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Factors influencing bike share membership: An analysis of Melbourne and Brisbane

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ABSTRACT

The number of bike share programs has increased rapidly in recent years and there are currently over 700 programs in operation globally. Australia's two bike share programs have been in operation since 2010 and have significantly lower usage rates compared to Europe, North America and China. This study sets out to understand and quantify the factors influencing bike share membership in Australia's two bike share programs located in Melbourne and Brisbane. An online survey was administered to members of both programs as well as a group with no known association with bike share. A logistic regression model revealed several significant predictors of membership including reactions to mandatory helmet legislation, riding activity over the previous month, and the degree to which *convenience* motivated private bike riding. In addition, respondents aged 18–34 and having docking station within 250 m of their workplace were found to be statistically significant predictors of bike share membership. Finally, those with relatively high incomes increased the odds of membership. These results provide insight as to the relative influence of various factors impacting on bike share membership in Australia. The findings may assist bike share operators to maximize membership potential and help achieve the primary goal of bike share – to increase the sustainability of the transport system.

1. Introduction

Bike share programs have existed for nearly 50 years, although the last decade has seen a sharp increase in both their prevalence and popularity worldwide (Shaheen et al., 2010). Shaheen et al. (2010) summarize the benefits of bike share as flexible mobility, emission reductions, physical activity benefits, reduced congestion and fuel use, individual financial savings and support for multimodal transport connections. Implicit in many of the purported benefits of bike share is an assumption that these bikes are being used as a replacement for trips previously undertaken by car (Midgley, 2011).

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In London and Washington, D.C. only 2% and and 7% of bike share users are substituting for car use (Transport for London, 2010; LDA Consulting, 2012). In Brisbane and Melbourne, these figures rise to 21% and 19%, respectively (Fishman et al., 2014). Other researchers have noted the intrinsic benefits of travel, in terms of creating a buffer between work and home, variety-seeking and independence (Mokhtarian, 2005), and it is plausible these benefits are applicable to bike share.

In 2010, Brisbane and Melbourne introduced bike share programs in their city centers and some of the local surrounding inner suburbs, known as *CityCycle* and *Melbourne Bike Share* (*MBS*), respectively. Bicycle riding for transport (on private bicycles) has increased significantly in Australia over recent years (Bauman et al., 2008), however Australia's bike share usage has been disappointing (Brisbane Times, 2011; Fishman, 2012; Fishman et al., 2013; Fyfe, 2010; Traffix Group, 2012). Melbourne and Brisbane schemes have usage rates significantly less than other bike share programs (Fishman et al., 2013; Meddin, 2011a). Both schemes have approximately 0.3–0.8 trips per day per bike according to information supplied by the operators to the authors (JCDecaux, 2011; Royal Automobile Club of Victoria, 2011), although the latter half of 2012 showed a strengthening usage rate (Alta Bike Share, 2012; Brisbane City Council, 2012). Most other schemes internationally report usage rates of around 3–6 trips per bike per day (Fishman, 2011; Meddin, 2011a, 2011b; Rojas-Rueda et al., 2011). There has been widespread speculation as to reasons behind the lower usage rates in Australian cities, yet relatively little empirical research has been conducted. This paper develops a logistic regression model to understand the influence of various factors impacting on bike share membership, using the results of online surveys conducted with annual members of the Melbourne and Brisbane bike share programs, as well as a panel composed of citizens with no known connection to bike share.

1.1. Existing research on Australian bike share programs

Limited research exists within the peer-reviewed literature regarding the motivating factors that lead to bike share membership, and of the research that does exist, few have focused on Australian programs. Understanding what factors motivate people to join bike share programs may be useful in future efforts to increase usage. By yielding an estimated relationship between key program features and the odds of joining the program, bike share planners are able to tailor their offering to increase the effectiveness of their efforts to increase participation.

The overwhelming majority of research investigating bike share in Australia appears in the non peer-reviewed literature, most often in consultant and operator reports. The operators of *MBS* conducted a market research exercise approximately six months after the program launched. The research was motivated in part by lower than expected usage and to assist in determining the impact of recent initiatives such as helmet vending machines, as mandatory helmet legislation exists in Australia (Alta Bike Share, 2011). The survey was completed online by self-selected Internet users, as well as in the field by people walking in close proximity to docking stations (where bicycles are picked up and dropped off). Just under 500 people were surveyed in each method, resulting in a sample where 31% of respondents had used the *MBS* program. It is important to recognize that these survey methods limit the generalizability of the results due to self-selection effects, as the sample only includes people who have visited the *MBS* website or walked past specific docking stations and were willing to be part of the study. Nevertheless, the survey revealed some interesting findings with regard to the barriers and motivators to using the scheme. Some 61% of the sample cited helmet issues as their main barrier. Melbourne experienced a particularly wet period around the time of the survey (Bureau of Meteorology, 2011) and this may have contributed to the large proportion (16%) who cited 'bad weather' as a barrier. Convenience relative to other travel options was found to be the key motivator for those who used *MBS* (Fishman et al., 2012a).

A more recent examination of the *MBS* program was recently undertaken on behalf of VicRoads (the statutory agency overseeing the program) (Traffix Group, 2012). This report included two data collection methods; an online survey ($n = 602$) and intercept survey ($n = 2945$). Snowball sampling was used to recruit online survey respondents, with the survey emailed to the *MBS* email list and links posted on the *MBS*, Melbourne University and RMIT University websites. Additionally, those who were approached during the intercept survey but were unable to participate were provided with a card inviting them to complete the online survey. These recruitment methods have implications for the interpretation of results – as it suggests a stronger underlying interest in bike share than might be found in the general population. The online survey, in which just under half the respondents reported having used the scheme, revealed that the main motivators remained those related to convenience (see Fig. 1 below). Multiple responses were permitted and participants were unable to select the degree to which these factors were motivators for using the scheme (such as a Likert scale).

