Utilization of Secure Bicycle Parking Rooms in Multi-Unit Residential Buildings

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Abstract

Existing research supports the importance of high-quality bicycle parking facilities for cycling promotion but does not provide quantitative data on utilization in residential buildings. Secure bicycle parking rooms in large developments are important for cycling policy in cities such as Vancouver, Canada, where 42% of households live in apartments in multi-unit buildings. A better understanding of how bicycle parking and storage spaces in these buildings are used can help develop guidelines that support residents choosing to cycle. The objective of this study was to provide quantitative information on the utilization of secure bicycle parking rooms in multi-unit residential buildings for university staff near a large post-secondary institution. Counts were made to quantify the number of bicycles in secure parking rooms used over time in three sample buildings, and residents were surveyed to investigate perceptions, preferences, and bicycle parking demand. Even meeting current guidelines with approximately 1.5 spaces per unit of secure bicycle parking capacity, there is heavy bicycle parking congestion in the study buildings with overall occupancy of 99%. Around 1/3rd of the bicycles were used within the first week of the study, increasing steadily to 2/3rd after 9 weeks. Most respondents with bicycles (65%) regularly store them in locations other than the bicycle parking rooms, indicating a high amount of latent demand for bicycle parking in this context. Policy recommendations include consideration of higher bicycle parking capacity in development standards, and provision of different types of bicycle parking for frequent, low-barrier access versus long-term storage.

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1 Introduction

High-quality parking facilities are an important component of broader strategies to facilitate sustainable and healthy transportation choices by encouraging urban cycling (*1*). Local development guidelines often stipulate bicycle parking requirements for developers and architects and shape the design of bicycle parking rooms. Requirements can include the number of bicycle parking spots, the location of bicycle rooms within the building, space and configuration rules, and hardware and security standards. In multi-unit residential buildings, space limitations in apartments and rules about bicycle transport and storage in units amplify the importance of bicycle parking room design decisions, as these are often the only secure locations residents are permitted to store bicycles. Necessary characteristics of attractive and well-used bicycle parking facilities in residential buildings are not well established, and guidelines are consequently often vague. A better understanding of how bicycle parking and storage spaces are used can help local governments and agencies improve guidelines and support residents choosing to cycle.

The literature on bicycle parking is limited, and focuses on bicycle parking at transit stations, the workplace, and other commercial areas or destinations (*2*–*6*). In reviewing literature for this study, few published papers were found of empirical studies on utilization of bicycle storage in residential buildings (*7*, *8*). In suburban and low-density urban environments dominated by single family homes, residential bicycle parking may not be an issue or barrier to cycling. But in high-density cities like Vancouver, Canada, where just 30% of households live in detached houses and 42% live in apartments in multi-unit buildings (*9*), the design of residential bicycle parking facilities is important for cycling promotion.

Two previous studies quantified (non-residential) bicycle parking utilization at U.S. post-secondary institutions with counts (*10*, *11*). Similarly, a study of secure bicycle parking in Melbourne's metropolitan rail stations used entrance-card data to track room access and show growing demand for secure bicycle parking facilities at the stations (*5*). Aside from these utilization studies, other research on bicycle parking and storage has taken the form of preference surveys to assess the perceived quality, adequacy, availability, or importance of bicycle parking (*6*, *7*, *12*, *13*). Surveys and studies of bicycle theft also touch on the quality and importance of bicycle parking, but similarly do not address the basic issue of utilization (*14*–*16*). The existing research supports the importance of high-quality bicycle parking facilities in residential buildings, with overcrowding and security as key issues reported by residents, but does not provide quantitative data on utilization. Key questions include parking demand and turnover, with some residents and building managers reporting issues of unused or abandoned bicycles occupying common-use bicycle parking capacity in large buildings.

The objective of this study is to provide quantitative information on the utilization of secure bicycle parking rooms in multi-unit residential buildings, a clear gap in existing literature. Building on previous utilization studies (*10*, *11*), a minimally-invasive method is used to quantify the number of bicycles used over time. A resident survey is also used to compare resident perceptions, preferences, and bicycle parking demand with the observed capacity issues. Policy recommendations are made based on the quantitative findings.

