

# Cycling to Work and the Gender Gap in Brisbane: a study of the environmental, sociocultural and individual determinants of gender disparity in commuter cycling in inner-Brisbane

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**Abstract:** Bicycling as a mode of transport is increasingly recognised by planners and policy-makers worldwide for its health, environmental, social and community benefits. Despite this, cycling continues to represent a very small share of the journey to work modes in Australia's major cities, falling between 1 and 2%, which is well below local government targets. Furthermore, significant proportions of these riders are men, with males in Brisbane accounting for roughly 81% of bicycle commuters. Understanding this substantial gender imbalance is consequently important to both planners and policy-makers alike.

Using a survey-based research design, this research study aims to understand which individual, environmental and sociocultural factors influence a person's decision to commute to work by bicycle in Brisbane, with a particular focus on how these factors differ by gender.

Both current cyclists and non-cyclists from the inner-Brisbane suburbs of West End and Newstead were surveyed on perceived barriers and motivators to commuting by bicycle. Findings from the survey indicate that the current cycling environment is the single largest barrier to commuter cycling among inner-Brisbane residents, with safety concerns (fear of riding with motorised traffic) and a disjointed and indirect network of bicycle paths preventing them from doing so. Female respondents were more likely to avoid certain roads or cycling altogether where perceived danger from riding on roads was high.

Findings from the study provide an evidence base to inform future policies and planning strategies for increasing transport cycling participation in Brisbane, particularly amongst women.

## 1 Introduction

Cycling as a means of practical transportation is an overwhelmingly marginalised practice in Australia and other English-speaking countries such as the USA and UK. In Australia, cycling accounts for only 1.3% of all journey to work trips, although regular recreational cycling participation among adult residents is higher at roughly 10.5% (ABS 2013). Of these riders in Australia women make up a very small proportion, accounting for 23% of cyclists travelling to work nationally (ABS 2013, Munro 2011). The success of other developed Western countries such as Denmark, Germany and the Netherlands in promoting cycling, which all have cycling to work rates above 10% and equal participation among genders, has led researchers to try and understand the underlying reasons for cycling's unpopularity in many countries (Pucher & Buehler 2008).

In order to develop effective strategies for increasing cycling as a transport mode in Brisbane, an understanding of the determinants of bicycle use for transport for particular subgroups such as women is essential. Little research has been performed in the field on Australian cities, including Brisbane to understand the many variables associated with travel mode choice for. Findings from studies done in North America and Europe are not entirely transferrable to an Australian context due to different cultural attitudes toward cycling and variance in cycling environments between cities (Heinen et al. 2009, Burke & Bonham 2010).

This paper aims to address current gaps in literature, providing an analysis of two inner-Brisbane communities in order to understand which individual, environmental and sociocultural factors influence the decision to commute to work by bicycle, and how these factors differ by gender. To address the research problem, the following research objectives have been identified: 1) identify factors which affect the decision to commute by bicycle, including environmental, sociocultural and individual variables; 2) determine which gender-specific variables influence and affect female cycling to work participation and 3) based on these findings, identify opportunities for increasing female cycling participation in Brisbane.

This study addresses gaps in literature and builds upon past research conducted in Australia, most notably by Heesch et al. (2012) and Chataway et al. (2014) by focusing specifically on journey to work trips and sampling from and disaggregating the general population into gender and cycling cohorts.

This approach will allow for a better understanding of both constraints to and opportunities to increase female cycling participation in Brisbane.

## **2 Literature Review**

### **Understanding journey to work behaviour – the Social Ecological Model**

Ecological models of health behaviour have been widely used in the journey to work literature to understand the multiple levels of influence on cycling behaviour (Saelens et al. 2003, Emond et al. 2009, Heesch et al. 2012). A core concept of ecological models is that individual behaviour is influenced by a number of factors, including elements of the individual (biological and psychological), social and cultural and physical environments (Sallis et al. 2008).

The social ecological model has been adapted from Saelens et al. (2003) in a transport cycling context to form the conceptual basis for this study, to categorise and understand the many potential variables which influence individual travel behaviour and how these influences may differ for men and women.

### **Factors influencing an individual's decision to cycle**

Aspects of the physical environment and their effect on cycling and broader travel behaviour are widely documented, with much of the focus in literature placed on the role of road design and cycling-specific infrastructure. Hunt & Abraham (2007) found that increasing physical separation from motorised road users correlated with a measurable increase of cycling activity on that path, with Buehler and Pucher (2012) later determining that bike path and bike lane supply account for 33% of the variability in bike commuting. Australian studies returned similar findings, with both Garrard et al. (2011) and Fishman et al. (2012) finding concerns about cycling in traffic with other road users and a lack of bicycle infrastructure to be the most important constraints on cycling. Other significant aspects of the built environment found in literature relate to convenience rather than safety, with distance a recurring factor (Pucher & Buehler 2008).

Aspects of the natural environment had much less consideration in the literature, and are highly dependent on the city in which a study took place. Topography was rarely considered in mode choice comparisons, though for cyclists it can significantly increase the amount of effort required. Weather was similarly absent from most papers, though was a significant determinant in some cases (CPF 2011).

Past studies have also indicated that individual variables, attitudes and aspects of the social environment were equally significant predictors of cycling behaviour as aspects of the physical environment, with age, gender, employment status, attitudes toward bicycle use and household structure all found to correlate to cycling in many instances (Emond et al. 2009, Handy et al. 2010 & Saelens et al. 2003). Health and fitness improvements provided by cycling was overwhelmingly found in literature to be the greatest motivator for cycling (Heesch et al. 2012, Winters et al. 2011, Garrard et al. 2011), although this was more significant for recreational cyclists in the respective studies. For transportation cyclists convenience, environmental concerns and cost-savings were major motivators (Heesch et al. 2012).

The influence of an individual's social surroundings on travel behaviour and attitudes toward cycling was another theme to emerge from the literature (Heinen et al. 2009). At a broad scale the decline of cycling for transportation purposes in western countries has led to the image of cycling as a solely recreational activity, which has prevented many considering cycling to work (Gatersleben & Appleton 2007). Studies by Dill & Voros (2007) and Aldred (2012) found however that a person's perception of cycling as a 'normal' activity through contact with family members, co-workers and greater cycling activity on the street was associated with a higher chance of cycling for transport, confirming the important role of social norms.