In addition to the results illustrated in Fig. 1, the Traffix Group study also contained an open text field for respondents to provide a comment on the *MBS* program. When these comments were coded for commonly occurring categories, the researchers found that approximately 46% of respondents cited mandatory helmet legislation as having a negative impact on the scheme. When participants were asked what prevented them from using *MBS* (or what prevented more frequent use by those who were members of the scheme), helmets continued to be a feature, as shown in Fig. 2 below. Helmets can act as deterrents to bike share use in at least two ways. Firstly, many bike share trips are spontaneous and prospective users may not have a helmet with them. Secondly, some people may have an aversion to using a helmet in the first instance. The Traffix Group study (see Fig. 2), as well as previous research (Fishman et al., 2012a) suggestions this first factor to be more pertinent. The responses "*Could not find a helmet to purchase*" and "*Do not want to carry a helmet around*" are convenience factors, rather than a direct aversion to helmet wearing and when combined, are over four times more prevalent than

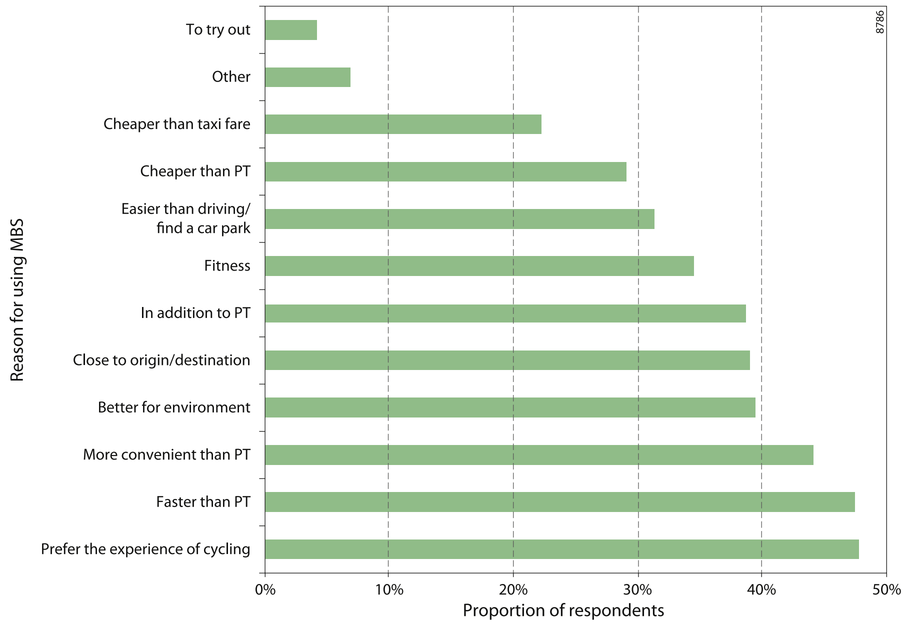

Fig. 1. Reasons for using Melbourne Bike Share. Source: Traffix Group (2012). NB: PT refers to public transit.

the response "*Do not want to wear a helmet*". This interpretation is supported by evidence showing an increase in *CityCycle* usage when helmets were distributed on bikes (Fishman et al., 2013).

These views on helmets are supported by US research conducted by Fischer et al. (2012) in which large differences were observed in the helmet wearing prevalence between public and private bike riders in both Boston and Washington, D.C. When controlling for sex, time of week, and city, the results showed a 4.4-fold greater odds that a person on a bike share bike will be without a helmet compared to a private bike rider.

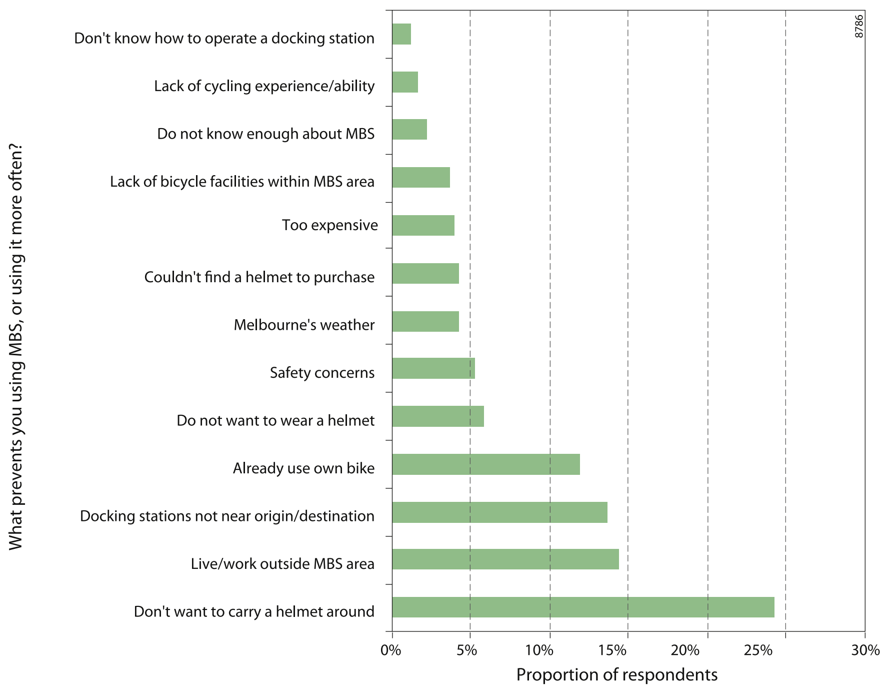

Fig. 2. Reasons preventing greater use of Melbourne Bike Share. Source: Traffix Group (2012).

Table 1
Survey sample and response rate.

	Melbourne Bike Share	CityCycle	InSPiRS Panel
Sample sent invitation email	921	2490[a]	436
Successfully received emails	914	2357	311
Fully completed surveys received	372	443	60
Response rate	40.7%	18.8%	19.3%

[a] Of these, 1926 were to annual members.

2. Methodology

A probabilistic sampling technique was employed, with separate, duplicate online surveys for both respondents within the *MBS* and *CityCycle* bike share programs. Invitations to participate were emailed by the operators of the respective bike share programs. Invitations were also sent to members of a research panel managed by the Centre for Accident Research and Road Safety – Queensland, known as the *Independent Survey Panel in Road Safety* (InSPiRS) Panel. This Panel was selected as they had no known connection with bike share and may therefore offer a useful sample group for understanding potential barriers to bike share. The InSPiRS Panel is made up of households who have accepted an invitation to be part of the Panel. Sample numbers and response rates are identified in Table 1. The low sample number for non-members has been addressed through weighting and is described in Section 2.1.1. The questions included in the survey are shown in Supplementary data.

Although the *CityCycle* survey was sent to anyone who had signed up to the mailing list, results show that 97% of respondents were annual members. Some 133 of the emails sent by the *CityCycle* operator 'bounced' as well as seven from the *MBS* operator and 125 sent to the InSPiRS Panel.

Each participant was aged over 18 years and lived, worked, or studied in the Brisbane or Melbourne areas. In recognition of their time, participants were offered the opportunity to enter a prize draw for one of ten $100 department store gift cards. The survey was developed in KeySurvey (http://www.keysurvey.com). In accordance with the requirements of the Queensland University of Technology Research Ethics Committee, each participant was provided with a participant information form and consent was implied if the prospective participant chose to proceed.