2 Method

The study took place in three residential buildings near the University of British Columbia, Vancouver (UBC) campus. The study neighborhood is an unincorporated area (UBC endowment lands) immediately west of Vancouver, Canada, an approximately 45-minute bicycle ride from Vancouver's downtown core. The median household income in the area in 2016 was CA$35,700, lower than Vancouver's CA$56,100 (*9*), likely due to the number of students living in the area.

Three buildings are investigated in the study: Dahlia House, Magnolia House, and Nobel House. The buildings were developed by UBC's development group (UBC Prosperities Trust) and managed by UBC's residential housing management group (Village Gate Homes). These buildings were selected because the secure bicycle parking rooms were made available to the researchers. All three buildings are "below market" rental buildings that can only be rented by UBC faculty or staff. Because of this requirement and the location close to campus, the study results are specific to this context.

The study method comprised two parts: manual counts of bicycle usage in secured bicycle parking rooms and a survey questionnaire administered to residents. Only the building residents were recruited for the questionnaire because it was intended to give context to the bicycle count information, rather than represent bicycle parking habits and preferences of the general population (which has been addressed in previous studies). Ethics approval for the study was obtained from the UBC Behavioural Research Ethics Board. Communication with residents was through building email lists facilitated by the housing management. Initial contacts and surveys were in English and simplified Chinese because of the population demographics in the area.

Residents do not pay an additional fee to use the bike parking rooms, which are located in underground parking garages. Bicycle rack hardware in each room was similar, allowing two bicycles to be secured to each rack. Dahlia and Magnolia Houses share an underground parking facility (including the six shared bicycle parking rooms), and so were combined in the analysis. Counts were taken in three of Dahlia/Magnolia's six bicycle parking rooms: the largest room closest to the garage's vehicle entrance; a smaller room in the middle of the garage; and a smaller room furthest from the vehicle entrance.

Table 1 Study building characteristics

	Dahlia House	**Magnolia House**	**Nobel House**
Floors	4	4	6
Number of units	60	47	94
Unit sizes (bedrooms)	1 to 3	1 to 3	1 to 4
Bicycle parking rooms	6 (shared with Magnolia)	6 (shared with Dahlia)	1
Construction complete	2012	2012	2015

An online questionnaire was distributed with an initial email notification to all residents on March 6, 2017 and a follow-up reminder on March 22. The survey closed on April 10. The survey incentive was a draw for one of four gift cards of CA$25 for local businesses. After providing consent, residents were given a series of questions about their bicycle storage habits and preferences and basic socio-demographics.

Separately from the questionnaire, an e-mail notice was sent by the building manger to all units to describe the bicycle counts that would take place and allow units to opt out by contacting building management or placing a note on their bicycles. One unit with bicycles stored in Dahlia/Magnolia opted out of the study. Following this notification, baseline capacity and occupancy were established with manual counts on February 23, 2017 between 1300 and 1500 (a clear, cold day with a high of 6 °C). Capacity was defined as the number of bicycles a facility was designed to accommodate, accumulation defined as the number of bicycles in the room at a point in time, and occupancy as the ratio of accumulation to capacity (*10*). Occupancy was recorded for discrete sections of rooms with parking capacity of 4-10 bicycles.

Parking duration measurement began on April 3, 2017 by marking the bicycle locks of all present bicycles between 13:00 and 15:00. The researchers placed a strip of high-quality clean-removal painter's tape on all bicycle locks securing a bicycle to a rack. The tape was placed across two pieces of the bicycle lock that would need to be separated or broken to unlock and move the bicycle (Figure 1). When marking and counting bicycle locks, child-size and non-standard bicycles (such as e-bikes) were included, and multiple bicycles locked using a single lock were counted once, and bicycles not locked to a rack were excluded. A researcher returned every Monday from April 10 to June 5, between 1300 and 2000, to count which locks had been opened (i.e., the marking tape was broken or had been removed). During this period, Vancouver transitioned from its cooler, rainy spring to the warmer, drier summer, with average daily temperatures rising from 13 to 18 °C. Events during the study period included the end of the academic term (late April), Bike to Work Week (May 29 through June 2), and statutory holidays on April 14, April 17, and May 22.