### **Gender based studies - Women and cycling**

Women's participation in cycling, according to the literature, is dependent on their level of risk aversion and alternative household roles and responsibilities. Observed behaviour studies (Garrard et al. 2008) as well as stated preference studies (Emond et al. 2009) identified an increased aversity to risk from women, which included avoiding major roads, taking longer detours along quiet paths, or avoiding riding all together. Safety concerns and a lack of confidence were found to affect a far greater proportion of females than males (Garrard et al. 2006), with concerns about cycling in traffic and aggressive behaviour from motorists identified as the most significant deterrents to cycling for women (Heesch et al. 2012, Winters et al. 2011).

An increasing volume of literature is exploring the influence household roles and responsibilities have on travel patterns and behaviour, particularly for women. In a review of past literature Emond et al. (2009) found that women tend to make more trips than men for household and family support activities and this was reflected in the findings of that paper, where women reported with greater frequency than men that “they need a car to do many of the things they like to do”, though it is uncertain if this a result of household obligations (p.18). The unequal division of household labour between men and women and the impact this has on female travel patterns are also recognised in studies such as Nobis & Lenz (2005) and Noble (2005), though in these studies and many others the issue is still not well understood, particularly as female travel behaviour is typically subject to ongoing change as changing life circumstances, most notably as primary caregivers of their children, affect their ability to cycle for transport (Bonham & Wilson 2011).

### **Summary**

Findings from literature indicate that travel behaviour and transport mode choices are complex, as these individual choices are influenced by a large number of potential variables. Individual, sociocultural and environmental aspects all contribute to commuter cycling uptake, most notably the presence of bicycle infrastructure (Winters et al. 2010, Heesch et al. 2012, Garrard et al. 2011), route distance and hills (Pucher & Buehler 2008), and positive peer group attitudes toward and wider participation in cycling (Gatersleben & Appleton 2007, Dill & Voros 2007, Aldred 2012).

Women have consistently demonstrated in stated preference studies that they feel less confident on the road and have more complex trip characteristics which may or may not be suited to a bicycle. There is a need to understand in detail all of the factors influencing female utility cycling in Australia, as limited research exists within the peer-reviewed literature on commuter cycling in Australia and the considerations unique to Australian cities.

Notable studies in the field include Pucher et al. (2011) comparing cycling trends in Melbourne and Sydney, Chataway et al. (2014) comparing safety perceptions of cycling in Brisbane with Copenhagen, Denmark and Garrard et al. (2008, 2011) in Victoria. While studies conducted by Heesch et al. (2011, 2012, 2013) represent the most comprehensive analysis of recreation and transport cycling performed in Australia, as the survey sample was sourced solely from a community cycling organisation it is unable to consider any factors which may be unique to non-cyclists or casual cyclists. This paper builds upon and addresses knowledge gaps in this and other Australian cycling research by including non-cyclists in the study and aiming for a representative inner-city population sample. Focusing specifically on cycling to work in a Brisbane context, this research presents new findings and analysis on the current barriers to cycling to work for both genders.

### **3 Data and Methodology**

A cross-sectional study of inner-city residents of Brisbane was undertaken, with primary data collected through an online survey. Located approximately 2km south-west and north-east respectively from the Brisbane CBD, the riverside suburbs of West End and Newstead were chosen as sample suburbs to understand the variables which affect cycling to work participation in inner-Brisbane. Both suburbs are predominantly residential in nature although each contains areas of remnant light industry and clustered commercial and retail precincts. As they are located on and alongside a river floodplain they are largely flat or gently sloping, particularly when compared to surrounding areas of Brisbane. Separate primary cycling routes into the Brisbane CBD service both suburbs running along the river; the New Farm-Newstead bikeway and New Farm Riverwalk service Newstead while Riverside Drive is the primary cycle route in West End.

West End and Newstead were selected as they differ significantly with respect to current commuting behaviour and socioeconomic indices. According to 2011 census data West End has the highest bicycle mode share of all Queensland Statistical Local Areas (SLA) at 9.08% of all single-mode trips and a low car ownership rate of 78.83% compared to a 3.77% cycling rate and a 91.12% car ownership rate for Newstead. The median weekly household income for Newstead is \$2472, compared to a figure of \$1485 for West End (ABS 2013).

### **Sampling Design**

Research participants were recruited at random through household mailbox delivery to capture a representative sample of the inner-Brisbane working population. This sampling design was chosen primarily to address current gaps in knowledge, as similar past research by Heesch et al. (2012) and Heesch & Sahlqvist (2013) used sampling methodologies that excluded non-cyclists and casual

cyclists from participating, failing to consider the barriers and facilitators to cycling to work for most of the non-cycling population.

1500 survey invitations were delivered by hand to household letterboxes across West End and Newstead over 2 midweek days in September 2014. A total of 825 letters were delivered to West End households and 675 letters to Newstead households, accounting for roughly 25% of the total households in each suburb (ABS 2013). Letter invitations provided a URL link to the online survey, which was accessible for two weeks before expiring for data analysis. Due to university ethical considerations, access to the survey was restricted to those over the age of 18. As the research is focused on journey to work trips, only residents who are currently employed full-time, part-time and commute to their workplace were invited to participate.

A total of 95 unique responses were received from the survey, for a total response rate of 6.33%. After filtering responses for eligibility and completeness, two responses were removed for a final sample size of 93. The low response rate may be partly explained by the restrictions placed on potential survey participants, being restricted to currently employed adults who commute to work. Lack of access to a computer and internet connection may also have precluded some potential participants. While the sample size was considered adequate for this study given the small population under study (working adults of West End and Newstead) and a survey response rate of 6.33%, it should be noted that similar studies conducted previously have achieved much larger sample sizes: 1862 (Heesch et al. 2012), 1402 (Winters et al. 2011), and 965 (Emond et al. 2009).

### **Survey development**

The survey contained a total of 32 questions, grouped into three sections. Section 1 covered demographic questions, to enable grouping into gender-based cohorts; section 2 focused on perceived barriers and motivators to cycling to work while Section 3 elicited potential opportunities for increasing cycling participation. An open-ended question at the end was included for the survey respondent to list other notable barriers not previously covered.

### **Data Analysis**

Primary data collected from the survey was exported into Microsoft Excel and SPSS for analysis. Descriptive statistics were produced from answers to questions 1-19 to establish and communicate characteristics of the sample population. These characteristics were used to split the population into cohorts based on gender (male or female) and main journey to work mode (cyclist or non-cyclist).