The surveys were launched in mid November 2012 and were open for two weeks. Sample groups were sent a reminder email after one week, with the exception of the *CityCycle* group, as the bike share operator has a policy of not sending more than one email per month to members. This lack of reminder email for the *CityCycle* group is suspected as the reason for their lower response rate compared to the *MBS* sample. The survey questions employed significant branching and logic, to customize the questions based on responses to previous questions. Where results are reported, the survey question is identified and a full set of questions can be found in Supplementary data. A series of focus groups, with bike share users and non-users conducted by the authors (Fishman et al., 2012a) provided the necessary understanding to develop the survey questions used in this study.

2.1. Logistic regression model methodology

In order to develop a model capable of predicting the odds of bike share membership, bivariate logistic regression analysis was conducted as described in Washington et al., 2011 using the computer program STATA version 12 (http://www.stata.com/). The dependent variable was *bike share membership* and a range of explanatory variables were tested for significance. An iterative process was used until a theoretically and practically justifiable model design was achieved.

2.1.1. Standardized weights

Standardized weights have been applied to correct for a biased sample in which approximately 95% of all survey respondents were bike share members. The weights were developed as follows; A target population was calculated using Australian Bureau of Statistics (ABS) 2011 Census data on the residential and working populations, using *Statistical Area – Level 2* geographic regions that encompass the bike share docking station catchments. The working and residential populations in these regions, for both Melbourne and Brisbane were combined, as non-members were sourced only from Brisbane. This weighting approach is consistent with methods found in Richardson et al. (1995) and Bethlehem (2009) and adjusts for socio-demographic characteristics of the population. The suburbs used in the calculation are shown below. Some suburbs included do not have docking stations but border areas that do.

Brisbane – Statistical Area Level 2 regions included	*Melbourne – Statistical Area Level 2 regions included*
Woolloongabba	Carlton
St Lucia	Docklands
Brisbane City	East Melbourne
Fortitude Valley	Melbourne
Highgate Hill	North Melbourne
Kangaroo Point	Parkville
New Farm	Southbank
South Brisbane	Albert Park
Spring Hill	Port Melbourne
West End	South Melbourne
East Brisbane	Collingwood
Newstead – Bowen Hills	Fitzroy
Auchenflower	Richmond
Paddington – Milton	
Toowong	

In order to avoid *double counting*, the target population was calculated in accordance with Census data showing that some 80% of residents living within the selected regions also work in one of these regions (Australian Bureau of Statistics, 2013). If such an assumption was not made, there may be frequent instances in which the same person is counted twice when calculating the population statistic (those who feature in both the residential and work populations collected by the Census). Only residents and workers between the ages of 15 and 79 were included.[4]

2.1.2. Calculation of weights

Table 2 below identifies the groups included in the calculation of weights used to correct for sampling bias.

The following calculations were undertaken to determine the sampling weights.

Ratio of target population non-members to members = (722,187–2847)/2847 = 252.67.

Ratio of sample non-members to members = 76/785 = 0.097–1.

Sample weight for non-members:

Weight_{nm} = 252.67 * 785/76 = 2609.81.

Weighted sample total = 785 + 76 * 2609.81 = 199,130.56.

Weight standardization factor = 199,130.56/861 = 231.28.

Standardized sample member weight = 1/231.28 = 0.0043.

Standardized sample non-member weight = 2609.71/231.28 = 11.28.

3. Results and discussion

3.1. Descriptive statistics

An examination of the survey results revealed similarities between bike share member groups and differences between these members and the InSPiRS Panel (non-members). Bike share members differed from the InSPiRS Panel in that they are significantly younger, more likely to know the distance between their home and work to their closest docking station, have

Table 2
Key groups included in weight calculation formula.

Group	Number of people
Brisbane working and residential population within and in close proximity to catchment	275,486
Melbourne working and residential population within and in close proximity to catchment	446,701
Combined target population	722,187
Members in sample[a]	785
Non members in sample	76
Total CityCycle members	1926
Total Melbourne Bike Share members	921
Combined bike share member population	2847

[a] Some *MBS* and *CityCycle* respondents indicated they were not members and have therefore been counted as non-members. Additionally, missing variables were found among some members and this accounts for the discrepancy between the number of members and non-members found in Tables 1 and 2.

[4] *CityCycle* users must be at least 17 years old to use the system. The Census age band that includes 17 year olds is 15–19, which is why people to the age of 15 have been used in these calculations. *Melbourne Bike Share* users must be at least 15 years old.

Table 3
Descriptive statistics of sample groups.

Variable		Melbourne Bike Share	CityCycle	InSPiRS Panel	Greater Melbourne[∞]	Greater Brisbane[∞]
Most frequent age range		30–34 (16.9%)	30–34 (16.6.%)	55–59 (19.8%)	25–29 (7.9%)	25–29 (7.6%)
Male		*N* = 285 (76.6%)	*N* = 265 (59.8%)	*N* = 25 (41.7%)	49.2%	49.3%
Female		*N* = 87 (23.4%)	*N* = 178 (40.2%)	*N* = 35 (58.3%)	50.8%	50.7%
Mean distance between home and work		10.7 km (SD 9.5)	8.6 km (SD 7.7)	13.2 km (SD 10.4)	10 km[*]	15.3 km[#]
Percentage living within 500 m of a docking station		44%	54.1%	5%[^]	NA	NA
Percentage working within 500 m of a docking station		83.9%	83.6%	15%[^]	NA	NA
Annual income range	Less than $41,599	7.6%	14.9%	21.7%	56.8%	55.4%
	$41,600–$77,999	20.0%	28.0%	48.3%	22.6%	24.0%
	$78,000–$103,999	19.2%	22.3%	15.0%	6.4%	7.0%
	$104,000 or more	43.0%	26.9%	5.0%	6.5%	6.3%
	No response	10.3%	7.9%	10.0%	7.6%	7.2%
Car ownership		76.6%	80.4%	100%	NA	NA
Free car park at work		19.9%	26%	63.3%	NA	NA
Mean number of family/friends who are bike share members		0.59 (SD 0.87)	0.95 (SD 1.10)	0.05 (SD 0.28)	NA	NA
Most frequently reported bicycle riding activity in past month		16+ trips (35.8%)	16+ trips (33%)	No bicycle riding activity (75%)	NA	NA

∞ Australian Bureau of Statistics (2013).
^ Approximately 50% of InSPiRS members responded "Do not know" in relation to the distance between their home and work and closest docking station.
\# ABS 2006 Census, for South East Queensland (Doonan, 2010).
* ABS 2011 Census, reporting median distance (Department of Transport, 2013).

pre tax incomes above $104,000 per annum and have friends or family who are bike share members. Moreover, bike share members were considerably more likely to have ridden a bicycle in the month prior to undertaking the survey. Bike share members are shown in Table 3 to be disproportionately male, and this is generally consistent with previous research showing higher cycling levels among males in Australia (Pucher et al., 2010) and the US (Pucher et al., 2011). A little over three quarters of *MBS* respondents were male, compared to just over 60% for *CityCycle* respondents. A Chi-Square test showed that there were statistically significant gender differences between the sample of bike share members and non-members ($\chi^2(1) = 17.55$, $p < .001$). The full set of survey questions are shown in Supplementary data.

