non-cyclists (64.9%). Interestingly, compared with other ethnicities, a high proportion of Māori are potential cyclists, suggesting that opportunities exist to encourage this group to become regular cyclists. The results of the Chi-Square test show a non-significant relationship between access to a car and bicycle user types ($X^2(2, 444)=2.475$, $p=0.29>0.05$). The results of the Chi-Square test show a significant relationship between access to a bicycle and bicycle user types ($X^2(2, 446)=190.661$, $p=0.000<0.005$). Access to a bicycle is high amongst regular cyclists (necessarily), however, 19.2% of those with access to a bicycle are non-cyclists and 31.9% of them are potential cyclists. The results of the Chi-Square test show a non-significant relationship between cycling injuries and bicycle user types ($X^2(2, 443)=4.241$, $p=0.120>0.05$). The results of the Chi-Square test also show a non-significant relationship between income level and bicycle user types ($X^2(8, 444)=8.744$, $p=0.364>0.05$). The results of the Chi-Square test show a significant relationship between employment situation and bicycle user types ($X^2(8, 445)=36.624$, $p=0.000<0.005$). Retired people have the highest percentage of non-cyclists (79.2%) and the lowest percentage of regular cyclists and potential cyclists. The results of the Chi-Square test show a significant relationship between education level and bicycle user types ($X^2(4, 431)=16.746$, $p=0.002<0.005$). As the level of education of the participants increased, the percentage of regular cyclists also increased. The results of the Chi-Square test show a significant relationship between cycling as the main purpose for using a bike and bicycle user types ($X^2(4, 215)=11.975$, $p=0.003<0.005$). Those who use a bicycle for recreational purposes are more likely to be potential cyclists, while those who use a bicycle for commuting and short trips are more likely to be regular cyclists.

Table 4.5: Demographic characteristics of bicycle user types

Socio-demographic characteristics	Categories	Regular cyclists	Potential cyclists	Non-cyclists
Age				
	18-20	20.6%	41.2%	38.2%
	21-30	42.4%	18.5%	39.1%
	31-40	37%	23.9%	39.1%
	41-50	25.8%	23.7%	50.5%
	51-60	9.4%	32.8%	57.8%
	>60	10.1%	11.2%	78.7%
Gender				
	Male	32.5%	20.8%	46.7%
	Female	19.6%	24.7%	55.7%
Ethnicity				
	Māori	24.2%	36.4%	39.4%
	Pacific Islander	16.2%	18.9%	64.9%
	Asian/Indian	30.7%	21.2%	48.2%
	European	16%	30%	54%
	NZ European	25.3%	19.6%	55.2%
	MELAA	38.9%	33.3%	27.8%
Access to a car				
	Yes	26.3%	22.1%	51.6%
	No	19.4%	30.6%	50%
Access to a bicycle				
	Yes	48.9%	31.9%	19.2%
	No	3.3%	14.2%	82.4%
Cycling injury experience				
	Yes	30.2%	25.2%	44.6%
	No	23.7%	21.8%	54.5%
Income level				
	No income	12.5%	27.5%	60%
	<30K	24.5%	27.3%	48.2%
	30K-70K	24.4%	22.6%	53%
	70-100K	30.1%	15.7%	54.2%

	>100K	32.3%	23.1%	44.6%
Employment situation				
	Not employed	17.6%	32.4%	50%
	Part-time	28.1%	34.4%	37.5%
	Full-time	32%	20%	48%
	Homemaker	16%	12%	72%
	Retired	9.4%	11.3%	79.2%
Education level				
	High school and below	13.4%	26.1%	60.6%
	Bachelors and diploma	29.7%	23.3%	47%
	Postgraduate	35.3%	17.6%	47.1%
Cycling Purpose				
	Commuting	76.2%	23.8%	-
	Short trips	67.2%	32.8%	-
	Recreation/exercise	44.5%	55.5%	-

4.5.2 Classification and Regression Tree (CART) Analysis

This section presents the result of the CART analysis to identify the ways in which different population groups differ in terms of their perceptions of cycling provision. CART is a type of decision tree classification algorithm that uses binary recursive partitioning (Breiman et al., 1984). CART analysis selects the best predictor variable for splitting the data into clusters with maximal purity. The process is repeated recursively for each cluster, until either the minimum size of the terminal cluster is reached, or no further split improves the purity of the terminal cluster (Lewis et al., 2000; Shim et al., 2020), in this case, until the clusters are significantly different to each other in terms of cycling infrastructure perception.

As shown in Figure 4.3, the strongest factor influencing the perception of the provision of bicycle infrastructure is the bicycle user type. People who are regular cyclists fall into a different cluster to non-cyclists and potential cyclists. The regular cyclists have a higher level of perception about cycling provisions compared with non-cyclists and potential cyclists. Among the non-cyclists and potential cyclists, ethnicity is the strongest demographic factor, resulting in three clusters: 1) Māori and Pacific Islanders (highest level of perception); 2) New Zealand European and Asian/Indian; and 3) European and MELAA (lowest level of perception). The responses provided by the New Zealand European and Asian/Indian participants were then classified into two clusters based on their level of education: 1) Lower levels of education with a high level of perception with respect to cycling provision. 2) Higher levels of education with a lower level of perception about cycling provision. Surprisingly, the availability of bicycle lanes was not found to influence respondents' perceptions within this classification, with bicycle user type, ethnicity, and education level being the most important factors influencing perceptions. The subsequent sections present further analysis carried out to highlight the factors influencing the perceptions of each bicycle user group about cycling provision.

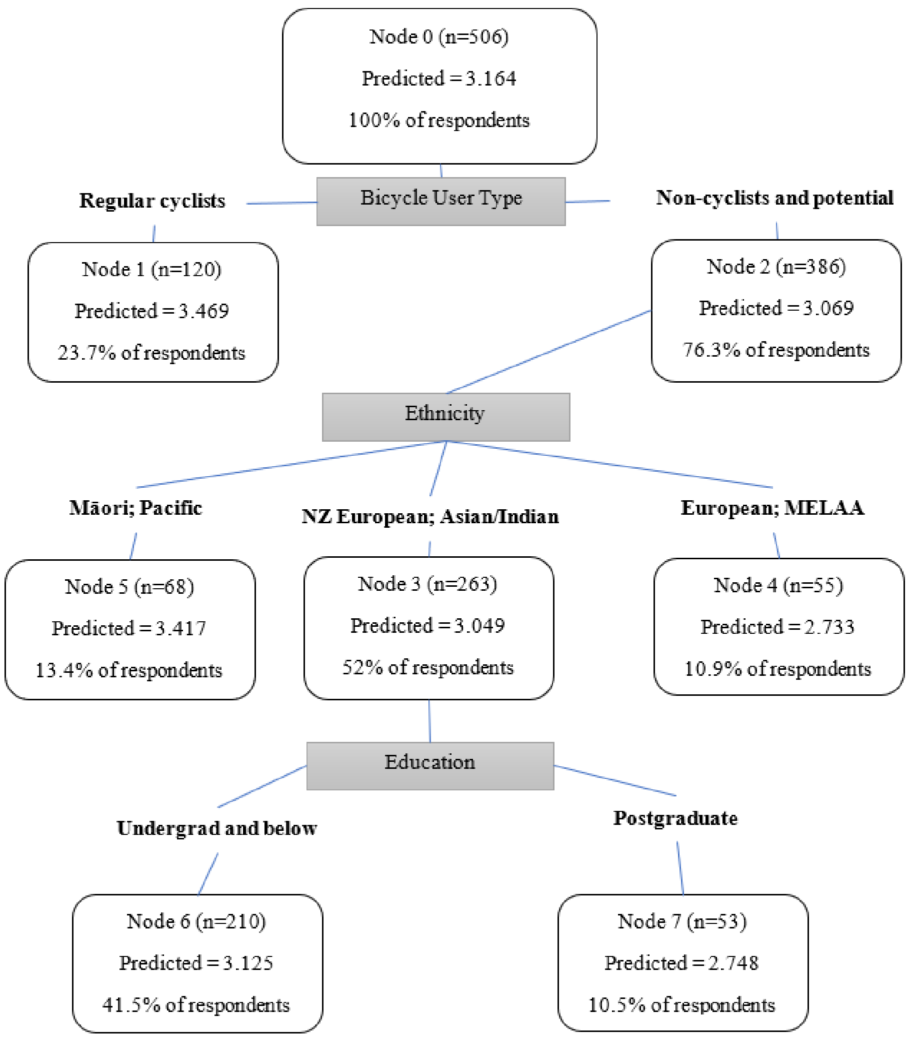

Figure 4.3: Results of classification and regression tree analysis for cycling provision perception

Note: The "predicted" values express the mean score based on the five-point Likert scale.

4.5.3 Factors influencing perceptions of cycling provision by Bicycle user type

Table 4.6 presents the results of a multiple linear regression analysis for regular cyclists investigating the impact of age, gender, ethnicity, education level, annual income, Bike Lane Score, cycling injury, access to a car, access to a bicycle, and employment status on perception of cycling provision. Using a linear regression is a common method to determine the character and strength of the association between a quantitative dependent variable and a series of other independent variables. It helps create models to make predictions. In this section, a linear multiple regression was used to assess the association between cycling provision perceptions and a series of independent variables, as mentioned above. A number of assumptions were tested before choosing this method including ensuring that the mean of the distribution of errors is zero, the variance of errors is constant across all levels of the independent variable, and the distribution of errors is normal.

In order to address the research objective, data were analysed through two stages. First, a regression model was applied to observe the significance of relationship between dependent and independent variables. The results in Table 4.6 show that for regular cyclists, age, education level, cycling injury, and Bike Lane Score all influence cycling provisions perception, resulting in a significant regression equation for the model ($X^2(32, 109)=47.671$, $p=0.037<0.05$). Scaled Deviance and Akaike's Information Criterion (AIC) were 109 and 258.562, respectively. Second, in order to understand the relationship between the significant independent variables including age, gender, education, cycling injury, Bike Lane Score and cycling provision perception, pairwise comparisons were applied (Appendix 4.1). The results show that in this group, overall, younger people have higher perceptions of bicycle infrastructure. Among regular cyclists, people who had postgraduate qualifications were found to have higher perceptions compared to those with bachelors and diploma-level qualifications. In addition, having experienced a cycling injury was shown to significantly adversely impact on a cyclists' perception of bicycle infrastructure. Lastly, people who live in areas with excellent levels of bicycle infrastructure have higher perceptions of cycling infrastructure compared with people who live in areas with poor or average levels of bicycle infrastructure. The R Squared value for goodness of fit for the applied model was 0.354.

Table 4.6: Multiple linear regression for predicting cycling provision perception by regular cyclists (Sample size=109)

Independent variable	**Chi-Square**	**Df**	**Sig**
Bike Lane Score	14.515	2	.001
Ethnicity	8.891	5	.113
Age	24.283	5	.001
Gender	10.585	2	.646
Education level	8.422	2	.020
Annual income (NZD)	1.478	4	.830
Cycling injury	4.806	1	.028
Access to a car	1.555	1	.212
Employment	1.456	4	.834
Access to a bicycle	.863	1	.353
Main cycling purpose	.610	2	.737
Cycling time per week	.108	3	.991
Cycling time per journey	.029	2	.985

Note: Shading indicates significant associations ($p<0.05$).

Table 4.7 presents similar results to Table 4.6 but this time for non-cyclists and potential cyclists. We combined non-cyclists and potential cyclists into one group based on the results of the CART analysis, which showed no significant difference in terms of cycling provision perception for these groups. The results of the model revealed a significant regression equation ($X^2(25, 309)=49.313$, $p=0.003<0.005$). Scaled Deviance and Akaike's Information Criterion (AIC) were 309 and 767.152, respectively. In this case, ethnicity is the main factor influencing cycling provision perception. Pairwise comparisons were then used to understand the relationship between ethnicity and cycling provision perception among non-cyclists/potential cyclists (Appendix 4.2). The results show that Māori, Pacific Islanders, and NZ European had significantly higher perceptions of bicycle infrastructure compared with MELAA and Europeans.

Table 4.7: Multiple linear regression for predicting cycling provision perception by non-cyclists/potential cyclists (Sample size=309)

Independent variable	Chi-Square	Df	Sig
Bike Lane Score	3.562	2	.168
Ethnicity	22.336	5	.000
Age	6.304	5	.278
Gender	1.254	2	.534
Education level	5.388	2	.068
Annual income (NZD)	6.657	4	.155
Cycling injury	.139	1	.709
Access to a car	.266	1	.606
Employment	2.749	4	.601
Access to a bicycle	1.071	1	.301

Note: Shading indicates significant associations ($p<0.05$).

4.5.4 Factors influencing cycling provision perception in areas with poor, average, and excellent bicycle infrastructure

This section investigates the factors influencing the perceptions of respondents with respect to cycling infrastructure when normalised for the availability of bicycle infrastructure. Specifically, this section assesses the impact of age, gender, ethnicity, education level, annual income, bicycle user groups, cycling injury, access to a car, access to a bicycle, and employment status on the respondents' perception of cycling provision for each level of bicycle infrastructure, clustered into the three levels: poor, average, and excellent.

Among those who live in areas with poor levels of bicycle infrastructure (282 participants), 23.1% were regular cyclists, 92.9% have access to a car and 93.6% know how to ride a bike. A multiple linear regression was undertaken to predict cycling provision perception, with a significant regression equation found for the model ($X^2(26, 233)=39.233$, $p=0.046<0.05$). Scaled Deviance and Akaike's Information Criterion (AIC) were 233 and 601.327, respectively. The results show that ethnicity and access to a bicycle influence cycling provision perception within this group (Table 4.8). Pairwise comparisons were also used to understand the relationship between ethnicity and access to a bicycle and cycling provision perception (Appendix 4.3). The results show that Māori, Pacific Islanders, and NZ European had significantly higher perceptions of bicycle infrastructure compared with others when they live in areas with a poor level of bicycle infrastructure. By contrast, MELAA and Europeans express lower perceptions about cycling provisions compared with others. Finally, those who have access to a bicycle have higher levels of perception about cycling provisions.

Table 4.8: Multiple linear regression for predicting cycling provision perception in areas with poor levels of infrastructure (Sample size=233)

Independent variable	**Chi-Square**	**Df**	**Sig**
Age	4.182	5	.524
Gender	1.753	2	.416
Ethnicity	18.668	5	.002
Education level	2.912	2	.233
Employment	2.886	4	.577
Annual income (NZD)	1.159	4	.885
Access to a bicycle	5.318	1	.021
Bicycle user type	2.307	2	.315
Cycling injury	1.344	1	.246
Access to a car	.126	1	.723

Note: Shading indicates significant associations ($p<0.05$).

Among those who live in areas with an average level of bicycle infrastructure (130 participants), 27.1% are regular cyclists and 96.1% have access to a car. As before, the association between sociodemographic characteristics and cycling provision perception is assessed amongst this group. A Multiple linear regression was undertaken to predict cycling provision perception revealing a non-significant regression equation for the model ($X^2(26, 107)=32.131$, $p=0.189>0.05$). The results show that there is no significant association between the independent variables and cycling provision perception (Table 4.9).

Table 4.9: Multiple linear regression for predicting cycling provision perception in areas with average levels of infrastructure (Sample size=107)

Independent variable	Chi-Square	Df	Sig
Age	3.998	5	.550
Gender	2.321	2	.313
Ethnicity	7.859	5	.164
Education level	3.389	2	.184
Employment	5.818	4	.213
Annual income (NZD)	10.081	4	.079
Access to a bicycle	2.859	1	.091
Bicycle user type	8.342	2	.065
Cycling injury	3.241	1	.072
Access to a car	.567	1	.451

Note: Shading indicates significant associations ($p<0.05$).

Among those who live in areas with an excellent level of bicycle infrastructure (94 participants), 28.7% are regular cyclists and 86.2% have access to a car. In this case the multiple linear regression revealed a significant regression equation for the model ($X^2(26, 78)=58.520$, $p=0.000<0.005$). Scaled Deviance and Akaike's Information Criterion (AIC) were 78 and 191.1, respectively. According to Table 4.10, ethnicity, annual income, and bicycle user type all influence cycling provision perception, and pairwise comparisons were used to understand the relationship between the independent variables and cycling provision perception (Appendix 4.4). Results show that, once again, Māori and Pacific Islanders are the groups with the highest levels of perception, while European and Asian/Indian have lower levels of perception. Differences among income level groups do not express any meaningful pattern. The results also show that regular cyclists have significantly higher levels of perceptions compared with non-cyclists and potential cyclists. Surprisingly, non-cyclists have significantly higher levels of perception compared with potential cyclists.

Table 4.10: Multiple linear regression for predicting cycling provision perception in areas with excellent levels of infrastructure (Sample size=78)

Independent variable	Chi-Square	Df	Sig
Age	10.138	5	.071
Gender	1.473	2	.479
Ethnicity	11.135	5	.049
Education level	4.606	2	.100
Employment	6.234	4	.182
Annual income (NZD)	22.368	4	.000
Access to a bicycle	1.507	1	.220
Bicycle user type	35.514	2	.000
Cycling injury	.063	1	.801
Access to a car	3.302	1	.069

Note: Shading indicates significant associations ($p<0.05$).

4.6 Discussion and conclusions

This research aimed to understand people's perceptions of cycling infrastructure provision, its relationship to the physical infrastructure provided, and how socio-demographic characteristics influence those perceptions. We investigated the factors influencing different cycling provision perceptions among various groups and the extent to which objective factors (in this case the availability of bicycle lanes) play a role in individual perceptions of cycling infrastructure. Auckland, New Zealand was chosen as the city of interest due to its low bicycle usage rate and high level of ethnic diversity within its population. The study considered the demographics of bicycle users/non-users across a wide range of levels of bicycle infrastructure availability to provide a holistic understanding of the factors associated with people's perceptions about cycling infrastructure provision.

In this chapter, the impact of sociodemographic characteristics and the availability of bicycle lanes on cycling provision perception were examined. A CART analysis confirmed that population groups in Auckland cluster into seven groups influenced by bicycle user type, ethnicity, and level of education. Interestingly, the availability of bicycle lanes was not found to be a factor influencing the clustering of population groups. The first cluster separated regular cyclists from non-cyclists/potential cyclists. Regular cyclists had higher levels of perception of bicycle infrastructure compared with non-cyclists/potential cyclists. All other clusters were subsets of non-cyclists/potential cyclists. Based on the significantly larger number of non-cyclists and potential cyclists in Auckland (consistent with the low bicycle usage rates), more attention needs to be given to this group of participants in order to better understand the factors which could encourage and empower them to use a bicycle. The non-cyclists/potential cyclists were further clustered into three ethnic groups. Also, NZ European and Asian/Indian were clustered to two groups based on education level. Although the impact of bicycle user types, ethnicity, and education on differentiating people's perceptions about cycling infrastructure is clear in the case of Auckland city, the CART analysis suggests that the provision of cycling infrastructure does not have a major influence on people's perceptions. Therefore, it is argued that it is important for local policy makers to implement a variety of cycling initiatives, and not only focus on cycling infrastructure provision.

Descriptive analyses indicate that Māori have the highest percentage of potential cyclists among all ethnicities. This is consistent with the line of argument of Jones et al who suggest that there is significant potential to achieving a high level of uptake of cycling amongst Māori (Jones et al., 2020). Pacific Islanders have the highest percentage of non-cyclist (64.9%), the lowest percentage of potential cyclists, and one of the lowest percentages of regular cyclists. This finding is also consistent with previous studies reported in the literature (e.g., (Shaw & Russell, 2017)). Younger people are the most likely to be regular cyclists or potential cyclists, while most elderly are non-cyclists. The high level of potential among people 18-20 years old indicates that more attention to this group's needs can considerably increase bicycle uptake in Auckland. Women make up a lower percentage of regular cyclists compared with men, while a higher percentage of potential cyclists are women. This suggest that there are opportunities to encourage women in Auckland to cycle more. Bicycle usage among those with no access to a bicycle at home is extremely low (3.3% are regular cyclists), suggesting that a better distribution of bicycle sharing systems (BSS and DBSS) could be helpful in terms of providing access to bicycles for those without a bicycle. Higher percentage of bicycle usage among those with a higher level of education might indicate that raising awareness of the option to cycle and educating about the benefits of cycling among non-cyclists could be helpful. In addition, lower percentages of bicycle usage among people with lower incomes might indicate that more analyses on affordability of cycling in Auckland could help address this issue.

The result of regression analyses showed that while for regular cyclists, age, education level, and cycling injury experience affected their perceptions of cycling provision, for non-cyclists, only the ethnicity of non-cyclists and potential cyclists significantly influenced their perception of cycling provision. It can, therefore, be argued that for people who are not currently or regularly cycling, only socio-cultural backgrounds play a significant role in perceptions. As for the influence of education level, it may be linked to employment conditions and therefore, inflexibilities in the workplace as a barrier to use a bicycle (Jones et al., 2020). It is important to note that the influence of socio-demographic characteristics is not shaped by a single axis of social division and it is the ‘‘intersections of them’’ (the combination of multiple socio-demographic variables) that create differences among different population groups (Hill Collins & Bilge, 2016). Among the regular cyclists, younger, male, those more educated, and those living in areas with an excellent level of bicycle infrastructure have higher perceptions of cycling infrastructure. People who have experienced cycling injuries have lower perceptions of cycling infrastructure. The ethnicity of regular cyclists was not found to be a factor influencing the different perceptions of cycling provision. However, for both non-cyclists and potential cyclists, ethnicity plays an important role. European and MELAA participants had significantly lower levels of perception about bicycle infrastructure. This could be due to the lower level of infrastructure present in New Zealand compared to some European countries or could be related to the unrealised expectations that some people from less developed countries have about New Zealand’s level of cycling infrastructure. Thus, understanding the differences between different communities’ expectations about bicycle infrastructure related to socio-cultural background can play an important role in policymaking. Interestingly, while Māori and Pacific people had the highest level of perceptions about cycling provision, studies have shown that bicycle usage rates among Māori and Pacific people remains significantly lower than for other ethnicities (Shaw & Russell, 2017).

Cycling provision perception was also investigated when normalised for the availability of bicycle infrastructure. The results illustrate that ethnicity and access to a bicycle are factors that shape the perception of people who live in areas with a poor level of bicycle infrastructure. Annual income, bicycle user type, and ethnicity were the factors that were found to influence people’s perception in areas with an excellent level of bicycle infrastructure. Ethnicity played a significant role in terms of cycling provision perception in areas with poor and excellent levels of bicycle infrastructure. For the areas with an average level of bicycle infrastructure, there is no significant relationship between the independent variables and cycling provision perceptions.

People's perceptions could influence planning for the provision of bicycle infrastructure and, therefore, could play a role in equity analysis. The current chapter has shown that cycling provision perception is more affected by factors such as ethnicity, education, and bicycle user type than objective measures of bicycle infrastructure provision. It has also shown that people with different backgrounds have different perceptions about the same level of infrastructure. Following the capabilities approach of justice (Sen, 2009; Pereira, 2017), focusing only on the provision of cycling resources such as bicycle lanes can be misleading, and socio-cultural factors such as ethnicity should also be considered in order to fairly encourage and empower all population groups to use bicycles. The results of this chapter suggest that "equity in cycling" should be a holistic system which considers "equity in the provision of cycling initiatives such as education and awareness" as well as "equity in the provision of cycling infrastructure". People need other motivations, in addition to bicycle infrastructure, and it is important to ensure equity is achieved in all aspects of cycling provision such as encouragement, awareness, skills, and more importantly, community-focused initiatives. Initiatives which address particular barriers for specific groups, could help improve equity in cycling. For example, Jones et al. (2020) and Russell et al. (2021) highlighted concerns about neighbourhood safety, addressing inadequate provisions to enable social cycling, and addressing a lack of adequate infrastructure to allow access to places of importance to Māori.

Consideration of individual perceptions could be critical in the development of cycling demand and supply indices and, ultimately, more equitable investment prioritisation – a step towards cycling equity analysis planning "with" people, as well as "for" people. Traditionally, equity in cycling has focused on the provision of cycling infrastructure to meet equity needs. However, as shown in this Chapter, bicycle infrastructure is not the only factor to shape equity policies and planning and we should consider all aspects of cycling and identify a comprehensive list of cycling initiatives and their role in improving equity in cycling. Therefore, the next chapter will identify all cycling initiatives in Auckland and discuss each initiative's target group and beneficiaries in order to analyse equity in cycling initiatives.

Chapter 5

Equity and cycling initiatives: a stakeholders' perspective on target groups, barriers to implementing cycling equity initiatives, and strategies to address barriers

5.1 Introduction

The preceding chapters showed that people need other motivations, in addition to bicycle infrastructure, to be encouraged to cycle, and it is important to ensure equity is achieved in all aspects of cycling provision such as encouragement, awareness, skills, and more importantly, community-focused initiatives. Initiatives which target particular barriers for specific groups could help improve unequal usage of bicycles and equity in cycling. Therefore, this chapter, using Auckland (New Zealand) as a case study, aims to identify the cycling initiatives and their role in cycling equity.

This chapter is structured as follows. First, the chapter provides some relevant background and outlines the research questions. Then, the research methodology adopted for this chapter is explained including study area and qualitative approach. This is followed by the results and thematic analysis of the interviews to answer the research questions. Finally, the results are discussed and conclusions are drawn.

5.2 Background

Active and sustainable mobility modes, such as cycling and walking are being promoted in many countries worldwide to help achieve health, environmental and societal goals through a reduction in reliance on private motorised vehicles. There are many types of initiatives aimed at improving cycling in cities. These cycling initiatives can be split into "hard" and "soft" measures. Hard measures are those cycling initiatives that influence cycling by improving the physical and built environment including the implementation of bicycle lanes, providing safer cycling infrastructure, establishing bicycle sharing systems, using specially designed trishaws to take older people on rides exploring their local area (Gray et al., 2022; Gray & Gow, 2020), and installation of bicycle self-repair stations (Mrkajić & Anguelovski, 2016) and public cycle pumps (Lam, 2018). Soft measures, on the other hand, include those cycling initiatives other than physical implementation, such as online blogs (Balkmar, 2020), community-focused initiatives (Hoffman et al., 2014; Batterbury & Vandermeersch, 2016), cycling promotion initiatives (Uttley & Lovelace, 2016), education about safe urban riding, using monitoring and evaluations to guide decision-making for cycling (Henry & Scott, 2017), and GPS tracking of cyclists for research purposes (Romanillos et al., 2016).

The adoption of cycling initiatives has become a key strategy in many countries for several reasons, including reducing reliance on private vehicles for mobility, environmental concerns and improving the safety of cyclists. However, little attention has been given to how resources allocated to cycling initiatives can be distributed fairly and equitably, in the sense that the benefits, as well as costs, are shared equitably across all members of society (Di Ciommo & Shiftan, 2017). There is a lack of consideration of equity in cycling, in particular during bicycle planning and decision making processes (Cunha & Silva, 2022). For example, a review of Canadian transport plans by Doran et al. (2021) indicated that most of the plans make limited or no effort to address and operationalize equity in cycling.

Equity in transportation can be discussed through the lens of distributive equity, procedural equity, or participatory equity (Pereira et al., 2017; Lee et al., 2017). In the cycling sector, distributive equity is a commonly used equity concept and typically investigates the distribution of cycling benefits and costs in society. Cycling equity can also be approached from different points of view, including social equity, spatial equity, or a combination of both (R. J. Lee et al., 2017). Equity needs to be considered for a number of different reasons: providing equitable rights and benefits of a service or programme for all, maximizing the welfare of the whole of a community, and improving outcomes for disadvantaged population groups (Thomopoulos et al., 2009). A recent comprehensive definition of cycling equity is "a situation where cycling is a safe, secure mode of travel that improves mobility and accessibility fairly, enabling all people to participate in socio-economic life" (Doran et al., 2021, p. 4). Critically, equity seeks fairness in society and this is the point of difference when compared with the concept of equality (Carleton & Porter, 2018; Pereira et al., 2017). 'Equal access to facilities and infrastructure' differs from 'equity in accessibility' as equal access does not consider the differences among population groups, with equity better considering the experiences of disadvantaged population groups. Although accessibility is one of the most commonly used measures for assessing equity in cycling, there is not a standardized method, principle or indicator to evaluate equity in cycling. Clearly, adequately measuring cycling equity is still in its early stages (Cunha & Silva, 2022).

As Chapter 2 showed, in cycling equity analysis, the equity measures used have primarily focused on hard measures and have typically considered equity in relation to the provision of cycling infrastructure. In order to discuss equity in cycling, previous studies focused on different criteria and methods, including the associations between socio-demographic characteristics and the availability of cycling infrastructure (Fuller & Winters, 2017; Pereira et al., 2017; Rodriguez et al., 2018; Deka & Connelly, 2012; Dill and Haggerty, 2009), the density of cycling routes (Pistoll & Goodman, 2014), availability, coverage, and connectivity of bicycle lanes (Braun et al., 2019), associations between accessibility to cycling infrastructure and socio-demographic characteristics using the deprivation index (Padeiro, 2022), the Gini coefficient (Wang & Lindsey, 2017), the Lorenz curve (Aman et al., 2021), Palma Ratio (Rosas-Satizábal et al., 2020), the Atkinson index (Zuo et al., 2020), and the Theil index (Hamidi, 2019). In all the aforementioned methods, accessibility to cycling infrastructure was the main indicator used to measure equity in cycling, and discussions were built upon the different levels of accessibility between the most and least deprived areas. Income, age, education, and ethnicity were the most used sociodemographic characteristics in cycling equity analyses (Cunha & Silva, 2022). The majority of studies that assessed and discussed cycling equity have focused on bicycle lanes (Deka & Connelly, 2012; Fuller & Winters, 2017; Houde et al., 2018; Winters et al., 2018; Tucker & Manaugh, 2018; Wang & Lindsey, 2017; Vanderslice et al., 2009) or bicycle sharing systems (Clark & Curl, 2016; Conrow et al., 2018; Duran-Rodas et al., 2020; Barajas, 2017; Hosford & Winters, 2018; Meng & Welch, 2018) as the main cycling provisions which should be distributed fairly.

