

Helmet Use Among Personal Bicycle Riders and Bike Share Users in Vancouver, BC

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Introduction: Public bike share users have low prevalence of helmet use, and few public bike share systems make helmets available. In summer 2016, a public bike share system launched in Vancouver, BC. Each bicycle is equipped with a free helmet, in response to BC's all-ages compulsory helmet law. This study assessed the prevalence of helmet use among adult cyclists on personal and public bicycles in Vancouver.

Methods: A survey of adult cyclists (age estimated at ≥ 16 years) at five screen line sites and at 15 public bike share docking stations was conducted. Observations were made on fair weather days in 2016. Observers recorded the gender of the rider, bicycle type, helmet use, and helmet type. In 2016, multivariable logistic regression was used to calculate the odds of helmet use by personal and trip characteristics.

Results: Observers conducted 87.5 hours of observation and recorded 11,101 cyclists. They observed 10,704 (96.4%) cyclists on personal bicycles and 397 (3.6%) public bicycle users. Overall, the prevalence of helmet use was 78.1% ($n=8,670/11,101$), higher for personal bicycle riders (78.6%, $n=8,416/10,704$) than bike share users (64.0%, $n=254/397$). Helmet use was associated with gender, bicycle facility type, and day and time of travel.

Conclusions: In a city with all-ages helmet legislation, helmet use is high but differs across infrastructure types and cyclist characteristics. Bike share systems could increase helmet use by providing complementary helmets coupled with supportive measures.

INTRODUCTION

Globally, public bike share (PBS) systems have grown in popularity, from just four systems in 2001 to more than 1,100 systems by 2016.¹

Evidence from cities with PBS systems demonstrates that PBS users wear helmets less frequently than cyclists using personal bicycles. Studies conducted in Toronto, Boston, New York, and Washington, DC report the prevalence of helmet use at about 20% for PBS users, versus closer to 50% for personal bicycle riders.²⁻⁶ Lower prevalence of helmet use was observed for PBS users in London, England (16% vs 64% of personal bicycle riders)⁷ and in Montreal (12% of PBS users).⁸ In all of these jurisdictions, adult helmet use is voluntary. It has been suggested that the low prevalence of helmet use among PBS users arises from the spontaneous nature of public bicycle use, and the fact that few bike share systems have helmets readily available for use.^{2-5,9-12}

Compulsory helmet legislation increases cyclists' helmet use.¹³⁻¹⁵ In Victoria, Australia, an all-ages helmet law was adopted in July 1990. A series of observational surveys conducted in Melbourne confirmed an increase in helmet use of 44 points from 31% in March 1990 to 75% in March 1991.¹⁶ When the province of Nova Scotia, Canada introduced all-ages legislation in 1997, helmet use in Halifax doubled from 38% to 75% in 1 year.¹⁷ The province of BC introduced helmet legislation in 1996 and 3 years later, an observational survey found 70% of adult cyclists wore helmets.¹⁸ There have been few controlled studies on helmet legislation and helmet use: A Cochrane review found only three, all in jurisdictions with child-only legislation, but in all helmet use in children increased.¹³

Helmet use prevalence varies by trip and personal characteristics. Observational surveys in Toronto and New York have found higher helmet use during morning commuter travel and lower use during weekend recreational trips.^{5,19} Grenier et al.⁸ observed cyclists in Montreal and found that path type was associated with helmet use. There are some conflicting findings for gender differences. Helmet use was more prevalent for men versus women in New York,^{5,6} but less prevalent in Washington, Boston, Toronto, Montreal, and London.^{2,7,8,19,20}

Currently, only four PBS systems operate in jurisdictions with all-ages helmet legislation: Melbourne Bike Share (launched in 2010) and CityCycle (2010) in Australia; Pronto Cycle Share (2014) in Seattle, U.S.; and Mobi (2016) in Vancouver, Canada. Vancouver's system

launched in July 2016 and will have 1,500 bicycles at 150 stations in its first year. Each Mobi bicycle is equipped with a free bicycle helmet for use while riding, and if unused, the helmet can be stored in the bicycle's front basket (Figure 1). Helmet liners are available at most docking stations and helmets are disinfected daily.²¹ With this, Mobi has the most accessible provision of helmets of any PBS system. In Melbourne, the PBS system partnered with a network of retail outlets and provided helmet vending machines that sold subsidized (5 Australian dollars) helmets.²² In Brisbane, CityCycle did not initially provide helmets, requiring users to bring their own. In response to poor system use, a suite of system changes were added later, including courtesy helmets for a quarter of the bicycle fleet.^{23,24} In Seattle, Pronto Cycle Share's innovations included helmet bins and return receptacles at every docking station, with cleaning after every use. Access to system helmets was included with annual subscriptions, but short-term users were charged US\$2 for daily use.²⁵⁻²⁷ Research on the longest operating systems (Melbourne Bike Share and CityCycle) implicate mandatory helmet laws in addition to other internal and external issues such as station density or geographic coverage, registration and payment processes, cost, operating hours, transit integration, and a lack of safe cycling infrastructure as barriers to system use and long-term success.^{11,12}