Table 3 presents some of similarities and variation between sample groups and a comparison with Census data for Greater Melbourne and Greater Brisbane is provided where possible.

As identified in Table 3, the most frequent age range from the Census is somewhat younger than bike share groups, and considerably younger than the InSPiRS Panel. This may reflect the fact that respondents to this study were required to be 18 years or older. When removing those under 18 years from the Census data, the distribution of age ranges show considerable similarity between bike share groups. Bike share members are more heavily represented within the 25–44 age band. By contrast, the InSPiRS Panel shows a larger proportion within the 50–64 age brackets. Fig. 3 illustrates the distribution of age ranges for all sample groups, including Census data for Greater Melbourne and Greater Brisbane. Those aged 60 and over

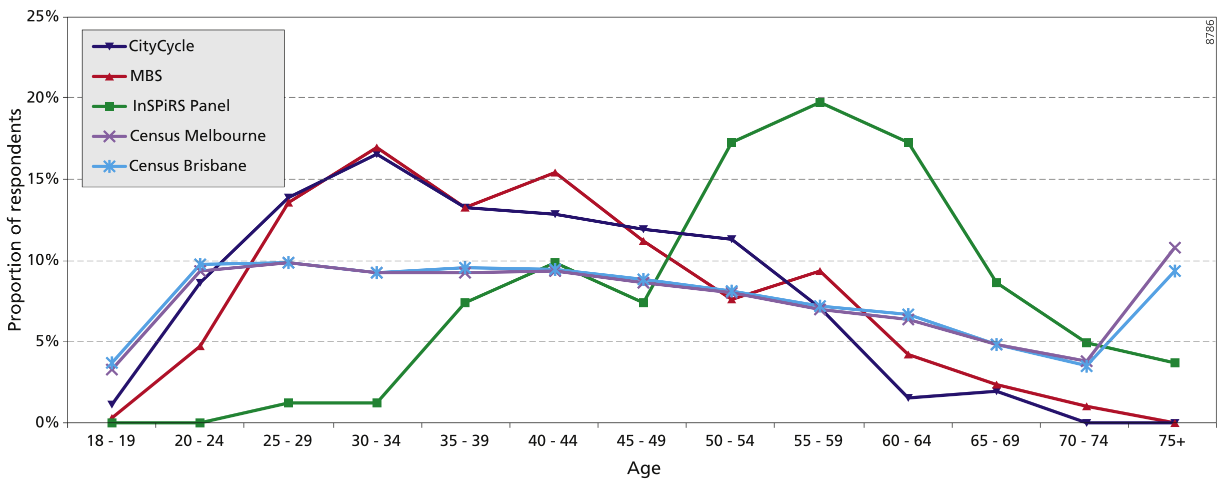

Fig. 3. Age range of sample groups and Greater Melbourne and Brisbane. Source: Greater Melbourne and Brisbane (Australian Bureau of Statistics, 2013).

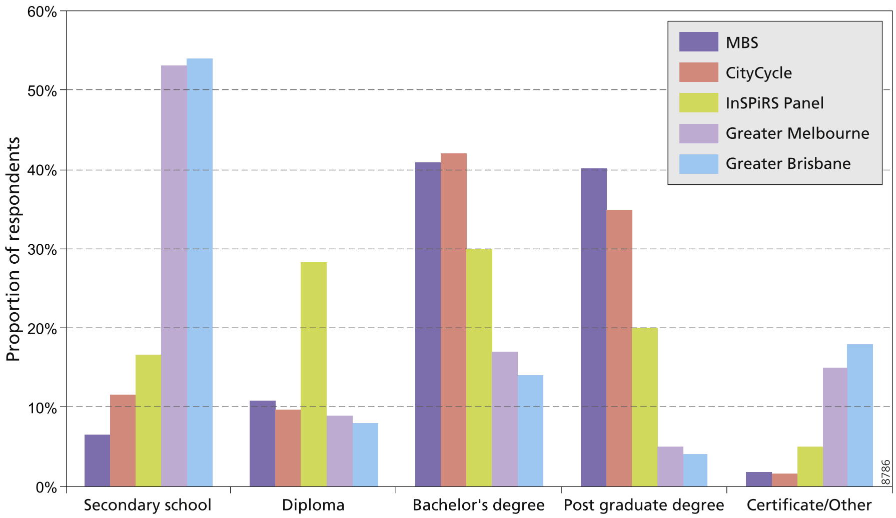

Fig. 4. Highest education level. Source: Greater Melbourne and Greater Brisbane (Australian Bureau of Statistics, 2012). NB: Greater Melbourne and Greater Brisbane included anyone over 15 years old, whereas sample groups were restricted to those over 18 years old.

are under-represented as bike share members, which is consistent with the findings of other researchers on bike share (LDA Consulting, 2012; Shaheen et al., 2012; Virginia Tech, 2012), as well as private cycling in North America (Pucher et al., 2011).

The highest level of education varied considerably between sample groups, and these groups differed substantially from Greater Melbourne and Greater Brisbane Census data. As shown in Fig. 4, bike share members achieved higher education levels than both the InSPiRS Panel members and the general population in both cities. For instance, some 81% and 77% of *MBS* and *CityCycle* members respectively have Bachelor's Degree or higher, compared to 50% for InSPiRS Panel members and 22% and 18% for Greater Melbourne and Greater Brisbane. Previous research has found similar results with respect to the educational attainment of bike share users (Shaheen et al., 2012).

In addition to the aforementioned demographic contrasts, a number of other differences that may influence bike share membership were apparent. Work place bicycle end of trip facilities (such as showers and lockers) were more likely to be available at workplaces of bike share members than the InSPiRS Panel sample (72% and 71% for *MBS* and *CityCycle*, compared to 52% for InSPiRS Panel members). Bike share members were also more likely to have a friend or family member who were bike share members (41% and 56% for *MBS* and *CityCycle* members, respectively, compared to just 3% for InSPiRS Panel members).