The literature on cycling equity also contains a number of studies which discussed cycling equity from perspectives other than the "traditional" method of observing associations between accessibility to cycling infrastructure and sociodemographic characteristics. However, such studies remained focused on bicycle lanes and/or bicycle sharing systems. For example, Rebentisch et al. (2019) discussed the equitable distribution of safe cycling infrastructure by comparing crash rates among different population groups in New York. Another study in four U.S. cities (Chicago, Cincinnati, Philadelphia, Portland) discussed the influence of public participation in locating bicycle sharing system stations on the equitable distribution of these stations (Piatkowski et al., 2017). In another study in the U.S. context, the equity considerations of 56 bicycle sharing systems were evaluated by questioning the service providers about their equity policies (Howland et al., 2017). An investigation of equity consideration in planning and policy making processes in Santiago de Chile also evaluated cycling infrastructure development in different areas of the city to determine inequity in cycling (Mora et al., 2021). As reported by Cunha and Silva (2022), reviewing equity in the distribution of bicycle-related benefits showed that the majority of studies used quantitative approaches and considered the cycling network or bicycle sharing system in equity assessments. One of the most recent studies introduced a planning tool for assessing equity in cycling. They similarly focused on the distribution of cycling infrastructure and accessibility levels across distinct socioeconomic groups (Cunha & Silva, 2023).

In contrast, only a limited number of studies discussed the importance of cycling initiatives beyond bicycle infrastructure for providing equity in cycling. Reviewing literature focused on active transport equity, Lee et al. (2017) highlighted that studies commonly assess spatial equity but do not consider engagement of transportation-disadvantaged groups in the public participation and decision-making process, and that there was therefore a lack of consideration of their needs and preferences. As argued by Batterbury and Vandermeersch (2016) investing solely on cycle routes does not solve the inequity issue in cycling, and implementing cycling policies that consider the lived experience of disadvantaged communities should be a priority for government from an equity perspective. A qualitative study in Hackney, London explored the extent to which equity is considered in cycling policies (Lam, 2018). This study showed that, despite Hackney having a good reputation for bicycle usage rates, the cycling policies did not consider equity for race and gender appropriately. As argued by Lam (2018), "hard" and "soft" cycling infrastructure must work in tandem and soft cycling infrastructure, specifically those which focus on education and encouragement of cycling disadvantaged target groups, should not be ignored in cycling equity policies. Another study in England showed that even by increasing cycling infrastructure in more disadvantaged areas, the level of bicycle usage remained low. This suggests that focusing only on cycling infrastructure is not fair, since the influence of cycling infrastructure on bicycle usage could be different among different population groups (Tortosa et al., 2021). As Chapter 4 shown, availability of cycling infrastructure is not the main factor that influences people's perceptions of cycling, and that considering soft cycling infrastructure in policy making and planning could help improve equity in cycling. In reviewing Canadian transport plans, Doran et al. (2021) emphasised that in order to better achieve equity in cycling, it should be improved socially as well, and that solely focusing on spatial analyses could be misleading. The importance of empowering and engaging diverse communities, and avoiding relying solely on the provision of fair cycling infrastructure, was also mentioned in a number of other studies in the U.S context (Parker, 2019; Lugo, 2013; Barajas, 2020; Lusk et al., 2017).

As outlined above, while enhancement and extension of bicycle infrastructure is recognised as part of the solution to improving the uptake of cycling, other provisions have also been found to be effective, especially if they are targeted to suit the needs of particular communities (Vietinghoff, 2021; Lam, 2018). Specifically, cycling provision can also be related to a population group's differing needs. These might include education and awareness about the benefits of cycling, improving cycling proficiency, and consideration of the sociocultural factors which can facilitate bicycle use for particular population groups, for example, demands for social and family cycling and the need to access places of importance for specific communities (see Chapter 4). This perspective of equity in cycling is in line with the message of the capabilities approach of justice, suggesting that focusing only on the provision of cycling infrastructure, such as bicycle lanes and bicycle sharing systems, can be misleading (Sen, 2009; Pereira et al., 2017). It can also result in other cycling initiatives being ignored due to the considerable importance of cycling infrastructure. The capabilities approach has recently gained increasing attention in the transport literature and, as Beyazit (2011) explained, its utilisation in transport opens an avenue to discover people's unique expectations and the way that transport systems can meet these expectations and enhance their capabilities. The capabilities approach considers the achievement that individuals could have based on the provisions rather than the level of access to those provisions. It also considers the diversity of people's perceptions, needs, and constraints in their travel choices (Hananel & Berechman, 2016; Pereira et al., 2017; Ryan & Pereira, 2020). Based on the capabilities approach in transport concept, the ability to convert the benefits of transportation into valuable functioning is not the same for all, suggesting that improving accessibility to cycling infrastructure does not necessarily improve people's access to valuable opportunities (Lira, 2019). In particular, based on the capabilities approach, the wide diversity of individuals and the way in which the distribution of transport resources could differently affect people's opportunities due to their personal features, aspirations and choices should be considered (Vecchio & Martens, 2021). Applying the capabilities approach to the concept of cycling equity explains that people with different sociodemographic characteristics may receive the same cycling provision, however the ability to convert these resources into actual freedoms would be different based on their various sociodemographic characteristics. Therefore, not only does the influence of cycling infrastructure on bicycle usage differ for all, but cycling infrastructure should not be the only provision to empower people to cycle. Focusing only on hard (spatial) cycling infrastructure and ignoring soft (social) infrastructure could, therefore, diminish equity in cycling.

Despite the emphasised importance of considering cycling initiatives beyond infrastructure in cycling equity assessments in the literature, currently there is limited understanding about aspects of equity in cycling initiatives other than bicycle lanes and bicycle sharing systems in relation to specific target groups. With better understanding, cycling initiatives could target different population groups, resulting in a fairer distribution of resources. Cycling initiatives should be comprehensive and consider various aspects of cycling to address cycling inequities, as focusing only on one aspect could be misleading. It is therefore important to identify current cycling initiatives, understand their target groups or resulting beneficiaries, and evaluate them with respect to equity.

Another challenge is the successful implementation of policy. For example, there could be barriers preventing councils from implementing cycling equity initiatives in practice. As suggested by Doran et al. (2021), highlighting the barriers to implementing these policies could help planners and decision makers improve the practicality of cycling equity initiatives. One study (May et al., 2006), divides the barriers into four main categories: legal and institutional, financial, political and cultural, and practical and technological. In comparison, Banister (2005) divides barriers into five groups with respect to measures towards sustainable mobility, namely: resource barriers, institutional and policy barriers, social and cultural barriers, legal barriers and unintended outcomes. Barriers to implementation of cycling equity initiatives specifically in relation to practice have yet to be considered, and this remains a gap in the literature.

5.3 Methodology

5.3.1 Study Area: Auckland, Aotearoa New Zealand

Auckland is one of the most culturally diverse cities in the world, spanning more than 220 ethnic groups, with four in ten Aucklanders having been born overseas. Auckland and its surrounding areas are home to 60 percent of the country's indigenous population, Māori, and boasts the largest Polynesian population in the world (World Population Review, 2021). The city has the lowest overall cycling rates amongst the large cities in New Zealand at 0.4%. In comparison, cycling rates are 3.6% for Christchurch, 1.9% for Tauranga, 1.4% for Wellington, 1.3% for Dunedin, and 1.1% for Hamilton (Shaw & Russell, 2017). Differences in cycling rates between cities can be partly attributed to differences in topography, but also the geographic extent of the city and urban compactness.

5.3.2 Qualitative approach

To address the research objectives, this chapter uses a qualitative approach. First, the goal is to identify and list current cycling initiatives in Auckland, and to discuss their effectiveness from the point of view of policymakers, decision-makers, planners, designers, and transportation professionals. Then, potential additional initiatives are investigated, along with barriers to implementing cycling equity initiatives in practice. Finally, possible solutions and enablers to address those barriers are discussed. Semi-structured interviews are used for this purpose. The specific study participants were transportation professionals with expertise in cycling provision with at least three years of experience in the transport sector. Participant recruitment was a combination of direct recruitment and snowballing. Potential participants were contacted via an invitation email, and continued to be recruited and interviewed until data saturation was reached. The invitation email requested that potential participants forward the email to other potential participants who they thought would be interested in participating. Interviews were conducted during June and July of 2022. The interviews lasted around 60 minutes and were audio-recorded and then transcribed by the researchers. The total number of participants was nine based on data saturation. No further initiatives were identified by the seventh interview, and no new insights were provided by the nineth interview. Among the interviewees, five of them were female and four of them were male. One of the interviewees worked for a not-for-profit organisation and the remainder worked in government organisations related to the transport sector. Detailed information about the participants is not provided in order to maintain confidentiality and anonymity of the participants.

The semi-structured questions used in the interviews were as follows:

1. What are the current cycling initiatives in Auckland designed to motivate people to cycle?
2. Do you consider this initiative to be more or less effective for any specific community or demographic?
3. What current definitions, metrics, and policies are used for equity in cycling in Auckland?
4. Are there other potential cycling initiatives, not currently being implemented, that you can think of that could be implemented to encourage the uptake of cycling?
5. What are the barriers to implementing cycling equity initiatives in practice? What are some of the strategies you can think of to address these barriers?

A thematic analysis approach was used to analyse the content of the interviews. Thematic analysis is widely used in qualitative studies, and is applicable across a wide range of subjects because of its flexibility, enabling scholars and researchers to apply multiple theories to this process for different subjects (Braun and Victoria, 2006). Also, it makes interpretation of themes supported by data more convenient (Guest, 2012), and facilitates categorization based on data (Saldana, 2009). As guided by Braun and Clarke (2006), the following steps were applied in this study for reading the transcriptions, making notes, and identifying the patterns:

1. Data familiarization including transcribing voice recording of interviewees, reviewing transcripts, making notes and developing ideas.
2. Developing initial codes.
3. Scanning the interview transcriptions for themes and sub-themes in line with the research aims.
4. Reassessing themes/sub-themes: Initial themes/sub-themes are reassessed for their relevance, significance and distinctness from other themes/sub-themes.

Figure 5.1 illustrates the themes and sub-themes identified from the thematic analysis.

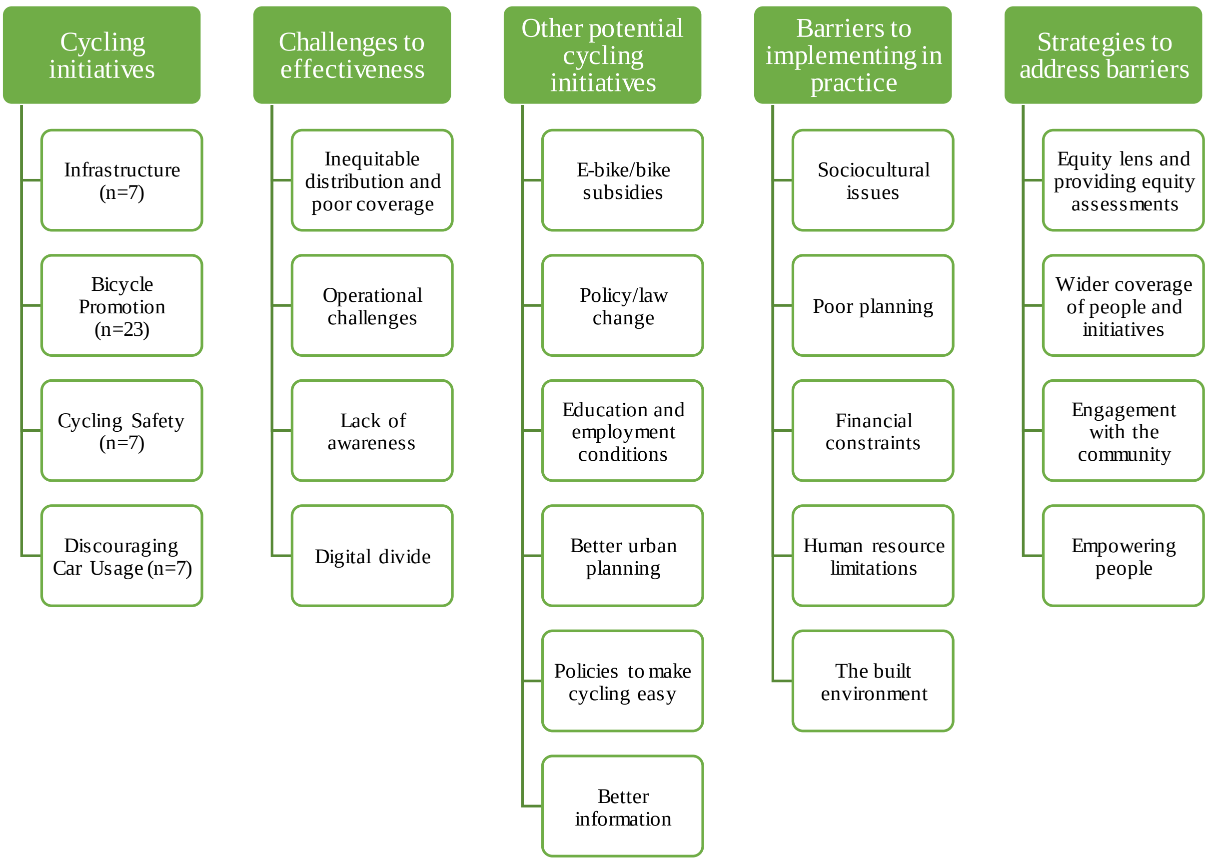

Figure 5.1. Themes (shaded) and sub-themes

5.4 Results

5.4.1 Current definitions, metrics, and policies for equity in cycling in Auckland

On the basis of the interviews carried out with policy makers, decision-makers, planners, designers, and transport professionals, there is no definition, metric, or policy specifically aimed at equity in cycling in Auckland. One of the interviewees mentioned that as an equity initiative, they used to count the number of cyclists and monitor gender for the purpose of understanding gender inequalities. However, equality and equity are different concepts, and it would therefore appear that a clear understanding of cycling equity is lacking. Another of the interviewees believed that they should *"have a specific cycling equity policy or framework or strategy"* but that *"it is [currently] missing*".

According to the interviews, there are some challenges related to policies on funding that affect the implementation of equity related policies. These primarily relate to the allocation of the funding which is set by central government. They believed that "*Central government have to make some policy changes on funding* ". From the viewpoint of the interviewees, the problem is about "*how the funding is allocated from the government"*. Their view is that *"it is very limited"* and that most of the money that they get is "*safety-related"*. Indeed, it could be argued that funding is the most important driving factor for implementing equity in cycling, and that without sufficient funding transport professionals feel that their "*hands are tied"*.

5.4.2 Current cycling initiatives and their target groups or resulting beneficiaries

Table 5.1 presents a summary of the main initiatives identified through the thematic analysis of the interviews, as well as the specific target groups or resulting beneficiaries for whom the initiatives were intended. In total, 44 different initiatives were identified, categorised into four main groupings based on thematic analysis and a review of the relevant documents within the transport sector. The first one is Infrastructure (incorporating seven initiatives) which relates to initiatives that provide or improve bicycle infrastructure such as bike lanes, bike parking, public end-of-trip facilities. The second is Bicycle Promotion (incorporating 23 initiatives) which relates to initiatives that promote and encourage bicycle usage. The third is Cycling Safety (incorporating seven initiatives), which includes initiatives that attempt to raise safety in cycling. The fourth, and last, category is Discouraging Car Usage (incorporating seven initiatives), which relates to initiatives that try to limit car usage in order to increase bicycle usage and public transport ridership. From Table 5.1 it is clear that a considerable number of initiatives target current cyclists, while only a few initiatives target non-cyclists, potential cyclists, and current car users. There are also a number of initiatives, albeit limited, which target lower socioeconomic groups specifically, including the e-bike trial/library, bike hubs, skills training in schools, and the community bike fund. There is only one initiative designed for women and the elderly. There are no targeted initiatives aimed specifically at population groups with lower bicycle usage rates.

Table 5.1: Implemented cycling initiatives in Auckland

Code	Cycling initiatives	Target groups or resulting beneficiaries
	Infrastructure	
IN1	Cycle network development: Cycle paths, on-street cycle lanes, shared paths (e.g. Northern Corridor cycling improvements, Henderson cycling SSBC (Single Stage Business Cases) priority one routes, Connected Communities routes, etc).	Higher income people with higher level of education who are traveling to or from the CBD and surrounding or that live in the area
IN2	Traffic calming and street redesign: Low traffic neighbourhoods, low speed neighbourhoods.	Less confident cyclists
IN3	Public cycle parking: Public cycle parking at key locations (secured with CCTV (closed-circuit television) where necessary).	Cyclists, potential cyclists, and non-cyclists
IN4	Bike security – 5am to 9pm garage, bike lock amnesty, etc: A wide programme of bike security initiatives including serial number registration and a bike lock swap	Cyclists
IN5	Public end-of-trip facilities: Public showers, changing rooms, lockers, workshops for registered members.	Cyclists
IN6	Minor Improvements: Minor improvements on the existing network to improve safety and enhance capacity. Pop-up protection program: A programme to add protection to existing cycleways	Cyclists, potential cyclists, and people who are more risk-averse
IN7	Implement more bus lanes: Likely on dual carriageway-arterial roads to support confident cyclists	Cyclists
	Bicycle Promotion	**Target group**
BP1	Bike (and scooter) share: Pay as you go bike and scooter share schemes	People who commute in CBD area and areas that the company can make money.
BP2	Bikes on public transport: Bikes on buses, trains, and ferries.	Cyclists and especially for those who cycle a long distance and are willing to change their mode of transport
BP3	Cycle monitoring: Cycle monitoring framework to capture more fit-for-purpose data related to cycling and micromobility	Everybody
BP4	Marketing and promotion: Marketing campaigns to normalise cycling and encourage uptake.	Everyone
BP5	E-bike trial / library: Scoping what an Auckland-wide free e-bike loan could look like for behaviour change. Supporting other research such as Māngere e-bike trials	Low to middle income people, people who know how to cycle but are less experienced
BP6	Pit Stops:	Cyclists

	Pop-up Pit Stop events to provide free bike safety checks, minor maintenance work and to engage customers.	
BP7	Community led Initiatives: Support community groups with the design, delivery and/or funding of their bike related activities.	Everybody
BP8	Bike Hubs: Support the expansion of community bike hubs at key locations across the region to divert bikes from landfill, carry out basic repairs to make them safe and usable and distribute to local communities. Bike hubs	Everyone, regardless of having a bike. Can also help to address some of the socioeconomic barriers
BP9	Bike Burbs: In partnership with Bike Auckland provide capacity building support to cycling focused community groups to empower and grow.	Cycling enthusiasts or advocates
BP10	Bike challenge/ gamification: A challenge traditionally being hosted in February to encourage cycling. Now looking to be expanded in a wider gamification platform for year-round encouragement.	Younger people, cyclists, fitter people, and people with access to mobile phone and internet services
BP11	Community Bike Fund: Administer a contestable grant fund for non-profit groups to apply for community-based cycling events and activities	Lower income communities
BP12	The journey planning mobile app: Ongoing development of the walking and cycling functions of the journey planning mobile app and Website tool	Everybody with access to technology (mobile phone, internet, etc.). Young children and the elderly would be disadvantaged
BP13	Skills Training in Schools: Grade 1: Provide basic off-road skills training to 5-6 children in schools. Grade 2: Provide basic on-road skills training to year 7-10 children in schools	Kids, particularly from low socioeconomic backgrounds
BP14	Bikes in Schools: Support the expansion of Bikes in Schools by funding an Auckland coordinator.	Kids
BP15	Community based cycle skills training: Kids Learn to Ride drop-in events, adult Bike Skills, and basic bike maintenance courses.	Less confident cyclists or people who have never ridden a bike before but own a bike
BP16	Wayfinding: improving signage and infrastructure for finding cycleways	Cyclists and potential cyclists
BP17	PJP- personal journey planning: Residential door knocking journey planning	Everyone
BP18	Travelwise Choices: Formal B2B programme offering travel planning and a wide variety of incentives to get staff traveling better.	Everyone who works
BP19	Guided tours – general or specific for communities: Guided e-bike rides for public and business, specific tours through partnerships with the community.	Everyone
BP20	Awareness of and encouragement to use cycleways: Activations and events to celebrate new and existing infrastructure.	Cyclists
BP21	Workshops for design activations (co-design) with communities: A new process to help co-design with communities how we activate areas and infrastructure in collaboration.	Everyone
BP22	Bikes for refugees/immigrants	Refugees

BP23	Bikes for disabled people	Disabled people
	Cycling Safety	**Target group**
CS1	Cycle lane enforcement: Enforcement to keep facilities clear of obstructions (e.g. bins)	Cyclists
CS2	Speed limit reductions Enable Road Controlling Authorities to reduce traffic speed limits in a more efficient manner.	Everybody, but in particular less confident cyclists.
CS3	Road rule changes: Road rules changes recommended by Cycling Safety Panel (e.g. automatic liability for hitting cyclists and allowing cyclists contraflow down one-way roads).	Cyclists
CS4	Vehicle regulations: Investigate changes to vehicle regulations recommended by Cycling Safety Panel –mandatory truck side-under-run protection and other vehicle safety features.	Cyclists
CS5	Road speed limit enforcement: Greater traffic speed enforcement to promote road safety	Everyone
CS6	Driver-cyclist interaction policing: A wider reaching communication (wider than the council led 'Bikelash' programme).	Cyclists
CS7	Lighting improvements particularly in parks and offroad areas (dark spaces)	Women, younger people, the elderly, or indeed anyone who may feel vulnerable without adequate lighting
	Discouraging Car Usage	**Target group**
DC1	Parking management (off and on-street): Employ parking management tools including time limits and priced parking to optimise parking utilisation.	Everyone
DC2	Street and cycle facility design standards: Design standards for street and cycle facilities (e.g. AT Transport Design Manual (TDM), Cycling Level of Service (LoS) tool, cycle facility design standards/ LoS tools etc.) to ensure cycle facilities meet customers' needs.	Everyone
DC3	Consultation for programme and projects: Apply an enhanced approach to public consultation that incorporates the broader behaviour change programme (i.e. Pre-Priming, Priming, Activating and Embedding Change phases)	Everyone
DC4	Road pricing: Congestion charging in areas with transport options.	Car users
DC5	Parking pricing: Increase the cost to park in areas with potential for high uptake of bike trips.	Car users
DC6	Vehicle taxes: Increase the cost of less sustainable vehicles and fund more sustainable modes.	Car users
DC7	Fuel taxes, Road User Charges: Increase the cost of less sustainable vehicles and fund more sustainable modes	Car users

5.4.3 Challenges to effectiveness

A number of challenges were discussed in the interviews in relation to the effectiveness of the initiatives. The challenges discussed in the interviews can be split into four main groups: inequitable distribution and poor coverage, operational challenges, lack of awareness, and the digital divide.

5.4.3.1 Inequitable distribution and poor coverage

The spatial and social distribution of cycling initiatives was found to be a significant challenge. In some cases, the spatial distribution was better in more affluent areas, and in other cases initiatives needed to be spatially and socially distributed more widely. For example, based on the respondents' perceptions, the distribution of public end-of-trip facilities is currently not equitable. Such facilities are expensive and, while they are available in some businesses, "*there are some communities that won't have these types of facilities unless they are provided by [a public] agency".*

Bike share systems in Auckland also appear to be inequitable in terms of spatial and social distribution. One of the most common equity challenges for bicycle sharing systems is the fact that these systems are managed by the private sector and their incentive is to provide the best efficiency in the system in terms of making a profit. Therefore, they are "*going [to focus on] areas where money is going to be made".* Another challenge, given that the bikes are left unattended when not in use, is theft and vandalism. Therefore, operators will focus on areas where "*their bikes are going to be safe"* and *"they won't have to constantly be replacing inventory".*

Pit stops are also not distributed fairly, based on the respondents' perceptions. The problem with pit stops is that they are usually implemented "*in the same few places",* typically *"where people are already cycling as commuters*". Therefore, it seems encouraging potential cyclists or non-cyclists is not currently a focus in the implementation of pit stops.

The Bikes in Schools programme (providing bicycles for kids in schools), also seems to have some equity challenges. Uptake of the Bikes in Schools initiative depends on the facilities that schools have and "*it's probably slightly better for schools that [have sufficient] resources and capability to engage*". Therefore, some schools are disadvantaged in the programme.

The attainment of equity in community-based cycling skills courses depends on the "*location of where these courses take place and who might have the time to do these courses".*

For example, someone that works, has multiple jobs, has children to support and look after might not have the time to participate.

Another equity challenge relates to adequate temporal distribution of certain initiatives, such as skills courses. For example, they could be run during the week and are therefore not feasible for everyone to attend.

5.4.3.2 Operational challenges

Operational challenges of cycling initiatives were also raised in the interviews. For example, carrying bikes on public transport is allowed, in theory, albeit currently only on trains and ferries. However, in practice there are challenges with respect to adequate capacity on public transport, especially during peak periods, whereby "*how many they can actually fit on there….. is at the discretion of the staff*". Further work is needed in terms of policies so that they can *"really say, yes, we want bikes on these modes".* Also, equipping buses with the space for bicycles would definitely encourage cyclists to use their bicycles for more integrated journeys and, potentially, encourage non-cyclists and potential cyclists to use their bicycles.
Interviewees also believed that Cycle lane enforcement "*is not happening*" adequately, and that while tools are provided for Street design standards they are *"not confident that they're helping*" - because there are too many. Finally, from an operational perspective, the general view was that public consultation with respect to initiatives *"needs to be a bit more proactive about how do you actually reach out to people and who you're actually getting that engagement with"* to ensure that it is equitable.

5.4.3.3 Lack of awareness of cycling initiatives

Sometimes the challenge is a lack of awareness. For example, with respect to the Bike fund, people can lose a great opportunity to participate in the program "*if [they] miss the promotion, if [they] don't hear about it*". Similar concerns were raised for travel-wise choices.
Poor promotion and marketing coverage was another challenge for the initiatives. According to the interviewees, promotion and marketing of the initiatives should be dispersed more widely (geographically), and "*it needs to be just in your face, on the TV stations, on the radio*", so that no one misses out because they were unaware it was happening.

5.4.3.4 Digital divide

A lack of access to technology, a digital divide, can be challenging with respect to achieving equity in cycling initiatives. For instance, interviewees think that in order to have a better Bike

Challenge programme, policy makers and others need to address the digital divide issue and they "*need to find a way to partner with a digital partner to help provide that digital piece for people that want to participate*". The Digital divide was also identified as one of the challenges for the journey planning mobile app. One interviewee went so far as to say that the technology *"needs to be supplemented....with paper maps*". At the end of the day, the digital divide seems to be an unavoidable challenge for initiatives that rely on any digital tool, and will result in people "*missing out [if they] are not using those tools*".

5.4.4 Other potential cycling initiatives

In addition to the existing cycling initiatives, the interviewees identified a number of additional initiatives that could be implemented to aid in achieving equity with respect to cycling. As shown in Figure 5.2, these have been split into six sub-themes using thematic analysis. Of the six sub-themes, four can be included in the previously identified categories (Education, Policies to make cycling easier, E-bike/bike subsidies, and Policy/law change), while two are new (Better urban planning and Better information).

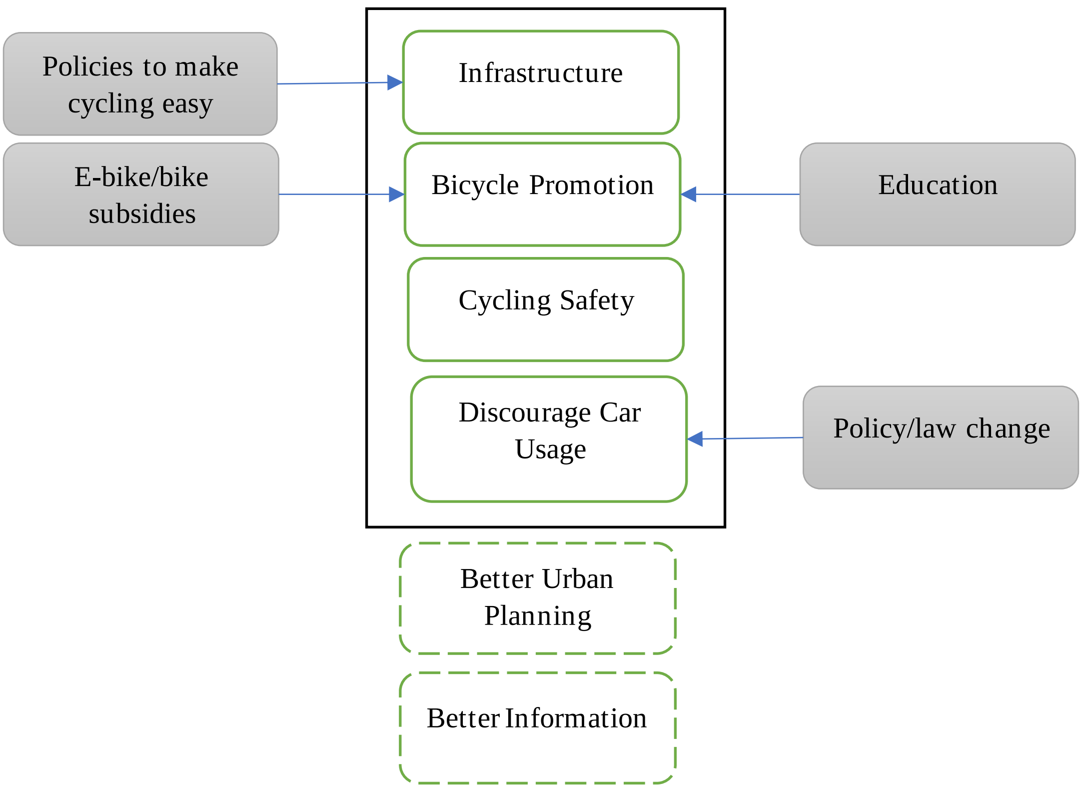

Figure 5.2: Other potential cycling initiatives

E-bike/bike subsidies

E-bike/bike subsidies were seen as a promising initiative, because access to bikes is one of the key barriers to cycling due to the cost, particularly for the e-bikes. Although e-bike trials do exist there isn't *"a programme to really subsidise people buying e-bikes"*. One suggestion was to extend it to "*trade in a vehicle to get a higher subsidy for a cargo bike*[6] *or something like that"*. Bike subsidies could be private or government-funded and it *"would mean that more people could afford to purchase bikes"*. Other suggestions included "*partnering with different bike-share programmes*" to subsidise bicycles, and to promote recycling of second hand bikes, given that "*there are plenty of bikes out there that could be fixed up and handed out to the community*". Interestingly, one participant did express doubt over whether bike subsidies work as an equity initiative based on experience with a number of large companies and organisations that offer bike/e-bike subsidies to their staff.