This study aimed to assess the prevalence of helmet use for personal bicycle riders and PBS users, and the personal and trip characteristics associated with helmet use. Observations were conducted at sites with a painted bicycle lane, a paved off-street cycle path, a cycle track, and at two local street bikeways, given the expectation that helmet use may vary by route type. This is the first observational survey of helmet use by PBS users in a jurisdiction with an all-ages compulsory helmet law.

METHODS

Data Sample

This study assessed the prevalence of helmet use among Vancouver adult cyclists (age estimated at ≥ 16 years) between June and September 2016. Observers conducted site observations on fair weather weekdays during the morning peak (07:00–09:00) mid-day (11:00–13:00) and afternoon peak (16:00–18:00) periods, and on weekends during mid-day (11:00–13:00) and afternoon peak (16:00–18:00) periods. Observers recorded the gender (male or female), helmet use (yes or no), and bicycle type (personal or public) for all adult cyclists crossing screen line

locations. Individuals walking with a bicycle were not counted. When two or more people were on a single bicycle, only the person steering was counted. Cyclists who crossed the screen line but were not on the designated infrastructure (such as sidewalk riding, illegal for adults in Vancouver)²⁸ were not counted. Observation sessions lasted 30 minutes at each site, with up to three sites observed per period.

Screen line sites were selected based on two criteria: bicycle volumes and bicycle facility type. Sites with high cyclist volumes were picked within each of the four types of bicycle facilities found in the PBS area: painted bicycle lanes, paved off-street cycle paths, cycle tracks, and local street bikeways (Figure 2). Two sites were used for the local street bikeway infrastructure.

To bolster the PBS sample, observations were also conducted at docking stations during September 2016. Cyclists were observed departing and arriving with a public bicycle at 15 PBS stations with the highest activity, a 10% sample of Vancouver's stations. Each station was observed for 30 minutes during five time periods (morning, mid-day, and afternoon periods on weekdays, and mid-day and afternoon periods on weekends). Observation time totalled 2.5 hours per station. Observers recorded cyclists' gender (male or female), helmet use status (yes or no), and helmet type (personal or public). These observations were ascribed "docking station" as facility type in the analysis.

Statistical Analysis

The proportion of cyclists that were helmeted was calculated for the entire sample, by bicycle type and across personal and trip characteristics: gender, bicycle facility, month, and trip day and time. Associations between predictors and helmet use were estimated using multivariable logistic regression. Analyses were completed in 2016, using R, version 3.3.0.

This study was exempt from institutional ethics review because it consisted solely of observations of human behavior in public places.

RESULTS

This study included 87.5 hours of observations: 50.0 hours at screen line sites and 37.5 hours at PBS docking stations. A total of 11,101 cyclists were observed, of which 397 (3.6%) were on PBS bicycles. Demographic and trip characteristics are in Table 1. Of the 397 PBS users, 68 (17.1%) were observed at screen lines and 329 (82.9%) were at docking stations. At each of the 15 docking stations, between two and 50 cyclists were observed. Overall, the sample was 38.4% female, but this proportion varied by facility type from a high of 40.5% on the off-street cycle path to 31.2% on the painted bicycle lane.

Overall, the prevalence of helmet use was 78.1% ($n=8,670/11,101$). For personal bicycle riders, helmet prevalence was 78.6% ($n=8,416/10,704$). For PBS users, helmet prevalence was 64.0% ($n=254/397$) overall. Of the PBS users observed at docking stations, 64.7% ($n=213/329$) wore helmets, compared with 60.3% ($n=41/68$) of those observed at screen lines, and helmet use was not different between groups (t -test for difference in proportions, $p=0.497$). Of those PBS users that wore a helmet, 18.3% ($n=39/213$) used their personal helmets and 81.7% ($n=174/213$) used the system-provided helmet. The highest helmet prevalence observed was for female cyclists on the cycle track during weekday mornings (93.3%, $n=235/253$), whereas the lowest was for male cyclists on the off-street cycle path during weekend afternoons (56.4%, $n=337/598$).