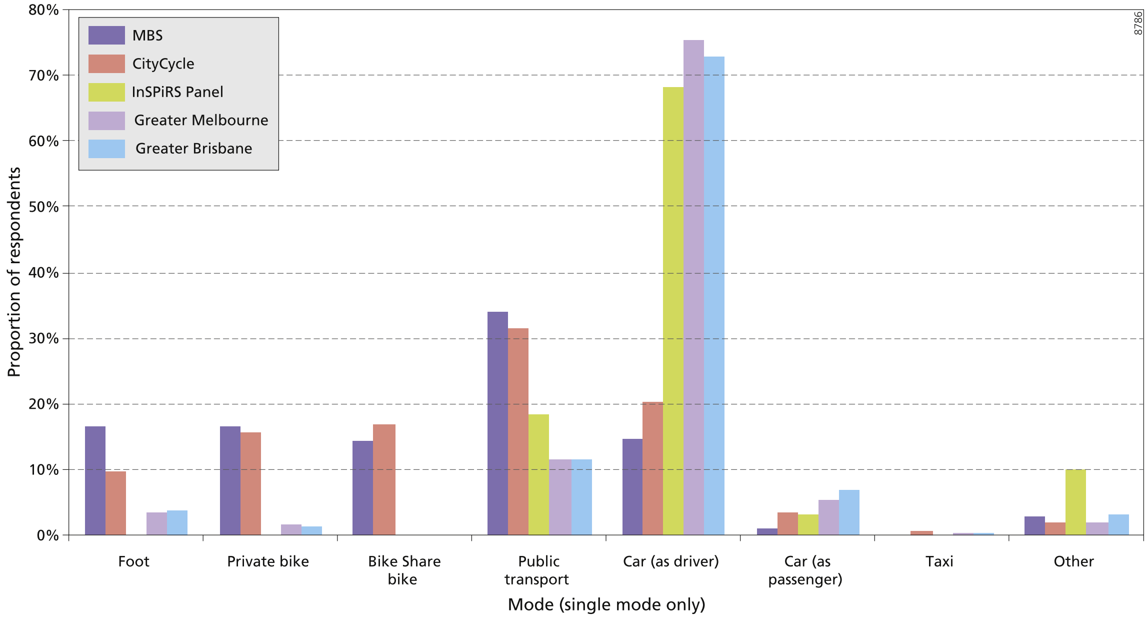

Fig. 5. Mode for most recent journey to work. Source: Greater Melbourne and Greater Brisbane (Australian Bureau of Statistics, 2012).

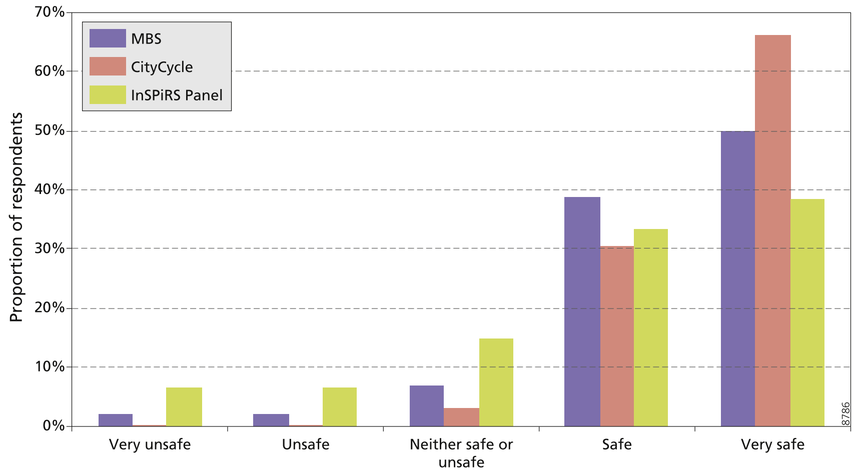

Fig. 6. How safe do you feel riding on a separated lane/path?

Respondents were asked their main mode of transport for their most recent journey to work. The results indicate that around one fifth of bike share members used bike share as their main mode, with a similar proportion travelling on a private bike. By contrast, Census data reveal that private bike travel constitutes the main mode in less than 2% of trips in both Greater Melbourne and Greater Brisbane. No InSPiRS Panel members nominated either public or private bikes as their main mode to work on the day the survey was undertaken. Full results are shown in Fig. 5.

Safety concerns are a well-known barrier to bicycle riding, in the UK (Horton et al., 2007), the US (Gardner, 2002) and Australia (Fishman et al., 2012a,b; Fishman et al., 2013; Garrard, 2003, 2011; Garrard et al., 2007). Survey respondents were shown images of three bicycle riding environments (separated on-street bike lane, painted bike lane and no bike infrastructure) and asked to rate how safe they would feel riding in these environments (see Supplementary data for full question, including the images presented). In general, non-members had lower perceptions of safety in all cases. Fig. 6 presents the results for a separated bike lane.

The results indicate the majority, across all sample groups would feel *safe* or *very safe* riding on separated bicycle infrastructure, which is consistent with previous research (Wardman et al., 2007). By contrast, when presented with no bicycle infrastructure, an overwhelming proportion of respondents, across all groups, reported feeling *very unsafe* or *unsafe*, as illustrated in Fig. 7 below. Whilst the level of bicycle infrastructure has improved in Melbourne and Brisbane over recent years, substantial areas within the *MBS* and *CityCycle* catchment have no bicycle infrastructure and the infrastructure that does exist is frequently disconnected, with the exception of waterway paths. These data may have implications for the ability of the *MBS* and *CityCycle* programs to attract those who currently do not ride.

In terms of mean scores, using a scale of 1 (very unsafe) to 5 (very safe), separated bicycle infrastructure received a mean score of 4.3 and 4.6 for *MBS* and *CityCycle* members respectively. Non-members mean score was 3.9. Similarly, when presented with a painted bicycle lane, mean scores were 3.4 and 3.3 for *MBS* and *CityCycle* members, but 2.8 for non-members. Both bike share member groups mean score for no bicycle infrastructure was 1.9. Non-members recorded a mean of 1.6. These results serve to highlight the difference in safety perceptions between those that do not ride, or do so infrequently (InSPiRS Panel) and bike share members.

3.2. Logistic regression model

A wide range of variables were tested for inclusion in the model (see Supplementary data for survey questions) to predict bike share membership. The variables that provided the optimum predictive capability of bike share membership were included in the model and are presented in Table 4 below. The Pseudo R^2 is 0.30, suggesting that significant factors that influence membership are omitted from the model or that unknown factors influence membership.