Policy/law changes

Changes to some of the existing cycling policies and regulations could help to address equity issues in cycling. For example, the ability to "*slowly roll through a crossing [on] a red light [during the pedestrian phase] if you are on a bike"* could be a key effective factor for cycling and could *"improve their efficiency*". Also, changes in the fringe benefit tax could help cycling and public transport. Currently, people "*don't have to pay fringe benefit tax on parking spots",* however, they do for *"employee benefits for public transport or cycling. That should change".*

Education and employment conditions

Improved education was identified as one of the initiatives that could help improve cycling equity. One participant suggested adding lessons to the school curriculum to teach children about the benefits of cycling, similar to how "*driving lessons or home economics used to be taught"* . Educating young people about the benefits of not becoming car-dependent and avoiding "*so much focus around young people getting their driver's license"* was suggested as an idea for improving cycling equity.

[6] A cargo bike (also known as a box bike, carrier cycle, freight bicycle, cycle truck, or freight tricycle) is a human-powered vehicle, designed and constructed specifically for transporting loads.

There are many businesses that require their staff to have a car, or be able to drive, as part of the hiring process and "*if workplaces removed these requirements, or even incentivised biking to work, it would be much more equitable and would help incentivise more people to bike*". Increasing the budget provided to "*The school cycle Skills Training Program [which] has a small budget"* could also help influence cycling equity. Overall, educating young people and businesses as to the repercussions of car dependency, adding cycling lessons to the school curriculum, and increasing the budget for teaching cycling skills in the schools could help achieve cycling equity.

Better urban planning

Better urban planning could help improve cycling equity. Designers and planners "*need to improve urban design [by] stopping green field developments unless unavoidable*". In addition, changes in transport planning and network planning could help to encourage bicycle usage. One participant believed that everyone could be encouraged to cycle "*if we had a greater remit to reallocate space on the transport network and had less car-focused planning and projects, and a greater focus on people movement via sustainable modes*".

Policies to make cycling easy

Policies to make cycling easier was also suggested to address some of the inequity issues. One of the interviewees' believed that "*people are psychologically lazy and take the easy option [and this has resulted in infrastructure] designed to make cars the easy option*". Car-free days would encourage people to use bicycles and decrease car usage. This initiative is an example of a *"smaller scale initiative",* which could gain traction and result in *"removing vehicles from the road"* which in turn would *"help to make cycling much more attractive*". Another suggestion is to make the cycling environment easier for children and *"complete the cycle network to enable all children in Auckland to be able to cycle to and from school safely".*

Better information

Having *"enough information [which could be related] to monitoring*" of bicycle usage and cycling equity is another suggestion for achieving equity in cycling. Sufficient monitoring of bicycle usage could help addressing equity issues by detecting disparities.

As a summary of this whole section, e-bike/bike subsidies, policy/law changes, education and employment conditions, better urban planning, policies to make cycling easy, and better information were identified as potential additional cycling initiatives that could help improve cycling equity in Auckland.

5.4.5 The barriers to implementing cycling equity initiatives in practice

This section presents the barriers to implementing cycling equity initiatives in practice, extracted from the interviews. As shown in Figure 5.3, five sub-themes were identified as barriers on the basis of the thematic analysis, including 'sociocultural issues', 'poor planning', 'financial constraints', 'human resource limitations', and the "built environment'. These have been identified as barriers in relation to both current and potential initiatives. The quotations below provide examples of what interviewees mentioned as potential barriers.

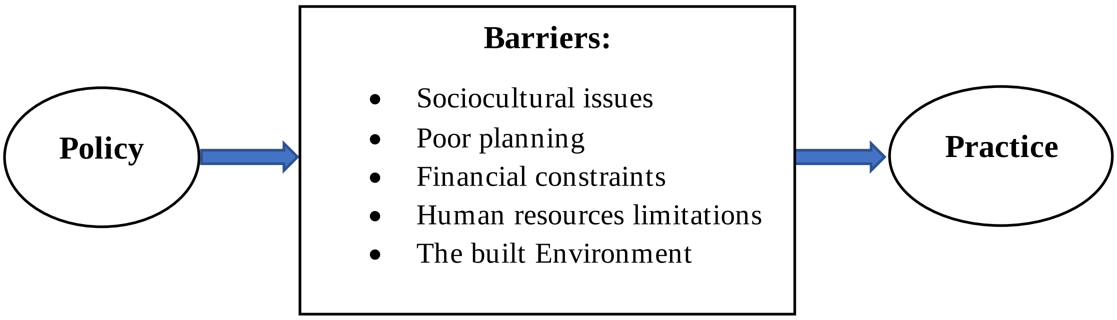

Figure 5.3: The barriers to implementing cycling equity initiatives in practice

Sociocultural issues

One of the barriers to implementing cycling equity initiatives was historical racism and working in a colonised system. For example, policy-makers, planners, designers, and transport professionals "*have to deal with the fact that the system that [they] are working in is a colonised system with [ingrained] racism and historical violence".* This has led to pushing certain communities into areas with underdeveloped transport infrastructure where the car is still the only available option. Therefore, every initiative implemented could be advantageous to privileged groups and unfavourable to disadvantaged population groups. For example, *"raising the fuel tax is inherently regressive (just as GST is) and …[it] is inequitable".* It seems paying attention to historical reasons and *"looking to those historical reasons to address their effects"* might help address inequity.

People's perceptions and awareness could also be barriers to implementing cycling equity initiatives, as "*some groups don't want to cycle or won't cycle at all or it is not in their culture to cycle"*.

Perceptions of parents about children's *"safety"* can also influence bicycle usage amongst children . People have become very "*risk-averse*" with how their kids travel to and from school.

From the viewpoint of the interviewees, some people do not think about equity, and it is in doubt whether *"they quite understand what it means*".

Poor planning

Poor planning could be a barrier to implementing cycling equity initiatives. For example, planning for e-bike subsidies should consider differences in people's income levels. For example, a previous e-bike subsidies trial was implemented in Auckland that targeted an "age *group that may not be able to afford e-bikes"*.

One of the issues related to planning is that it is *"not as proactive as it could be. It's more reactive",* with planners and policy makers *"waiting for [people] to come to [them]".*

Policies need to have balance with respect to being both simple and practical. One of the key barriers in equity is the balance between having a very simple program that is easy to roll out, and easy to get across the line without many roadblocks for people to be able to access, while still achieving targeted, equitable outcomes. *"That's why so many of the big ideas, like e-bikes for all, have to come from a wider paradigm shift in society".*

Financial constraints

Many of the interviewees believed that funding and prioritization are significant barriers to implementation of cycling equity initiatives. Financial problems/limitations is a reason that some parts of the city are left out. Policymakers and transport planners "*can't deliver all projects and initiatives needed everywhere".* Therefore, there is always going to be a street or a community or a town centre that is left out until there's money available for that area. There is a trade-off decision in Auckland for spending the limited funding. Overall, there is *"limited funding",* and policy makers and transport planners are starting from a *"low base".* Therefore, they have to make trade-off decisions about who they are targeting. The trade-off is that they should weigh up the value of getting quick uptake on cycling (the low hanging fruit) versus providing everybody with equal access to cycling, or preferably providing better access for more vulnerable, lower-income, disabled people, etc. The current strategy that policy makers and transport planners in Auckland have is *"to try and build a core [base] of use".* They encourage the early adopters, and everybody else will join later.

An important challenge could be the priorities between various needs in more disadvantaged areas: "*The elected representatives in places like South Auckland would argue that there are a lot of issues lower income communities face that are perhaps more important than cycling infrastructure".* There are many areas that currently have problems in *"health services, education services, and public transport".* Those are things that probably generally would be *"ranked higher in priority than cycling infrastructure*". Therefore, "*fundamental needs*" are understandably a priority compared to improving the cycling environment.

Human resource limitations

The current capacity for human resource and skills could be a barrier to implementing cycling equity initiatives in practice. Language skills could be one of the resources. Currently, in transport planners' teams they have English speakers, but they don't have people *"that are fluent in Te Reo Māori, Chinese or any of these other languages of the different groups that [they] want to be targeting".* It can be said that they do not have the *"capability to be able to talk to different groups".*

Expanding the team responsible for cycling could also help better provide equity in cycling: "*We are such a small team, we have only focused on targeting 100 or more businesses, which are primarily in the CBD area*". It seems they could do better if they had the capacity in their team to be able to work with different groups or different universities or communities, but *"[they] are so busy working with businesses at the moment*". Having "*the right skill set"* to work on cycling equity could also be helpful for achieving cycling equity.

Built environment

Urban design and housing density could be a barrier to implementing cycling equity initiatives. South Auckland is a good area for riding a bicycle. It is flat, without hills, and with wide roads. However, use of active modes is not that popular for many reasons, including *"relating to* *housing density and relating to when and where people work".* Cycling infrastructure provision is primarily focussed on the CBD and surrounding areas, where the wealthier people live and work. However, for people in South Auckland *"there are very few options for them to get to work other than driving early in the morning".* Therefore, it can be argued that disadvantaged populations are not being served well. However, the fact is that areas such a South Auckland are very dispersed, densification not being a factor due to the distance from the CBD and other business areas, and providing sufficient infrastructure coverage is always going to be a challenge economically.

5.4.6 Strategies to address the barriers

This section reports on the strategies suggested by the interviewees to address barriers to successfully implement cycling equity initiatives. As shown in Figure 5.4, four sub-themes were identified through thematic analysis. Interviewees, only in a very limitedly way, mentioned strategies to address the barriers. The quotations below provide examples of some of the strategies mentioned.

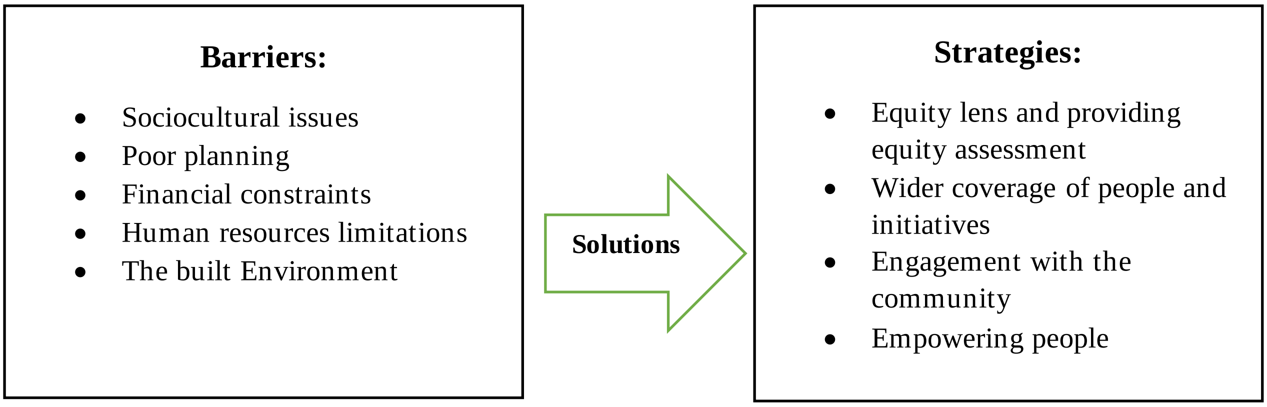

Figure 5.4: The strategies to address the barriers

Having an "*equity lens*" in cycling initiatives is one of the strategies suggested to address the barriers, so that *"they are not too focused on one specific [advantaged] location or one specific [affluent] socio-economic group*". Another strategy could be bringing equity into the assessment tools so that *"project teams run that lens across their options*". In addition, a wider variety of trips need to be considered and focusing only on commuting be avoided. Historically, cycle development has been quite focused on the commuter trips to and from the city centre, however, planners and policy-makers are currently *"looking at a wider variety of trips like* *people getting to school and to the local shop, and the post office*". In addition, having variety of cycling initiatives for population groups and avoiding *"one size fits all"* is an important strategy. Cycling initiatives should not be solely about infrastructure. While a considerable amount of funding is going towards protected cycle facilities, policymakers and planners should know that it is not the only barrier to people's cycling and they also need to invest in *"cycle parking and initiatives like cycle skills training, and marketing".* One suggestion is for planners and policymakers to consider a balanced range of initiatives and not only focus on one solution. Engagement with a wide range of community groups and stakeholders is a strategy which can address barriers and "*certainly helps to bring a more balanced perspective*". One of the strategies suggested to address barriers was supporting people in their communities and "*mapping out what those areas are and what kind of capability [policy-makers and planners] would need in order to reach those groups".* Policymakers and transport planners should identify champions and they can support people in their communities to help be those champions because it is important for people *"to take more ownership of their local area and transport in their area*". The last strategy which was discussed in the interviews was empowering people to help improve cycling equity. One of the interviewees believed that *"there are plenty of people out there wanting to help"* and that success would require finding "*the right people, motivated to do the right thing for altruistic reasons".*

5.5 Discussion

This chapter aimed to identify the cycling initiatives currently being implemented in Auckland, along with their intended target groups or resulting beneficiaries. The chapter also investigated equity issues in cycling initiatives, other potential initiatives not currently being implemented, barriers to implementing cycling initiatives in practice, and possible solutions to address these barriers.

This section discusses the results, departing from the five research questions presented in the introduction. Firstly, this chapter attempted to uncover definitions or/and metrics with respect to equity in cycling in Auckland. From what we understood from the interviews, there is no clear understanding of definition of, or metric for, cycling equity. Although there have been some efforts made in the transport sector to address cycling inequity issues, a lack of a clear definition and metrics and a lack of a systematic plan, with priorities for funding and capabilities, results in challenges and barriers to addressing cycling equity. As argued by Cunha and Silva (2023), one of the key reasons behind the inequitable distribution of cycling provisions is the lack of knowledge about the equity-oriented measures and methods during planning and decision-making processes. Lam (2018) also showed that poor understanding of equity by policy makers and planners was one of the reasons for an inequitable cycling environment.

This chapter identified the cycling initiatives currently being implemented in Auckland, along with their intended target groups or resulting beneficiaries. The chapter also investigated equity issues in cycling initiatives, other potential initiatives not currently being implemented, barriers to implementing cycling initiatives in practice, and possible solutions to address these barriers. All the findings were extracted from the opinions of policymakers, decision-makers, planners, designers, and transport professionals. However, understanding the viewpoints of population groups in terms of cycling initiatives could add invaluable knowledge to appropriately target population groups, in particular those with lower bicycle usage and with more barriers to bicycle usage. Therefore, the next chapter evaluates the effectiveness of cycling initiatives in Auckland from the point of view of population groups and compares those with stakeholders' opinion in this chapter.

Secondly, based on the interviews, this study identified 44 different cycling initiatives currently being implemented in Auckland. These can be categorized into four groups consisting of 1) Infrastructure, 2) Bicycle Promotion, 3) Cycling Safety, and 4) Discouraging Car Usage. Looking at the cycling initiatives, 14 of the initiatives specifically targeted current cyclists and confident cyclists while five targeted less confident cyclists. Among the initiatives, the e-bike trial/library, bike hubs, skills training in schools, and the community bike fund targeted lower income population groups. Only one initiative (lighting improvements) targets women, younger people, and the elderly. A recent study investigating the health benefits of active transport in New Zealand suggested that such benefits are not evenly distributed across the population. Specifically, while Māori receive significantly fewer health benefits from cycling generally (Bassett et al., 2020), the relative benefits are higher when they partake (Jones et al., 2020). Amongst the various ethnic groups, European New Zealanders and males are the most likely to use a bicycle in New Zealand, while Pacific peoples are the least likely (Shaw & Russell, 2017).

Thirdly, this study highlights a number of challenges to effectiveness in some areas, including inequitable distribution and poor coverage of cycling initiatives, operational challenges, a lack of awareness, and the digital divide. Equity in some of the initiatives depends on their locations and coverage. It seems that the spatial distribution of some of the initiatives is not currently equitable in Auckland. There are some reasons for this inequitable distribution, including lack of sufficient funding, prioritization of funds, and a lack of adequate human resource. Many of the initiatives remain focused on the CBD and surrounding affluent neighbourhoods. Some of the initiatives, such as facilities at the end of trips (shower, lockers, changing room, etc.), are in principle for everyone but are not equitably distributed.

A common finding of previous studies also shows that bicycle infrastructure is not equitably distributed among different population groups. It is typically reported that there is lower access to bicycle infrastructure amongst disadvantaged populations (Flanagan et al., 2016; Pistoll & Goodman, 2014; Tucker & Manaugh, 2018; Clark & Curl, 2016; Winters et al., 2018; Duran et al., 2018; Hosford & Winters, 2018). Some initiatives, such as being able to carry bicycles on public transport systems, are equitable initiatives but they still have some challenges and barriers in terms of operation, such as adequate capacity on public transport, especially during peak periods. It seems there is still a challenge in terms of informing people about cycling initiatives, thereby making the whole system inequitable because of lack of awareness. As explained by Bernatchez et al. (2015), awareness of the benefits of cycling in Montreal, Canada was found to play an important role in bicycle usage. Also, awareness was one of the most important factors identified for raising bicycle usage in Iran (Jahanshahi et al., 2019). One of the problems of equity for some of the initiatives, including the Bike Challenge and the journey planning mobile app, are ones related to the existence of a digital divide and technology acceptance. The public's acceptance or rejection of ideas, systems and programme has important implications in terms of the likelihood of success of attempts to persuade behaviour modification. The digital divide and access to technology should be investigated further to understand the solutions to address these barriers. Future studies can use technology acceptance models to evaluate this issue more. While some studies have investigated acceptance of cycling technologies (Hazen et al., 2015; Jahanshahi et al., 2020; Wolf & Seebauer, 2014), the relationship between technology acceptance and cycling equity is yet to be fully understood.

Fourthly, this study identified potential additional initiatives to the currently implemented cycling initiatives. For example, e-bike subsidies have been implemented in many European countries and could help promote cycling in Auckland, by overcoming the reluctance to cycle due to the hilly terrain and barriers due to the cost of e-bikes. (Mirza & Wang, 2007; Tin Tin et al., 2012). A growing number of European countries have run schemes to provide grants for e-bike purchase. The European Cyclists' Federation in 2016 identified subsidy schemes at regional or local level in Austria, Belgium, France, Germany, Italy, the Netherlands and Spain (Newson & Sloman, 2019). There is a lack of understanding of the feasibility of e-bike subsidies in the Auckland context, and further studies are required to evaluate and investigate whether an e-bike subsidy would be successful in Auckland.

Policy and law change was another suggested additional initiative. Changes to policy suggested by the interviewees were around taxes, network planning for increasing spaces for cycling and making cycling easier in terms of safety. These policies could be supplementary regulations to the current initiatives for discouraging car usage. Education can also play an important role in addressing inequity by changing people's travel behaviour. The educational level and cycling awareness of population groups can affect their bicycle use preferences (Bernatchez et al., 2015). Better urban planning, policies to make cycling easier and better information were the remaining potential additional initiatives identified. Interestingly, better information and communication was identified as one of the factors influencing bicycle usage in Auckland in a previous study (Jahanshahi et al., 2022).

Fifthly, this study shows that there are five main barriers to implementing cycling equity initiatives in practice, including financial constraints, poor planning, sociocultural issues, human resources limitations, and the built environment. Financial constraints are a limiting factor in implementing cycling initiatives. Financial barriers include budget restrictions limiting overall expenditure on the strategy, financial restrictions on specific instruments, and limitations on the flexibility with which revenues can be used to finance the full range of instruments (May et al., 2006). Poor planning included, in hindsight, some errors in implementation of initiatives that interviewees believed could be done differently. For example, a lack of consideration of population groups with respect to income levels in bike subsidy (trial) plans, being more reactive and not proactive, and promoting complicated programmes – instead of simple ones that are easy to understand and, therefore, accessible to all. Sociocultural barriers, such as historic racism, was identified as one of the barriers which requires more in-depth investigation in future studies. Another example of sociocultural barriers is the perception that people have about cycling, as some people do not want to cycle for cultural reasons. Also, perceptions of parents in relation to the safety of their children when cycling was identified as one of the sociocultural barriers. Human resource was another barrier, which is related to the team capacity and skillsets of transport planners/designers in order to address inequity in cycling. Given the size of the cycling equity challenge, additional resource is needed to implement the required initiatives. The built environment was identified as another barrier to implementing cycling equity initiatives that should be addressed. The built environment as a barrier to cycling equity has not been discussed in previous studies. This is related to the influence of urban design, housing density, employment locations, and place of living, on the implementation of cycling initiatives. Further research is required to investigate the solutions for urban design and housing density associated with bicycle usage behaviour.

Finally, in terms of the suggested strategies, four main strategies were identified, including incorporating an equity lens in the assessment of planning proposals, wider coverage of people and initiatives, engagement with the community, and empowering people. Further research is required to understand the feasibility of the aforementioned strategies.

The current study investigated the opinions of policymakers, decision-makers, planners, designers, and transport professionals. However, understanding the viewpoints of population groups in terms of cycling initiatives could add invaluable knowledge to the literature. Future studies could evaluate the effectiveness of cycling initiatives in Auckland from the point of view of population groups and compare those with stakeholders' opinion in this study.

5.6 Conclusion

Despite the increasing number of studies discussing and assessing cycling equity, the reported measures of assessment are mainly based on accessibility to bicycle lanes and/or bicycle sharing systems as indicators to evaluate equity in cycling. Inequity issues as a result of ignoring soft cycling infrastructure, such as increasing participation in decision-making, online blogs, community-focused initiatives, cycling promotion initiatives, and targeted education and encouragement, could be more pronounced in multi-cultural and ethnic diverse contexts like Auckland, New Zealand. Auckland is not only one of the most culturally diverse cities in the world, spanning more than 220 ethnic groups, but it is also home to 60 percent of the country's indigenous population, Māori (World Population Review, 2021). This study has, therefore, emphasised the importance of identifying cycling initiatives beyond physical infrastructure and aimed to provide guidance for decision makers and planners by answering a number of research questions.

The main contribution of this research was the increased understanding of the whole cycling equity environment through identification of cycling initiatives in Auckland, beyond the provision of bicycle infrastructure, and the role they can play in cycling equity. This was achieved by identifying a comprehensive list of cycling initiatives in Auckland, their intended target groups or resulting beneficiaries, the current level of understanding of cycling equity in Auckland, potential additional cycling initiatives, barriers to implementing cycling equity policies in practice, and strategies to address the barriers. These findings will help decision-makers to better understand what type of initiatives influence cycling equity, and how they might solve barriers to implementing cycling equity policies.

Based on the findings of this study, in order to improve equity in cycling in Auckland, it is crucial for government to ensure that there is a clear and common understanding of equity in transportation, and in particular cycling, in their organisations. The current definitions and metrics of equity in transportation were derived from deep philosophical debates on justice and equity.

Highlighting the resulting beneficiaries of cycling initiatives in Auckland showed that, consistent with what we know about bicycle usage in Auckland, it seems only limited effort has been expended on empowering women and low-income groups to cycle. In addition, there are no initiatives aimed specifically at any particular cycling disadvantaged ethnic group, such as Māori or Pacific people. Despite the low bicycle usage rates of Māori and Pacific people, it seems that current cycling initiatives are not specifically focused on these groups. Although some initiatives are available for particular population groups if they are pro-active and request assistance, this kind of policy is based on "want" and not "need" and, therefore, will not be effective in addressing equity issues. It is suggested that, in order to improve equity in cycling in Auckland, resources should be expended on adequately exploring different communities' perceptions, needs, and potential motivations, as well as observing the difference between their perceptions of effectiveness of cycling initiatives. This would help provide a better understanding of the equitable distribution of cycling initiatives for policy makers and planners in Auckland.

Based on the findings of this study relating to barriers and possible strategies, more funding would, obviously, allow planners and policymakers to increase the coverage of initiatives. However, an important challenge is how they prioritize spending of constrained funding in different areas. For example, decision-makers for disadvantaged areas such as South Auckland could argue that there are a lot of issues lower income communities face that are perhaps more important than cycling infrastructure, such as health services, education services, and public transportation. As discussed in the interviews, it seems prioritization is assessed on a case-by-case basis and the level of bicycle usage. For example, funding in Auckland, aimed at increasing bicycle use and facilitating the fast uptake of cycling, may be best used to expand the capacity of the system (infrastructure). In contrast, in places with high bicycle usage rates (such as Amsterdam and Copenhagen) funding could be used to encourage disadvantaged population groups to start cycling. Therefore, although addressing equity in cycling in Auckland need to pass initial stages of development in cycling environment, as Auckland matures in terms of its cycling journey, it is hoped that the findings in this paper will help shape equitable policy and funding decision-making, resulting in fair outcomes for all.

Chapter 6

Who benefits from cycling initiatives? An evaluation of perceived effectiveness and differences among population groups

6.1 Introduction

A list of cycling initiatives provided in Auckland was identified in the previous chapter. The perceptions of experts (policymakers, decision-makers, planners, designers, and transportation professionals) about the intended target groups and resulting beneficiaries of the cycling initiatives were also explored. This chapter extends this by evaluating different population groups' perceptions of cycling initiatives through a quantitative survey and compares them with the findings from the previous chapter.

This chapter is structured as follows. First, the chapter provides some relevant background. Then, the research methodology adopted for this chapter is explained including participants and questionnaire, as well as the data analysis strategy. This is followed by the results and analysis of the data to answer the research questions. Finally, the results are discussed and conclusions are drawn.

6.2 Background

Urban transportation systems should be designed to counteract the negative aspects of rapid urbanization and increased demand for transportation, while ensuring access for all. This can be addressed by providing alternative transportation modes for better access, economically and socially (Mateo-babiano, 2015). Achieving sustainable transportation is, therefore, a key challenge presented by rapid urbanization and its associated health, social, economic, and environmental issues (Ahmad & Puppim de Oliveira, 2016). Bicycles can be considered as one of the most efficient methods of achieving sustainable urban mobility (Berloco & Colonna, 2012), given their minimal consumption of energy and resource (Shaheen et al., 2011). Bicycles are ideal vehicles for short distances, and can also be integrated with other transportation modes to cover medium and long distances. The use of bicycles includes a range of health, environmental and socioeconomic benefits. Using bicycles instead of motor vehicles improves air quality and health outcomes, as well as decreasing traffic congestion, fuel consumption, and the cost of transportation (Shaheen et al., 2010; Berloco & Colonna, 2012; Bernatchez et al., 2015; Karki & Tao, 2016; Midgley, 2011; Tran et al., 2015). It is, therefore, not surprising that many countries promote bicycle usage as a vital strategy to reduce reliance on motor vehicles.

In New Zealand, studies have suggested that cycling benefits are not evenly distributed across the population. Specifically, while Māori (the indigenous population in New Zealand) receive significantly fewer health benefits from cycling generally (Bassett et al., 2020), the relative benefits are higher when they do partake in cycling (Jones et al., 2020). As reported by the Ministry of Health (2022), rates of obesity are higher among minority populations and those on lower incomes, while their bicycle usage rates are lower. Amongst the various ethnic groups, the least likely to be cyclists are Pacific peoples, while European New Zealanders are the most likely to be cyclists (Shaw & Russell, 2017). In addition, evidence shows a significant disparity in terms of the gender gap, with only one-quarter of regular cyclists in New Zealand being female (Shaw et al., 2020). Given the inequalities in bicycle usage that exist, and the unequal levels of general health amongst population groups, there is benefit in investigating cycling equity in New Zealand.

Studies on cycling equity have typically focussed on the association between the provision of cycling infrastructure and socio-economic characteristics of population groups, such as income levels as well as place of residence and employment (Pistoll & Goodman, 2014; Fuller & Winters, 2017; Houde et al., 2018; Mooney et al., 2019; Kent & Karner, 2019; Qian & Niemeier, 2019). A significant body of research has analysed the access to cycling infrastructure, such as bicycle lanes, access to bike-sharing systems (BSS) and dock-less bike-sharing systems (DBSS), or access to key destinations by bicycle (Tucker & Manaugh, 2018; Chen et al., 2019; Hosford & Winters, 2018; Winters et al., 2018). These studies have found that minority population groups, people who live in lower-income areas, the elderly, women and immigrants, cycle less than others and, usually, have relatively poor access to cycling infrastructure or bicycle sharing systems (Chapter 2).

In cycling equity studies, there is a lack of literature on cycling initiatives other than access to bicycle lanes and bicycle sharing systems. Therefore, it is important to first identify the range of cycling initiatives that have been implemented, and then to assess their effectiveness for different socio-demographic groups. The previous chapter, identified the range of cycling initiatives provided in Auckland, the most populous city in New Zealand, though semi-structured interviews with experts (policymakers, decision-makers, planners, designers, and transportation professionals). The chapter also explored their perceptions in terms of the intended target groups and resulting beneficiaries of the cycling initiatives. However, the perceptions of these initiatives from the point of view of the different population groups for whom they were intended have yet to be considered. This is important because people encounter unique barriers to cycling depending on their sociodemographic characteristics and individual identity (Vietinghoff, 2021). There is, therefore, a need for closer attention to be paid to the unique circumstances of different communities and demographic groups within the population. As argued by Cropanzano et al. (2015), the level of satisfaction and the decision outcome success could be influenced by people's attitudes and their perceptions of how they have been affected by a decision. Therefore, it would be helpful to understand to what extent the perceptions of experts differ from those of the people that they serve in terms of the effectiveness of cycling initiatives to encourage cycling, as well as evaluating differences among different population groups.

6.3 Methodology

6.3.1 Participants and questionnaire

Participation was limited to those 18 years of age and older, consequently the elderly and disabled, for whom cycling may not be an option, were not excluded. The questionnaire was only provided in English, and therefore only those with a sufficiently high command of the English language would have been able to complete it. The questionnaire was administered during the period of October to November 2022. The data collection method described in Chapter 3 what also adopted for this survey. In total, 1163 responses were collected. After removing incomplete questionnaires and those containing invalid answers, 732 were retained for data analysis. In total, 1489 approaches were made, and 1163 responses were collected. After removing incomplete questionnaires, as well as those that had been answering with patterns, such as providing the same answer to all of the questions and providing very unlikely answers, 732 were retained for data analysis, resulting in a response rate of 49%. The response rates in cycling related studies could be various, range from about 20% to 80% and depends on the nature of data collection and case studies (Høye et al., 2020; Schepers et al., 2020; Howland et al., 2017; McTigue et al., 2018; Dill & McNeil, 2013; C. F. Lee & Huang, 2014; Zhao & Zhang, 2019). Therefore, the response rate in this study is consistent with the literature.

The first section of the questionnaire related to participant demographics, including age, ethnicity, gender, education, employment status, income, and access to a car. A summary of the demographic characteristics of the participants is presented in Table 6.1. The data collected are very similar to Auckland with respect to distributions of age, gender, ethnicity, and income levels (www.stats.govt.nz, 2022), as shown in parenthesis in Table 6.1.