Responses from Likert scale questions were treated as interval data. Overall and cohort mean scores for questions in each theme were calculated and reported to find the most important factors influencing cycling to work in the sample.

### **Comments on Sample Quality and Representativeness**

Although attempts were made to minimise self-selection bias in the survey sample, the survey sample is not entirely representative of the West End or Newstead population nor can it be assumed to represent the greater Brisbane population as certain characteristics of the sample population differed significantly from baseline census data from the ABS. Cyclists are significantly overrepresented in both the West End and Newstead sample, with 48.2 and 16.2% of participants reporting cycling to work respectively, compared to census figures of 9.1% and 3.77% (ABS 2013). While the sample is not representative of the population it does reflect the demographics of the cycling population. Men and non-cyclists, both cohorts that are underrepresented in the sample, may have been discouraged from participating in the survey given that the study has a particular focus on cyclists, particularly women.

## 4 Results

### Demographic profile of sample

**Table 1: Summary of survey sample, disaggregated into travel mode and gender cohorts**

Variables/Characteristics	Cyclists (n = 33)		Non-Cyclists (n = 60)		Total (n = 93)	
	n	%	n	%	n	%
<b>Gender</b>						
Male	17	51.52%	23	38.33%	40	43.01%
Female	16	48.48%	37	61.67%	53	56.99%
<b>Age</b>						
18-24	2	6.06%	4	6.67%	6	6.45%
25-34	10	30.30%	11	18.33%	21	22.58%
35-44	12	36.36%	18	30.00%	30	32.26%
45-54	9	27.27%	13	21.67%	22	23.66%
55-64	0	0.00%	12	20.00%	12	12.90%
65+	0	0.00%	2	3.33%	2	2.15%
<b>Location</b>						
West End (4101)	27	81.82%	29	48.33%	56	60.22%
Newstead (4006)	6	18.18%	31	51.67%	37	39.78%

Note – 'Non-Cyclists' include all respondents who reported travel to work by means other than bicycle on the survey

Within the survey sample, cycling was far more popular in West End with almost half the suburbs sample (48.2%) reporting cycling to work, accounting for 81.8% of the cycling sample.

The cyclist cohort in the sample can be seen to vary from non-cyclists on a number of demographic characteristics. Cyclists were typically younger than the non-cycling cohort, with no respondents aged 55 years or older and a far higher proportion of 25 to 44 year olds. This finding agrees with results from the Australian Cycling Participation 2011 report which recorded a noticeable decline in cycling participation with age (Munro 2011).

Couples (38.7%) and couples with dependent children (34.4%) were the most common household compositions in the sample, followed by singles (15.1%) and shared dwellings (8.6%). Cohort analysis revealed that more cyclists live in households with dependent children (51.5%) than non-cyclists (28.3%). This statistic alone would suggest that having dependent children is not a major barrier to cycling in the sample, a finding reflected in Gatersleben & Appleton (2006). No discernible pattern between travel mode and educational attainment or total household income was revealed when broken down by cycling status, though a greater proportion of non-cycling households earn \$2000 or more weekly.

Most households in the sample owned either a single car (55.9%) or two cars (32.3%). Some differences were apparent between travel mode cohorts at the two extremities; current cyclists were more likely to avoid car ownership at all (9.1% vs. 3.3%) and non-cyclists were more likely to own three or more cars (8.3% vs. 3%). Most respondents (n=76, 81.7%) also reported owning or having frequent access to a bicycle, including a majority of non-cyclists (71.7%). Significantly, far fewer females reported owning or having frequent access to a bicycle (73.6% compared to 92.5% of males).

#### Employment, workplace and journey to work statistics

Due to a skewed sample cycling was the most commonly reported method of travel to work overall (35.5%), followed by driving, public transport and then walking. Consistent with findings from census data and past research in Australia fewer women reported cycling to work in this sample than men, and were instead more likely to walk or catch public transport (Table 2).

Most respondents worked in the Brisbane CBD and inner suburbs (within 5km of the CBD) (n=70, 75.3%). Workplace location did not vary significantly between cyclists and non-cyclists, although a far

higher proportion of cyclists reported working in the inner suburbs, making cycling the most popular travel to work mode overall of workplaces in the inner suburbs. Public transport was the most common mode of transport for travel to the CBD (40%) followed by cycling (28.6%), potentially reflecting the high cost and demand of parking in the Brisbane CBD. All other areas of Brisbane reported low rates of public transport use with only 3 respondents catching public transport to workplaces outside the CBD. Travel to work outside of Brisbane was performed entirely by car (n=4).

Employment status was mostly uniform across cohorts, though fewer females respondents worked full-time (69.8%, 82.5% for males), with 26.4% working part-time and 3.8% working casually.

**Table 2: Employment and journey to work statistics of sample cohorts**

Variables/Characteristics	Cyclists (n = 33)		Non-Cyclists (n = 60)		Males (n = 40)		Females (n = 53)		Total (n = 93)	
	n	%	n	%	n	%	n	%	n	%
<b>Primary travel to work mode</b>										
<i>Bicycle</i>	33	100.00%	0	0.00%	17	42.50%	16	30.19%	33	35.48%
<i>Car (driver or passenger)</i>	0	0.00%	27	45.00%	12	30.00%	15	28.30%	27	29.03%
<i>Public Transport</i>	0	0.00%	17	28.33%	6	15.00%	11	20.75%	17	18.28%
<i>Walking</i>	0	0.00%	15	25.00%	5	12.50%	10	18.87%	16	17.20%
<b>Workplace Location</b>										
<i>Brisbane CBD</i>	10	30.30%	25	41.67%	14	35.00%	21	39.62%	35	37.63%
<i>Brisbane inner suburbs</i>	17	51.52%	18	30.00%	15	37.50%	20	37.74%	35	37.63%
<i>Brisbane middle/outer suburbs</i>	6	18.18%	13	21.67%	9	22.50%	10	18.87%	19	20.43%
<i>Outside of Brisbane</i>	0	0.00%	4	6.67%	2	5.00%	2	3.77%	4	4.30%
<b>Employment</b>										
<i>Full-time employed</i>	25	75.76%	45	75.00%	33	82.50%	37	69.81%	70	75.27%
<i>Part-time employed</i>	5	15.15%	13	21.67%	4	10.00%	14	26.42%	18	19.35%
<i>Casually employed</i>	3	9.09%	2	3.33%	3	7.50%	2	3.77%	5	5.38%
<b>Workplace provides end of trip facilities</b>										
<i>Yes</i>	26	78.79%	51	85.00%	35	87.50%	42	79.25%	77	82.80%
<i>No</i>	7	21.21%	8	13.33%	4	10.00%	11	20.75%	15	16.13%
<i>Unsure</i>	0	0.00%	1	1.67%	1	2.50%	0	0.00%	1	1.08%

End of trip facilities for employees who cycle or walk were provided at most workplaces in the sample. Surprisingly, fewer commuter cyclists reported having access to end of trip facilities at their workplace, suggesting that it was not an important catalyst for riding to work. When stated, the most common facilities provided at workplaces were showers (95.4%), secure parking (70.8%), lockers (63.1%) and unsecured parking (13.9%).