Respondents were asked whether the legal requirement to wear a bike helmet affects how often they ride.[5] Responding that compulsory helmet requirements reduce riding frequency was found to *increase* their odds of being a bike share member (OR 24.5). This is a somewhat peculiar result, given that those who feel mandatory helmet legislation reduces their riding frequency were also found to be more likely to report having ridden in the previous month. As identified in *Limitations*, it is suspected that this variable may be endogenous. Indeed this variable may be reflecting scheme members' opinion on mandatory helmet use rather than that same person's proclivity to use bike share. Finally, the confidence interval for this variable is large, which lowers our confidence in this estimate.

[5] Actual question: *The legal requirement to wear a bicycle helmet...* (a) Does not affect how often I ride, (b) somewhat reduces how often I ride or (c) significantly reduces how often I ride. Option (b) and (c) were collapsed.

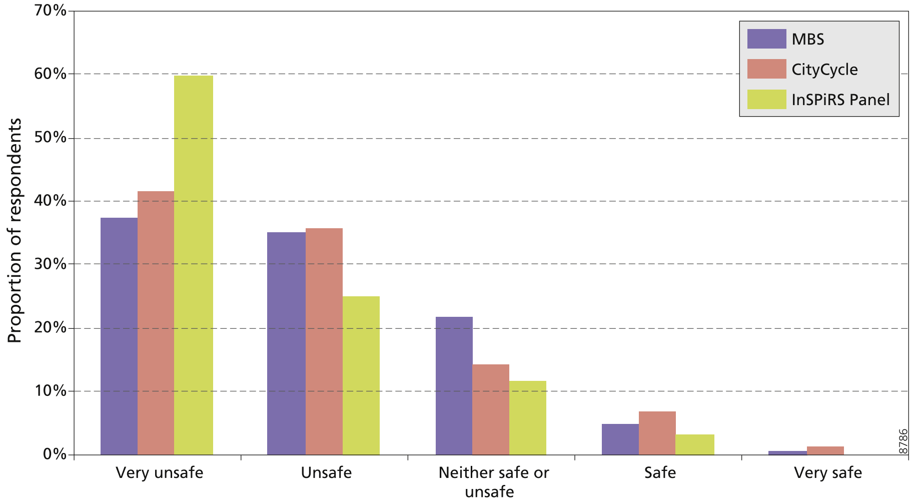

Fig. 7. How safe do you feel when riding on road with no bike lane?

Table 4
Logistic regression analysis.

Variables included in the model	Level/referent	z-Statistic	Coefficient	Sig.	Odds ratio	Odds ratio 95%CI
Impact of mandatory helmet legislation on riding (0 = does not reduce riding, 1 = reduces riding)	Does not reduce riding	5.85	3.20	<0.001	24.5	8.4–71.6
Riding activity in the past month (0 = no riding, 1 = riding)	No riding	32.33	1.75	0.020	5.8	1.3–25.3
Convenience as an encouraging factor for private bike riding (1 = not at all, 5 = a lot)	Not at all	2.29	0.65	0.022	1.9[#]	1.09–3.33
Age (0 = 35 years and over, 1 = 18 = 34)	35 years and over	2.0	1.2	0.047	3.3	1.02–10.83
Income (1 = $10,400 or less, 10 = $104,000 or more)	<$10,400	2.51	0.27	0.012	1.3[#]	1.06–1.61
Work within 250 m of docking station (0 = no, 1 = yes)	No	7.18	3.40	<0.001	29.9	11.81–75.49
Constant		−8.76	−13.86	<0.001	9.56e-07	4.30e-08–0.0000212

[#] This value is cumulative, meaning that for each higher increment, the odds of being a bike share member increases by the Odds Ratio (OR).

Riding activity in the previous month was found to be a reliable predictor of bike share membership. Riding at least once in the previous month was associated with a 5.8-fold increase in the odds of being a bike share member compared to those who reported no bike riding in the month prior to undertaking the survey. This is generally consistent with previous research, which has found those who ride a private bike are more likely to be bike share members (Fishman et al., 2012a; Fuller et al., 2011; Shaheen et al., 2011). It is further supported by the notion that there are, in broad terms, two categories of barrier to bike share usage. The first relates to barriers to riding in general (such as safety perceptions or distance). The second concerns bike share specific barriers (such as lack of close proximity to docking stations). By definition, regular bike riders have not found the first set of barriers insurmountable and therefore find fewer barriers to the use of bike share.

The level of convenience respondents associated with private bike riding was found to be a significant predictor of bike share membership. Respondents were asked to what degree convenience acts as an encouragement to private bike riding, using a 1–5 scale from '*Not at all*' to '*A lot*'. Each increment towards '*A lot*' increased the odds of bike share membership 1.9-fold. This corresponds with research on motivation for *public* bike riding, with consultant reports on the *MBS* program (Alta Bike Share, 2011; Traffix Group, 2012), peer-reviewed research on the *CityCycle* scheme (Fishman et al., 2012a) and North American research (Shaheen et al., 2012). Each body of work found convenience to be a key factor motivating bike share membership and usage.

Those aged 18–34 had 3.3-fold greater odds of being a bike share member than all other age groups. Previous research has shown bike share members are typically younger than the general adult population (Fuller et al., 2011; LDA Consulting, 2012; Lewis, 2011; Transport for London, 2010). Income (pre-tax) was found to be a significant predictor of bike share membership. Each higher increment along a 10-point scale (less than $10,400–$104,000+) was associated with a 1.3-fold increase in the odds of being a bike share member. This finding is generally consistent with a survey of London bike share members, which found users of the scheme to be disproportionately white, aged 25–44 and wealthy relative to the general London population (Transport for London, 2010). Respondents who indicated they work within 250 m of a docking station had 29.9-fold greater odds of being a bike share member. The confidence interval for this variable was large however, which reduces our confidence in this estimate. Distance from docking station has been found by other researchers to be an important association with bike share membership. Fuller et al. (2011) investigated the prevalence of using the Montreal bike share scheme (known as BIXI) at least once depending on whether the subject lived within 250 m of at least one docking station. For those living within 250 m of a docking station, 14.3% of residents had used BIXI, whereas only 6% had when living greater than 250 m of a docking station. As shown in Table 4, bike share members were considerably more likely to work rather than live within 500 m of a docking station. This finding may be influenced by the configuration of the bike share docking station catchments and this is especially so for Melbourne. The *MBS* program is particularly small relative to the size of the city (600 bikes and a Greater Melbourne population of approximately four million). The docking stations are largely in the central employment district, rather than residential neighborhoods. Therefore, the finding that distance between docking station and work was more powerful than the distance between home and docking station may be influenced by the current catchment configuration.