Table 6.1: Sociodemographic characteristics of the sample and the general population

Characteristics	Sample% (Auckland%)	Characteristics	Sample% (Auckland%)
Age (in years)		**Ethnicity**	
18-20	5.1 (not reported)	Māori	10.5 (11.5)
21-30	35.5 (20.5)	Pacific peoples	21.9 (15.5)
31-40	25.3 (18.8)	Asian	18 (28.2)
41-50	14.9 (17)	MELAA*	1.4 (2.3)
51-60	9.3 (15.7)	Indian	6.8 (not reported)
>60	9.9 (23)	European/NZ European	39.1 (53.5)
Gender		Other ethnicities	2.2 (1.1)
Men	52.8 (49)		
Women	46.3 (51)		
Diverse	0.8 (not reported)	**Personal annual income (NZD)**	
Highest completed degree		No income	7.3 (8.7)
High School or below	34.1	<30K	15.8 (36.8)
Undergrad degree	52.4	30K-70K	38.2 (34.1)
Master's degree/ Postgraduate	13.5	70K-100K	23.2 (10.3)
		>100K	15.6 (9.5)
Employment situation		**Car access in the household**	
Not employed	12.7	Yes	92.4
Part-time employed	13.3	No	7.6
Full-time employed	62.4		
Homemaker	5.7		
Retired	5.9		

* MELAA: Middle Eastern/Latin American/African

A summary of the cycling profile of the participants is presented in Table 6.2, including whether they have access to a bicycle at home, the extent of bicycle usage, the bicycle user types of the participants, their purpose for cycling if they do indeed cycle, and their BSS usage. Both cyclists and non-cyclists were included as participants in the study. Those categorised as 'cyclists' were split into two groups: 'Regular Cyclists' and 'Potential Cyclists', following the categorisation proposed by Wang and Akar (2018). Regular Cyclists are those who indicated having cycled in the past month for any purpose; Potential Cyclists are those who had cycled at least once in the past 12 months and Non-Cyclists are those who had not cycled in the past 12 months. In addition, in total, 40 participants (5.5%) reported having disabilities, but ones that do not prevent them from cycling, and 37.4% of participants reported that they had experienced injuries because of cycling.

Table 6.2: Cycling profile of the study participants

Characteristics	%	Characteristics	%
Access to a bicycle at home		**Cycling purpose**	
Yes	55.6	Commuting	9.7
No	44.4	Short trips	26.5
Average bicycle usage (per week)		Recreation/exercise	63.7
0 times	23.5	**Average daily bicycle usage** (time)	
1-3 times	64.4	<15 mins	26.6
4-5 times	8.3	15-30 mins	47.1
>5 times	3.8	31-60 mins	20.8
Bicycle user type		>60 mins	5.5
Non-cyclists	37	**Cycling injuries**	
Regular cyclists	39.7	Yes	37.4
Potential cyclists	23.3	No	62.6
Bicycle sharing ever used		**Bicycle sharing user type**	
Yes	35.4	Non-cyclists	7.4
No	64.6	Regular cyclists	56.4
		Potential cyclists	36.2

The second section of the questionnaire asked participants how effective cycling initiatives (37 items) were in encouraging them, individually, to cycle. The list of cycling initiatives and categories were generated based on the previous qualitative study in Chapter 5, with questions designed based on a five-point Likert scale ranging from ‘very low’ to ‘very high’. Referring to Table 6.3, the questions were divided into four categories (named ‘constructs’): Infrastructure (IN), Bicycle Promotion (BP), Cycling Safety (CS), and Discourage Car Usage

(DC), with the division not visible to the respondents in order to avoid any possible bias arising due to the label used.

Table 6.3: Questionnaire items for cycling initiatives constructs

Code	Cycling initiatives
	Infrastructure
IN1	Improving the quantity and quality of cycle lanes
IN2	Reducing traffic speed in neighbourhoods
IN3	Public parking facilities for bicycles
IN4	Public parking facilities for bicycles (secured with CCTV)
IN5	Bicycle security initiatives, such as serial number registration and the opportunity to swap your bicycle lock for a better, more secure, one.
IN6	Availability of public showers, changing rooms, and lockers at the end of your trip
IN7	Adding protection such as kerbs or dividers to existing cycleways in order to separate them from road traffic.
IN8	Implement more bus lanes. Note that cyclists can travel in bus lanes.
	Bicycle promotion
BP1	Pay-as-you-go bike share schemes (ONZO, Lime, Jump, etc.)
BP2	Ability to carry your bicycle onto buses, trains, and ferries.
BP3	E-bike trial and loan schemes
BP4	Free bike safety checks and minor maintenance work
BP5	Support for community groups with the design, delivery and/or funding of their ideas for promoting cycling in their neighbourhoods.
BP6	Support the expansion of community bike hubs at key locations across the region to divert bikes from landfill, carry out basic repairs to make them safe and usable and distribute low-cost bikes to local communities.
BP7	Provide support to cycling-focused community groups to empower and grow (such as supporting their cycling skills events, bicycle maintenance events, etc).
BP8	Bike challenge: A challenge to encourage cycling where you use an app on your phone to record when and how far you cycle. The more you cycle the more points you score.
BP9	Community Bike Fund for non-profit groups to apply for ideas to promote cycling in their neighbourhoods.
BP10	Auckland Transport mobile app for planning your cycling journey. The app will suggest the best cycling routes for your journey.
BP11	Cycling skills training in schools when you were growing up or for your children (You need your own bike).
BP12	A container full of bikes in a school with additional training for teachers for how to teach kids how to ride (when you were growing up or for your children).
BP13	Kids Learn-to-Ride drop-in events, adult bike skills courses, and basic bike maintenance courses (free events).
BP14	Improving signage and pavement markings to help you find cycleways and cycle routes.
BP15	Residential door knocking journey planning (coming to you for asking about your journeys and offer plans)
BP16	Offering travel planning and a wide variety of incentives through work, to get staff traveling to work by bicycle, (such as providing an advance on your wages or salary to buy a bike, discounts for buying a bicycle, flexible times for arriving at work, etc.)
BP17	Guided e-bike tours for the public and businesses.
BP18	Events to improve awareness of, and to celebrate, new and existing cycling infrastructure.
BP19	Consultation with the community and listening to people before designing bike infrastructure in their neighbourhoods.
	Cycling Safety

CS1	Enforcement to keep cycling infrastructure and facilities clear of obstructions (e.g. bins and other obstacles)
CS2	Road rule changes to improve cycling safety (e.g. automatic liability for hitting cyclists)
CS3	Vehicle safety features that reduce the injury to cyclists if hit by a vehicle.
CS4	Road speed limit enforcement to promote road safety.
CS5	Campaigns (via social media, advertising and events) that normalise bicycle usage in the minds of drivers - so that they respect cyclists and are happy to share the road with them.
CS6	Lighting improvements on cycleways, particularly in parks and off-road areas
	Discouraging car usage
DC1	Parking management to ban on-street car parking in certain areas.
DC2	Congestion charging in areas with other transport options, resulting in reduced traffic flows
DC3	Increase the cost to park in areas that could easily be accessed by cycling, resulting in reduced traffic in these areas.
DC4	Increase the cost of owning a car and subsidise bike ownership.

6.3.2 Data analysis strategy

To check the reliability of the questionnaire, the ranges of Cronbach's α coefficients were first explored. Then, using AMOS 22, a confirmatory factor analysis was executed to validate the convergence and divergence of all 37 of the model's items. Using SPSS 22 software and following Fishman et al. (2014), a repeated measure ANOVA was used to compare the effectiveness of the constructs. A Friedman Test was then used to compare the effectiveness of factors within each construct. Using MANOVA and Box's Test of Equality of Covariance Matrices, Levene's Test of Equality of Error Variances, Wilks' Lambda, univariate tests and pairwise comparison, the relationship between the perceived effectiveness of the constructs and the participant socio-demographic characteristics were investigated, including age, income, gender, education, cycling user type, and ethnicity. In order to investigate the relationship between the effectiveness of the cycling initiatives themselves and the socio-demographic characteristics of the study participants, a Classification and Regression Tree (CART) analysis was used to classify the participants into different groups based on their rating of the effectiveness of cycling initiatives. For this purpose, age, income, gender, education, cycling user type, and ethnicity were all considered.

6.4 Results

6.4.1 Descriptive analysis

This section presents the descriptive statistics for cycling initiatives. Table 6.4 shows the key statistics for the initiatives: the median, mean, standard deviation and percentages for each of the 37 initiatives rated on the Likert scale. The highest mean scores were achieved by the initiatives in the Cycling Safety and Infrastructure constructs, implying respondents believe that these cycling initiatives are more effective in encouraging cycling from an individual perspective. Two initiatives within the Cycling Safety construct were rated the most highly (high mean scores): vehicle safety features that reduce the injury to cyclists (CS3) and lighting improvements on cycleways, particularly in parks and off-road areas (CS6), while residential door knocking journey planning (BP15) under the Bicycle Promotion construct and increasing the cost of owning a car and subsidising bike ownership (DC4) under the Discourage Car Usage construct were rated as the least effective on the basis of low mean scores. This section shows that Cycling Safety, in particular, is considered to be effective in encourage cycling.

6.4.2 Measurement steps

6.4.2.1 Reliability

Assessing the reliability of a research instrument is a vital step in any study as it illustrates to what extent the study is able to be replicated; studies exploring perceptions are no exception (Rosenthal and Rosnow, 1991; Drost, 2011). Consequently, this section analyses the reliability of the studied constructs. Since the cycling initiatives were clustered into four constructs, in line with the previous qualitative study, it was necessary to conduct a confirmatory factor analysis (CFA) to ensure the convergent and discriminant validity of the factors (Churchill, 1979; Byrne, 2012). Using CFA, it is possible to confirm the relationships between a set of observed variables and a set of common factors (Muthen and Muthen, 2010). In addition, CFA allows researchers to determine whether the hypothesized structure provides a good fit to the data (Diana, 2014). In this regard, we first applied CFA to the initiatives, as shown in Table 6.5. All of the initiatives resulted in valid loading factors above the recommended threshold value of 0.4 (Field, 2013), and were therefore retained. Then, the Cronbach's α coefficients of the constructs were estimated, with all exceeding the 0.6 threshold, confirming the reliability of the model's constructs and indicating acceptable internal consistency for every construct (Hair et al., 2010).

The relationships between pairs of constructs were then investigated, as shown in Table 6.6. Following Cohen et al. (1988), all of the constructs are highly positively correlated (significant at the 0.01 level). The positive correlation coefficients suggest that, typically, those who perceive the effectiveness of one of the constructs as being high also perceive the effectiveness of other constructs as high. In terms of the range, the strongest correlation is between Infrastructure and Bicycle Promotion (0.767) and the weakest correlation is between Infrastructure and Discouraging Car Usage (0.561).

Table 6.4: Descriptive statistics for cycling initiatives

Question	Mean	Median	Std. Deviation	Very low %	Low %	Moderate %	High %	Very high %
IN1	3.06	3.00	1.112	10.2	16.9	40.4	21.2	11.2
IN2	3.00	3.00	1.132	9.8	22.8	36.3	19.4	11.6
IN3	3.10	3.00	1.041	6.7	19.6	40.9	22.8	10.0
IN4	3.24	3.00	1.114	7.9	14.9	35.9	27.3	14.0
IN5	3.10	3.00	1.101	8.6	19.0	37.3	23.8	11.2
IN6	2.98	3.00	1.092	10.4	21.6	35.8	24.3	7.9
IN7	3.33	3.00	1.079	5.3	15.5	35.6	28.0	15.6
IN8	3.08	3.00	1.086	8.8	18.8	38.4	24.0	10.1
BP1	2.73	3.00	1.117	15.8	25.8	34.7	17.2	6.4
BP2	3.13	3.00	1.119	9.6	16.7	36.9	25.2	11.6
BP3	2.94	3.00	1.082	10.5	22.0	38.2	21.3	7.9
BP4	3.21	3.00	1.061	5.2	19.5	37.5	24.9	12.9
BP5	3.04	3.00	1.033	8.1	19.3	41.1	23.6	7.9
BP6	3.08	3.00	1.009	7.3	17.4	42.8	24.8	7.8
BP7	3.05	3.00	1.004	7.2	18.9	43.0	23.5	7.4
BP8	2.91	3.00	1.065	10.7	22.8	38.0	21.9	6.7
BP9	2.97	3.00	1.041	9.6	20.2	41.3	22.0	7.0
BP10	3.15	3.00	1.043	7.0	18.1	37.3	28.5	9.1
BP11	3.20	3.00	1.062	6.8	16.4	37.5	28.0	11.2
BP12	3.20	3.00	1.087	7.1	17.1	37.0	26.2	12.6
BP13	3.25	3.00	1.039	6.3	13.9	40.2	27.9	11.7
BP14	3.26	3.00	1.034	5.9	15.5	36.4	31.6	10.7
BP15	2.51	3.00	1.104	22.5	25.7	33.6	14.4	3.8
BP16	2.90	3.00	1.066	11.6	20.8	39.9	21.2	6.4
BP17	2.82	3.00	1.083	12.3	25.3	36.5	19.3	6.6
BP18	2.95	3.00	1.021	8.2	23.1	40.4	21.6	6.7
BP19	3.20	3.00	1.020	5.9	16.0	40.7	27.0	10.3
CS1	3.20	3.00	1.003	5.8	15.1	41.8	27.6	9.7
CS2	3.23	3.00	1.088	7.3	15.0	38.4	25.9	13.4
CS3	3.34	3.00	1.033	4.8	13.6	38.2	29.4	14.0
CS4	3.20	3.00	1.071	7.0	16.2	39.2	25.4	12.2
CS5	3.04	3.00	1.067	9.1	19.2	39.3	23.8	8.7
CS6	3.38	3.00	1.039	4.7	12.7	38.0	29.2	15.4
DC1	3.02	3.00	1.164	12.5	17.7	36.6	21.7	11.5
DC2	2.92	3.00	1.070	11.6	19.3	41.4	20.5	7.1
DC3	2.71	3.00	1.166	19.0	22.7	34.0	17.1	7.1
DC4	2.51	3.00	1.212	28.6	18.7	31.5	15.8	5.5

Table 6.5: Factor loadings and Cronbach's α coefficients of the constructs

Constructs	Cycling initiatives	Factors Loading	Cronbach's α	Mean	Standard deviation
Infrastructure			0.886		
	IN1	0.717		3.06	1.108
	IN2	0.701		3.00	1.132
	IN3	0.781		3.10	1.042
	IN4	0.808		3.25	1.109
	IN5	0.795		3.10	1.101
	IN6	0.659		2.98	1.091
	IN7	0.767		3.33	1.080
	IN8	0.744		3.08	1.088
Bicycle Promotion			0.939		
	BP1	0.600		2.72	1.112
	BP2	0.676		3.13	1.115
	BP3	0.645		2.94	1.078
	BP4	0.687		3.21	1.055
	BP5	0.758		3.04	1.025
	BP6	0.736		3.09	1.005
	BP7	0.764		3.05	1.000
	BP8	0.718		2.91	1.065
	BP9	0.778		2.96	1.040
	BP10	0.727		3.15	1.042
	BP11	0.675		3.20	1.058
	BP12	0.673		3.20	1.085
	BP13	0.721		3.25	1.031
	BP14	0.710		3.26	1.036
	BP15	0.596		2.50	1.099
	BP16	0.685		2.90	1.066
	BP17	0.655		2.82	1.080
	BP18	0.740		2.95	1.011
	BP19	0.601		3.19	1.023
Cycling Safety			0.873		
	CS1	0.738		3.20	1.003
	CS2	0.805		3.22	1.086
	CS3	0.827		3.34	1.034
	CS4	0.814		3.19	1.070
	CS5	0.757		3.03	1.065
	CS6	0.753		3.38	1.041
Discouraging Car Usage			0.828		
	DC1	0.785		3.02	1.164
	DC2	0.833		2.92	1.066
	DC3	0.868		2.71	1.165
	DC4	0.768		2.50	1.209

Table 6.6: Correlations between the constructs

Constructs	A	B	C	D
A: Infrastructure	1			
B: Bicycle Promotion	.767**	1		
C: Cycling Safety	.709**	.761**	1	
D: Discouraging Car Usage	.561**	.641**	.612**	1

**. Correlation is significant at the 0.01 level (2-tailed).

6.4.2.2 Constructs effectiveness comparison

This section presents a relative comparison of the effectiveness of the constructs on the basis of the initiatives within in terms of encouraging bicycle usage. We present a repeated measures ANOVA analysis to compare the effectiveness of the constructs: Wilks' Lambda $F(3,639)=63.159$ with a significance value of $p< 0.001$. In addition, Mauchly's Test of Sphericity and the Greenhouse-Geisser test both show significance levels of < 0.001, indicating the reliability of the constructs' differences, allowing the constructs to be compared. This was carried out using pairwise comparisons with a Bonferroni correction. Table 6.7 presents the results of this analysis. It reveals that initiatives under the Discouraging Car Usage construct are less effective compared to other constructs with the most effective being Cycling Safety, Infrastructure and the Bicycle Promotion. As is shown in the table, the mean difference for Discouraging Car Usage is negative for all the other constructs (-0.172, -264, and -0.381 for Bicycle Promotion, Infrastructure, and Cycling Safety, respectively) showing that it is less effective compared to other constructs and the largest difference in terms of effectiveness is with Cycling Safety. In contrast, Cycling Safety has positive mean differences with all the other constructs, which indicates that it is the most effective construct.

Table 6.7: Pairwise comparisons for constructs

Constructs (I)	Constructs (J)	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Infrastructure	Bicycle Promotion	.085*	0.02	000	0.032	0.137
	Cycling Safety	-.123*	0.023	000	-0.184	-0.062
	Discouraging Car Usage	.264*	0.028	000	0.178	0.325
Bicycle Promotion	Infrastructure	-.085*	0.02	000	-0.137	-0.032
	Cycling Safety	-.208*	0.02	000	-0.261	-0.155
	Discouraging Car Usage	.172*	0.024	000	0.104	0.23
Cycling Safety	Infrastructure	.123*	0.023	000	0.062	0.184
	Bicycle Promotion	.208*	0.02	000	0.155	0.261
	Discouraging Car Usage	.381*	0.026	000	0.307	0.442
Discouraging Car Usage	Infrastructure	-.264*	0.028	000	-0.325	-0.178
	Bicycle Promotion	-.172*	0.024	000	-0.23	-0.104
	Cycling Safety	-.381*	0.026	000	-0.442	-0.307

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons using Bonferroni correction.

6.4.2.3 Initiatives effectiveness comparison

This section presents the perceived effectiveness of each cycling initiative in terms of encouraging bicycle usage, and compares them within each construct. The Friedman Test was used to compare the perceived effectiveness of the initiatives in each construct. A non-parametric Friedman test of differences between Infrastructure, Bicycle Promotion, Cycling Safety, and Discourage Car Usage was conducted, and rendered Chi-square values of $\chi^2(7, 726)=121.945$, $\chi^2(18, 718)=730.475$, $\chi^2(5, 721)=103.143$, and $\chi^2(3, 726)=163.883$ respectively, revealing that all constructs were significant and, therefore, a comparison of the initiatives of all of the constructs was able to be undertaken ($p < 0.005$). As shown in Figures 6.1 to 6.4, adding protection to existing cycleways and improving signage and pavement markings were the initiatives with the highest mean rankings within the Infrastructure and Bicycle Promotion constructs, respectively. The availability of public showers, changing rooms, and lockers at the end of trip were ranked as the lowest in the Infrastructure construct. Residential door knocking journey planning was rated as the lowest within the Bicycle Promotion construct. Within Cycling Safety, lighting improvements on cycleways was considered to be the most effective, while campaigns aimed at normalising bicycle usage in the minds of drivers was rated the lowest. Regarding Discouraging Car Usage, the initiative rated as the highest was parking management to ban on-street car parking in certain areas, whereas increasing the cost of owning a car and subsidising bike ownership were considered to be the least effective.

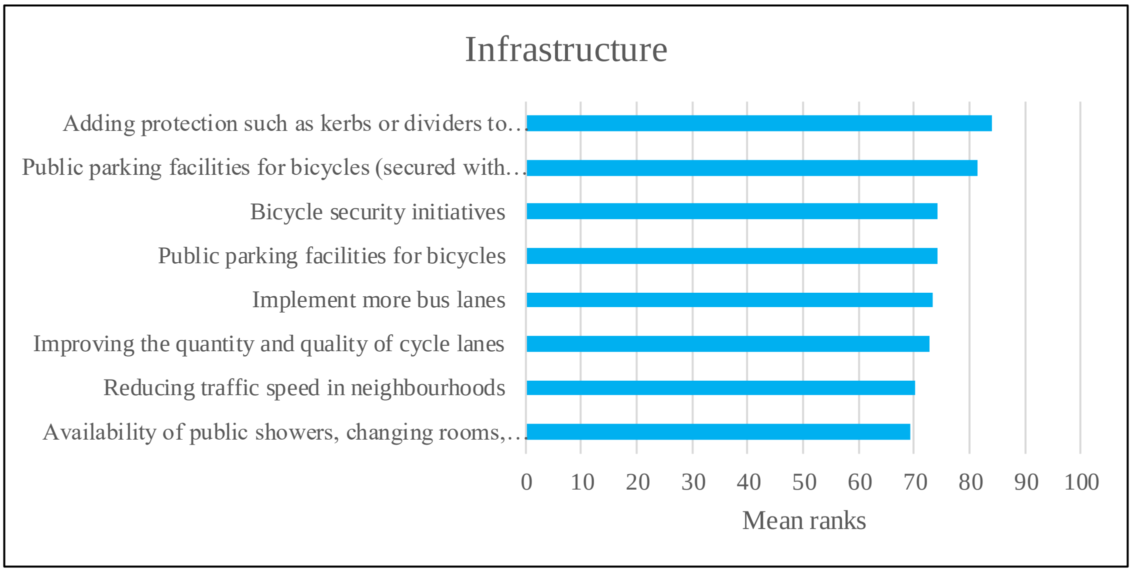

Figure 6.1: Comparison of initiatives within the Infrastructure construct

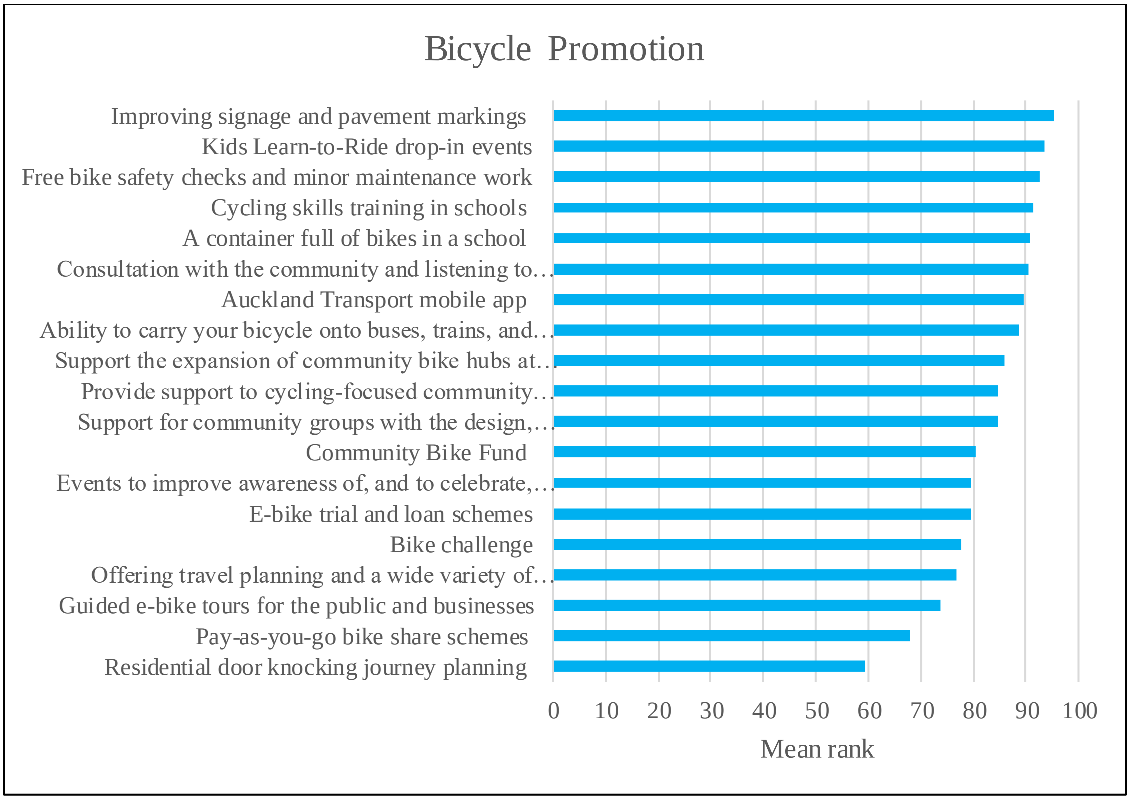

Figure 6.2: Comparison of initiatives within the Bicycle Promotion construct

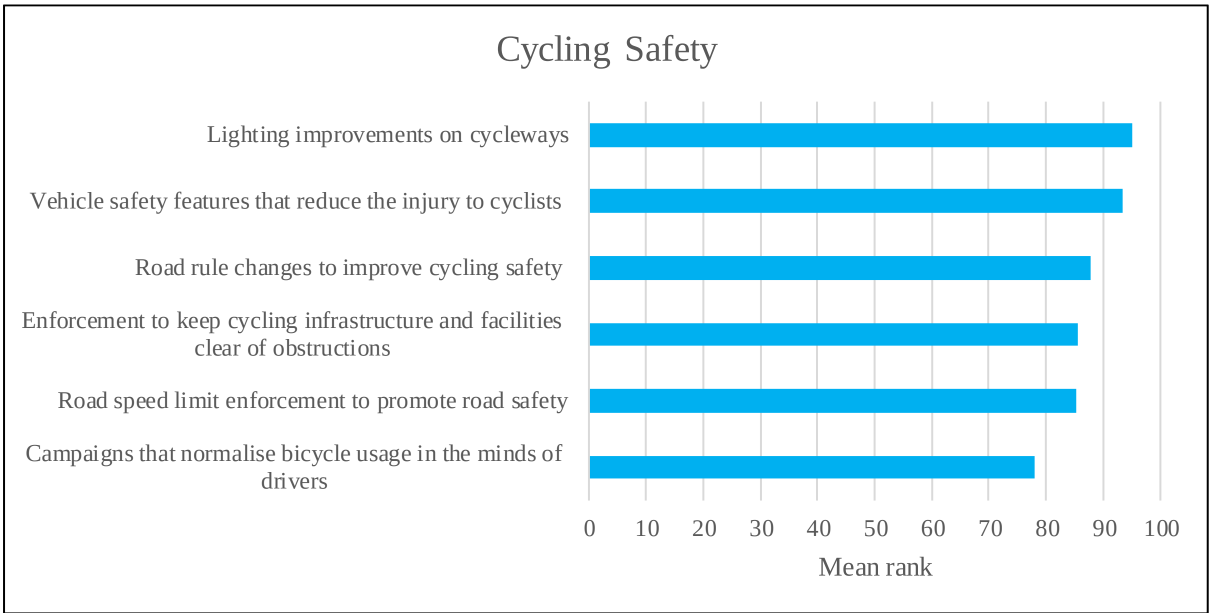

Figure 6.3: Comparison of initiatives within the Cycling Safety construct

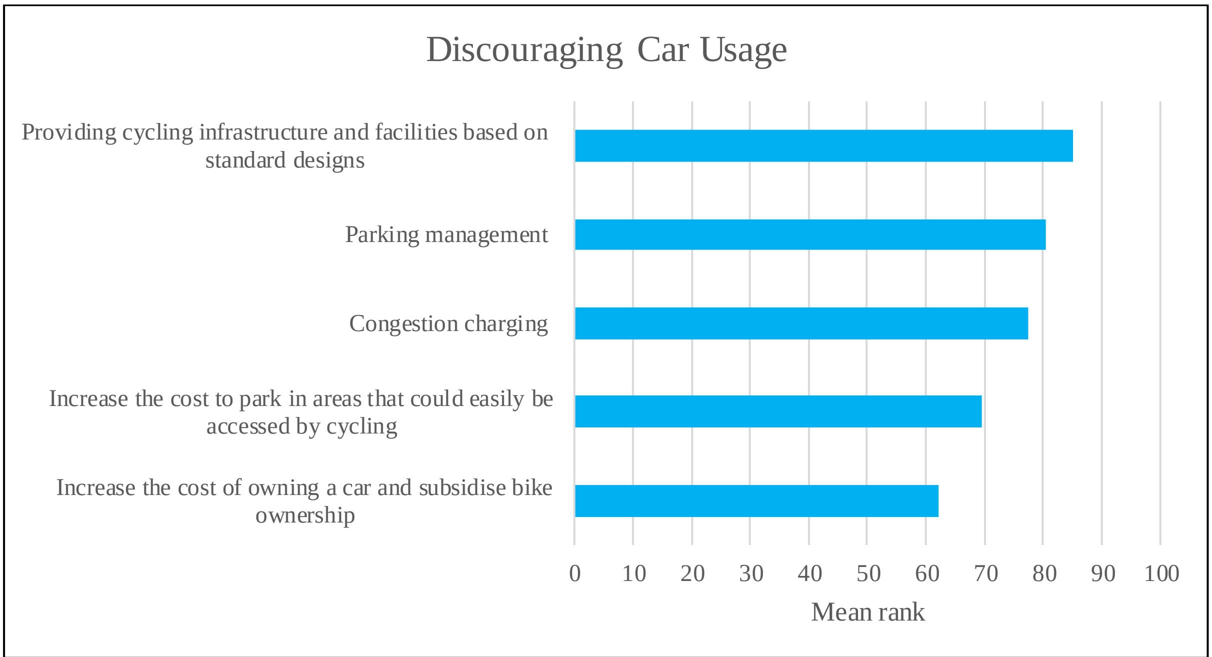

Figure 6.4: Comparison of initiatives in the Discouraging Car Usage construct

6.4.2.4 Relationship between constructs and sociodemographic characteristics

In this section, we explore the relationship between sociodemographic characteristics (age, income, gender, education, cycling user type, and ethnicity) and the perceived effectiveness of constructs using MANOVA analysis. For this purpose, we used Box's test to evaluate the equality of covariance matrices and Levene's test to evaluate the equality of error variances, followed by a Wilks' Lambda test to explore significant differences between the ratings of constructs amongst the various socio-demographic groups. The results reveal that the requirements were not met for gender, income, or educational levels. Thus, only the remaining sociodemographic characteristics (age, ethnicity, and bicycle user type) are considered for this purpose.