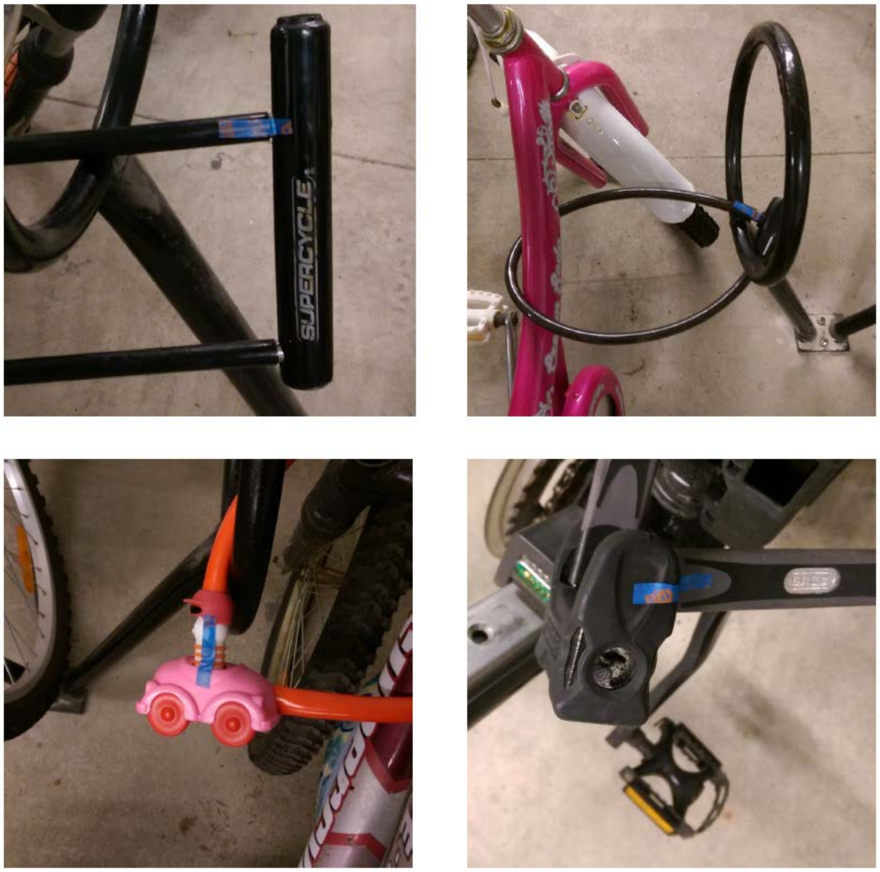

Figure 1: Application of Tape to Locks

3 Results

3.1 Bicycle parking counts

The bicycle parking capacity in the studied buildings is summarized in Table 2. Capacity per unit was 1.59 in Dahlia/Magnolia and 1.30 in Nobel – near the development standards of 1.25 and 1.5 per unit for Class I storage in Vancouver and at UBC, respectively. Most (75%) of the bicycles were standard adult bicycles, while 16% were children's bicycles and 9% were other types (e-bikes, cargo bikes). Overall occupancy was 99% (290 bicycles in rooms with a cumulative capacity of 292), ranging from 64% to 110% per room (including double- and triple-parked bicycles). High occupancy rates indicate there may be latent demand from residents who wish to store their bicycles in bike parking rooms but are unable to find space.

Table 2. Bicycle parking capacity and occupancy

	Parking capacity	Room size (square feet)	Square-feet per bicycle capacity	Distance to vehicle entrance (ft)	Occupancy
Dahlia/Magnolia					
Room 1	14	230	16	210	64%
Room 2	16	330	21	420	106%
Room 3	17	405	24	280	88%
Room 4	6	120	20	260	83%
Room 5	84	1515	18	170	110%
Room 6	33	720	22	170	76%
Nobel	122	1144	9	160	104%

Figure 2 shows the weekly and cumulative percent of bicycles moved in all rooms over the duration study. Cumulative movement increased throughout the nine weeks, although the rate appeared to be slowing and would likely eventually level off. Note that the study method reveals minimal (one-time) use, but not the frequency of use. Overall, 27% of bicycles were moved in the first week, 8% more in the second and third weeks each, and so on to a cumulative of 64%. Conversely, 36% of bicycles were not moved at all over the 9-week study period.