3.2.1. Application of logistic regression model

The logistic regression results are used to predict how changing variable values alter the odds of bike share membership. When variable values are held at their means, the probability of bike share membership is at or close to 0 – which broadly reflects the current usage of bike share in both Melbourne and Brisbane, in which only a very small proportion of the population are members. Nevertheless, as illustrated in some of the hypothetical scenarios below, it is possible to predict a relatively high probability of being a bike share member through the manipulation of key variables. The variable *Convenience as an encouraging factor for private bike riding*, in which respondents were asked to rate the level to which this statement is true (1 = not at all, 5 = a lot) has been used as the horizontal axis in Fig. 8 below, extrapolating the means, from 1 through to 5.

Income $104K+, work <250 m docking describes a scenario in which incomes are set at their highest level and the distance between place of work and closest docking station is within 250 m. In the second scenario, *work <250 m docking*, the settings are the same as the previous scenario, with the exception of the income variable, which has been left at the mean. The third scenario in Fig. 8 holds values at their mean, with the exception of *riding in the previous month*, which has been changed to '*yes*'. The fourth scenario in Fig. 8 is identical to the previous scenario, with one crucial addition; the distance between work and the closest docking station is now *within 250 m*. There is a considerable difference in the probability of bike share membership between these two scenarios, shown in Fig. 8 and is indicative of the importance of proximity between workplace and docking station.

Fig. 9 below uses the variable of annual income on the horizontal axis, to predict bike share membership, with five scenarios shown.

Highest scenario + no riding previous month differs from previous scenarios in that the means for each variable have not been selected by default. In this scenario, the means have intentionally been adjusted to the values most typical of a bike share member. Should this procedure be carried out for all variables, the probability of being a bike share member rises to 1. For illustrative purposes, this scenario has adjusted the riding activity variable to equal 0 (no riding in previous month),

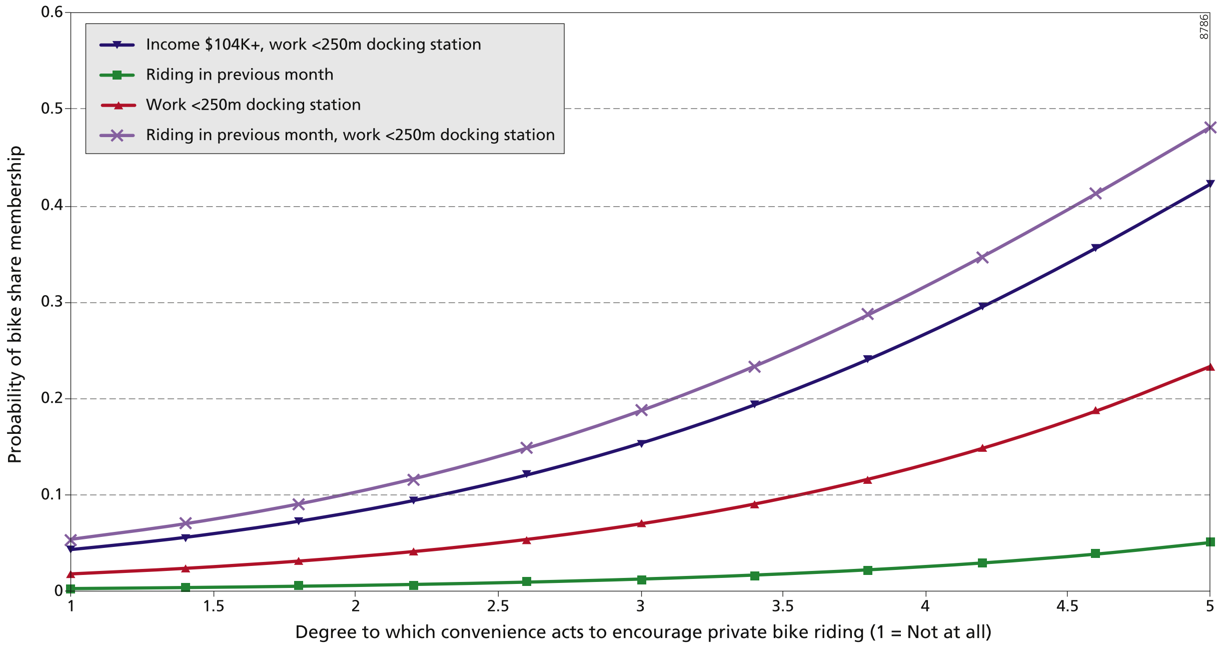

Fig. 8. Probability of bike share membership under different scenarios, with *convenience* extended through its range of means.

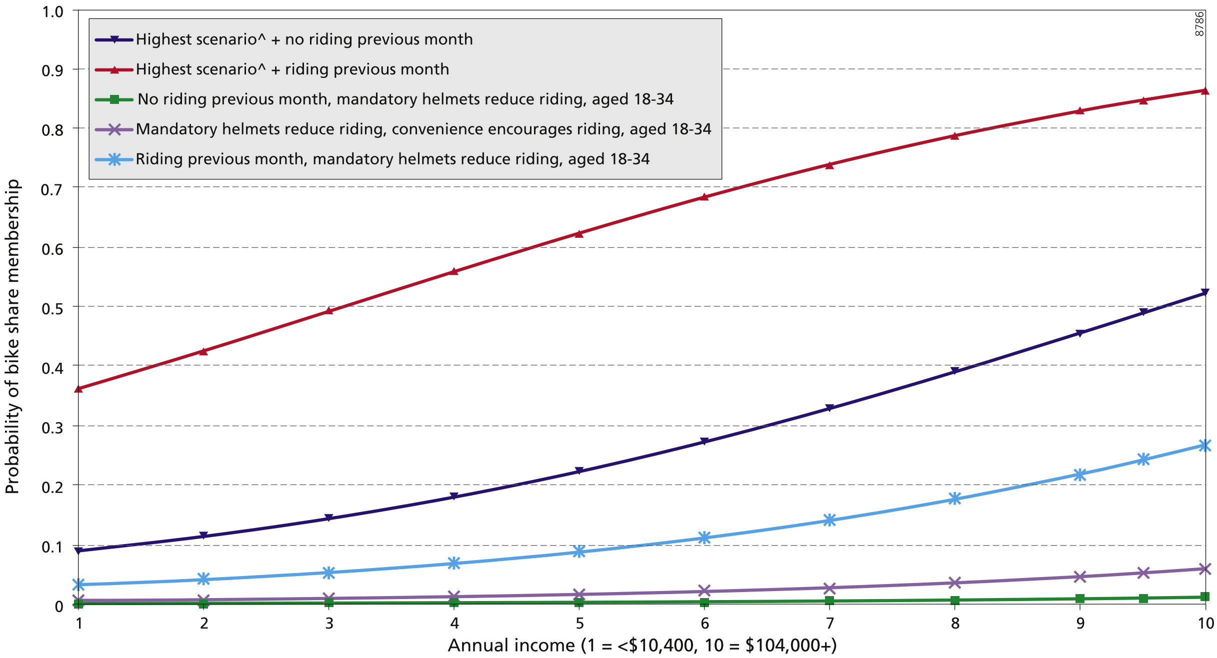

Fig. 9. Probability of bike share membership under different scenarios, with *income* extended through its range of means. ^This scenario includes being aged between 18 and 34, working within 250 m of a docking station, convenience acting as a strong motivator for private bike riding, and mandatory helmets reducing bike riding.

with probabilities rising from 0.09 at the lowest income bracket ($10,400 or less) to 0.52 at the highest income level ($104,000+). *Highest scenario + riding previous month* can be understood based on the explanation of the previous scenario. Bike share membership probabilities rise from 0.36 to 0.86 from the lowest to highest income level. The difference between these two scenarios demonstrates the influence riding during the previous month has on increasing bike share membership probabilities.