Following this, a univariate test is used to illustrate which constructs differ amongst socio-demographic groups. Finally, a pairwise comparison is used to revealed how demographic characteristics are related to the perceived effectiveness of the constructs.

6.4.2.4.1 Age levels

In relation to age, the results of the aforementioned tests show that a MANOVA is able to be used reliably (SIG < 0.05). In order to determine the significance of the MANOVA a Wilks' Lambda test was then conducted. Results indicate that there is a statistically significant difference, based on age levels, in all of the constructs ($F=6.13$, $p < 0.05$; Wilks' $\Lambda=0.896$, partial $\eta^2=0.041$).

Univariate tests were conducted to ascertain the influence of age on the perceived effectiveness of the constructs. As shown in Table 6.8, age has a statistically significant influence on the perceived effectiveness of initiatives within the Infrastructure ($F=3.55$; $p < 0.05$; partial $\eta^2=0.024$), Bicycle Promotion ($F=8.03$; $p < 0.05$; partial $\eta^2=0.053$), and Discouraging Car Usage ($F=11.57$; $p < 0.05$; partial $\eta^2=0.036$) constructs, whereas no significant influence was found within the Cycling Safety ($p > 0.05$) construct. To compare the effect of age on the perceived effectiveness of the Infrastructure, Bicycle Promotion, and Discouraging Car Usage construct scores, pairwise comparisons were used. The results suggest that older participants, in general, reported lower levels of effectiveness with respect to the significant constructs. Figure 6.5 illustrates the different levels of perceived effectiveness of the constructs by different age groups.

Table 6.8: Univariate tests for age levels

	Mean Square	F	Sig.	Partial Eta Squared
Infrastructure	2.330	3.557	0.003	0.024
Bicycle Promotion	4.123	8.038	0.000	0.053
Cycling Safety	0.741	1.100	0.359	0.008
Discouraging Car Usage	7.232	11.578	0.000	0.036

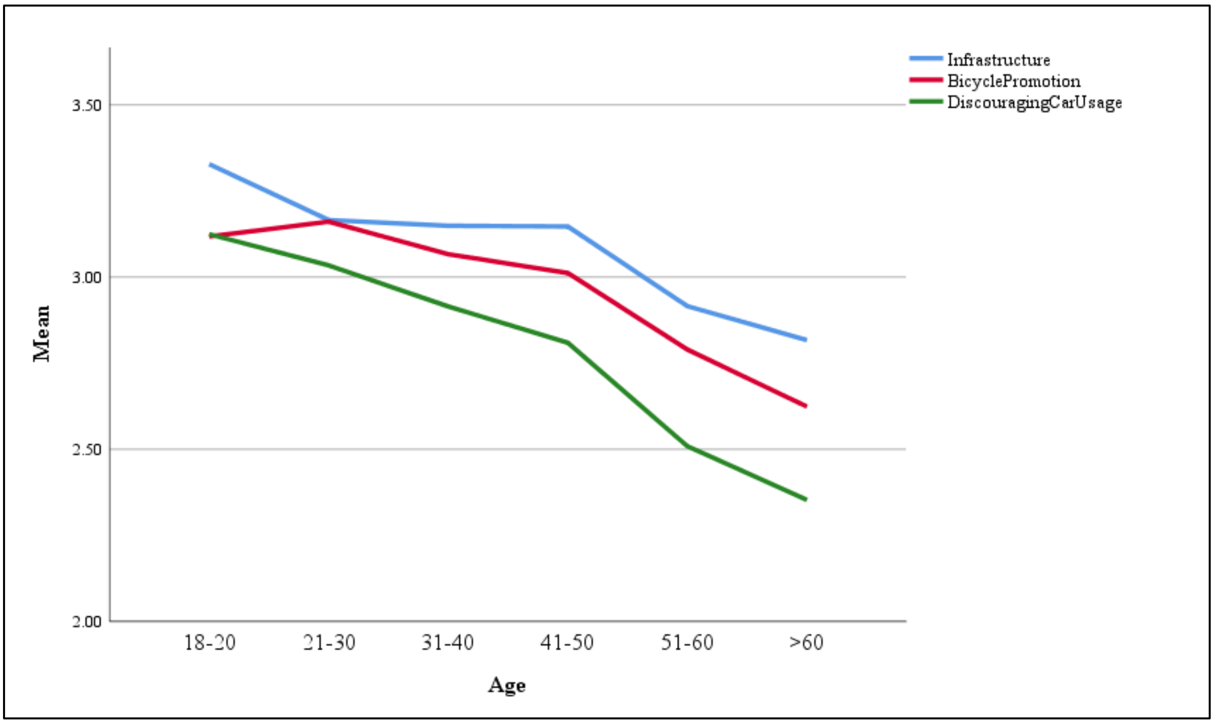

Figure 6.5. Levels of perceived effectiveness of the constructs by different age levels

6.4.2.4.2 Bicycle Usership

In relation to the Bicycle Usership category, the results of the Box and Levene tests indicate that a MANOVA is able to be used reliably (SIG < 0.05 for both). A Wilks' Lambda test was then used to determine the statistical significance of the MANOVA. Results indicated that there is a statistically significant difference in all of the constructs based on Bicycle Usership, $F=7.63$, $p < 0.05$; Wilks' $\Lambda=0.976$, partial $\eta^2=0.057$.

Univariate tests were conducted to ascertain the impact of Bicycle Usership on the perceived effectiveness of the constructs. As shown in Table 6.9, Bicycle Usership has a statistically significant influence on the perceived effectiveness of initiatives within the Infrastructure ($F=15.01$; $p < 0.05$; partial $\eta^2=0.043$), Bicycle Promotion ($F=24.54$; $p < 0.05$; partial $\eta^2=0.068$), Discouraging Car Usage ($F=16.48$; $p < 0.05$; partial $\eta^2=0.058$), and Cycling Safety ($F=8.61$; $p < 0.05$; partial $\eta^2=0.025$) constructs. To evaluate and compare the influence of Bicycle Usership on the perception of the effectiveness of the Bicycle Promotion, Cycling Safety, Infrastructure, and Discouraging Car Usage constructs, a pairwise comparison was used. Results show that people who cycle more report higher levels of effectiveness with respect to all of the constructs. Figure 6.6 illustrates the different levels of perceived effectiveness of the constructs by different bicycle user types.

Table 6.9: Univariate tests for Bicycle Usership

	Mean Square	F	Sig.	Partial Eta Squared
Infrastructure	9.396	15.015	0.000	0.043
Bicycle Promotion	12.438	24.547	0.000	0.068
Cycling Safety	5.759	8.617	0.000	0.025
Discouraging Car Usage	11.142	16.486	0.000	0.058

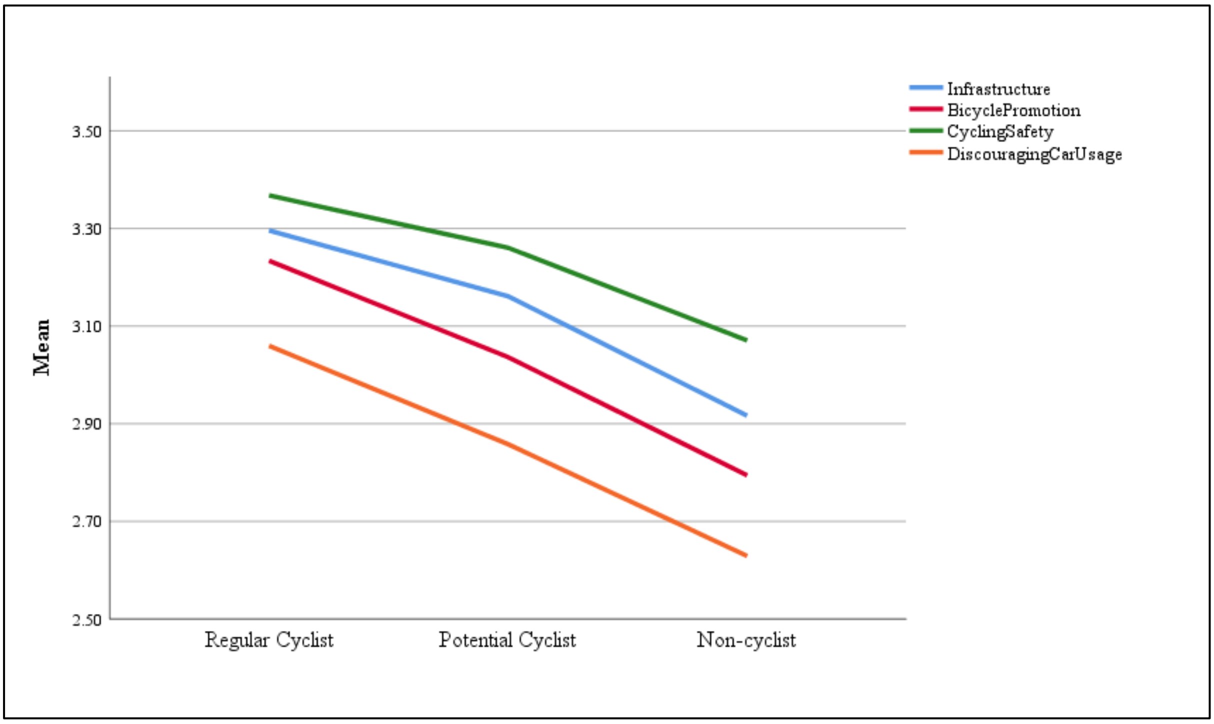

Figure 6.6. Levels of perceived effectiveness of the constructs by different bicycle user type

6.4.2.4.3 Ethnicity

For ethnicity, results of the Box and Levene tests indicate that it is reliable to use MANOVA (SIG < 0.05 for both). A Wilks' Lambda test was then used to determine whether the MANOVA is statistically significant or not. Results indicated that there is a statistically significant difference in all the constructs based on ethnicity, F=3.31, $p < 0.05$; Wilks' Λ=0.823, partial $\eta 2$=0.032.

Univariate tests were conducted to ascertain the impact of ethnicity on the perceived effectiveness of the constructs. As shown in Table 6.10, ethnicity has a statistically significant influence on the perceived effectiveness of initiatives within the Bicycle Promotion (F=4.13; $p < 0.05$; partial $\eta 2$=0.044) and Discouraging Car Usage (F=6.26; $p < 0.05$; partial $\eta 2$=0.048) constructs, whereas no significant influence was found within the Cycling Safety or Infrastructure ($p > 0.05$ for both) constructs. A pairwise comparison was used to evaluate and compare the effect of different ethnicities on Bicycle Promotion and Discouraging Car Usage. Results show that Māori and Pacific participants consider initiatives within both the Bicycle Promotion and Discouraging Car Usage constructs as more effective compared with European and New Zealand European participants. Figure 6.7 illustrates the different levels of perceived effectiveness of the constructs by different ethnicities.

Table 6.10: Univariate tests for Bicycle Usership

	Mean Square	F	Sig.	Partial Eta Squared
Infrastructure	1.177	1.783	0.077	0.019
Bicycle Promotion	2.147	4.135	0.000	0.044
Cycling Safety	1.021	1.524	0.145	0.017
Discouraging Car Usage	3.742	6.261	0.000	0.048

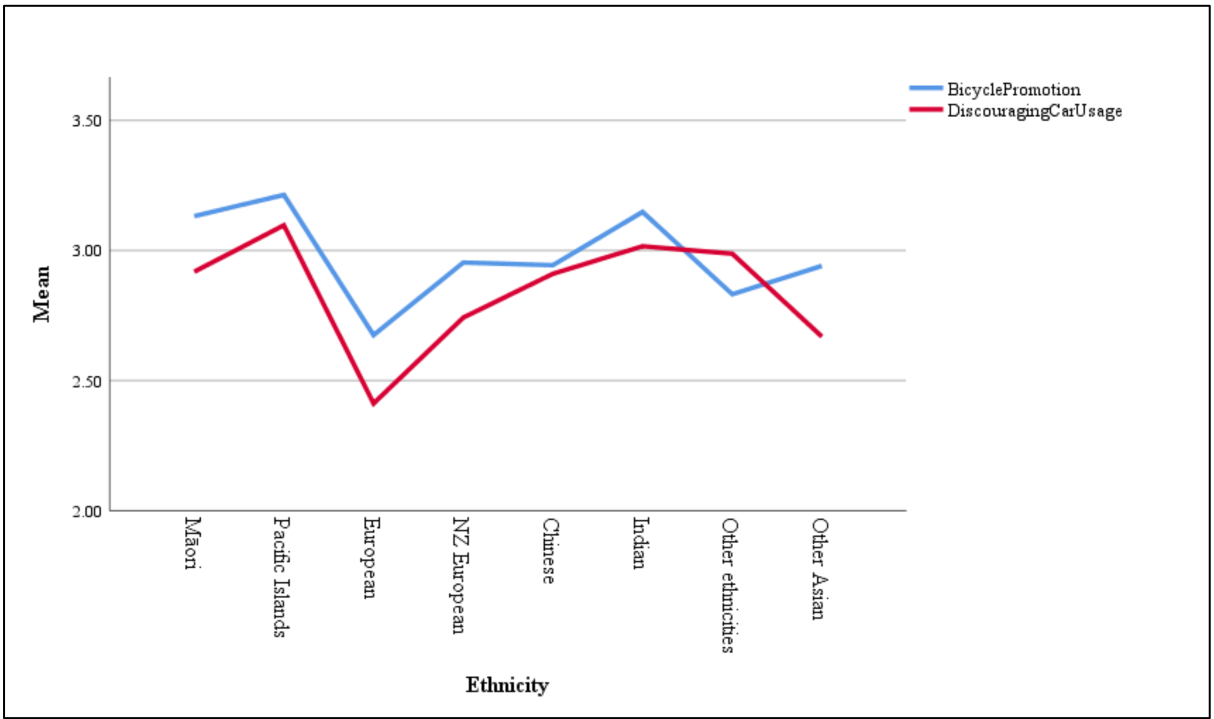

Figure 6.7. Levels of perceived effectiveness of the constructs by ethnicity

6.4.2.5 Relationship between initiatives and sociodemographic characteristics

This section presents the results of a CART analysis, used to identify the ways in which different population groups differ in terms of their perceived effectiveness of the individual cycling initiatives, independent of the constructs to which they were assigned. CART is a type of decision tree classification algorithm that uses binary recursive partitioning (Breiman et al., 1984). It selects the best predictor variable for splitting the data into clusters with 'maximum purity'. The process is repeated recursively for each cluster until either the minimum size of the terminal cluster is reached, or no further split improves the purity of the terminal cluster (Lewis et al., 2000; Shim et al., 2020) – in this case, until the clusters are significantly different from each other in terms of the perceived effectiveness of the cycling initiatives. CART analysis was implemented for all 37 of the initiatives. The key results are included in Table 6.11. However, for the sake of brevity, the CART analysis figures and tables are not included.

Overall, the CART analysis identified a significant number of cycling initiatives where age was a determining factor in terms of clustering the perceived effectiveness data. In all of these cases, the results indicate that as participants get older, the initiatives are perceived as being less effective. A similar outcome was reported for numerous other initiatives, as listed in Table 6.11, whereby older participants, specifically people older than 50 or 60, reported lower levels of effectiveness compared to other age groups. Also, the analyses only identified a limited number of cycling initiatives where gender, educational levels, and income levels were a determining factor in terms of clustering the perceived effectiveness data. Men reported higher levels of effectiveness, compared with women for implementing more bus lanes, whereas women reported higher levels of effectiveness compared to men for offering travel planning and a wide variety of incentives through work, to get staff traveling to work by bicycle. People with personal income levels lower than 100K NZD reported higher levels of perceived effectiveness for bicycle security initiatives, support for community groups with the design, delivery and/or funding of their ideas for promoting cycling in their neighbourhoods, and the Auckland Transport mobile app for planning your cycling journey, compared with people with higher income levels. People with a high school qualification reported lower levels of perceived effectiveness than people with a university degree for cycling initiatives, including improving the quantity and quality of cycle lanes, public parking facilities for bicycles, e-bike trial and loan schemes, and events to improve awareness of, and to celebrate, new and existing cycling infrastructure. Analyses identified a significant number of cycling initiatives where bicycle user type and ethnicity were a determining factor in terms of clustering the perceived effectiveness data.

Table 6.11: Cycling initiatives and perceived effectiveness of population groups

Socio-demographic characteristics	**Target groups based on perceived effectiveness of population groups (CART analysis)**	**Cycling initiatives**
Age	Participants aged 50 or younger reported higher levels of effectiveness compared to participants older than 50	IN5, IN7, IN8 BP3, BP4, BP7, BP12, BP13 BP18, CS3 DC2
	Participants aged 60 or younger reported higher levels of effectiveness compared to participants older than 60	BP6, BP10
	Younger people reported this initiative more effective compared to older people	BP1, BP2, BP5, BP8, BP9, BP15, BP16, BP17 DC1, DC3, DC4
Gender	Men reported higher levels of effectiveness compared to women	IN8
	Women reported higher levels of effectiveness compared to men	BP10
Education	Participants with a university degree reported higher levels of effectiveness compared to people with a high school degree	IN1, IN3 BP3, BP18
Ethnicity	Māori and Pacific people reported higher levels of effectiveness compared to other ethnicities	IN2, IN6, IN8 BP3, BP5, BP6, BP7, BP8, BP9, BP10, BP12, BP13, BP15, BP17, BP18 CS4 DC2, DC4
	Māori and Pacific people reported higher levels of effectiveness compared to other ethnicities, while Chinese and European people reported lower levels of effectiveness	BP1
Income Level	Participants with an income level of less than 100K NZD reported higher levels of effectiveness compared with people with higher income levels	IN5 BP5, BP10
Bicycle User Type	Regular cyclists and potential cyclists reported higher levels of effectiveness compared to non-cyclists	IN1, IN3, IN4, IN5, IN8 BP1, BP2, BP8, BP9, BP10, BP12, BP13, BP14, BP16, BP17, BP18, BP19 CS1, CS2, CS3, CS4, CS5, CS6 DC1, DC3
	Regular cyclists reported higher levels of effectiveness compared to potential cyclists and non-cyclists	IN6, IN7 BP3, BP4, BP5, BP6, BP7, BP11, BP15, DC2, DC4

6.5 Discussion

This research aimed to understand people's perceptions of cycling initiatives and how socio-demographic characteristics influence those perceptions. It is noted, however, that perceptions and reality are not always aligned. For example, perceived safety is the degree to which individuals "perceive" that using a system is safe for them and could be different to objective measures of safety (Jahanshahi et al., 2020). However, as people's perceptions are what drive behaviour, it can be argued that the measure is appropriate in terms of encourage more people to cycle.

The effectiveness of cycling initiatives were investigated from the viewpoint of different population groups in Auckland, New Zealand. The city was chosen due to its high ethnic diversity and low bicycle usage rate, especially with respect to Māori and Pacific people and lower income populations (see Chapter 4). The study considered regular cyclists, potential cyclists and non-cyclists, as well as demographic groups, to provide a holistic understanding of the association between the perceived effectiveness of cycling initiatives and socio-demographic characteristics, including age, gender, income level, educational level, ethnicity, and bicycle user type, both on terms of the individual initiatives and also when grouped (analysed as constructs).

Descriptive analyses indicate that initiatives within the Cycling Safety construct are considered to be the most effective, with lighting improvements and vehicle safety features rated as the most effective amongst all of the cycling initiatives. In contrast, initiatives within the Discouraging Car Usage construct were considered to be the least effective. All four of the constructs were found to be strongly correlated, indicating that participants who rate any of the initiatives highly tend to also rate others highly.

Next, analyses were conducted to observe the ranking of the effectiveness of initiatives within each construct. The most effective initiative within the Infrastructure construct was adding protection such as kerbs or dividers to existing cycleways. This initiative is also indirectly related to cycling safety and indicates that infrastructure provisions that increase cycling safety are perceived as being more effective than others. Regarding the effectiveness of initiatives under the Bicycle Promotion construct, improving signage and pavement markings were rated the highest. This initiative is also indirectly related to cycling safety and further emphasises that cycling safety is one of the most important factors. Among the initiatives in Cycling Safety, lighting improvements on cycleways was reported as the most effective initiative, as expected given that it was the most effective initiative among all of the initiatives, as reported above. Based on the previous chapter, this initiative is particularly targeted at women, the elderly, children, and other vulnerable population groups. Initiatives within the Discouraging Car Usage construct were those that generally had the lowest perceived effectiveness, with the least effective initiative within this construct being increasing the cost of owning a car and subsidising bike ownership. It would appear, therefore, that participants do not see indirect cycling initiatives, such as those in the Discouraging Car Usage construct, as being highly effective in encouraging bicycle usage.

Finally, a CART analysis was undertaken to identify the ways in which different population groups differ in terms of their perceived effectiveness for each cycling initiative. This paragraph also shows the differences between experts' opinions about target groups and the perceived effectiveness from the viewpoint of participants. Younger people reported higher levels of effectiveness for bicycle sharing systems, which is in line with previous findings that showed that younger people are more interested in bicycle sharing systems than older people (Jahanshahi et al., 2019; Jahanshahi et al., 2020). One of the main reasons for this could be the fact that younger generations are more comfortable adopting and interacting with technology and mobile apps, compared to older generations. The ability to carry bicycles onto buses, trains, and ferries was another initiative that younger people reported as being more effectiveness compared to older people. This could be related to the fact that cyclists are usually younger people and that this initiative is also reported as effective for cyclists. Similarly, the Bike challenge was reported as more being effective for younger people. This is in line with the findings of previous chapter where access to technology and technology acceptance were a key reason experts believed this initiative to be more attractive to younger people. Initiatives which discourage car usage by increasing the cost of owning and parking a car were also reported as being more effective for younger people. This could be because younger people (on average) have lower income levels and people with lower incomes are more price sensitive. Given the quantum of initiatives where younger people believe that the initiatives are more effective compared to older people, it is interesting to note that the experts in Chapter 5 only identified lighting improvements on cycleways and the Bike Challenge as initiative specifically targeting younger people.

The only initiative that was identified by experts in Chapter 5 as specifically targeting women was lighting improvements on cycleways. Interestingly, this was not scored differently by men and women in this study, indicating that men are also safety conscious when deciding whether or not to cycle. Although safety-related initiatives traditionally target more vulnerable and risk-averse people, it seems that safety issues and concerns are very much generic. The Auckland Transport mobile app, which suggests the best/safest cycling routes for the journey, was reported as being more effective for women. This might be related to another aspect of safety where women are generally more risk-averse, and information regarding the safest cycling routes will alleviate that risk. In addition, opening more bus lanes, noting that cyclists can travel in bus lanes, were perceived as more effective by men. This could be related to women's safety concerns with respect to sharing road space with a bus.

Cycling initiatives identified by experts in Chapter 5 as specifically targeting lower income groups, such as cycling skills training in schools, community Bike Fund for non-profit groups, support the expansion of community bike hubs at key locations across the region, and E-bike trials and loan schemes were not identified in the CART analysis. The findings of this study indicate that bicycle security initiatives were reported as being more effective for lower income groups. This could be because lower income groups are more concerned about losing their bicycle, due to the cost of replacement or not having insurance cover, and such security initiatives provide a level of assurance against theft.

In Chapter 5, experts did not identify any initiatives as specifically targeting ethnic groups. However, this chapter showed that Māori and Pacific people reported higher levels of effectiveness with respect to a number of cycling initiatives compared to other ethnicities. The potential reasons for differences between Māori and Pacific people's and others perceived effectiveness is not entirely clear and further investigations need to be undertaken to discover the fundamental reasons for this. Given that Māori and Pacific people are considered to be disadvantaged population groups in terms of cycling benefits (Bassett et al., 2020; Shaw & Russell, 2017), cycling policies should attempt to address barriers to their bicycle use. The cycling initiatives reported in Table 6.11 that are more effective from the viewpoint of Māori and Pacific people will assist in this process.

In Chapter 5, experts identified numerous cycling initiatives that targeted current cyclists, and a similar outcome was expected in this chapter. Many of the cycling initiatives shown in Table 6.11 returned higher levels of effectiveness for regular cyclists or potential cyclists, compared with non-cyclists. Of concern is that none of the cycling initiatives were considered to be more effective by non-cyclists compared with regular and potential cyclists.

6.6 Conclusion

As argued by Levinson (2010), a policy deemed equitable to researchers or policymakers may not necessarily be considered equitable by those affected by the policy. Consequently, an equitable cycling policy should also consider population needs and perceptions. The current chapter has clearly shown that people with different sociodemographic backgrounds have different perceptions about the level of effectiveness of cycling initiatives, with cycling initiatives in Auckland is more strongly related to factors such as ethnicity, age, and bicycle user type, compared to other sociodemographic characteristics. Overall, however, initiatives in the Cycling Safety construct were considered to be the most effective, with indirect cycling initiatives, such as those in the Discouraging Car Usage construct, being the least effective. In addition, many of the cycling initiatives were more attractive to population groups other than the intended target group.

Non-cyclists, along with older people and women – three groups associated with low cycling rates, consistently reported lower perceived effectiveness with respect to cycling initiatives. This suggests that cycling initiatives need to be more creative and targeted if these groups are to be given priority. In contrast, Māori and Pacific people, another group with a low cycling rate, reported higher levels of perceived effectiveness compared to others for many of the listed initiatives. Interestingly, Māori and Pacific people reported higher levels of effectiveness for the majority of the initiatives in the Bicycle Promotion construct. Such initiatives include various forms of engagement and consultation with, as well as support for, communities. A better understanding of the spatial and social distribution of such events across Auckland may help understand if such promotions are reaching these target groups.

More generally, population needs and perceptions should influence planning for the provision of cycling initiatives and, therefore, should play a role in equity analysis. It could also be critical in the development of cycling demand and supply indices and, ultimately, more equitable investment prioritisation – a step towards cycling equity analysis planning "with" people, as well as "for" people. The findings of this chapter could be used to provide better insights for policymakers and local governments for improving cycling policies, initiatives, and investment in order to decrease inequity in cycling.

Finally, it should be noted that Auckland is young in terms of its cycling journey. With the lowest cycling rates among New Zealand cities, the primary aim is increasing bicycle use and facilitating the rapid uptake of cycling. In contrast, in places with high bicycle usage rates and an established cycling culture (such as in Amsterdam), there is more capacity to focus on issues such as equity. As Auckland matures in terms of its cycling journey, it is hoped that the findings in this paper will help shape equitable policy and funding decision-making, resulting is fair outcomes for all.

Chapter 7

Conclusions and Recommendations

7.1 Overview

Traditionally, equity in cycling has focused on the provision of cycling infrastructure to meet equity needs. However, a policy deemed equitable to researchers or policymakers may not necessarily be considered equitable by those affected by the policy. An equitable cycling policy should, therefore, also consider population needs and perceptions. Following the capabilities approach of justice, focusing only on the provision of cycling resources, such as bicycle lanes, can be misleading, and socio-cultural factors, such as ethnicity, should also be considered in order to fairly encourage and empower all population groups to use bicycles. Other aspects of cycling equity, such as people's perceptions and needs and the equity role of cycling initiatives other than bicycle lanes, have received limited attention. With this in mind, an investigation to gain a better understanding of equity in cycling, including perceptions, initiatives, and barriers, has been conducted in Auckland, New Zealand.

This research has synthesized relevant literature, and examined and interpreted the outcomes of multiple phases of data collection using quantitative and qualitative approaches to provide a comprehensive understanding of aspects of cycling equity such as population needs, usage behaviour and perceptions of cycling infrastructure, and to identify cycling initiatives other than bicycle infrastructure, highlight barriers to implementing cycling equity policies in practice, and evaluate their effectiveness from the view point of population groups.

This chapter presents the conclusions of the study and recommendations for future research. The chapter outlines the achievement of the research objectives, thereby highlighting the value and significance of the research in the field of cycling equity. This is followed by a statement of the limitations of the research and, finally, recommendations for future studies are suggested.

7.2 Achievement of research objectives

The main aim of the research, as set out in Chapter 1, was to gain a more comprehensive understanding of equity in cycling and to evaluate equity in cycling in aspects beyond bicycle infrastructure. Five objectives were established to achieve this aim, as follows:

1. To synthesize the key findings and knowledge gaps from studies focused on bicycling equity

2. To develop a psychological model which explains the influence of perceptions of cycling on bicycle usage in Auckland

3. To understand people's perceptions of cycling infrastructure provision, their relationships to the physical infrastructure provided, the ways in which socio-demographic characteristics influence those perceptions, and how these are influenced by individual experience in using the cycling infrastructure

4. To understand equity in cycling initiatives, barriers to implementing cycling equity policies, and strategies to address the barriers

5. To determine the effectiveness of cycling initiatives among different population groups and compare these against the intended target groups

In the following sub-sections, the connection between each chapter and achievement of the equivalent research objectives are described.

7.2.1 Review of Key Findings and Future Directions for Assessing Equitable Cycling Usage

The first objective was achieved by conducting the literature review presented in Chapter 2. The study in Chapter 2 provides a review of the key equity findings to date in cycling usage and identifies knowledge gaps. Barriers to cycling from an equity perspective are examined from three perspectives: policy and planning, infrastructure and cycling facilities, and population groups. The review includes both peer-reviewed and grey papers. Using a structured exploratory literature review process, out of 73 documents, 33 which met the scope of the study were carefully examined. The review showed that accessibility is the most common measure for bicycling equity.

Overall, through a review of the literature on bicycling equity and subsequent identification of the gaps in the literature, it can be concluded that future research should focus on the following key topics:

- Developing a better understanding of an equitable cycling environment, by exploring various aspects of cycling such as population needs, usage behavior, and perceptions of cycling infrastructure.
- Identifying cycling initiatives other than bicycle infrastructure, assessing their effectiveness, and highlighting barriers to implementing cycling equity policies in practice.
- Developing equity measures for policymaking that incorporate various aspects of bicycling equity and evaluating their effectiveness.

7.2.2 Understanding the influence of sociodemographic characteristics on perceptions of cycling and bicycle usage in Auckland

The second objective was achieved by conducting the study presented in Chapter 3. The study explores a number of sociodemographic characteristics to determine their influence on bicycle usage in Auckland. This research aimed to understand the factors influencing Aucklanders' bicycle usage and, in addition, the sensitivities of different population groups to those factors. For this purpose, age, income levels, gender, and ethnicity were investigated separately, as well as combined, through the use of an intersectionality approach. The particular aim of the study was to examine whether the constructs Sociocultural Factors, Price Value, Perceived Safety and Security, Cycling Provision Perception, and Information and Communication could explain bicycle usage in Auckland, and whether age, gender, ethnicity, and income level moderate such relationships. This study expanded the theoretical horizon of cycling perceptions by introducing a new construct, Information and Communication, and investigating the factors influencing bicycle usage in the multicultural city of Auckland. A conceptual model of Bicycle Usership was proposed which includes the constructs Sociocultural Factors, Price Value, Perceived Safety and Security, Cycling Provision Perception, and Information and Communication. The conceptual model was then analysed using Structural Equation Modelling (SEM) to examine the effect of the constructs on various sociodemographic groups. The moderating effects of age, gender, ethnicity and income level on the relationship between these constructs and Bicycle Usership was also examined.