Table 2 shows the unadjusted ORs and AORs for helmet use by personal and trip characteristics. In unadjusted models, gender, bicycle type, bicycle facility, and month, day, and time of travel were associated with the use of helmets. In adjusted analyses, PBS users had a 39% lower odds of helmet use compared with cyclists on personal bicycles (OR=0.61, 95% CI=0.37, 1.01). Women had 54% higher odds of wearing a helmet than men (OR=1.54, 95% CI=1.39, 1.69). Compared with the off-street cycle path, cyclists using a bicycle lane, local street bikeway, or cycle track demonstrated higher odds of helmet use (OR=1.69, 95% CI=1.37, 2.09; OR=1.74, 95% CI=1.56, 1.94; and OR=1.84, 95% CI=1.58, 2.14, respectively). Finally, compared with the weekday morning trip, odds of helmet use were between 41% and 68% lower for mid-day and afternoon periods on weekdays and weekends. A sensitivity analysis was run using only PBS users observed at screen line sites, and regression results were very similar.

DISCUSSION

This study observed more than 11,000 cyclists to assess the prevalence of helmet use for PBS users compared with cyclists on personal bicycles in a jurisdiction where helmet use is compulsory for all cyclists. Overall helmet use was relatively high, with variation by gender, bicycle facility type, and day and time of travel. The prevalence of helmet use for PBS users was 15 percentage points lower than for cyclists on personal bicycles (64% vs 79%).

In Vancouver, each Mobi bicycle is equipped with a complementary helmet, and as a matter of system design, a rider must handle the helmet when removing a bicycle from its dock. Despite this engineering “nudge,” use remains below that of personal bicycle riders. This gap is consistent with observational studies from jurisdictions where helmet use is voluntary.^{2,4-8,19,20} This work suggested some issues with helmet fit and cleanliness. For example, while in the field, observers heard PBS users remark that the shared helmet was too large or small, and cycled away from the station not wearing a helmet. Helmet cleanliness is a prominent point raised in media,²⁹ and indeed observers witnessed that almost one in five PBS users who were wearing a helmet were using their own helmet. Additionally, observers suggested that about one in six of those wearing a shared helmet also used a barrier device such as a hat or one of the helmet liners. Emerging technologies such as EcoHelmet (www.ecohelmet.com) may be personalized solutions to facilitate helmet use for spontaneous cycle trips in the future. The lower helmet use by PBS users may also be related to the perceived safety of PBS trips. For instance, cyclists on public bicycles may have improved visibility from upright riding, and PBS trips are generally slower and shorter (2 km vs 5 km) than trips made with personal bicycles.³⁰⁻³³ Users have also reported improved driver behaviour around cyclists using a public bicycle.^{10-12,32}

This research brings some new insights on helmet and PBS use in a city with all-ages legislation. For instance, despite the gap between PBS and personal bicycle riders’ helmet use, PBS users in Vancouver have more than three times greater helmet use compared with PBS users in jurisdictions where there is no all-ages legislation and helmets are not available or easily accessible (64% vs about 20%). This may also reflect a cycling population more accepting of helmet use. Of note, however, is this study found that the gap in helmet use between PBS users and

personal bicycle riders is much greater in systems that don't provide helmets (between 30 and 48 percentage points reported in studies from Toronto, Boston, New York, Washington, London, and Montreal),²⁻⁸ compared with the 15 percentage point gap observed in Vancouver. This suggests that, irrespective of the helmet law, complementary helmets and supportive policies could increase helmet use substantially in these systems. Additionally, over August to October 2016, the Mobi system usage was two to three trips per bicycle per day,³⁴⁻⁴⁰ higher than summertime usage in the Melbourne, Brisbane, and Seattle systems of fewer than one trip per bicycle per day.⁴¹ System use did improve after one quarter of the CityCycle fleet and most of the Melbourne Bike Share fleet were outfitted with complementary helmets.^{10-12,22,30,42-44} With a hopeful outlook, this suggests that provision of helmets with the bicycle fleet may improve system use in jurisdictions where helmets are compulsory, as a complement to other factors such as station siting, cost, and quality and extent of cycling infrastructure.