### Cycling and travel behaviour

A majority of respondents reported cycling for both recreation and transport, although with a quarter of the sample cycling solely for recreation, transport cycling was less common overall (table 3). As a cohort, commuter cyclists were more likely to ride for recreation than non-cyclists. Overall, riding for transportation was most commonly performed 4 or more times a week while riding for recreation was more infrequent, most commonly performed less than once a week.

**Table 3: Cycling participation of sample cohorts**

Variables/Characteristics	Cyclists (n = 33)		Non-Cyclists (n = 60)		Males (n = 40)		Females (n = 53)		Total (n = 93)	
	n	%	n	%	n	%	n	%	n	%
<b>Cycling behaviour</b>										
<b>Cycle for recreation</b>	24	72.73%	36	60.00%	29	72.50%	31	58.49%	60	64.52%
<i>Less than once a week</i>	14	63.64%	21	60.00%	19	67.86%	16	55.17%	35	58.33%
<i>1-3 times a week</i>	8	36.36%	14	40.00%	9	32.14%	13	44.83%	22	36.67%
<i>4+ times a week</i>	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
<i>Not Stated</i>	2	8.33%	1	2.78%	1	3.45%	2	6.45%	3	5%
<b>Cycle for transport</b>	33	100.00%	20	33.33%	26	65.00%	27	50.94%	52	56.99%
<i>Less than once a week</i>	0	0.00%	8	40.00%	3	11.54%	5	18.52%	8	15.38%
<i>1-3 times a week</i>	2	6.25%	10	50.00%	6	23.08%	6	22.22%	12	23.08%
<i>4+ times a week</i>	30	93.75%	2	10.00%	17	65.38%	15	55.56%	32	61.54%
<i>Not Stated</i>	1	3.03%	0	0.00%	0	0.00%	1	3.70%	0	0.00%

Note – 'Cyclists' in this table refers to respondents who reported cycling to work in the survey

Females are less likely to participate in cycling for either recreation or transport in the sample. Gender appeared to have little influence on riding frequency however, with participating females riding almost as frequently as males for both recreation and transport.

A third of non-commuter cyclists reported cycling for transport. It is unknown how many in the commuter cyclist cohort rode for transport for reasons other than journey to work as the survey question did not make this distinction. The overwhelming majority of those who reported cycling to work cycled at a frequency of 4 or more times a week, likely indicating that cycling was their sole mode of transport to work.

### **Factors influencing commuter cycling**

#### **Motivations and justification for travel choice mode**

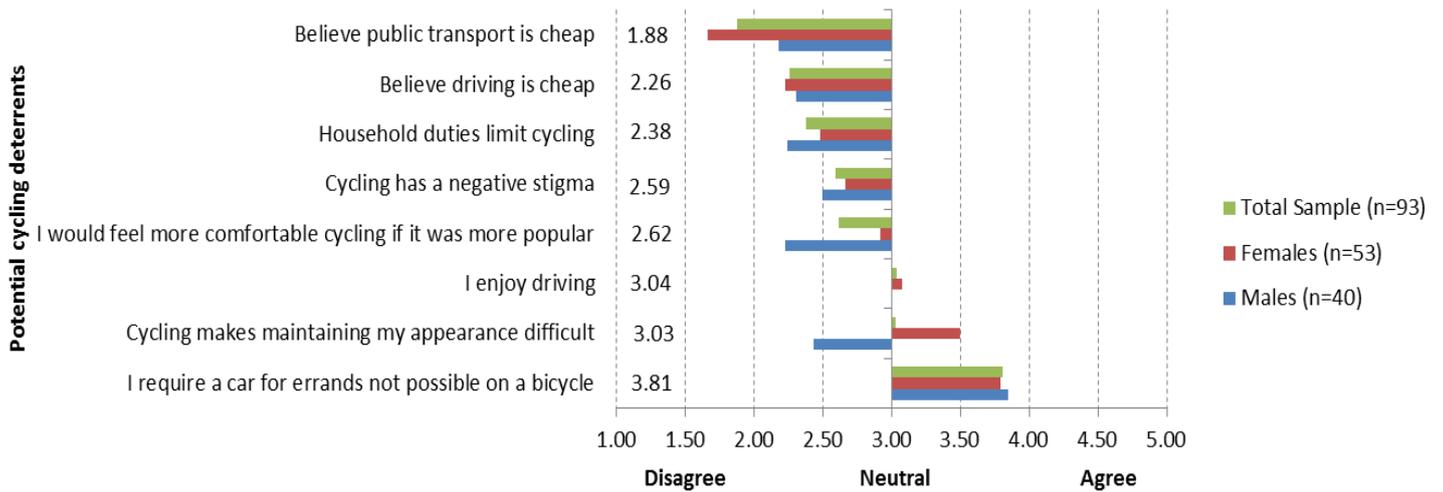
To understand motivations and justifications for travel choice mode respondents were asked why they chose to cycle, walk or catch public transport to work, with qualitative responses coded into themes and counted. For commuter cyclists it was the health and fitness aspects of riding which emerged as the most common theme (n=26, 78.8% of cyclists), followed by cost savings (n=19), time savings (n=11), convenience (n=10), and enjoyment (n=6). Respondents walking to work cited similar motivators/benefits as commuter cyclists, with fitness being the most common theme (n=10, 62.5% of walkers) followed by cost savings (n=5), enjoyment (n=5) and convenience (n=4). 'Finding a park was hard' was mentioned by cyclists, walkers and public transport users as a deterrent to driving.