Chapter 3 showed that bicycle infrastructure is not the only important cycling provision and that there are other factors to consider in cycling equity. Based on Chapter 3, Sociocultural Factors showed the strongest relationship with bicycle usage. This relates to the impact of people around the participants, such as family and friends, on their bicycle usage and the image of bicycles in society. People who perceived that others (for example, their family and friends) believe that they should use a bicycle showed a significantly higher bicycle usage rate. Also, people who were not embarrassed to be seen riding a bicycle showed a significantly higher bicycle usage rate. Perceived Safety and Security was another factor with a positive impact on bicycle usage. Individuals feeling safe while bicycling cycled more. The newly introduced construct, Information and Communication, was found to be an important factor which influences Bicycle Usership. Information and Communication focused on the promotion of cycling, awareness of traffic regulations, and having access to the reporting of cycling issues in the city. People who perceived that they have better access to information have a higher rate of bicycle usage. An interesting finding was that Māori and Pacific peoples are significantly less sensitive to Sociocultural Factors, compared with NZ European. This means that the impact of family and friends, in terms of influencing bicycle usage, is more important for NZ European than Māori and Pacific peoples. Women and high-income people are sensitive to the effect of Perceived Safety and Security on Bicycle Usership.

This research has shown that an individual's sociodemographic characteristics can result in different perceptions about cycling and that cycling provision perception is more affected by factors such as ethnicity, education, and bicycle user type than objective measures of bicycle infrastructure provision. It has also shown that people with different backgrounds have different perceptions about the same level of infrastructure. It could be argued that people's perceptions could influence planning for the provision of bicycle infrastructure and, therefore, could play a role in equity analysis. Establishing policies which focus more on sociocultural factors than infrastructure can increase bicycle usage for those who are more sensitive to these factors. The results of this research suggest that "equity in cycling" should be a holistic system which considers "equity in the provision of cycling initiatives, such as education and awareness", as well as "equity in the provision of cycling infrastructure".

7.2.3 Understanding perceptions of cycling infrastructure provision and its role in cycling equity

The third objective was achieved by conducting the study presented in Chapter 4. The study aimed to understand people's perceptions of cycling infrastructure provision, its relationship to the physical infrastructure provided, and how socio-demographic characteristics influence those perceptions. The factors influencing different cycling provision perceptions among various groups, and the extent to which objective factors (in this case the availability of bicycle lanes) play a role in individual perceptions of cycling infrastructure, were investigated. Auckland, New Zealand was chosen as the city of interest due to its low bicycle usage rate and high level of ethnic diversity within its population. The study considered the demographics of bicycle users/non-users across a wide range of levels of bicycle infrastructure availability to provide a holistic understanding of the factors associated with people's perceptions about cycling infrastructure provision.

Based on Chapter 4, Māori have the highest percentage of potential cyclists among all ethnicities. Pacific Islanders have the highest percentage of non-cyclist (64.9%), the lowest percentage of potential cyclists, and one of the lowest percentage of regular cyclists. The result of Chapter 4 showed that while for regular cyclists, age, education level, and cycling injury experience affected their perceptions of cycling infrastructure provision, only the ethnicity of non-cyclists and potential cyclists significantly influenced their perception of cycling infrastructure provision. It can, therefore, be argued that for people who are not currently or regularly cycling, only socio-cultural backgrounds play a significant role in perceptions. As for the influence of education level, it may be linked to employment conditions and, therefore, inflexibilities in the workplace as a barrier to use a bicycle. Interestingly, while Māori and Pacific people had the highest level of perceptions about cycling provision, studies have shown that bicycle usage rates among Māori and Pacific people remains significantly lower than for other ethnicities. This Chapter shows that perceptions of cycling infrastructure provision do not significantly influence bicycle usage and that other factors play a more important role in bicycle usage. Therefore, to better analyze cycling equity we should consider factors other than cycling infrastructure.

7.2.4 Equity and cycling initiatives: a stakeholders' perspective on target groups, barriers to implementing cycling equity policies, and strategies to address barriers

The fourth objective was achieved by conducting the study presented in Chapter 5. The study aimed to evaluate equity in cycling initiatives and their operational challenges by reviewing a wide range of cycling initiatives implemented in Auckland. The current initiatives with respect to various target groups or resulting beneficiaries were discussed, along with potential additional initiatives, barriers to implementing cycling equity initiatives in practice, and possible solutions to address such barriers. By interviewing policy-makers, decision-makers, planners, designers, and transportation professionals, 44 cycling initiatives were identified.

Chapter 5 showed that there is no clear definition of, or metric for, cycling equity. Although there have been some efforts made in the transport sector to address cycling inequity issues, a lack of a clear definition and metrics, and a lack of a systematic plan, with priorities for funding and capabilities, results in challenges and barriers to addressing cycling equity. Chapter 5 identified 44 different cycling initiatives currently being implemented in Auckland where only one initiative (lighting improvements) targets women, younger people, and the elderly. Consistent with what we know about bicycle usage in Auckland, it seems only limited effort has been expended on the aforementioned groups. In addition, there are no initiatives aimed specifically at any particular cycling disadvantaged ethnic group. Specifically, while Māori receive significantly fewer health benefits from cycling generally, the relative benefits are higher when they partake. Chapter 5 shows that the spatial distribution of some of the initiatives is not currently equitable in Auckland. There are some reasons for this inequitable distribution, including lack of sufficient funding, prioritization of funds, and a lack of adequate human resource. A common finding of previous studies also shows that bicycle infrastructure is not equitably distributed among different population groups. It seems there is still a challenge in terms of informing people about cycling initiatives, thereby making the whole system inequitable because of lack of awareness. Chapter 5 also identified potential additional initiatives to the currently implemented cycling initiatives. For example, e-bike subsidies have been implemented in many European countries and could help promote cycling in Auckland, by overcoming the reluctance to cycle due to the hilly terrain and barriers due to the cost of e-bikes. Interestingly, better information and communication was also identified as one of the factors influencing bicycle usage in Auckland in Chapter 3. Based on Chapter 5 the built environment was identified as a new found barrier to implementing cycling equity initiatives that should be addressed. The built environment as a barrier to cycling equity has not been discussed in previous studies. This is related to the influence of urban design, housing density, employment locations, and place of living, on the implementation of cycling initiatives.

It seems that current cycling initiatives are not focused on Māori and/or Pacific people specifically. Although some initiatives are available for particular population groups if they are proactive and request assistance, this kind of policy is based on “want” and not “need”, and therefore will not be effective in addressing equity issues. Obviously, more funding would allow planners and policymakers to increase the coverage of initiatives. However, an important matter is how they prioritize the constrained funding in different areas. As discussed in Chapter 5, it seems prioritization is assessed on a case-by-case basis and the level of bicycle usage. For example, funding in Auckland, aimed at increasing bicycle use and facilitating the fast uptake of cycling, may be best used to expand the capacity of the system (infrastructure). As another example of funding priorities, decision-makers for disadvantaged areas such as South Auckland could argue that there are a lot of issues lower income communities face that are perhaps more important than cycling infrastructure, such as health services, education services, and public transport.

7.2.5 Who benefits from cycling initiatives? An evaluation of perceived effectiveness and differences among population groups

The last objective was achieved by conducting the study presented in Chapter 6. The study aimed to explore the effectiveness of cycling initiatives in encouraging bicycle usage, and the relationship with sociodemographic characteristics amongst residents of the multi-cultural city of Auckland, New Zealand. The study considered regular cyclists, potential cyclists, as well as non-cyclists across demographic groups, including age, gender, income level, educational level, ethnicity, and bicycle user type to provide a holistic understanding of the association between the perceived effectiveness of cycling initiatives in encouraging bicycle usage.

Chapter 6 showed that younger people reported higher levels of effectiveness for bicycle sharing systems. The ability to carry bicycles onto buses, trains, and ferries was another initiative that younger people reported as being more effective compared to older people. This could be related to the fact that cyclists are usually younger people and that this initiative is also reported as effective for cyclists. Similarly, the Bike Challenge was reported as being more effective for younger people. This is in line with the findings of Chapter 5 where access to technology and technology acceptance were key reasons experts believed this initiative to be more attractive to younger people. Given the quantum of initiatives where younger people believe that the initiatives are more effective compared to older people, it is interesting to note that the experts in Chapter 5 only identified lighting improvements on cycleways and the Bike Challenge as initiatives specifically targeting younger people. The only initiative that was identified by experts in Chapter 5 as specifically targeting women was lighting improvements on cycleways. Interestingly, this was not scored differently by men and women in Chapter 6, indicating that men are also safety conscious when deciding whether or not to cycle. Although safety-related initiatives traditionally target more vulnerable and risk-averse people, it seems that safety issues and concerns are very much generic. Cycling initiatives identified by experts in Chapter 5 as specifically targeting lower income groups, such as cycling skills training in schools, community Bike Fund for non-profit groups, supporting the expansion of community bike hubs at key locations across the region, and E-bike trials and loan schemes were not identified in the CART analysis. In Chapter 5, experts did not identify any initiatives as specifically targeting ethnic groups. However, Chapter 6 showed that Māori and Pacific people reported higher levels of effectiveness with respect to the majority of cycling initiatives compared to other ethnicities. Given that Māori and Pacific people are considered to be disadvantaged population groups in terms of cycling benefits, cycling policies should attempt to address barriers to their bicycle use. In Chapter 5, experts identified numerous cycling initiatives that targeted current cyclists, and a similar outcome was expected in this chapter. Many of the cycling initiatives returned higher levels of effectiveness for regular cyclists or potential cyclists, compared with non-cyclists. Of concern is that none of the cycling initiatives were considered to be more effective by non-cyclists compared with regular and potential cyclists.

Chapter 6 has clearly shown that people with different sociodemographic backgrounds have different perceptions about the level of effectiveness of cycling initiatives and many of the cycling initiatives were more attractive to population groups other than the intended target group. Non-cyclists, along with older people and women – three groups associated with low cycling rates – consistently reported lower perceived effectiveness with respect to cycling initiatives. This suggests that cycling initiatives need to be more creative and targeted if these groups are to be given priority. In contrast, Māori and Pacific people, another group with a low cycling rates, reported higher levels of perceived effectiveness compared to others for many of the listed initiatives. Interestingly, Māori and Pacific people reported higher levels of effectiveness for the majority of the initiatives in the Bicycle Promotion construct. Such initiatives include various forms of engagement and consultation with, as well as support for, communities. A better understanding of the spatial and social distribution of such events across Auckland may help understand if such promotions are reaching these target groups.

More generally, population needs and perceptions should play a role in equity analysis. It could also be critical in the development of cycling demand and supply indices and, ultimately, more equitable investment prioritisation – a step towards cycling equity analysis planning "with" people, as well as "for" people. Finally, it should be noted that Auckland is young in terms of its cycling journey. With the lowest cycling rates among New Zealand cities, the primary aim is increasing bicycle use and facilitating the rapid uptake of cycling. In contrast, in places with high bicycle usage rates and an established cycling culture (such as in Amsterdam), there is more capacity to focus on issues such as equity. As Auckland matures in terms of its cycling journey, it is hoped that the findings in this paper will help shape equitable policy and funding decision-making, resulting is fair outcomes for all.

Addressing equity in cycling can indeed pose a challenge when it comes to recommending funding priorities to decision makers. The issue arises from the need to demonstrate tangible results and usage to secure ongoing funding and political support for cycling initiatives. This emphasis on immediate and measurable outcomes can potentially hinder efforts to address equity in cycling for several reasons. Inequitable distribution of resources: Funding decisions based solely on demonstrated usage may perpetuate existing inequalities in cycling infrastructure. Areas with already high cycling rates or well-developed infrastructure are more likely to show immediate usage results, whereas underserved communities or areas lacking infrastructure may struggle to demonstrate comparable usage in the short term. In addition, disadvantaged communities often face systemic barriers that limit their access to safe and convenient cycling infrastructure. These barriers can include factors such as limited infrastructure, safety concerns, lack of bike-sharing programs, or inadequate connectivity to key destinations. Overcoming these barriers and building equitable cycling systems may require upfront investments that may not yield immediate high usage rates, making it challenging to secure continued funding based solely on short-term metrics. Encouraging more diverse and inclusive participation in cycling requires addressing long-standing behavioral patterns and cultural norms. It takes time to build awareness, shift attitudes, and change behaviors, particularly in communities that have historically been marginalized or underserved. Funding decisions solely based on short-term usage metrics may undermine efforts to promote equitable cycling, as it may not allow sufficient time for behavior change to occur and for communities to embrace cycling as a viable mode of transportation.

To address these challenges, it is important for policy makers to advocate for a broader understanding of success metrics beyond immediate usage rates. They should emphasize the importance of equity, accessibility, and inclusivity in cycling initiatives. This can involve considering factors such as the level of service provided to underserved areas, the potential for long-term behavior change, and the overall impact on community health and well-being. By highlighting the social and environmental benefits of equitable cycling initiatives, policy makers can help decision makers recognize the value of investing in projects that prioritize equity, even if they may not yield immediate high usage rates.

7.3 Value and significance of the research

The first major contribution of the research was developing a psychological model to predict bicycle usage based on a range of sociocultural and socioeconomic factors, and related constructs. The model also expanded the theoretical horizon of cycling perceptions by introducing a new construct, namely Information and Communication. The findings of the model will help decision-makers better understand the how Aucklanders' perceptions of cycling differ between population groups and how these influence their bicycle usage. With that knowledge, they will be better equipped to develop policies to improve cycling equity in Auckland.

The second major contribution of the research was the evaluation of the role that bicycle infrastructure plays in cycling equity. By investigating the relationships between perceptions of bicycle infrastructure provision and bicycle usage, accounting for differences among population groups, this research showed that investing solely in bicycle lanes will not address inequity in cycling. This finding is an important message to decision-makers as, traditionally, the response was to provide more bicycle infrastructure to solve cycling equity issues. This research showed that other factors, such as sociocultural factors and different needs of communities, influence cycling usage more than bicycle infrastructure. This has the potential to influence investment decision-making in the transport industry through the prioritization of non-traditional cycling initiatives.

The third, and main, contribution of this research was to develop an understanding of the whole cycling equity environment through identification of cycling initiatives in Auckland, beyond the provision of bicycle infrastructure, and the role they can play in cycling equity. This was achieved by identifying all the cycling initiatives, their operational challenges, barriers to implementing them in practice, potential strategies to address the barriers, and perceived effectiveness of the initiatives from the viewpoint of different population groups. These findings will help decision-makers to better understand what type of initiatives influence bicycle usage for different population groups, and how they might solve barriers to implementing cycling equity policies.

7.4 Research limitations

This section discusses the potential limitations of the research and these should be considered when interpreting the findings of this research. These limitations can be summarized as follows:

- Due to the limitations of proportional quota sampling, it was not possible to achieve a truly representative sample of the population. While proportional quota sampling aims to include representation from different subgroups, the convenience element in the sampling means that the results are less generalizable to a population than a truly random sample.

- A potential limitation for any study of this type is the risk of bias due to self-selection, as well as respondents tending towards providing socially-acceptable answers. Such self-selection is unavoidable in that the participants are those who received the online questionnaire and decided to complete it.

- Another limitation of this study might be a selection effect due to the language barrier, given that the questionnaire was only provided in English. Also, the questionnaire was online and it could, potentially, exclude people who are not comfortable with online surveys.

- The standard weights for the Bike Lane Score were used in this study for reasons of consistency with other studies in the international literature; however, it is acknowledged that the generalizability of the original study may be a limitation.

7.5 Recommendations for future research

Based on the findings of the research that have been outlined above, a number of recommendations are put forward to pave the way for further research in cycling equity, as follows:

- Further research is required to understand the extent to which the low levels of bicycle usage amongst Māori and Pacific people is linked to socio-cultural factors, despite their higher perceptions of bicycle infrastructure provision and their higher perceptions of the effectiveness of many of the cycling initiatives.

- Given that Māori and Pacific people reported higher levels of perceived effectiveness for bicycle promotion initiatives, but are among those with the lowest bicycle usage rates, a better understanding of the spatial and social distribution of cycling events across Auckland is needed to help understand if such promotions are reaching these target groups.

- A key knowledge gap is the lack of robust measures to determine inequities in cycling and evaluate the distribution of benefits across population groups. This is attributed to the lack of suitable measures to effectively evaluate a program or policy from an equity perspective. Consequently, further research is required to develop such equity measures.

- Longitudinal studies are needed in order to better understand the impact of cycling equity policies over time, in order to objectively assess the effectiveness of initiatives and policies.

- The digital divide and access to technology should be investigated further to understand the solutions to address these barriers, possibly through the use of technology acceptance models. While some studies have investigated acceptance of cycling technologies (Hazen et al., 2015; Jahanshahi et al., 2020; Wolf & Seebauer, 2014), the relationship between technology acceptance and cycling equity is yet to be fully understood.

- One of the barriers raised to the successful implementation of cycling equity initiatives was historical racism and working in a colonized system. Further research is required for a more in-depth investigation of historical racism and its impact on transport equity, not only in cycling planning and policy-making, but in all areas of transportation planning.

- Further research is required to investigate the challenges and potential solutions to cycling inequity related to urban design and housing density.

- In terms of the suggested strategies to address cycling inequity, four main strategies were identified, including incorporating an equity lens in the assessment of planning proposals, wider coverage of people and initiatives, engagement with the community, and empowering people. Further research is required to understand the feasibility of the aforementioned strategies.

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Appendix 3.1: One-by-one comparison of ethnicities with respect to their moderating effect on the relationships between the constructs and Bicycle Usership.

	IC -> BU	IF -> BU	PS -> BU	PV -> BU	SC -> BU
Path Coefficients-diff (Māori and Pacific peoples - NZ European)	0.115	0.005	-0.007	-0.003	-0.224
Path Coefficients-diff (Māori and Pacific peoples - Indian)	-0.240	0.151	0.030	0.157	-0.167
Path Coefficients-diff (Māori and Pacific peoples - Asian)	-0.066	-0.095	-0.047	0.060	0.069
Path Coefficients-diff (Māori and Pacific peoples - European)	0.087	-0.084	-0.056	-0.037	-0.148
Path Coefficients-diff (NZ European- Indian)	-0.355	0.146	0.037	0.160	0.056
Path Coefficients-diff (NZ European- Asian)	-0.181	-0.100	-0.040	0.063	0.292
Path Coefficients-diff (NZ European- European)	-0.028	-0.089	-0.049	-0.034	0.076
Path Coefficients-diff (Indian - Asian)	0.174	-0.246	-0.076	-0.097	0.236
Path Coefficients-diff (Indian - European)	0.327	-0.235	-0.086	-0.194	0.020
Path Coefficients-diff (Asian - European)	0.153	0.011	-0.009	-0.097	-0.216
p-Value new (Māori and Pacific peoples vs NZ European)	0.340	0.913	0.869	0.972	0.030
p-Value new (Māori and Pacific peoples vs Indian)	0.226	0.609	0.850	0.367	0.290
p-Value new (Māori and Pacific peoples vs Asian)	0.653	0.739	0.902	0.640	0.607
p-Value new (Māori and Pacific peoples vs European)	0.602	0.758	0.865	0.930	0.335
p-Value new (NZ European vs Indian)	0.052	0.536	0.860	0.312	0.703
p-Value new (NZ European vs Asian)	0.129	0.425	0.771	0.586	0.004
p-Value new (NZ European vs European)	0.852	0.531	0.714	0.934	0.580
p-Value new (Indian vs Asian)	0.371	0.311	0.733	0.590	0.137
p-Value new (Indian vs European)	0.125	0.363	0.705	0.515	0.909
p-Value new (Asian vs European)	0.355	0.988	0.957	0.767	0.155

Appendix 3.2: One-by-one comparison of the age groups with respect to their moderating effect on the relationships between the constructs and Bicycle Usership.

	IC -> BU	IF -> BU	PS -> BU	PV -> BU	SC -> BU
Path Coefficients-diff (18-20 - 21-30)	0.103	-0.409	-0.126	0.193	-0.130
Path Coefficients-diff (18-20 - 31-40)	-0.168	-0.349	-0.380	0.203	0.268
Path Coefficients-diff (18-20 - 41-50)	-0.054	-0.588	0.017	0.094	0.120
Path Coefficients-diff (18-20 - 51-60)	0.173	-0.233	-0.183	0.011	0.025
Path Coefficients-diff (18-20 - >60)	0.085	-0.504	-0.094	0.092	-0.014
Path Coefficients-diff (21-30 - 31-40)	-0.270	0.060	-0.254	0.010	0.398
Path Coefficients-diff (21-30 - 41-50)	-0.157	-0.179	0.142	-0.099	0.250
Path Coefficients-diff (21-30 - 51-60)	0.070	0.176	-0.057	-0.182	0.155
Path Coefficients-diff (21-30 - >60)	-0.018	-0.095	0.032	-0.101	0.116
Path Coefficients-diff (31-40 - 41-50)	0.114	-0.238	0.396	-0.109	-0.148
Path Coefficients-diff (31-40 - 51-60)	0.341	0.116	0.197	-0.192	-0.243
Path Coefficients-diff (31-40 - >60)	0.252	-0.155	0.286	-0.111	-0.282
Path Coefficients-diff (41-50 - 51-60)	0.227	0.354	-0.200	-0.083	-0.095
Path Coefficients-diff (41-50 - >60)	0.138	0.084	-0.111	-0.002	-0.134
Path Coefficients-diff (51-60 - >60)	-0.089	-0.271	0.089	0.081	-0.039
p-Value new (18-20 vs 21-30)	0.585	0.135	0.538	0.344	0.501
p-Value new (18-20 vs 31-40)	0.405	0.157	0.066	0.348	0.179
p-Value new (18-20 vs 41-50)	0.770	0.067	0.935	0.562	0.502
p-Value new (18-20 vs 51-60)	0.441	0.253	0.496	0.859	0.864
p-Value new (18-20 vs >60)	0.642	0.094	0.646	0.571	0.975
p-Value new (21-30 vs 31-40)	0.107	0.756	0.090	0.977	0.001
p-Value new (21-30 vs 41-50)	0.274	0.304	0.337	0.446	0.035
p-Value new (21-30 vs 51-60)	0.710	0.356	0.777	0.189	0.247
p-Value new (21-30 vs >60)	0.907	0.583	0.833	0.440	0.354
p-Value new (31-40 vs 41-50)	0.458	0.129	0.007	0.497	0.239
p-Value new (31-40 vs 51-60)	0.100	0.487	0.405	0.231	0.077
p-Value new (31-40 vs >60)	0.122	0.329	0.054	0.488	0.029
p-Value new (41-50 vs 51-60)	0.228	0.058	0.406	0.536	0.467
p-Value new (41-50 vs >60)	0.315	0.548	0.460	0.982	0.261
p-Value new (51-60 vs >60)	0.640	0.126	0.687	0.553	0.761

Appendix 3.3: One-by-one comparison of the gender groups with respect to their moderating effect on the relationships between the constructs and Bicycle Usership.

	IC -> BU	IF -> BU	PS -> BU	PV -> BU	SC -> BU
Path Coefficients-diff (MALE - FEMALE)	-0.059	0.142	-0.040	0.002	-0.003
p-Value new (MALE vs FEMALE)	0.510	0.113	0.668	0.973	0.985

Appendix 3.4: One-by-one comparison of the income groups with respect to their moderating effect on the relationships between the constructs and Bicycle Usership.

	IC -> BU	IF -> BU	PS -> BU	PV -> BU	SC -> BU
Path Coefficients-diff (NO INCOME - <30,000)	0.123	-0.027	0.075	-0.385	-0.191
Path Coefficients-diff (NO INCOME - 30,000-70,000)	0.141	-0.162	0.110	-0.352	-0.127
Path Coefficients-diff (NO INCOME - 70,000-100,000)	-0.102	-0.056	-0.102	-0.302	-0.068
Path Coefficients-diff (NO INCOME - >100,000)	0.087	-0.130	-0.002	-0.328	0.053
Path Coefficients-diff (<30,000 - 30,000-70,000)	0.018	-0.135	0.036	0.033	0.064
Path Coefficients-diff (<30,000 - 70,000-100,000)	-0.225	-0.029	-0.177	0.083	0.123
Path Coefficients-diff (<30,000 - >100,000)	-0.036	-0.104	-0.077	0.057	0.244
Path Coefficients-diff (30,000-70,000 - 70,000-100,000)	-0.243	0.106	-0.213	0.050	0.058
Path Coefficients-diff (30,000-70,000 - >100,000)	-0.054	0.031	-0.112	0.024	0.179
Path Coefficients-diff (70,000-100,000 - >100,000)	0.188	-0.075	0.100	-0.026	0.121
p-Value new (NO INCOME vs <30,000)	0.488	0.873	0.673	0.199	0.211
p-Value new (NO INCOME vs 30,000-70,000)	0.410	0.401	0.591	0.240	0.389
p-Value new (NO INCOME vs 70,000-100,000)	0.586	0.771	0.835	0.284	0.680
p-Value new (NO INCOME vs >100,000)	0.655	0.541	0.879	0.275	0.770
p-Value new (<30,000 vs 30,000-70,000)	0.875	0.230	0.769	0.771	0.443
p-Value new (<30,000 vs 70,000-100,000)	0.080	0.832	0.219	0.412	0.267
p-Value new (<30,000 vs >100,000)	0.804	0.475	0.635	0.731	0.115
p-Value new (30,000-70,000 vs 70,000-100,000)	0.039	0.391	0.099	0.625	0.585
p-Value new (30,000-70,000 vs >100,000)	0.698	0.847	0.445	0.900	0.219
p-Value new (70,000-100,000 vs >100,000)	0.213	0.618	0.540	0.818	0.441

Appendix 3.5: The moderating effect of each combined group for each path in the model.

GROUP	PATH	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	gender	income	ETH	N
G1	IC -> BU	0.408	0.590	0.690	0.490	MALE	LOW	M & P	14
G2	IC -> BU	-0.122	0.195	0.626	0.531	MALE	LOW	OTHER	42
G3	IC -> BU	0.105	n/a			MALE	AVERAGE	M & P	16
G4	IC -> BU	0.049	0.116	0.419	0.676	MALE	AVERAGE	OTHER	92
G6	IC -> BU	-0.014	0.177	0.078	0.938	MALE	HIGH	OTHER	42
G7	IC -> BU	0.150	0.374	0.401	0.688	FEMALE	LOW	M & P	25
G8	IC -> BU	0.043	0.113	0.381	0.704	FEMALE	LOW	OTHER	70
G9	IC -> BU	0.077	0.322	0.239	0.811	FEMALE	AVERAGE	M & P	19
G10	IC -> BU	0.039	0.080	0.495	0.621	FEMALE	AVERAGE	OTHER	118
G12	IC -> BU	0.188	0.220	0.853	0.394	FEMALE	HIGH	OTHER	26
G1	IF -> BU	-0.187	0.608	0.308	0.758	MALE	LOW	M & P	14
G2	IF -> BU	0.091	0.148	0.612	0.541	MALE	LOW	OTHER	42
G3	IF -> BU	-0.471	n/a			MALE	AVERAGE	M & P	16
G4	IF -> BU	0.186	0.125	1.484	0.138	MALE	AVERAGE	OTHER	92
G6	IF -> BU	0.118	0.229	0.515	0.606	MALE	HIGH	OTHER	42
G7	IF -> BU	-0.091	0.343	0.265	0.791	FEMALE	LOW	M & P	25
G8	IF -> BU	-0.029	0.140	0.211	0.833	FEMALE	LOW	OTHER	70
G9	IF -> BU	0.419	0.441	0.951	0.342	FEMALE	AVERAGE	M & P	19
G10	IF -> BU	0.033	0.082	0.396	0.692	FEMALE	AVERAGE	OTHER	118
G12	IF -> BU	-0.163	0.236	0.690	0.490	FEMALE	HIGH	OTHER	26
G1	PS -> BU	-0.097	0.566	0.171	0.864	MALE	LOW	M & P	14
G2	PS -> BU	0.157	0.175	0.901	0.368	MALE	LOW	OTHER	42
G3	PS -> BU	0.258	n/a			MALE	AVERAGE	M & P	16
G4	PS -> BU	-0.007	0.118	0.061	0.952	MALE	AVERAGE	OTHER	92
G6	PS -> BU	0.180	0.190	0.946	0.344	MALE	HIGH	OTHER	42
G7	PS -> BU	0.170	0.308	0.552	0.581	FEMALE	LOW	M & P	25

G8	PS -> BU	0.027	0.116	0.230	0.818	FEMA LE	LOW	OTHER	70
G9	PS -> BU	0.310	0.407	0.762	0.446	FEMA LE	AVER AGE	M & P	19
G10	PS -> BU	0.234	0.083	2.820	0.005	FEMA LE	AVER AGE	OTHER	11 8
G12	PS -> BU	0.345	0.218	1.583	0.114	FEMA LE	HIGH	OTHER	26
G1	PV -> BU	0.224	0.524	0.427	0.670	MALE	LOW	M & P	14
G2	PV -> BU	0.201	0.182	1.102	0.271	MALE	LOW	OTHER	42
G3	PV -> BU	-0.394	n/a			MALE	AVER AGE	M & P	16
G4	PV -> BU	0.102	0.108	0.942	0.346	MALE	AVER AGE	OTHER	92
G6	PV -> BU	0.018	0.273	0.065	0.949	MALE	HIGH	OTHER	42
G7	PV -> BU	-0.409	0.415	0.986	0.324	FEMA LE	LOW	M & P	25
G8	PV -> BU	0.099	0.168	0.587	0.557	FEMA LE	LOW	OTHER	70
G9	PV -> BU	0.073	0.354	0.207	0.836	FEMA LE	AVER AGE	M & P	19
G10	PV -> BU	-0.037	0.091	0.414	0.679	FEMA LE	AVER AGE	OTHER	11 8
G12	PV -> BU	0.431	0.240	1.792	0.073	FEMA LE	HIGH	OTHER	26
G1	SC -> BU	0.313	0.583	0.537	0.592	MALE	LOW	M & P	14
G2	SC -> BU	0.477	0.155	3.073	0.002	MALE	LOW	OTHER	42
G3	SC -> BU	0.250	n/a			MALE	AVER AGE	M & P	16
G4	SC -> BU	0.434	0.091	4.749	0.000	MALE	AVER AGE	OTHER	92
G6	SC -> BU	0.339	0.164	2.070	0.039	MALE	HIGH	OTHER	42
G7	SC -> BU	0.050	0.223	0.223	0.824	FEMA LE	LOW	M & P	25
G8	SC -> BU	0.601	0.084	7.155	0.000	FEMA LE	LOW	OTHER	70
G9	SC -> BU	0.231	0.277	0.833	0.405	FEMA LE	AVER AGE	M & P	19
G10	SC -> BU	0.577	0.058	9.969	0.000	FEMA LE	AVER AGE	OTHER	11 8
G12	SC -> BU	0.093	0.192	0.482	0.630	FEMA LE	HIGH	OTHER	26

Appendix 3.6: One-by-one comparison of the combined groups with respect to their moderating effect on the relationships between the constructs and Bicycle Usership.