Helmet use prevalence varied substantially across bicycle facility type, gender, and commuting time in the 11,101 personal and PBS cyclists observed in this study. Compared with cyclists on the paved off-street cycle path away from motorized traffic, those travelling on the bicycle lane and local street bikeways were about 70% more likely to be wearing helmets, and cyclists on the cycle track were 84% more likely to use a helmet. These observations align with the perceived risk of different bicycle facilities.⁴⁵⁻⁴⁹ The similar rates of helmet use on the bicycle lane and local street bikeways may result from similar perceptions of traffic risk.⁵⁰ The helmet prevalence trends by infrastructure type may also reflect differences in cyclists' comfort and experience, as route choice varies by experience, and may impact helmet use. Also, the highest bicycle volumes were seen at the off-street and separated infrastructure locations. Bicycle facilities separated from motorized traffic are more appealing to a broader demographic of travellers^{49,50} and can induce a shift in travel from parallel corridors that lack this physical separation.⁵¹ This study also found that women had 54% higher odds of helmet use compared with men (82% of women vs 76% of men wore a helmet), which may be due to women's greater aversion to traffic risk.^{49,52} Finally, helmet use was highest in the morning weekday time period, when the majority of cyclists might be commuting. Other studies have also found higher helmet use during morning and afternoon commuting times.^{4-7,19}

Limitations

Trained observers conducted field-based observations of helmet use to overcome issues of recall bias or social desirability bias in self-reported data. The observers indicated they had little difficulty assigning gender based on hair, facial features, body morphology, and clothing.

Observations were restricted to fair weather days for two reasons: to capture higher volumes and to capture a greater cross section of cyclists, as rain tends to dissuade occasional cyclists more than regular riders.⁵³ PBS users were oversampled by counting at docking stations given the low volumes of PBS users at the screen line sites. Observations were conducted at five locations, selected for diversity in infrastructure and for high cycling volumes, but a more extensive count program would be needed to assess spatial variability in helmet use. This study did not observe cyclists at a site absent of any cycling infrastructure; given the extensive cycling network in Downtown Vancouver, there are typically very low cycling volumes on such corridors. Finally, this work was conducted in the first year of the PBS system. Subsequent studies may assess if system and helmet use changes as the system becomes more established.

CONCLUSIONS

In BC, helmets are required for all cyclists. Helmet use does not prevent crashes from happening, but is associated with reduced risk of facial and head injury among those injured in a crash.⁵⁴ This study found that the prevalence of helmet use among Vancouver cyclists is high, and highest for female cyclists and those travelling in a cycle track during weekday mornings. The prevalence of helmet use in Vancouver's PBS users was high compared with systems operating in cities where helmet use is voluntary and helmets are not provided. PBS users' helmet use was lower than for cyclists on personal bicycles, but the gap was less substantial than what has been reported from other cities with PBS systems. Innovations in the Mobi system suggest certain measures that may support helmet use: Helmets are freely available with each public bicycle, system design requires a user to handle the helmet when removing a bicycle from its dock, and helmet liners are provided at every docking station. With helmets readily available, the fit and perceived cleanliness of shared helmets may be outstanding barriers to their use. Surveys and focus groups could be used to more deeply probe barriers to helmet use in users of the system.

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LIST OF FIGURES

Figure 1. Mobi bicycles with attached helmets at a docking station.

Figure 2. Observation sites, by bicycle facility type.

Table 1. Characteristics of Cyclists Observed in Vancouver, British Columbia, in 2016

Characteristic
Hours of observations
Bicycle type
Total observations
Gender
Male
Female
Bicycle facility
Off-street cycle path
Bicycle lane
Local street bikeway
Cycle track
Docking station
Month
June
July
August
September
Trip day and time
07:00-09:00 weekdays
11:00-13:00 weekdays
16:00-18:00 weekdays
11:00-13:00 weekends
16:00-18:00 weekends

Table 2. Logistic Regression Results for Helmet Use Amongst Cyclists in Vancouver, British Columbia in 2016

1
Total observations
Bicycle type
Personal
Public bike share
Gender
Male
Female
Bicycle facility
Off-street cycle path
Bicycle lane
Local street bikeways
Cycle track
Docking station ^b
Month
June
July
August
September
Trip day and time
07:00-09:00 weekdays
11:00-13:00 weekdays
16:00-18:00 weekdays
11:00-13:00 weekends
16:00-18:00 weekends

Note: Boldface indicates statistical significance ($p < 0.05$).

^aAORs are controlled for bicycle type, gender, bicycle facility, and trip day and time.

^bCyclists observed at docking stations were not assigned a specific facility type as they were not observed in travel.



Cycle Track

An on-street bicycle only lane physically separated from motorised and pedestrian traffic.

Dunsmuir Viaduct, East of Citadel Parade

**Bicycle Lane**

An on-street travel lane reserved for bicycles. Demarcated by a painted line and located next to a travel lane and the curb or parked cars.

Burrard St., South of Helmcken St.

**Off-Street Cycle Path**

An off-street, paved bicycle only path.

Seaside, East of Carrall St.

**Local Street Bikeway**

A local residential street with motorised traffic calming and bicycle priority measures.

10th Ave., East of Ontario St.



Union St., West of Hawks St.