Convenience was overwhelmingly observed as the main motivator for driving to work (n=22, 81.48% of drivers). The only other common themes to emerge were: time savings (n=6), distance travelled (n=5), safety (4) and having no alternative (n=2). Public transport users also cited convenience as the main reason for catching public transport (n=10, 58.82%). Cost savings (presumably over driving) and safety were also mentioned (n=3, n=2).

The term 'convenience' was a recurring response among users from all modes of transport, although the term is problematic as it can be used to refer to a range of different factors depending on the individual and mode of transport used, encompassing cost, accessibility, time and energy expenditure, among others. Unfortunately all survey responses coded into 'convenience' did not provide a further explanation to their answer.

#### **Personal and Sociocultural Barriers to Cycling**

Survey respondents were presented with eight statements relating to travel to work and cycling and asked to rate on a scale whether they agree or disagree with a statement. The statement, "I require a car for errands not possible on a bicycle" was met with the most agreement from respondents (figure 1).



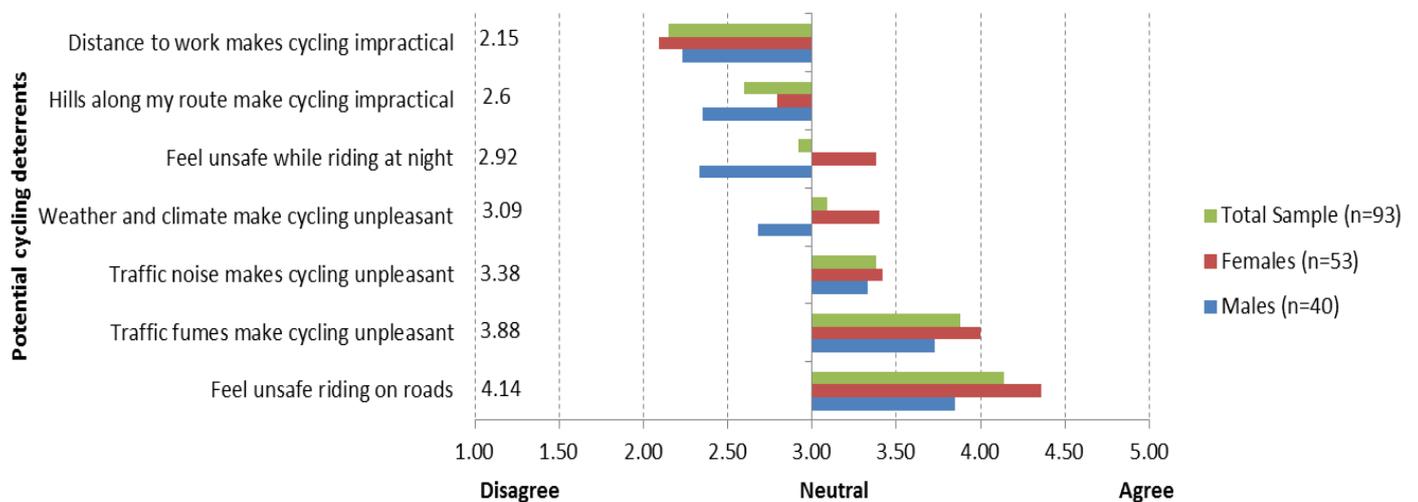
**Figure 1:** Potential personal and sociocultural barriers to cycling - mean scores of survey respondents

The cost-savings associated with commuting by bicycle have been consistently cited in literature as a major reason for choosing to ride to work (Heesch et al. 2012, De Geus et al. 2008). Two variables in Question 20 were designed to test this, by asking respondents whether they believe driving or catching public transport to be cheap. Survey respondents were in strong disagreement; most particularly cyclists (mean score of 1.70 and 2.20 for public transport and driving respectively) indicating that the costs associated with driving or catching public transport could provide significant motivation to cycle to work instead.

Women were far more likely to agree with the statement, “Cycling makes maintaining my appearance difficult”, (mean score of 3.50) contrasting significantly with males (2.43). Although only achieving a mean score of 2.92 among women, “I would feel more comfortable cycling if it was more popular” was also of greater importance to females, potentially explained by the much lower proportion of female cyclists in Brisbane.

**Environmental Barriers to Cycling**

Seven aspects of the physical environment which may act as barriers to cycling were tested. Respondents strongly agreed with the statement, “I feel unsafe riding on roads”, supporting overwhelming findings from Australian (Fishman et al. 2012, Heesch et al. 2012) and overseas (Winters et al. 2011) that fear of sharing roads with motorised vehicles is the single largest barrier to cycling. Women were more likely to report feeling unsafe while riding, either from traffic or fear of crime at night, indicating a greater sensitivity to risk than men. Women were also more likely to be deterred by weather and climate (figure 2).



**Figure 2:** Potential environmental barriers to cycling - mean scores of survey respondents

'Distance to work' and 'hills along the route' were found to be insignificant, though again this is likely a reflection on the sample area which is relatively flat and within 3km of the CBD. Non-cyclists were more likely to consider distance between home and work to be impractical to ride (mean scores of 2.38 for non-cyclists, 1.73 for cyclists).

### Conflict with motorists and behaviour modification

Questions 24 to 26 probed respondents on their relationship and experiences with motorists while riding on the road, to determine the extent of road conflict between cyclists and motorists and the effect this has on riders and riding behaviour, particularly for females who have been identified in literature as being more risk-averse (Garrard et al. 2008, Emond et al. 2009). A summary of findings is illustrated below (table 4).