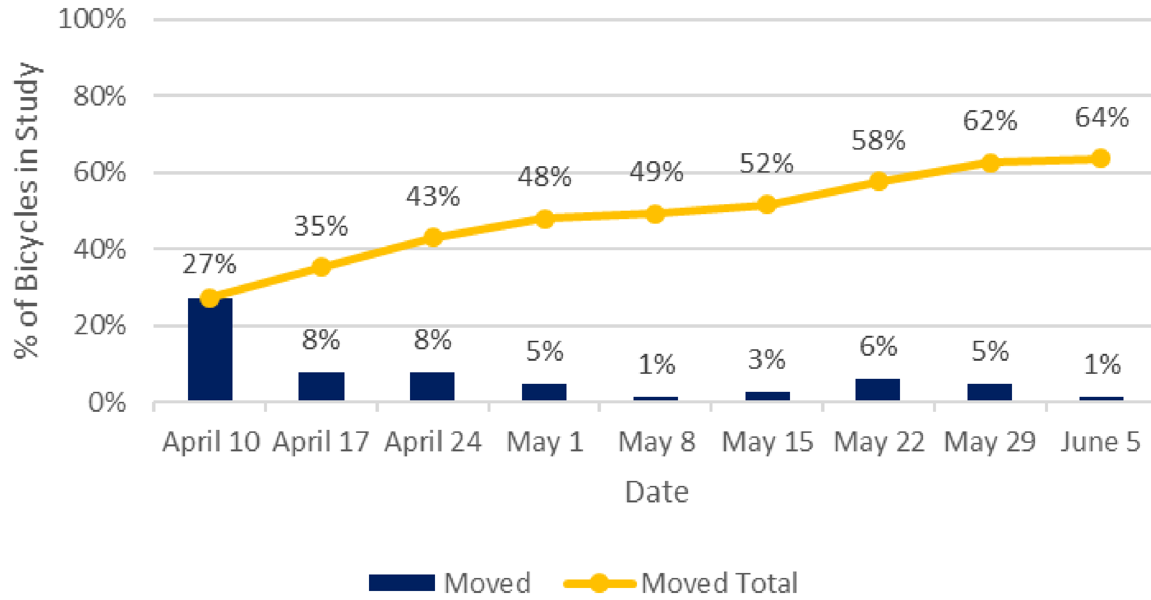

Figure 2: Bicycles moved in all rooms over study period

The number of bicycles moved in each room each week is given in Table 3. The occupancy of the rooms during marking ranged from 41% to 94% (lower than the initial capacity and occupancy evaluation in February). The cumulative movement of bicycles was similar among the rooms, ranging from 43% to 69% by the end of 9 weeks. The lowest-utilized Dahlia/Magnolia Room 3 had the smallest number of bicycles observed and the lowest occupancy during initial marking, which may have affected the results (i.e., more of the bicycles regularly stored in that room were not present during marking).

Table 3: Bicycles Moved Within Each Room and Each Building

Location	Marked bicycles (% of capacity)	Cumulative number moved by week W1	W2	W3	W4	W5	W6	W7	W8	W9	Total percent moved
Dahlia/Magnolia											
Room 2	15 (94%)	4	9	9	9	9	10	10	10	10	67%
Room 3	7 (41%)	1	2	3	3	3	3	3	3	3	43%
Room 5	57 (68%)	11	13	18	22	22	24	31	32	33	58%
Total	79 (68%)	16	24	30	34	34	37	44	45	46	58%
Nobel	86 (70%)	29	34	41	45	47	48	51	58	59	69%
Overall	165 (69%)	45	58	71	79	81	85	95	103	105	64%

In addition to variation between rooms and buildings, there was also variation in utilization within rooms. Figure 3 shows the percent of bicycles moved in different parts of the study rooms after 2 and 9 weeks of the duration study (with cumulative movement of 35% and 64%, respectively). The more accessible locations (i.e., near aisles and the entrance) generally saw higher utilization, although the spatial pattern was not constant.