	IC -> BU	IF -> BU	PS -> BU	PV -> BU	SC -> BU
Path Coefficients-diff (G10 - G12)	-0.148	0.195	-0.111	-0.468	0.484
Path Coefficients-diff (G10 - G4)	-0.009	-0.154	0.241	-0.139	0.143
Path Coefficients-diff (G10 - G6)	0.053	-0.085	0.053	-0.055	0.238
Path Coefficients-diff (G10 - G7)	-0.111	0.124	0.064	0.372	0.527
Path Coefficients-diff (G10 - G8)	-0.003	0.062	0.207	-0.136	-0.024
Path Coefficients-diff (G10 - G9)	-0.037	-0.387	-0.076	-0.111	0.346
Path Coefficients-diff (G10 - g1)	-0.368	0.22	0.33	-0.261	0.264
Path Coefficients-diff (G10 - g2)	0.162	-0.058	0.076	-0.238	0.1
Path Coefficients-diff (G10 - g3)	-0.066	0.503	-0.025	0.357	0.327
Path Coefficients-diff (G12 - G4)	0.139	-0.349	0.352	0.329	-0.341
Path Coefficients-diff (G12 - G6)	0.201	-0.281	0.165	0.413	-0.247
Path Coefficients-diff (G12 - G7)	0.037	-0.072	0.175	0.84	0.043
Path Coefficients-diff (G12 - G8)	0.145	-0.133	0.318	0.332	-0.508
Path Coefficients-diff (G12 - G9)	0.111	-0.582	0.035	0.358	-0.138
Path Coefficients-diff (G12 - g1)	-0.22	0.024	0.442	0.207	-0.22
Path Coefficients-diff (G12 - g2)	0.31	-0.254	0.187	0.23	-0.384
Path Coefficients-diff (G12 - g3)	0.082	0.308	0.087	0.825	-0.157
Path Coefficients-diff (G4 - G6)	0.062	0.068	-0.187	0.084	0.095
Path Coefficients-diff (G4 - G7)	-0.101	0.277	-0.177	0.511	0.385
Path Coefficients-diff (G4 - G8)	0.006	0.216	-0.034	0.003	-0.166
Path Coefficients-diff (G4 - G9)	-0.028	-0.233	-0.317	0.029	0.203
Path Coefficients-diff (G4 - g1)	-0.359	0.373	0.089	-0.122	0.121
Path Coefficients-diff (G4 - g2)	0.171	0.095	-0.165	-0.099	-0.043
Path Coefficients-diff (G4 - g3)	-0.057	0.657	-0.265	0.496	0.184
Path Coefficients-diff (G6 - G7)	-0.164	0.209	0.01	0.427	0.29
Path Coefficients-diff (G6 - G8)	-0.057	0.148	0.154	-0.081	-0.261
Path Coefficients-diff (G6 - G9)	-0.091	-0.301	-0.13	-0.055	0.108
Path Coefficients-diff (G6 - g1)	-0.421	0.305	0.277	-0.206	0.026
Path Coefficients-diff (G6 - g2)	0.109	0.027	0.023	-0.183	-0.138
Path Coefficients-diff (G6 - g3)	-0.119	0.589	-0.078	0.412	0.089
Path Coefficients-diff (G7 - G8)	0.107	-0.061	0.143	-0.508	-0.551
Path Coefficients-diff (G7 - G9)	0.073	-0.51	-0.14	-0.482	-0.181
Path Coefficients-diff (G7 - g1)	-0.258	0.096	0.267	-0.633	-0.263
Path Coefficients-diff (G7 - g2)	0.272	-0.182	0.013	-0.61	-0.427
Path Coefficients-diff (G7 - g3)	0.045	0.38	-0.088	-0.015	-0.201
Path Coefficients-diff (G8 - G9)	-0.034	-0.449	-0.283	0.026	0.37
Path Coefficients-diff (G8 - g1)	-0.365	0.157	0.123	-0.125	0.288
Path Coefficients-diff (G8 - g2)	0.165	-0.12	-0.131	-0.102	0.124
Path Coefficients-diff (G8 - g3)	-0.062	0.441	-0.231	0.493	0.35
Path Coefficients-diff (G9 - g1)	-0.331	0.606	0.407	-0.151	-0.082

Path Coefficients-diff (G9 - g2)	0.199	0.329	0.153	-0.128	-0.246
Path Coefficients-diff (G9 - g3)	-0.028	0.89	0.052	0.467	-0.019
Path Coefficients-diff (g1 - g2)	0.53	-0.278	-0.254	0.023	-0.164
Path Coefficients-diff (g1 - g3)	0.302	0.284	-0.355	0.618	0.063
Path Coefficients-diff (g2 - g3)	-0.228	0.561	-0.101	0.595	0.227
t-Value(|G10 vs G12|)	0.731	0.978	0.556	2.193	3.096
t-Value(|G10 vs G4|)	0.066	1.092	1.753	1.006	1.326
t-Value(|G10 vs G6|)	0.31	0.454	0.303	0.256	1.736
t-Value(|G10 vs G7|)	n/a	n/a	n/a	n/a	n/a
t-Value(|G10 vs G8|)	0.025	0.416	1.51	0.803	0.23
t-Value(|G10 vs G9|)	0.153	1.474	0.3	0.428	1.863
t-Value(|G10 vs g1|)	0.144	0.308	0.214	0.027	0.021
t-Value(|G10 vs g2|)	0.894	0.367	0.449	1.306	0.732
t-Value(|G10 vs g3|)	0.24	1.755	0.092	1.19	1.492
t-Value(|G12 vs G4|)	0.552	1.336	1.428	1.375	1.688
t-Value(|G12 vs G6|)	0.724	0.833	0.56	1.076	1.007
t-Value(|G12 vs G7|)	n/a	n/a	n/a	n/a	n/a
t-Value(|G12 vs G8|)	0.653	0.495	1.388	1.092	2.801
t-Value(|G12 vs G9|)	0.289	1.267	0.083	0.887	0.433
t-Value(|G12 vs g1|)	0.04	0.016	0.133	0.01	0.008
t-Value(|G12 vs g2|)	1.021	0.984	0.679	0.779	1.57
t-Value(|G12 vs g3|)	0.186	0.611	0.202	1.671	0.402
t-Value(|G4 vs G6|)	0.296	0.288	0.878	0.346	0.549
t-Value(|G4 vs G7|)	n/a	n/a	n/a	n/a	n/a
t-Value(|G4 vs G8|)	0.035	1.155	0.204	0.014	1.271
t-Value(|G4 vs G9|)	0.093	0.697	1.023	0.098	0.849
t-Value(|G4 vs g1|)	0.124	0.451	0.051	0.011	0.008
t-Value(|G4 vs g2|)	0.776	0.462	0.797	0.484	0.246
t-Value(|G4 vs g3|)	0.168	1.798	0.81	1.471	0.663
t-Value(|G6 vs G7|)	n/a	n/a	n/a	n/a	n/a
t-Value(|G6 vs G8|)	0.293	0.588	0.741	0.274	1.608
t-Value(|G6 vs G9|)	0.266	0.679	0.338	0.12	0.372
t-Value(|G6 vs g1|)	0.098	0.253	0.106	0.012	0.001
t-Value(|G6 vs g2|)	0.415	0.102	0.09	0.565	0.634
t-Value(|G6 vs g3|)	0.307	1.213	0.195	0.77	0.256
t-Value(|G7 vs G8|)	n/a	n/a	n/a	n/a	n/a
t-Value(|G7 vs G9|)	n/a	n/a	n/a	n/a	n/a
t-Value(|G7 vs g1|)	n/a	n/a	n/a	n/a	n/a
t-Value(|G7 vs g2|)	n/a	n/a	n/a	n/a	n/a
t-Value(|G7 vs g3|)	n/a	n/a	n/a	n/a	n/a
t-Value(|G8 vs G9|)	0.126	1.275	0.95	0.07	1.709
t-Value(|G8 vs g1|)	0.11	0.169	0.061	0.01	0.017
t-Value(|G8 vs g2|)	0.798	0.563	0.661	0.398	0.762
t-Value(|G8 vs g3|)	0.203	1.147	0.744	1.17	1.349

t-Value(|G9 vs g1|)	0.051	0.338	0.104	0.006	0.003
t-Value(|G9 vs g2|)	0.539	0.904	0.418	0.352	0.843
t-Value(|G9 vs g3|)	0.052	1.312	0.09	0.768	0.041
t-Value(|g1 vs g2|)	0.123	0.238	0.098	0.001	0.008
t-Value(|g1 vs g3|)	0.043	0.144	0.083	0.023	0.002
t-Value(|g2 vs g3|)	0.545	1.412	0.266	1.374	0.651
p-Value (G10 vs G12)	0.466	0.33	0.579	0.03	0.002
p-Value (G10 vs G4)	0.947	0.276	0.081	0.316	0.186
p-Value (G10 vs G6)	0.757	0.65	0.762	0.798	0.085
p-Value (G10 vs G7)	0.5	0.5	0.5	0.5	0.5
p-Value (G10 vs G8)	0.98	0.678	0.133	0.423	0.818
p-Value (G10 vs G9)	0.878	0.143	0.765	0.67	0.065
p-Value (G10 vs g1)	0.885	0.758	0.831	0.979	0.983
p-Value (G10 vs g2)	0.373	0.714	0.654	0.194	0.466
p-Value (G10 vs g3)	0.81	0.082	0.927	0.236	0.138
p-Value (G12 vs G4)	0.582	0.184	0.156	0.172	0.094
p-Value (G12 vs G6)	0.472	0.408	0.577	0.286	0.317
p-Value (G12 vs G7)	0.5	0.5	0.5	0.5	0.5
p-Value (G12 vs G8)	0.516	0.622	0.168	0.278	0.006
p-Value (G12 vs G9)	0.774	0.212	0.934	0.38	0.667
p-Value (G12 vs g1)	0.968	0.987	0.895	0.992	0.994
p-Value (G12 vs g2)	0.311	0.329	0.499	0.439	0.121
p-Value (G12 vs g3)	0.853	0.544	0.841	0.103	0.69
p-Value (G4 vs G6)	0.767	0.773	0.381	0.73	0.584
p-Value (G4 vs G7)	0.5	0.5	0.5	0.5	0.5
p-Value (G4 vs G8)	0.972	0.25	0.839	0.988	0.206
p-Value (G4 vs G9)	0.926	0.487	0.308	0.922	0.398
p-Value (G4 vs g1)	0.902	0.653	0.959	0.991	0.993
p-Value (G4 vs g2)	0.439	0.645	0.427	0.629	0.806
p-Value (G4 vs g3)	0.867	0.075	0.42	0.144	0.509
p-Value (G6 vs G7)	0.5	0.5	0.5	0.5	0.5
p-Value (G6 vs G8)	0.77	0.558	0.46	0.785	0.111
p-Value (G6 vs G9)	0.791	0.5	0.736	0.905	0.711
p-Value (G6 vs g1)	0.923	0.801	0.916	0.99	0.999
p-Value (G6 vs g2)	0.68	0.919	0.929	0.574	0.528
p-Value (G6 vs g3)	0.76	0.23	0.846	0.444	0.799
p-Value (G7 vs G8)	0.5	0.5	0.5	0.5	0.5
p-Value (G7 vs G9)	0.5	0.5	0.5	0.5	0.5
p-Value (G7 vs g1)	0.5	0.5	0.5	0.5	0.5
p-Value (G7 vs g2)	0.5	0.5	0.5	0.5	0.5
p-Value (G7 vs g3)	0.5	0.5	0.5	0.5	0.5
p-Value (G8 vs G9)	0.9	0.206	0.345	0.944	0.091
p-Value (G8 vs g1)	0.913	0.867	0.951	0.992	0.986
p-Value (G8 vs g2)	0.427	0.574	0.51	0.691	0.448

p-Value (G8 vs g3)	0.839	0.255	0.459	0.245	0.181
p-Value (G9 vs g1)	0.96	0.738	0.918	0.995	0.998
p-Value (G9 vs g2)	0.592	0.37	0.677	0.726	0.402
p-Value (G9 vs g3)	0.959	0.199	0.929	0.448	0.967
p-Value (g1 vs g2)	0.903	0.813	0.923	0.999	0.994
p-Value (g1 vs g3)	0.966	0.886	0.935	0.982	0.999
p-Value (g2 vs g3)	0.588	0.164	0.791	0.175	0.518

Appendix 4.1: Pairwise comparisons for predicting cycling provision perception among regular cyclists

4.1.1: Pairwise comparisons for predicting cycling provision perception by age among regular cyclists

Age	Age	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
18-20	21-30	-1.1927a	.42372	.005	-2.0232	-.3623
	31-40	-.8159	.44700	.068	-1.6920	.0602
	41-50	-1.2979a	.42463	.002	-2.1302	-.4656
	51-60	-.2292	.52180	.660	-1.2520	.7935
	>60	-1.3528a	.54875	.014	-2.4284	-.2773
21-30	18-20	1.1927a	.42372	.005	.3623	2.0232
	31-40	.3768a	.16798	.025	.0476	.7061
	41-50	-.1052	.17561	.549	-.4494	.2390
	51-60	.9635a	.33948	.005	.2981	1.6289
	>60	-.1601	.39327	.684	-.9309	.6107
31-40	18-20	.8159	.44700	.068	-.0602	1.6920
	21-30	-.3768a	.16798	.025	-.7061	-.0476
	41-50	-.4820a	.19228	.012	-.8589	-.1051
	51-60	.5866	.33431	.079	-.0686	1.2419
	>60	-.5369	.40245	.182	-1.3257	.2519
41-50	18-20	1.2979a	.42463	.002	.4656	2.1302
	21-30	.1052	.17561	.549	-.2390	.4494
	31-40	.4820a	.19228	.012	.1051	.8589
	51-60	1.0687a	.33843	.002	.4054	1.7320
	>60	-.0549	.39677	.890	-.8326	.7227
51-60	18-20	.2292	.52180	.660	-.7935	1.2520
	21-30	-.9635a	.33948	.005	-1.6289	-.2981
	31-40	-.5866	.33431	.079	-1.2419	.0686
	41-50	-1.0687a	.33843	.002	-1.7320	-.4054
	>60	-1.1236a	.47016	.017	-2.0451	-.2021
>60	18-20	1.3528a	.54875	.014	.2773	2.4284
	21-30	.1601	.39327	.684	-.6107	.9309

	31-40	.5369	.40245	.182	-.2519	1.3257
	41-50	.0549	.39677	.890	-.7227	.8326
	51-60	1.1236a	.47016	.017	.2021	2.0451

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations.

4.1.2: Pairwise comparisons for predicting cycling provision perception by education among regular cyclists

Education level	Education level	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
High School or below	Undergrad degree (for example Diploma, Bachelors)	.1870	.21661	.388	-.2376	.6115
	Master's degree/Postgraduate	-.3234	.26600	.224	-.8447	.1980
Undergrad degree (for example Diploma, Bachelors)	High School or below	-.1870	.21661	.388	-.6115	.2376
	Master's degree/Postgraduate	-.5104a	.17926	.004	-.8617	-.1590
Master's degree/Postgraduate	High School or below	.3234	.26600	.224	-.1980	.8447
	Undergrad degree (for example Diploma, Bachelors)	.5104a	.17926	.004	.1590	.8617

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations.

4.1.3: Pairwise comparisons for predicting cycling provision perception by cycling injury among regular cyclists

Cycling injury	Cycling injury	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
Yes	No	-.3074a	.14021	.028	-.5822	-.0326

No	Yes	.3074a	.14021	.028	.0326	.5822

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations.

4.1.4: Pairwise comparisons for predicting cycling provisions perception by Bike Lane Score among regular cyclists

Bike Lane Score	Bike Lane Score	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
Poor	Average	-.2033	.15096	.178	-.4992	.0925
	Excellent	-.6201a	.16299	.000	-.9396	-.3006
Average	Poor	.2033	.15096	.178	-.0925	.4992
	Excellent	-.4168a	.17188	.015	-.7536	-.0799
Excellent	Poor	.6201a	.16299	.000	.3006	.9396
	Average	.4168a	.17188	.015	.0799	.7536

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations.

Appendix 4.2: Pairwise comparisons for predicting cycling provision perception among non-cyclists/potential cyclists

4.2.1: Pairwise comparisons for predicting cycling provisions perception by ethnicity among non-cyclists/potential cyclists

Ethnicity	Ethnicity	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
Asian/Indian	European	.3600a	.16015	.025	.0461	.6739
	Māori	-.4113a	.19621	.036	-.7959	-.0267
	MELAA	.7117a	.25597	.005	.2100	1.2134
	NZ European	.0164	.11920	.890	-.2172	.2501
	Pacific Islanders	-.2224	.17492	.204	-.5652	.1204
European	Asian/Indian	-.3600a	.16015	.025	-.6739	-.0461
	Māori	-.7713a	.22068	.000	-1.2038	-.3388
	MELAA	.3517	.27265	.197	-.1827	.8861
	NZ European	-.3436a	.15237	.024	-.6422	-.0450
	Pacific Islanders	-.5824a	.20624	.005	-.9867	-.1782
Māori	Asian/Indian	.4113a	.19621	.036	.0267	.7959
	European	.7713a	.22068	.000	.3388	1.2038
	MELAA	1.1230a	.29770	.000	.5395	1.7065
	NZ European	.4277a	.19005	.024	.0552	.8002
	Pacific Islanders	.1889	.22329	.398	-.2488	.6265
MELAA	Asian/Indian	-.7117a	.25597	.005	-1.2134	-.2100
	European	-.3517	.27265	.197	-.8861	.1827
	Māori	-1.1230a	.29770	.000	-1.7065	-.5395
	NZ European	-.6953a	.24768	.005	-1.1807	-.2098
	Pacific Islanders	-.9341a	.28460	.001	-1.4919	-.3763
NZ European	Asian/Indian	-.0164	.11920	.890	-.2501	.2172
	European	.3436a	.15237	.024	.0450	.6422
	Māori	-.4277a	.19005	.024	-.8002	-.0552
	MELAA	.6953a	.24768	.005	.2098	1.1807
	Pacific Islanders	-.2388	.17303	.167	-.5780	.1003
Pacific Islanders	Asian/Indian	.2224	.17492	.204	-.1204	.5652
	European	.5824a	.20624	.005	.1782	.9867

	Māori	-.1889	.22329	.398	-.6265	.2488
	MELAA	.9341a	.28460	.001	.3763	1.4919
	NZ European	.2388	.17303	.167	-.1003	.5780

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations

Appendix 4.3: Pairwise comparisons for predicting cycling provision perception among people who live in areas with poor level of infrastructure

4.3.1: Pairwise comparisons for predicting cycling provisions perception by ethnicity among people who live in areas with a poor level of infrastructure

Ethnicity	Ethnicity	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
Asian/Indian	European	.5470a	.19666	.005	.1615	.9324
	Māori	-.2058	.22359	.357	-.6440	.2324
	MELAA	.6246a	.24297	.010	.1484	1.1008
	NZ European	.0575	.12634	.649	-.1901	.3051
	Pacific Islander	-.0822	.22424	.714	-.5217	.3573
European	Asian/Indian	-.5470a	.19666	.005	-.9324	-.1615
	Māori	-.7528a	.26483	.004	-1.2719	-.2337
	MELAA	.0776	.28125	.783	-.4736	.6288
	NZ European	-.4895a	.18982	.010	-.8615	-.1175
	Pacific Islander	-.6292a	.26549	.018	-1.1495	-.1088
Māori	Asian/Indian	.2058	.22359	.357	-.2324	.6440
	European	.7528a	.26483	.004	.2337	1.2719
	MELAA	.8304a	.29998	.006	.2425	1.4184
	NZ European	.2633	.21653	.224	-.1611	.6877
	Pacific Islander	.1236	.28398	.663	-.4330	.6802
MELAA	Asian/Indian	-.6246a	.24297	.010	-1.1008	-.1484
	European	-.0776	.28125	.783	-.6288	.4736
	Māori	-.8304a	.29998	.006	-1.4184	-.2425
	NZ European	-.5671a	.23689	.017	-1.0314	-.1028
	Pacific Islander	-.7068a	.30026	.019	-1.2953	-.1183
NZ European	Asian/Indian	-.0575	.12634	.649	-.3051	.1901
	European	.4895a	.18982	.010	.1175	.8615
	Māori	-.2633	.21653	.224	-.6877	.1611
	MELAA	.5671a	.23689	.017	.1028	1.0314
	Pacific Islander	-.1397	.21689	.520	-.5648	.2854
	Asian/Indian	.0822	.22424	.714	-.3573	.5217

Pacific Islander	European	.6292a	.26549	.018	.1088	1.1495
	Māori	-.1236	.28398	.663	-.6802	.4330
	MELAA	.7068a	.30026	.019	.1183	1.2953
	NZ European	.1397	.21689	.520	-.2854	.5648

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations.

4.3.2: Pairwise comparisons for predicting cycling provisions perception by access to a bicycle among people who live in areas with a poor level of infrastructure

Access to a bicycle	Access to a bicycle	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
Yes	No	.3551a	.10603	.001	.1473	.5629
No	Yes	-.3551a	.10603	.001	-.5629	-.1473

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations.

Appendix 4.4: Pairwise comparisons for predicting cycling provision perception among people who live in areas with excellent level of infrastructure

4.4.1: Pairwise comparisons for predicting cycling provisions perception by ethnicity among people who live in areas with an excellent level of infrastructure

Ethnicity	Ethnicity	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
Asian/Indian	European	.0249	.24836	.920	-.4619	.5116
	Māori	-.7774a	.33840	.022	-1.4407	-.1141
	MELAA	-.0714	.49417	.885	-1.0400	.8971
	NZ European	-.1891	.18738	.313	-.5564	.1781
	Pacific Islanders	-.8369a	.35971	.020	-1.5419	-.1318
European	Asian/Indian	-.0249	.24836	.920	-.5116	.4619
	Māori	-.8023a	.37183	.031	-1.5310	-.0735
	MELAA	-.0963	.51848	.853	-1.1125	.9199
	NZ European	-.2140	.23885	.370	-.6821	.2541
	Pacific Islanders	-.8617a	.37311	.021	-1.5930	-.1305
Māori	Asian/Indian	.7774a	.33840	.022	.1141	1.4407
	European	.8023a	.37183	.031	.0735	1.5310
	MELAA	.7060	.57444	.219	-.4199	1.8319
	NZ European	.5883	.32334	.069	-.0455	1.2220
	Pacific Islanders	-.0595	.45463	.896	-.9505	.8316
MELAA	Asian/Indian	.0714	.49417	.885	-.8971	1.0400
	European	.0963	.51848	.853	-.9199	1.1125
	Māori	-.7060	.57444	.219	-1.8319	.4199
	NZ European	-.1177	.49942	.814	-1.0966	.8611
	Pacific Islanders	-.7655	.55675	.169	-1.8567	.3258
NZ European	Asian/Indian	.1891	.18738	.313	-.1781	.5564
	European	.2140	.23885	.370	-.2541	.6821
	Māori	-.5883	.32334	.069	-1.2220	.0455
	MELAA	.1177	.49942	.814	-.8611	1.0966
	Pacific Islanders	-.6477	.35283	.066	-1.3393	.0438
Pacific Islander	Asian/Indian	.8369a	.35971	.020	.1318	1.5419
	European	.8617a	.37311	.021	.1305	1.5930

	Māori	.0595	.45463	.896	-.8316	.9505
	MELAA	.7655	.55675	.169	-.3258	1.8567
	NZ European	.6477	.35283	.066	-.0438	1.3393

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations.

4.4.2: Pairwise comparisons for predicting cycling provisions perception by annual income among people who live in areas with an excellent level of infrastructure

Income	Income	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
No income	<30,000	1.0247a	.30478	.001	.4274	1.6221
	30,000-70,000	.7528a	.31234	.016	.1406	1.3650
	70,000-100,000	.8417a	.35594	.018	.1441	1.5393
	>100,000	.5579	.32011	.081	-.0695	1.1853
<30,000	No income	-1.0247a	.30478	.001	-1.6221	-.4274
	30,000-70,000	-.2719	.20116	.176	-.6662	.1223
	70,000-100,000	-.1830	.25399	.471	-.6808	.3148
	>100,000	-.4668a	.22917	.042	-.9160	-.0177
30,000-70,000	No income	-.7528a	.31234	.016	-1.3650	-.1406
	<30,000	.2719	.20116	.176	-.1223	.6662
	70,000-100,000	.0889	.25292	.725	-.4068	.5846
	>100,000	-.1949	.22693	.391	-.6396	.2499
70,000-100,000	No income	-.8417a	.35594	.018	-1.5393	-.1441
	<30,000	.1830	.25399	.471	-.3148	.6808
	30,000-70,000	-.0889	.25292	.725	-.5846	.4068
	>100,000	-.2838	.27219	.297	-.8173	.2497
>100,000	No income	-.5579	.32011	.081	-1.1853	.0695
	<30,000	.4668a	.22917	.042	.0177	.9160
	30,000-70,000	.1949	.22693	.391	-.2499	.6396
	70,000-100,000	.2838	.27219	.297	-.2497	.8173

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations.

5.3: Pairwise comparisons for predicting cycling provisions perception by bicycle user type among people who live in areas with an excellent level of infrastructure

		Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower	Upper
Regular cyclist	Potential Cyclist	1.1395a	.22650	.000	.6956	1.5835
	Non-cyclist	.5298a	.17380	.002	.1892	.8705
Potential Cyclist	Regular cyclist	-1.1395a	.22650	.000	-1.5835	-.6956
	Non-cyclist	-.6097a	.21271	.004	-1.0266	-.1928
Non-cyclist	Regular cyclist	-.5298a	.17380	.002	-.8705	-.1892
	Potential Cyclist	.6097a	.21271	.004	.1928	1.0266

a. The mean difference is significant at the .05 level. Note: Shading indicates significant associations.

Appendix 5: Ethics approval letters

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UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE (UAHPEC)

26/02/2021

Dr Subeh Chowdhury

Re: Application for Ethics Approval (Our Ref. UAHPEC3237): Approved

The Committee considered your application for ethics approval for the study entitled "**Understanding the cycling perceptions of Auckland neighbourhoods; Behavioural evaluation of bicycling inequity**".

We are pleased to inform you that ethics approval has been granted for a period of three years.

The expiry date for this approval is **26/02/2024**.

Completion of the project: In order that up-to-date records are maintained, you must notify the Committee once your project is completed.

Amendments to the approved project: Should you need to make any changes to the approved project, please follow the steps below:

- Send a request to the UAHPEC Administrators to unlock the application form (using the Notification tab in the Ethics RM form).
- Make all changes to the relevant sections of the application form and attach revised documents (as appropriate).
- Change the Application Type to "Amendment request" in Section 13 ("Submissions and Sign off").
- Add a summary of the changes requested in the text box.
- Submit the amendment request (PI/Supervisors only to submit the form).

If the project changes significantly, you are required to submit a new application.

Funded projects: If you received funding for this project, please provide this approval letter to your local Faculty Research Project Coordinator (RPC) or Research Project Manager (RPM) so that the approval can be notified via a Service Request to the Research Operations Centre (ROC) for activation of the grant.

The Chair and the members of UAHPEC would be happy to discuss general matters relating to ethics approvals. If you wish to do so, please contact the UAHPEC Ethics Administrators at humanethics@auckland.ac.nz in the first instance.

Additional information:

- Do not forget to fill in the 'approval wording' on the PISs, CFs and/or advertisements, using the date of this approval and the reference number, before you use the documents or send them out to your participants.

All communications with the UAHPEC regarding this application should indicate this reference number: **UAHPEC3237**.

UAHPEC Administrators

University of Auckland Human Participants Ethics Committee

c.c. , Mr Danial Jahanshahi

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The University of Auckland
Private Bag 92019
Auckland, New Zealand

Level 3, 49 Symonds Street
Auckland, New Zealand
Telephone (09) 373 7599 Ext 83711

UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE (UAHPEC)

20/05/2022

Assoc Prof Seosamh Costello
Civil and Environmental Engineering

Re: Application for Ethics Approval (Our Ref. UAHPEC24053): Approved with Comment

The Committee considered the application for ethics approval for your study entitled "**Equity and cycling initiatives: Perceived effectiveness and accessibility - A qualitative approach**". We are pleased to inform you that ethics approval has been granted with the following comment(s) or required minor changes:

Email script: Please include the email script at the end of the text. This should read: Approved by the University of Auckland Human Participants Ethics Committee on ...... for three years. Reference Number ....

The expiry date for this approval is **20/05/2025**.

Completion of the project: In order that up-to-date records are maintained, you must notify the Committee once your project is completed.

Amendments to the approved project: Should you need to make any changes to the approved project, please follow the steps below:

- Send a request to the UAHPEC Administrators to unlock the application form (using the Correspondence tab in Ethics RM).
- Make all changes to the relevant sections of the application form and attach revised documents (as appropriate).
- Change the Application Type to "Amendment request" in Section 13 ("Submission and Sign off").
- Add a summary of the changes requested in the text box.
- Submit the amendment request (PI/Supervisors only to submit the form).

If the project changes significantly, you are required to submit a new application.

Funded projects: If you received funding for this project, please provide this approval letter to your local Faculty Research Project Coordinator (RPC) or Research Project Manager (RPM) so that the approval can be notified via a Service Request to the Research Operations Centre (ROC) for activation of the grant.

The Chair and the members of UAHPEC would be happy to discuss general matters relating to ethics approvals. If you wish to do so, please contact the UAHPEC Ethics Administrators at humanethics@auckland.ac.nz in the first instance.