**Table 4: Crosstab – Results from Questions 24 – 26 by gender and cycling status**

<b>Q24- Have you previously experienced aggression from a motorist whilst riding a bicycle on the road?</b>										
<b>Available Responses</b>	<b>Male (n=40)</b>		<b>Female (n=53)</b>		<b>Cyclist (n=33)</b>		<b>Non-Cyclist (n=60)</b>		<b>Total (n=93)</b>	
	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>
Yes	26	65.00%	21	39.62%	26	78.79%	21	35.00%	47	50.54%
No	12	30.00%	21	39.62%	7	21.21%	26	43.33%	33	35.48%
N/A - No prior road riding experience	2	5.00%	11	20.75%	0	0.00%	13	21.67%	13	13.98%
<b>Q25 - Has this previous aggression affected your attitude toward riding or your cycling behaviour?</b>										
<b>Available Responses</b>	<b>Male (n=26)</b>		<b>Female (n=21)</b>		<b>Cyclist (n=26)</b>		<b>Non-Cyclist (n=21)</b>		<b>Total (n=47)</b>	
	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>
No	11	42.31%	3	14.29%	7	26.92%	7	33.33%	14	29.79%
Yes - More conscious of safety but no change to riding behaviour	12	46.15%	10	47.62%	17	65.38%	5	23.81%	22	46.81%
Yes - Avoid that road or area now	1	3.85%	5	23.81%	0	0.00%	6	28.57%	6	12.77%
Yes - Ride less overall	2	7.69%	3	14.29%	2	7.69%	3	14.29%	5	10.64%
<b>Q26 - Would you take a significant detour (20% of total trip distance) along quiet backstreets or trails in order to avoid an unpleasant route?</b>										
<b>Available Responses</b>	<b>Male (n=40)</b>		<b>Female (n=53)</b>		<b>Cyclist (n=33)</b>		<b>Non-Cyclist (n=60)</b>		<b>Total (n=93)</b>	
	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>	<b>%</b>
Yes	28	70.00%	43	81.13%	21	63.64%	50	83.33%	71	76.34%
No - Ride on the footpath instead	7	17.50%	9	16.98%	8	24.24%	8	13.33%	16	17.20%
No - Take the most direct route	5	12.50%	1	1.89%	4	12.12%	2	3.33%	6	6.45%

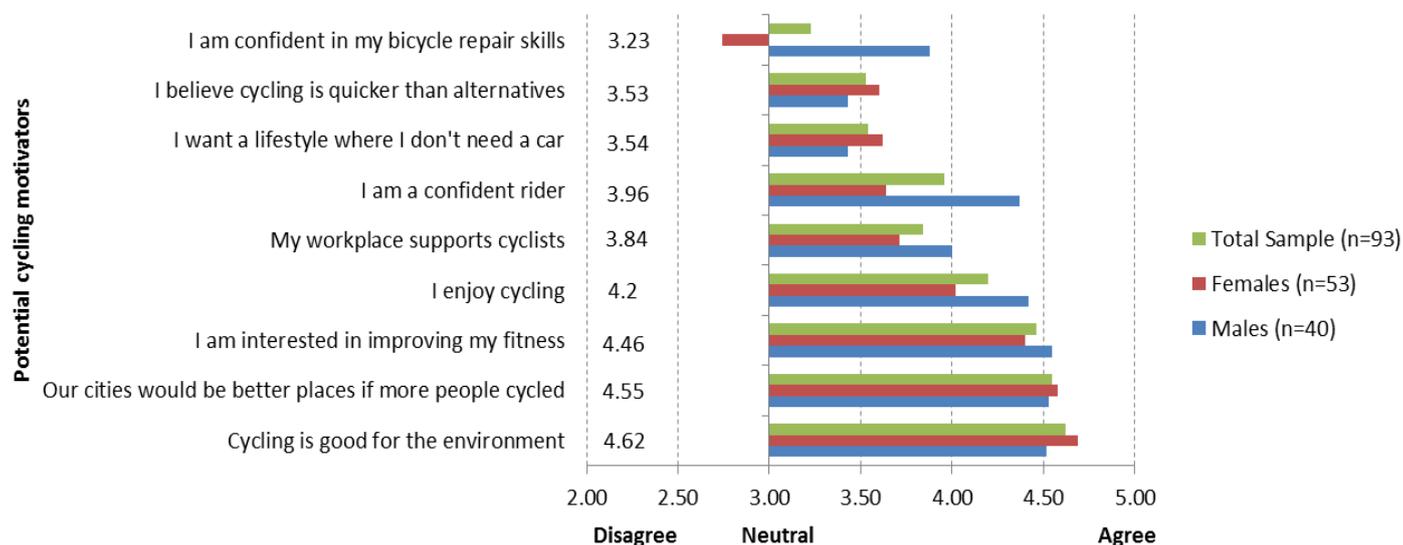
Over half of respondents have experienced aggression from motorists whilst riding on the road (Q24), which comprised of shouting (51.3%), deliberately close passes (38.5%), honking (30.8%) and being 'cut-off' (23.1%). Isolated cases included having objects thrown, spitting, rude gestures and sexual harassment. The frequency and nature of reported aggressive acts indicate that sharing the road between motorists and cyclists in Brisbane is problematic.

70% of affected cyclists felt that this previous aggression had an impact on their cycling (Q25), although only 23.4% modified their riding behaviour as a result. While still significant, fewer proportions of women (50%) reported experiencing aggression while riding than men (68.4%), yet they were more likely to modify their behaviour after experiencing aggression. Non-cyclists were also more sensitive to aggression when compared to commuter cyclists.

Although not directly related to incidents of motorist aggression, Q26 similarly probed respondents on avoidance behaviour by gauging how willing cyclists were to take significant detours to avoid unsafe or unpleasant routes, of which the majority of respondents indicated they would. Only 6 respondents indicated they would take the most direct route, of which 5 were males. Supporting findings from Q25, women were more likely to adopt avoidance behaviour when faced with potential conflict from road users, with a higher proportion of female respondents willing to detour than men. A small number of respondents indicated they would rather ride on the footpath instead. Another pattern emerging from these results is that non-cyclists are far more risk averse than current cyclists, with a greater proportion indicating they would modify their behaviour.

### Motivators to Cycling

The benefits of cycling were appreciated by a majority of respondents regardless of cycling status, with all cohorts in strong agreement that “cycling is good for the environment” and “our cities” (figure 3). Considering the number of respondents who disagreed in Q20 that driving or public transport was cheap, these findings reflect a study by De Geus et al. (2008) that found the decision to cycle to be influenced by ‘ecological-economic awareness’, an understanding and belief that cycling is both cheaper and better for the environment (p. 704).



**Figure 3:** Potential personal and sociocultural motivators of cycling - mean scores of survey respondents

The greatest variance observed between males and females were variables relating to cycling ability and confidence, with females significantly less likely to express confidence in their bicycle repair skills or riding ability.

### Road Type Appraisal

In Q28 respondents were presented with a series of photographs of varying road environments found within Brisbane, varying in road width, traffic volume, traffic function and the presence or absence of bicycle lanes. Answers were selected along a four point scale; 1 ‘total avoidance’, 2 ‘uncomfortable’, 3 ‘comfortable’ and 4 ‘actively seek out roads such as this’, and mean scores calculated (table 5).