Figure 3: Percent of bicycles moved within sections of each room after 2 and 9 weeks of study period

3.2 Questionnaire

Sixty-four responses were received from the 3 buildings, representing 28% of units in Dahlia, 23% in Magnolia, and 38% in Nobel. Respondents took an average of 12 minutes to complete the survey. Sample characteristics by building are summarized in Table 4. Median household income was in the range of CA$100,000-CA$125,000, high for Vancouver and the area (as expected given that one resident in each household must be employed by UBC). The average persons per household (2.5 to 3.4) was higher than the census tract (2.3) and the percent adults (61% to 77%) was lower than the census tract (85%), indicating more households with children. As stated in the Methods, the questionnaire was used to give context to the bicycle parking counts, rather than represent the broader population.

Table 4. Survey respondents

	Dahlia House	Magnolia House	Nobel House
Number of units responding	17 (28%)	11 (23%)	36 (38%)
Average household size (persons)	2.6	2.5	3.4
Percent adults (age 18+)	77%	74%	61%
Number of bicycles per unit	2.6	2.2	3.4

Among respondents, 95% reported that bicycle storage was "important" or "very important" to them. This, coupled with the high number of bicycles per unit (2.2-3.4), indicates that the survey sample is likely biased toward residents with higher bicycle storage needs and for whom bicycle storage is more of an issue (who would be more motivated to respond to a survey about bicycle parking). Furthermore, respondents reported typically used their bicycles daily (75%) or weekly (20%).

Respondents from just these 26% of units in Dahlia and Magnolia had 69 bicycles stored in the building, representing 41% of parking room capacity. Noble House respondents (38% of units) reported 121 bicycles stored in the building (99% of parking room capacity). The responding units alone create bicycle parking demand of 0.64 per unit and 1.29 per unit in Dahlia/Magnolia and Nobel buildings, respectively, supporting the capacity issues shown in Table 2. If these units were representative of the entire building, the bicycle parking demand of 2.2-3.4 per unit would be double the current standards in Vancouver and UBC. If the other (non-responding) 68% of units had just 1/4th of the demand rates of these units, the buildings would still be at 100% secure bicycle parking occupancy.

Given the parking room congestion, it is clear that many residents are storing bicycles in other locations. Figure 4 gives responses to a question of where residents regularly store their bicycles in the buildings (allowing for multiple locations per unit). A large majority (89%) regularly use the secure bicycle parking rooms. In addition, large portions regularly use their unit (23%) and private deck (21%) for storage, which are violations of the rental agreements. Other storage locations included outdoor parking and motor vehicle parking stalls in the parking garage. Of the residents who store bicycles in the buildings, just 35% use the bicycle rooms exclusively, while 65% regularly use locations other than the bicycle parking rooms.