Additional information:

- Do not forget to fill in the 'approval wording' on the PISs, CFs and/or advertisements, using the date of this approval and the reference number, before you use the documents or send them out to your participants.

All communications with the UAHPEC regarding this application should indicate this reference number: **UAHPEC24053**.

UAHPEC Administrators

University of Auckland Human Participants Ethics Committee

c.c. Prof Kim Dirks Mr Danial Jahanshahi

The University of Auckland
Private Bag 92019
Auckland, New Zealand

Level 3, 49 Symonds Street
Auckland, New Zealand
Telephone (09) 373 7599 Ext 83711

UNIVERSITY OF AUCKLAND HUMAN PARTICIPANTS ETHICS COMMITTEE (UAHPEC)

03/10/2022

Assoc Prof Seosamh Costello
Civil and Environmental Engineering

Re: Application for Ethics Approval (Our Ref. UAHPEC24106): Approved

The Committee considered the application for ethics approval for your study entitled "**Equity and cycling initiatives: Perceived effectiveness and accessibility (Quantitative)**".

We are pleased to inform you that ethics approval has been granted for a period of three years.

The expiry date for this approval is **03/10/2025**

Completion of the project: In order that up-to-date records are maintained, you must notify the Committee once your project is completed.

Amendments to the approved project: Should you need to make any changes to the approved project, please follow the steps below:

- Send a request to the UAHPEC Administrators to unlock the application form (using the Correspondence tab in Ethics RM).
- Make all changes to the relevant sections of the application form and attach revised documents (as appropriate).
- Change the Application Type to "Amendment request" in Section 13 ("Submissions and Sign off").
- Add a summary of the changes requested in the text box.
- Submit the amendment request (PI/Supervisors only to submit the form).

If the project changes significantly, you are required to submit a new application.

Funded projects: If you received funding for this project, please provide this approval letter to your local Faculty Research Project Coordinator (RPC) or Research Project Manager (RPM) so that the approval can be notified via a Service Request to the Research Operations Centre (ROC) for activation of the grant.

The Chair and the members of UAHPEC would be happy to discuss general matters relating to ethics approvals. If you wish to do so, please contact the UAHPEC Ethics Administrators at humanethics@auckland.ac.nz in the first instance.

Additional information:

- Do not forget to fill in the 'approval wording' on the PISs, CFs and/or advertisements, using the date of this approval and the reference number, before you use the documents or send them out to your participants.

All communications with the UAHPEC regarding this application should indicate this reference number: **UAHPEC24106**.

UAHPEC Administrators

University of Auckland Human Participants Ethics Committee

c.c. Prof Kim Dirks Mr Danial Jahanshahi

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Appendix 6: Participants Information sheet (PIS) A

Department of Civil and Environmental Engineering

Faculty of Engineering Building, 20 Symonds Street, City Campus, Auckland

The University of Auckland

Private Bag 92019

Auckland 1142

New Zealand

PARTICIPANT INFORMATION SHEET

Cycling Perceptions of Auckland Neighbourhoods

Name of Student Researcher: Danial Jahanshahi

Name of Principal Investigator/Supervisor (PI): Dr Subeh Chowdhury, Associate Professor Seosamh Costello

Researcher Introduction

My name is Danial Jahanshahi. I am a PhD student in the Department of Civil and Environmental Engineering at the University of Auckland. My research supervisors are Dr Subeh Chowdhury, and Associate Professor Seosamh Costello in the Faculty of Engineering.

Project description and invitation

I am conducting a study to better understand barriers in cycling by exploring people's perception of the cycling environment. Both cyclists and non-cyclists are invited to the study. Policy decisions can be informed with a clear understanding of the type of facilities and social support people need to cycle freely and safely in their neighborhoods. We would be grateful for the time you are voluntarily giving and your feedback on the cycling environment in your neighborhood. Only participants who are 18 years old or greater are eligible for the study.

A summary of the results will be offered to participants to acknowledge the time they dedicated to the study. If you are happy to receive this summary, please write down your email address at the end of the questionnaire.

Project Procedures

You are invited to participate in this research to provide your perception about cycling environment and your cycling needs. **Your participation is voluntary**. Answering the survey will take around 10 minutes. You will answer an online questionnaire provided in Qualtrics. As a participant, there is no risk for you to be a part of this study. We cannot foresee any risk for you as a participant. All information provided by you will be done in a way that does not identify you as its source.

However, should there be any issue, please notify Dr Chowdhury (contact details given below) and the University of Auckland Human Participants Ethics Committee will be informed. Only the research team will have access to your answers to the questions.

Data Storage, Retention, Destruction and Future Use

All the answers to the questionnaire will be stored under the university's IT server, which is protected with a password. The data will be kept with the PI for six years and will be deleted after this time has elapsed.

How long: The data will be stored for a minimum of six years.

Destruction: After the minimum storage time has elapsed, the data will be destroyed by deleting the file.

Right to Withdraw from Participation

You can choose to withdraw from participation at any time. Once you have submitted the questionnaire, you cannot withdraw, as your identity is anonymous.

Anonymity and Confidentiality

Any personal information which can identify you is not collected in the questionnaire, so your identity is anonymous.

If you wish to know about the findings, please feel free to contact me. My email address is given below. It is expected the analysis will be completed by April 2021.

CONTACT DETAILS AND APPROVAL

Student Researcher name and contact details	Supervisor/Co- investigator name and contact details	Head of Department/School name and contact details
Danial Jahanshahi Djah422@aucklanduni.ac.nz	Dr Subeh Chowdhury s.chowdhury@auckland.ac.nz Telephone No.: 923 4116	Professor Jason Ingham j.ingham@auckland.ac.nz Telephone No.: 923 7803

	Associate Professor Seosamh Costello s.costello@auckland.ac.nz	

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 ext. 83711. Email: humanethics@auckland.ac.nz.

Approved by the University of Auckland Human Participants Ethics Committee on 26/02/2021 for three years. Reference Number is UAHPEC3237.

Appendix 7: Questionnaire survey A

Cycling Perceptions Assessment Survey
I am conducting a study to understand better the barriers to cycling by exploring people's perceptions of the cycling environment. Both cyclists and non-cyclists are invited to participate in this research. Your participation is voluntary. Answering the survey will take around 10 minutes.

Section 1: Demographic Questions

Do you live in Auckland?

- ○ Yes
- ○ No

---

1. What is your age?

- ○ 18-20
- ○ 21-30
- ○ 31-40
- ○ 41-50
- ○ 51-60
- ○ >60

---

2. What is your gender?

- ○ Male
- ○ Female
- ○ Gender Diverse

3. Which category best describes your race/ethnicity? (You may select multiple options)

- ○ Maori
- ○ Pacific Islands
- ○ Middle Eastern
- ○ Chinese
- ○ Indian
- ○ Other Asian
- ○ Latin American
- ○ African
- ○ European
- ○ NZ European
- ○ Other ethnicities

4. What is the highest level of education you have received?

- ○ High School or below
- ○ University degree (for example Diploma, Bachelors)
- ○ Master's degree/Postgraduate

5. What is the current status of your employment situation? (You can have multiple answer)

- ☐ Not employed
- ☐ Student
- ☐ Part-time employed
- ☐ Full-time employed
- ☐ Homemaker
- ☐ Retired

6. What is your annual income? (NZD)

- ○ No income
- ○ <30,000
- ○ 30,000-70,000
- ○ 70,000-100,000
- ○ >100,000

7. Do you have a disability?

- ○ Yes
- ○ No

7b. Does the disability prevent you from riding a bicycle?

- ◯ Yes
- ◯ No

8. Do you own a bicycle/ have access to a bicycle?

- ◯ Yes
- ◯ No

9. Do you know how to ride a bicycle?

- ◯ Yes
- ◯ No

9a. Please choose one of the following options:

- ◯ I cycled in the past month (for any purpose)
- ◯ I cycled at least once in the past 12 months
- ◯ I did not cycle in the past 12 months

10. How many times per week do you cycle?

- ○ 0 times
- ○ 1-3 times
- ○ 3-5 times
- ○ >5 times

---

11. How long is your typical journey time by bicycle?

- ○ <15mins
- ○ 15-30mins
- ○ 30-60mins
- ○ >60mins

---

12. What is the main purpose of your bicycle trips?

- ○ Commuting (work, education)
- ○ Short trips (visiting family/friends, shopping, running errands)
- ○ Recreational/fitness

---

13. Did you cycle more in 2020 after the COVID-19 lockdown in March?

- ○ Yes
- ○ No

13b. What were your reasons for cycling more during COVID-19?

- ◯ Less cars in the streets (More cycling safety)
- ◯ It did not feel safe to ride public transport
- ◯ Working from home gave me more opportunity/time to cycle
- ◯ Other reasons: ____

14. Have you ever had an injury from cycling?

- ◯ Yes
- ◯ No

15. Do you have access to a car?

- ◯ Yes
- ◯ No

16. Which residential suburb do you live?

____

17. Which residential suburb do you work/study?

____

Section 2: Your Thoughts on Your Current Cycling Environment

Please choose your preferred answer for each statement from “Strongly disagree” to “Strongly agree”.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. I am not embarrassed to be seen riding a bicycle.					
2. My friends and family encourage me to ride a bicycle.					
3. People who I know (family and friends) cycle often.					
4. Cycling is becoming more popular as a transport mode in Auckland.					
5. I find the cost of purchasing a bicycle reasonable.					
6. I find the cost of purchasing bicycle equipment reasonable (helmet, lights, lock, etc.).					
7. I can securely store my bicycle at home and at my destination.					
8. I find the overall cost of commuting with a bicycle cheaper than other transport modes.					
9. I find the cost of maintaining a bicycle affordable.					
10. There are sufficient cycling facilities such as bicycle lanes and/or dedicated cycleways in my residential neighbourhood.					
11. There are sufficient cycling facilities to my common destination(s).					
12. There are sufficient street lighting and traffic signals in intersections in my journeys.					
13. There are appropriate road marking and bicycle signage in bicycle lanes.					
14. It is easy for me to carry my bicycle inside public transport vehicles.					
15. I can securely park my bicycle at the station.					
16. I am not concerned about becoming a victim of crime or harassment while riding a bicycle.					
17. I feel safe cycling on-road.					
18. Streets and footpaths in my neighbourhood feel safe to ride on (traffic, safe routes).					
19. I feel that children in my neighbourhood can safely cycle to school.					
20. I can easily find cycling promotional events and attend them.					

21. I can easily access information about traffic regulations for cyclists.					
22. I can easily report issues to the council about cycling facilities and enforcement.					

Section 3: Your Cycling Needs

1. Please rank the reasons which will encourage you to cycle more often. (You can drag your preferred choices to order the ranking)

______ Better safety provisions for cyclists
______ Campaigns to make car drivers aware that cyclists have right of way
______ More street-lighting
______ More cycling facilities that are off-road
______ Social gatherings/initiatives by the government
______ More training for cyclists

2. Please rank the reasons which are closely linked to your confidence. (You can drag your preferred choices to order the ranking)

______ Traffic volume is too high
______ Car drivers’ attitude towards cyclist
______ Personal safety (feeling vulnerable)
______ The crime and safety level of my neighbourhood
______ Information on training is hard to find
______ Not enough separated cycle lanes.
______ The lighting on cycle lanes available to me is poor
______ I can easily be injured by cars

3. Please give a score to the following characteristics of bicycle lanes, from 1 (lowest) to 10 (highest):

_______ Proximity to Home
_______ Proximity to key destinations
_______ Slope level
_______ Proximity to bicycle parking
_______ Proximity to public transport stations
_______ Proximity to bicycle maintenance stores

4. Please give a score to the following characteristics of bicycle parking, from 1 (lowest) to 10 (highest):

_______ Proximity to Home
_______ Proximity to key destinations
_______ Proximity to bicycle lanes
_______ Proximity to public transport stations

---

5. Please give a score from 1 (lowest) to 10 (highest) to the following bicycle lanes:

_______ On-road protected cycle lanes (two-ways)
_______ On-road protected cycle lanes (one-way)
_______ Off-road cycle path (only bicycle)
_______ Off-road shared paths (with pedestrians)
_______ Quiet routes
_______ On-road buffered cycle lanes
_______ On-road unbuffered cycle lanes

---

6. Please give a score from 1 (lowest) to 10 (highest) to the following infrastructure and facilities:

_______ Bicycle lanes
_______ Bicycle parking (regular bike rack)
_______ Bicycle parking (bike cage with camera)
_______ Bicycle parking in public transport stations
_______ Bicycle signage in roads
_______ Road marking for cycling
_______ Traffic lights with bicycle box
_______ Traffic lights with designed cycling lights

Thank you for your time. If you are interested in participating in future research, are happy to join us sometime for a chat about cycling in Auckland, or want to join future possible cycling gatherings, please contact me (Djah422@aucklanduni.ac.nz) or leave your contact details here:

____

Appendix 8: Participants Information sheet (PIS) B

Department of Civil and Environmental Engineering

Faculty of Engineering

Building, 20 Symonds Street, City Campus, Auckland

The University of Auckland

Private Bag 92019

Auckland 1142

New Zealand

PARTICIPANT INFORMATION SHEET

Project title: Equity and cycling initiatives: Perceived effectiveness and accessibility

Principal Investigator/Supervisor (PI): Associate Professor Seosamh Costello

Co-Investigator: Professor Kim Dirks

Student Researcher: Danial Jahanshahi

Researcher Introduction

My name is Danial Jahanshahi and I am carrying out this research as part of a PhD degree in Civil and Environmental Engineering at the University of Auckland. My research supervisors are Associate Professor Seosamh Costello and Professor Kim Dirks from the Faculty of Engineering.

Project description and invitation

You are invited to participate in research about cycling initiatives. I am undertaking this study to understand the range of cycling initiatives available in Auckland in order to encourage people to cycle. I am also interested in the locations of these initiatives. Finally, I am interested in your views about the effectiveness of these initiatives with respect to different population groups. Only participants who are 18 years and older are eligible to participate. Participants should have at least three years' experience working in the transport sector, as well as experience working on Auckland cycling initiatives. **Your participation is voluntary.**

Project Procedures

The study will involve participation in an individual interview. If you accept the invitation to participate in the interview, I will be in touch via email to propose suitable days and times for participation. The interview will take a maximum of one hour and will be facilitated by me, the researcher. The interview will be held online via Zoom video-conferencing. The interview will be audio-recorded.

The findings of this research will be reported in a way that does not identify you as a research participant.

The results of the findings will be collated into a chapter that will form part of my thesis, with the aim to have the paper published in a journal.

Right to Withdraw from Participation

You have the right to withdraw from the interview at any time without having to give a reason. If you withdraw from the research, you can also withdraw all information provided at that point. If you complete the interview, you will be given the opportunity to review the transcript and you will have two weeks after the receipt of the transcript to withdraw your interview or request any edits to the transcript. You can skip any questions if you do not wish to answer. However, the interviews must be recorded and turning off the recording means withdrawing or ending the interview.

Data Storage, Retention, Destruction and Future Use

The electronic files of the interview audio recordings will be stored on the University of Auckland server. Once the audio recordings have been transcribed by the student researcher, they will be permanently deleted. Signed copies of the consent form will be stored electronically, along with the transcriptions, at the University of Auckland for a period of at least six years. Consent Forms will be stored separately from the research data. After this time, the data will be permanently deleted. Access to the Consent Forms will be restricted to the Principal Investigator and the researchers.

Anonymity and Confidentiality

Every effort will be made to ensure your confidentiality. If the information you provide is reported/published, this will be done in a way that does not identify you by name as its source. However, complete confidentiality cannot be guaranteed, as it may be possible that you will be able to be identified by readers through the comments that you make. During the transcription, participants' names will not be transcribed, and a code will be assigned to each participant.

CONTACT DETAILS AND APPROVAL

If you wish to receive a summary of the findings of this research, please tick the following box ☐.

It is expected the analysis will be completed by August 2022.

Should you have any queries about this research you can contact Danial Jahanshahi (researcher), Seosamh Costello (supervisor), Professor Kim Dirks (Co-Investigator), or Jason Ingham (Head of Department) at the following:

Student Researcher name and contact details	Supervisor/Co-Investigator name and contact details	Head of Department/School name and contact details
Danial Jahanshahi djah422@aucklanduni.ac.nz	Assoc. Prof. Seosamh Costello s.costello@auckland.ac.nz Telephone No.: 923 8164 Professor Kim Dirks k.dirks@auckland.ac.nz Telephone No.: 923 9755	Professor Jason Ingham j.ingham@auckland.ac.nz Telephone No.: 923 7803

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 ext. 83711. Email: humanethics@auckland.ac.nz.

Approved by the University of Auckland Human Participants Ethics Committee on 20/05/2022 for three years. Reference Number UAHPEC24053.

Appendix 9: Questionnaire survey B

Equity and cycling initiatives: Perceived effectiveness and accessibility

Transport Professionals (policy-makers, decision-makers, researchers, planners and designers):

I am conducting a study to investigate equity in cycling considering various cycling initiatives in Auckland. I am interviewing you as an expert in the topic. Your participation is voluntary. Answering the questions will take around 60 minutes.

Section 1: Introductory Questions

1. How many years of experience do you have working in the transport industry and what has this work entailed?
2. How many years have you worked specifically in cycling and what has this entailed?

Section 2: Semi-structured questions

3. What are the current cycling initiatives in Auckland designed to motivate people to cycle? Could you list them and, if possible, provide further information about them, including their locations, where relevant?
4. In your opinion, how effective are each of the initiatives – on a scale of 1 to 5 where 1 is Very Low and 5 is Very High? On what basis do you assess their effectiveness?
5. Do you consider this initiative to be more or less effective for any specific community or demographic – on a scale of 1 to 5 where 1 is Very Low and 5 is Very High? Why you think these initiatives work better (or worse) for these particular groups?
6. Are there other potential cycling initiatives, not currently being implemented, that you can think of that could be implemented to encourage the uptake of cycling? Who would they be targeting and why do you think they would be effective?
7. What are the barriers to implementing cycling equity initiatives in practice? What are those initiatives and barriers?
8. What are some of the strategies you can think of to address these barriers?
9. Please indicate if you are happy for me to contact you after the interview, in case I need to clarify any of your responses to the questions above.

Thank you for your time.

Appendix 10: Participants Information sheet (PIS) C

Department of Civil and Environmental Engineering

Faculty of Engineering Building, 20 Symonds Street, City Campus, Auckland

The University of Auckland

Private Bag 92019

Auckland 1142

New Zealand

PARTICIPANT INFORMATION SHEET

Project title: Equity and cycling initiatives: Perceived effectiveness (quantitative)

Principal Investigator/Supervisor (PI): Associate Professor Seosamh Costello

Co-Investigator: Professor Kim Dirks

Student Researcher: Danial Jahanshahi

Researcher Introduction

My name is Danial Jahanshahi and I am carrying out this research as part of a PhD degree in Civil and Environmental Engineering at the University of Auckland. My research supervisors are Associate Professor Seosamh Costello and Professor Kim Dirks from the Faculty of Engineering.

Project description and invitation

I am undertaking this study to understand your views about the effectiveness of cycling initiatives in Auckland. Following a number of demographic questions, you will be asked to rate the effectiveness of a number of cycling initiatives in encouraging you to cycle. Both cyclists and non-cyclists are invited to participate. Only participants who are 18 years old or greater are eligible to participate. **Your participation is voluntary.**

Project Procedures

You are invited to participate in this research, via an online questionnaire survey, to provide your views about the effectiveness of cycling initiatives. Answering the survey will take around 15-20 minutes. You will answer an online questionnaire provided in the University of Auckland's Qualtrics platform. The questionnaire will be distributed to Auckland suburbs by a University of Auckland-affiliated survey company (Dynata). We cannot foresee any risk for you to take part in this study. All information provided by you will be done in a way that does not identify you as its source. The results of the findings will be collated into a chapter that will form part of my thesis, with the aim to have the paper published in a journal.

Data Storage, Retention, Destruction and Future Use

All the answers to the questionnaire will be stored on the university's IT server, which is protected with a password. The data will be kept with the PI for six years and will be deleted after this time has elapsed.

Right to Withdraw from Participation

You can choose to withdraw from participation at any time prior to submitting the questionnaire. Once you have submitted the questionnaire, you cannot withdraw, as your identity is anonymous and we will not know what information belongs to you.

Anonymity and Confidentiality

No personal information which can identify you is collected in the questionnaire, so your identity is anonymous. The only people who will see the responses are the researchers of this study and the survey company which collects the data. By submitting the anonymous questionnaire, participants are giving their consent for their data to be used in the research.

Summary of Results

If you are interested in receiving a summary of the results, please insert your email address in the following link:

https://auckland.au1.qualtrics.com/jfe/form/SV_cGvn6qI1QOZyvA2

If you do request a summary of the results, then the researcher will know that you received an invitation to participate but will not know if you completed the questionnaire or, if you did complete the questionnaire, what your responses were. It is expected that the analysis will be completed by November 2022.

CONTACT DETAILS AND APPROVAL

Should you have any queries about this research you can contact Danial Jahanshahi (researcher), Seosamh Costello (supervisor), Kim Dirks (Co-Investigator), or Jason Ingham (Head of Department) at the following:

Student Researcher name and contact details	Supervisor/Co-Investigator name and contact details	Head of Department/School name and contact details
Danial Jahanshahi djah422@aucklanduni.ac.nz	Assoc. Prof. Seosamh Costello s.costello@auckland.ac.nz Telephone No.: 923 8164 Professor Kim Dirks k.dirks@auckland.ac.nz Telephone No.: 923 9755	Professor Jason Ingham j.ingham@auckland.ac.nz Telephone No.: 923 7803

For any queries regarding ethical concerns you may contact the Chair, The University of Auckland Human Participants Ethics Committee, The University of Auckland, Research Office, Private Bag 92019, Auckland 1142. Telephone 09 373-7599 ext. 83711. Email: humanethics@auckland.ac.nz.

Approved by the University of Auckland Human Participants Ethics Committee on 03/10/2022 for three years. Reference Number is UAHPEC24106

Appendix 11: Questionnaire survey C

Equity and cycling initiatives: Perceived effectiveness

I am undertaking this study to understand your views about the effectiveness of cycling initiatives in Auckland. Your participation is voluntary. Answering the questions will take around 15-20 minutes.

Section 1: Demographic Questions

Do you live in Auckland?

- ◯ Yes
- ◯ No

---

1. What is your age?

- ◯ 18-20
- ◯ 21-30
- ◯ 31-40
- ◯ 41-50
- ◯ 51-60
- ◯ >60

---

2. What is your gender?

- ◯ Male
- ◯ Female
- ◯ Gender Diverse

---

3. Which category best describes your race/ethnicity? (You may select multiple options)

- ◯ Māori
- ◯ Pacific Islands
- ◯ Middle Eastern/Latin American/African
- ◯ Chinese
- ◯ Indian
- ◯ Other Asian
- ◯ European
- ◯ NZ European
- ◯ Other ethnicities

---

4. What is the highest level of education you have received?

- ◯ High School or below
- ◯ University degree (for example Diploma, Bachelors)
- ◯ Master’s degree/Postgraduate

---

5. What is the current status of your employment situation? (You can have multiple answer)

- ☐ Not employed
- ☐ Student
- ☐ Part-time employed
- ☐ Full-time employed
- ☐ Homemaker
- ☐ Retired

---

6. What is your annual income? (NZD)

- ○ No income
- ○ <30,000
- ○ 30,000-70,000
- ○ 70,000-100,000
- ○ >100,000

---

7. Do you have a disability?

- ○ Yes
- ○ No

7b. Does the disability prevent you from riding a bicycle?

- ◯ Yes
- ◯ No

---

8. Do you own a bicycle/ have access to a bicycle?

- ◯ Yes
- ◯ No

---

9. Do you know how to ride a bicycle?

- ◯ Yes
- ◯ No

9a. Please choose one of the following options:

- ◯ I cycled in the past month (for any purpose)
- ◯ I cycled at least once in the past 12 months
- ◯ I have not cycled in the past 12 months

---

10. How many times per week do you cycle?

- ◯ 0 times
- ◯ 1-3 times
- ◯ 4-5 times
- ◯ >5 times

---

11. How long is your typical journey time by bicycle?

- ◯ <15mins
- ◯ 15-30mins
- ◯ 31-60mins
- ◯ >60mins

---

12. What is the main purpose of your bicycle trips?

- ◯ Commuting (work, education)
- ◯ Short trips (visiting family/friends, shopping, running errands)
- ◯ Recreational/fitness

---

13. Have you ever used bicycle sharing systems? (Jump, Beam, Nextbike, etc.)

- ◯ Yes
- ◯ No

13b. Please choose one of the following options:

- ◯ I used bicycle sharing systems in the past month (for any purpose)
- ◯ I used bicycle sharing systems at least once in the past 12 months
- ◯ I did not use bicycle sharing systems in the past 12 months

---

14. Have you ever had an injury from cycling?

- ◯ Yes
- ◯ No

---

15. Do you have access to a car?

- ◯ Yes
- ◯ No

---

16. Which residential suburb do you live in?

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17. Which suburb do you work/study in?

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18. What is your main way of commuting? (You can select multiple answers)

- ◯ Car
- ◯ Bus
- ◯ Train
- ◯ Ferry
- ◯ Bicycle
- ◯ Walk
- ◯ Scooter
- ◯ Ride hailing (Uber, Ola, taxi, etc.)

Section 2: Perceived effectiveness and accessibility

How effective would the following cycling initiatives be in encouraging you to cycle?
Please choose your preferred answer for each statement from "Very low" to "Very high".

Row	How effective would the following cycling initiatives be in encouraging you to cycle?					
	Initiatives (For participants)	Effectiveness				
1	Improving the quantity and quality of cycle lanes	Very low	low	moderate	high	Very high
2	Reducing traffic speed in neighbourhoods	Very low	low	moderate	high	Very high
3	Public parking facilities for bicycles	Very low	low	moderate	high	Very high
4	Public parking facilities for bicycles (secured with CCTV)	Very low	low	moderate	high	Very high
4	Bicycle security initiatives, such as serial number registration and the opportunity to swap your bicycle lock for a better, more secure, one.	Very low	low	moderate	high	Very high
5	Availability of public showers, changing rooms, and lockers at the end of your trip	Very low	low	moderate	high	Very high
6	Adding protection such as kerbs or dividers to existing cycleways in order to separate them from road traffic.	Very low	low	moderate	high	Very high
7	Implement more bus lanes. Note that cyclists can travel in bus lanes.	Very low	low	moderate	high	Very high

8	Pay-as-you-go bike share schemes (ONZO, Lime, Jump, etc.)	Very low	low	moderate	high	Very high
9	Ability to carry your bicycle onto buses, trains, and ferries.	Very low	low	moderate	high	Very high
10	E-bike trial and loan schemes	Very low	low	moderate	high	Very high
11	Free bike safety checks and minor maintenance work	Very low	low	moderate	high	Very high
12	Support for community groups with the design, delivery and/or funding of their ideas for promoting cycling in their neighbourhoods.	Very low	low	moderate	high	Very high
13	Support the expansion of community bike hubs at key locations across the region to divert bikes from landfill, carry out basic repairs to make them safe and usable and distribute low-cost bikes to local communities.	Very low	low	moderate	high	Very high
14	Provide support to cycling-focused community groups to empower and grow (such as supporting their cycling skills events, bicycle maintenance events, etc).	Very low	low	moderate	high	Very high
15	Bike challenge: A challenge to encourage cycling where you use an app on your phone to record when and how far you cycle. The more you cycle the more points you score.	Very low	low	moderate	high	Very high
16	Community Bike Fund for non-profit groups to apply for ideas to promote cycling in their neighbourhoods.	Very low	low	moderate	high	Very high
17	Auckland Transport mobile app for planning your cycling journey. The app will suggest the best cycling routes for your journey.	Very low	low	moderate	high	Very high
18	Cycling skills training in schools when you were growing up or for your children (You need your own bike).	Very low	low	moderate	high	Very high
19	A container full of bikes in a school with additional training for teachers for how to teach kids how to ride (when you were growing up or for your children).	Very low	low	moderate	high	Very high
20	Kids Learn-to-Ride drop-in events, adult bike skills courses, and basic bike maintenance courses (free events).	Very low	low	moderate	high	Very high

21	Improving signage and pavement markings to help you find cycleways and cycle routes.	Very low	low	moderate	high	Very high
22	Residential door knocking journey planning (coming to you for asking about your journeys and offer plans)	Very low	low	moderate	high	Very high
23	Offering travel planning and a wide variety of incentives through work, to get staff traveling to work by bicycle, (such as providing an advance on your wages or salary to buy a bike, discounts for buying a bicycle, flexible times for arriving at work, etc.)	Very low	low	moderate	high	Very high
24	Guided e-bike tours for the public and businesses.	Very low	low	moderate	high	Very high
25	Events to improve awareness of, and to celebrate, new and existing cycling infrastructure.	Very low	low	moderate	high	Very high
26	Consultation with the community and listening to people before designing bike infrastructure in their neighbourhoods.	Very low	low	moderate	high	Very high
27	Enforcement to keep cycling infrastructure and facilities clear of obstructions (e.g. bins and other obstacles)	Very low	low	moderate	high	Very high
28	Road rule changes to improve cycling safety (e.g. automatic liability for hitting cyclists)	Very low	low	moderate	high	Very high
29	Vehicle safety features that reduce the injury to cyclists if hit by a vehicle.	Very low	low	moderate	high	Very high
30	Road speed limit enforcement to promote road safety.	Very low	low	moderate	high	Very high
31	Campaigns (via social media, advertising and events) that normalise bicycle usage in the minds of drivers - so that they respect cyclists and are happy to share the road with them.	Very low	low	moderate	high	Very high
32	Lighting improvements on cycleways, particularly in parks and off-road areas	Very low	low	moderate	high	Very high
33	Parking management to ban on-street car parking in certain areas.	Very low	low	moderate	high	Very high
34	Providing cycling infrastructure and facilities based on standard designs to ensure consistent design of cycleways.	Very low	low	moderate	high	Very high
35	Congestion charging in areas with other transport options, resulting in reduced traffic flows	Very low	low	moderate	high	Very high

36	Increase the cost to park in areas that could easily be accessed by cycling, resulting in reduced traffic in these areas.	Very low	low	moderate	high	Very high
37	Increase the cost of owning a car and subsidise bike ownership.	Very low	low	moderate	high	Very high

Thank you for your time. If you are interested in participating in future research, and you are happy to join us sometime for a chat about cycling in Auckland, please contact me (djah422@aucklanduni.ac.nz) or leave your contact details here:

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