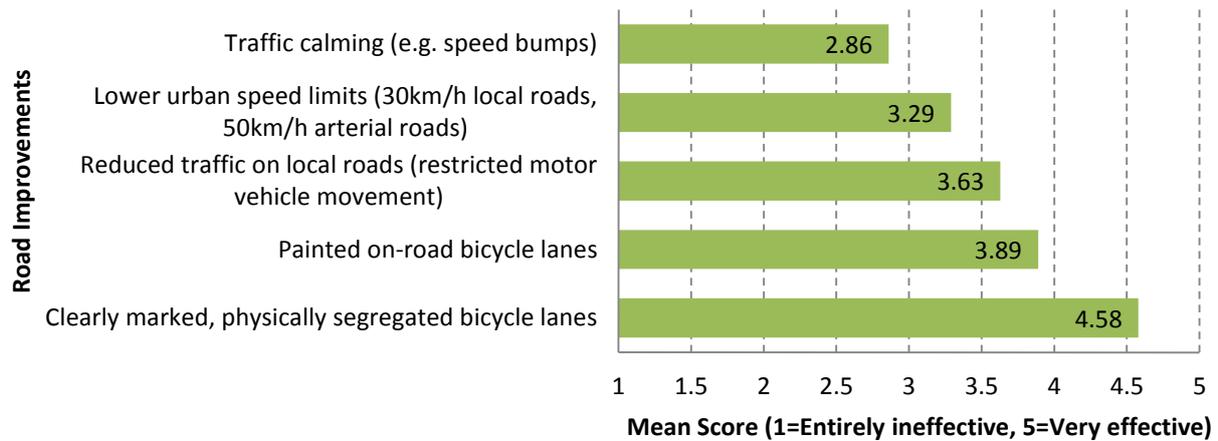
**Table 5: Mean scores of Q28 – ‘How comfortable would you feel riding on the following roads’**

	Males (n=40)	Females (n=53)	Cyclists (n=33)	Non-Cyclists (n=60)	Total Sample (n=93)	Std. Deviation
A - High traffic volume, no bicycle lane	1.40	1.10	1.36	1.15	1.23	0.447
B - High traffic volume, on-road bicycle lane	2.30	1.98	2.33	2.00	2.12	0.693
C - High traffic volume, segregated bicycle lane	2.88	2.65	3.00	2.61	2.75	0.807
D - Low traffic volume, no bicycle lane	2.93	2.79	2.97	2.78	2.85	0.645
E - Low traffic volume, bicycle lane	3.40	3.37	3.61	3.25	3.38	0.531
F - Local road, no traffic calming	3.25	3.02	3.27	3.03	3.12	0.571
G - Local road with traffic calming	3.12	3.04	3.15	3.03	3.08	0.615
H - Off-road shared bicycle and pedestrian path	3.45	3.65	3.61	3.54	3.57	0.617

Results indicate that traffic volume on roads is a more significant consideration for cycling than the presence or absence of bicycle infrastructure on a road, with all high traffic road examples scoring the lowest despite examples B and C including a bicycle lane. Bicycle lanes, particularly those offering physical segregation from traffic were still an important factor as roads of similar traffic volume and function scored much higher when they contained a bicycle lane. Off-road shared paths scored the highest with a mean score of 3.57, supporting findings from Q23 that a fear of riding on roads is the single largest barrier to cycling. A comparison between genders once again revealed that females are more risk-averse and sensitive to traffic on roads, scoring all roads for comfort lower than males except for example H.

**Opportunities for increasing cycling participation**

Question 31 in the survey asked respondents to rate the effectiveness of five theoretical improvements to the road environment, to determine how effective these potential changes would be in encouraging them to cycle more. As male and female responses were near identical, Figure 4 below has been simplified to show the total mean score.



**Figure 4:** Mean scores of survey response, rating the effectiveness of the road environment for cycling

Only clearly marked, physically segregated bicycle lanes were considered to be effective with a mean score of 4.58 ('effective'). Lower speed limits and reduced traffic on local roads achieved much lower scores of 3.29 and 3.63 respectively. These results run contrary to findings from Q28, where traffic volume and speeds were found to be the most important consideration for cyclists when riding on roads, rather than the presence or absence of bicycle paths.

Question 32 asked non-cyclists to consider whether or not they would consider cycling in the future given a significant change in individual circumstances or the physical environment. Of those who responded (n=58), (77.6%) answered 'yes' to the statement: 'I consider myself to be a potential future commuter cyclist'. When asked to state the most important catalyst to shift their travel behaviour toward cycling, the overwhelming majority of respondents (64.4%) identified segregated cycling paths, which was the only significantly recurring theme. Other themes identified by multiple respondents were end of trip facilities, less traffic and lighting improvements.

**5 Discussion, conclusions and further research**

**Significant determinants of cycling to work in inner-Brisbane**

Cycling was regarded positively in the sample, recognised as being good for the environment and city, individual fitness and enjoyed by a majority of respondents. All significant deterrents to cycling in the sample were related to negative externalities of sharing the road with cars, with feeling unsafe while riding on roads and contending with traffic noise and fumes the most significant environmental constraints.

Results from the survey indicate the perceptions of comfort and safety while cycling on roads is a function of both traffic volume and the degree of separation between cyclists and motorists, though traffic volume was found to be a more significant consideration for riders than the presence or absence of bicycle infrastructure on the road. A study by Dill (2009) in Portland, Oregon also found

avoiding streets with traffic a more important consideration for cyclists than riding in a bike lane, although with half of cyclist traffic in the city occurring on segregated paths despite making up 8% of the road network, bike lanes are clearly also a significant factor for cycling comfort. Other studies on cycling route choice also found a similar equal preference for routes with cycle paths or routes with little traffic (Bernhoft & Cartensen 2007).

End of trip facilities at a workplace did not correlate to riding to work. Although identified as a priority action in the Queensland Cycling Strategy and now a mandatory requirement for all new development under the Queensland Development Code, past research that has tested the influence of end of trip facilities on cycling to work arrived at similar findings (Queensland Government 2011). Winters et al. (2011) found bicycle parking and end of trip facilities to have only a moderate influence on the likelihood of cycling, and Heesch et al. (2012) similarly found a lack of end of trip facilities to be insignificant, identified as a constraint by 30-40% of the sample.