Mandatory helmets reduce riding, convenience encourages riding, aged 18–34 illustrates a scenario in which the mandatory helmets variable has been adjusted to reduce riding and convenience has been adjusted to be a powerful motivator for riding a private bike (5 on a scale of 1–5). Moreover, the age category has been adjusted to include only those aged 18–34. The lowest income levels in this scenario shows a probability of bike share membership of 0.01, rising to 0.06 for the highest income bracket. The final scenario *No riding previous month, mandatory helmets reduce riding, aged 18–34* is similar to the previous scenario, however *convenience* has been replaced with no riding during the previous month. This case provides the lowest probability of membership for the scenarios shown in Fig. 9, reaching a maximum probability of 0.01 at the highest income bracket.

4. Limitations

Although every reasonable action has been taken to ensure the validity of the results, several limitations are noted here. Although a probabilistic sampling method was employed, the authors cannot be certain all responses were received from those within the three sample groups. It was made clear in the instructions not to pass the survey hyperlink on to others, and this may reduce but not eliminate the possibility that this occurred.

The InSPiRS Panel is a less than ideal control group and responses drawn from this sample cannot be generalized to the wider population. As shown in Fig. 3 the InSPiRS Panel respondents were considerably older than both bike share samples, as well as the general Melbourne and Brisbane population. Moreover, only 60 fully completed responses were received, insufficient for generalizing the results at the population level. There may also be additional differences between the InSPiRS Panel (who have volunteered to be part of a university research panel) and the general population (non-response bias). For instance, the results for perceptions of safety may be influenced by the fact that InSPiRS Panel members have volunteered to be part of a panel focused on road safety. These factors make the InSPiRS Panel a less than ideal control group. Nevertheless, the sampling techniques employed for this study were selected in an effort to avoid a 'snowballing' sample, which would have had greater distortive impacts in relation to how that sample group may have differed from the wider population.

In the future, sampling techniques designed to capture a larger number of non-member responses, from a sample that more closely reflect the characteristics of the general population will enhance the generalizability of the results. There may also be benefit in attempting to target those who live or work within the geographical area of the bike share program/s under study, to provide an improved method of understanding factors influencing bike share membership. Alternatively, internal re-weighting, with a larger sample size may help improve the degree to which the non-member sample represent the wider population. Standardized weights were applied in an effort to counter the sampling bias.

Despite the above limitations, the approach to analysis used in this study help establish a conceptually useful method of modeling bike share membership. These techniques offer useful insight for researchers and practitioners interested in forecasting membership likelihood under various scenarios, but, as identified, would benefit by enhanced non-member data collection techniques.

As the bike share member survey invitation was sent out by the operators of the scheme in Melbourne and Brisbane, and only to their list (*MBS* = 100% annual members, *CityCycle* 97% annual members) casual users were, in the main, not included in the study and it is possible their preferences and travel behavior may differ from that of annual members. According to data supplied by the *MBS* operator to the authors, 50% of *MBS* trips were undertaken by annual members in the month the survey was conducted (Royal Automobile Club of Victoria, 2014). The survey relies on self-reported behavior and it is possible some survey respondents provided information that did not reflect their behavior or circumstance, although there would be little motive for knowingly doing so.

Finally, endogeneity is suspected in the variable *impact of mandatory helmet legislation on riding*—that is riding a bicycle influences one's view of mandatory helmet legislation. This finding suggests that people who ride often are more likely to object to mandatory helmet legislation, perhaps because they believe they are competent bicyclists and perhaps because they are constantly reminded of the legislation through frequent riding. It also suggests that for at least some frequent riders and scheme users, they believe that they would ride more often if the mandatory helmet legislation was not in place. Future research may benefit by adapting the question on mandatory helmets included in this survey (see Footnote 4) to more easily differentiate between how regular riders response differs from those who do not ride. These issues serve to highlight the considerable complexity associated with determining the impact mandatory helmet legislation has on bike share membership and indeed on bike use generally.

5. Conclusions

This paper has analyzed the results of online surveys with bike share members and non-members to understand the factors influencing membership. The results of this study illustrate the magnitude of influence for various factors associated with bike share membership. The findings of this study provide bike share operators and policy makers with an improved ability to influence membership levels. Convenience emerged as an important predictor of membership. Policy makers interested in expanding the membership base of bike share programs may benefit from designing bike share to be easily accessible. The distance to the closest docking station was found to be a predictor of membership and this is consistent with previous research (Molina-Garcia et al., 2013; Fuller et al., 2011). This underscores the importance of planning a bike share system capable of providing the network benefits that provide a compelling proposition to citizens. Targeted expansion of docking stations, particularly around employment precincts and especially for those with large number of employees aged under 35 may provide a significant increase in membership.

The differences in safety perceptions between bike share members and non-members when presented with different levels of infrastructure provision provide insights for bicycle infrastructure planners and those seeking to encourage bike share use. Specifically, non-members show lower levels of perceived safety in all bike-riding environments tested in this study. This suggests an expansion of the bicycle infrastructure network, particularly separated bicycle lanes, may be useful in growing bike share membership.

Bike share members recorded significantly higher incomes than other groups. This is influenced, at least in part, by the current position of docking stations, in central Melbourne and Brisbane. Research using Census data shows that inner city residents have higher average incomes that those who reside in outer suburbs in Melbourne (Fishman and Brennan, 2010) and Brisbane (Kelly et al., 2013). As bike share is often provided under public subsidy, greater focus on how to include a broader participation across the income spectrum is needed. Finally, the results of this study related to helmet issues are complicated and it is difficult to make clear conclusions. Further research on the impact of mandatory helmet legislation on bike share usage may help inform policy development.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.tra.2014.10.021.

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