Encouraging city residents to adopt cycling over driving or other motorised transport may prove difficult. Respondents who chose to drive to work did so for the convenience it affords them and many in the sample, including cyclists, believe that they require a car to perform errands not otherwise possible or practical, partly explaining also the similar car ownership rates between the two cohorts. In Brisbane the private motor vehicle remains the predominant transport choice for most journeys and destinations, appreciated for its time efficiency and comfort (Buys et al. 2011). Burke & Bonham (2010) explains that the “dispersed urban form and car-oriented suburban landscapes” shared by Australian and US cities have led to a dependence on motor vehicles (p. 273). Although the survey sample area is inner-city and has significantly higher dwelling densities and greater amenity than outer suburbs, this finding suggests that car dependence is still endemic within inner-Brisbane.

Employing strategies such as financial incentives have been found to only have a minor influence on shifting travel behaviour away from driving. In a study by Dickinson et al. (2003) women responded less positively to financial incentives and were more likely to see cars as essential for extraneous activities incorporated into commuting such as shopping and dropping children at school.

### **Encouraging women to ride - the greatest barriers**

As found in the study and consistent with census data and findings from past studies, fewer women rode for recreation or transport than men and fewer women also owned or had frequent access to a bicycle. Two major themes emerged from the results on major barriers affecting women:

#### **1. Lifestyle and individual/cultural barriers**

Female participants were more likely than men to state lifestyle and sociocultural variables to be a barrier to riding to work, even if these did not score significantly in the sample. Women in the sample felt that both a difficulty in maintaining their appearance on the journey to work and a belief that cycling would be more comfortable to them if it were more popular and ‘normalised’ to be of far greater importance than male respondents. Numerous past studies on Australian women and cycling have arrived at similar results, with respondents stating that women’s clothing is difficult to cycle in, cycling disrupts hair and makeup, dress codes and appearance standards at workplaces are difficult to maintain if cycling to work and a notable lack of women’s cycle clothing in a male dominated bicycle retail environment all constrain cycling to work (CPF 2013, Garrard et al. 2011).

However unlike past research by Nobis & Lenz (2005), Noble (2005) and Dickinson et al. (2003) which found that differing household roles alter female travel patterns, women in this study were only marginally more likely to agree that household duties and commitments limit their ability to cycle to work.

#### **2. Risk minimisation and environmental sensitivities**

Females were consistently more risk-averse than males in the sample and less likely to cycle for either transport or recreation. Like the male cohort, women avoided cycling where traffic volume was high. Consistent with past observed (Garrard et al. 2008) and stated preference studies (Heesch et al. 2012) women were more sensitive to highly-trafficked roads and more likely to adopt avoidance behaviour such as taking detours and riding on footpaths when faced with potential conflict from road users, preferring greater physical separation from motor vehicles.

While less significant than traffic-related concerns, there were a number of environmental variables for which women were distinctly sensitive to, the most significant of these being a fear of riding at night with far more women agreeing that deters them from cycling to work. Similar results were found in a survey of women conducted by the Cycling Promotion Fund (2013) where only 16% of females agreed it was safe to ride a bike at night.

The survey also indicates that women are less confident than in their repair skills and riding ability - these two variables were similarly important constraints in a study by Garrard et al. (2011). While this alone does not indicate that this is a significant overall consideration for journey to work mode for women due to the survey design, CPF (2013) found a lack of confidence in cycling ability to be a major reason why the studied women did not ride.

### **Opportunities for increasing commuter cycling participation in Brisbane**

To consider opportunities for increasing cycling to work participation it is most useful to study the non-cycling population. Based on survey findings a large proportion of non-cyclists in the study area could be considered potential cyclists with the majority having access to a bicycle (72%) and working within riding distance of their workplace (72%). Importantly 78% of non-cyclists indicated they could consider cycling to work in the future.

As the greatest barriers to cycling for both men and women in the survey were comfort and safety concerns from sharing roads with motor vehicles, the most effective means of increasing commuter cycling participation in Brisbane would likely be through the construction of bicycle lanes separated from motorised traffic, particularly as the majority of non-cyclists felt this to be the most important catalyst to shift their travel behaviour. The importance of segregated cycle routes is well-understood for providing both perceived and tangible safety benefits for cyclists (Pucher & Dijkstra 2003) and correlating with increased cycling participation (Buehler & Pucher 2012), with the current Queensland Cycling Strategy identifying the construction of safe, direct and connected cycle networks to be the most important priority for increasing cycling for transport (QLD Government 2011).

Broach et al. (2012) in an Australian study quantified the influence and importance of segregated bicycle paths on cyclist behaviour, finding that cyclists of all skill levels and characteristics will go out of their way to use bike paths and roads with minimal traffic volumes. The study also revealed that cyclists are highly sensitive to distance and turn frequency, and are only willing to deviate from the shortest route by an upper limit of 20%. Responses from the survey sample support this observation, as many expressed the need to take significant detours in their journey to work to follow segregated paths or quiet roads, increasing trip distances and negating the time savings afforded by cycling: a major motivator to cycling identified in the survey. This highlights the importance of not only segregation from motor vehicles but also a well-connected network of segregated paths linking major employment and population centres in increasing cycling amenity and cycling to work participation.

With the perceived high costs of public transport and driving to work and high levels of participation and enjoyment in recreational cycling from the sample, improvements to cycling infrastructure could shift the travel behaviour of many inner-Brisbane residents to cycling.

### **Directions for further research**

Strengths of the study include the large number of variables covered within the survey. As one of very few studies on cycling undertaken in Brisbane and one of even fewer sampling from the general population it also presents new data on attitudes toward cycling in inner-Brisbane. However, this research could be improved by conducting a more thorough survey that considers a greater number of variables and allows the researcher to understand the relative weight and influence of these variables.

Future research on female cycling to work correlates in the Australian population could include a greater number of variables than those considered here. While open-ended questions allowed respondents to list any barriers to cycling that were not included in the survey, elements of cycling unique to Australian cities such as mandatory helmet laws and their impact on both the image and culture and accessibility of cycling were not explored.

As the sample area was restricted to inner suburbs with conditions conducive to cycling such as a flat elevation profile and high cycling amenity, a similar study performed over a larger and more diverse geographic area including the middle and outer suburbs would provide a better understanding of the barriers to cycling faced by most Brisbane residents.

Finally, with a larger survey sample it could be useful to divide the sample population into small cohorts based on their proximity to cycling infrastructure, to determine the impact of bike paths on cycling participation and attitudes toward cycling.

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