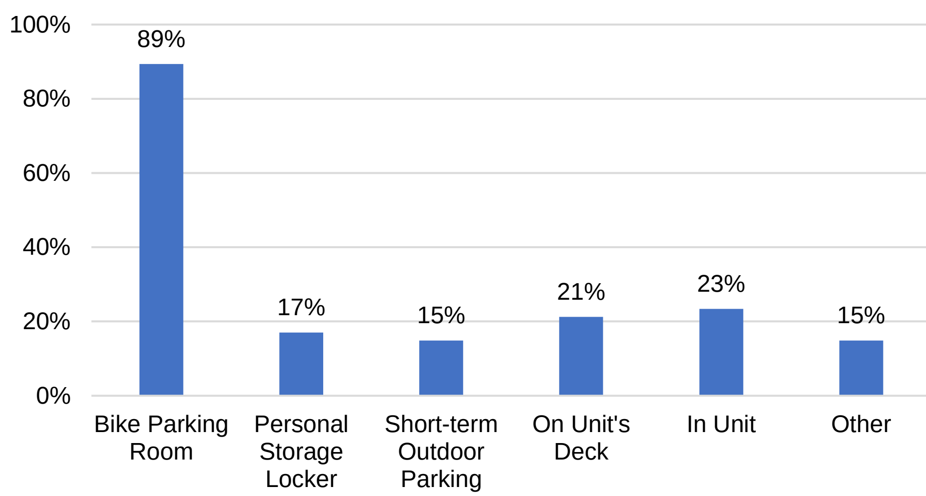

Figure 4: Stated locations regularly used for residential bicycle parking (of respondents who store bicycles in the buildings)

Finally, residents were asked about needed improvements to bicycle storage in their buildings. Security and crowding were consistently identified as the top issues in all three buildings (security first in Dahlia/Magnolia and crowding first in Nobel, consistent with higher congestion in Nobel). Although bicycle parking room security was identified as an issue, allowing storage in units and decks was rated as a low priority, indicating a preference for improving communal bicycle parking facilities in the buildings.

4 Discussion

Study results indicate that even meeting current guidelines, a secure bicycle parking provision ratio of around 1.5 spaces per unit in the study buildings is deficient, leading to heavy bicycle parking congestion. There was agreement between count data and resident surveys that parking congestion is an issue in the buildings, confirming anecdotal information from the building managers. Parking duration measurements indicated that around 1/3rd of the bicycles in secure storage were used within the first week, which increased steadily to 2/3rd of bicycles used at least once by the end of 9 weeks. Parking within the rooms was unevenly utilized, with sections of large rooms closer to the door more heavily used.

The context for these data is important for interpretation. The residents of these buildings are mostly university employees living near campus, and the utilization measurements were made during springtime in Vancouver. How the findings might translate to other buildings and cities would vary, and should be explored in future studies measuring bicycle parking utilization in other residential contexts. Vancouver generally has high cycling rates compared to other cities in North America, but low compared to parts of Europe. Utilization would presumably be higher in summer and lower in winter, and would also vary with tenancy, building and unit size, land use context, and the myriad factors affecting cycling rates in general (*17–19*). An additional contextual issue to consider is the likely bias in the questionnaire sample toward residents more concerned about bicycle parking. This sample bias would not negate the finding that existing capacity was deficient to meet the bicycle parking needs of residents.

Inadequate bicycle parking facilities are a barrier to use (*5*, *12*), and increasing their supply in multi-unit residential buildings could increase cycling activity. Increasing parking supply would likely activate latent demand (bicycles currently parked in units or residents hesitant to purchase a bicycle because of storage issues) and congestion could return, but that is an induced demand which may align with transportation system goals aiming to reduce auto dependency. Table 5 gives a summary of bicycle storage guidelines for residential buildings in areas near the study location, as well as examples from other contexts. The capacity guidelines and provision for the study buildings (1.5 per unit) is toward the upper end of the range of indoor parking minimums.

In addition to the consideration of higher capacity in development standards, regulations could be revisited to consider different types of bicycle usage, including year-round daily commuting (which requires regular, low-barrier access), and seasonal, recreational riding (for which the accessibility needs are lower). Roughly 1/3rd of bicycles parked in parking rooms in the study buildings were not used in at least 9 weeks, and perhaps could have been accommodated with less accessible storage options reducing congestion in the rooms for more regular users. Alternatives to ownership and storage could also be considered such as building-specific bike-share programs.

Table 5. Summary of residential bicycle storage guidelines

Bylaw or Guideline	Minimum Number of Indoor Bicycle Parking Spaces (Per Unit Unless Noted)
UBC, *University of British Columbia Development Handbook*, 2016	1.5
UBC, *Vancouver Campus Plan: Design Guidelines*, 2010	0.75 to 1.5
UBC, *Residential Environmental Assessment Program (REAP), Version 3.0*, 2014	1.75 (1.5 in Version 2.1, 2009)
City of Vancouver, 2014 (*20*)	1.25 to 2.25
City of Richmond, 2009 (*21*)	1.25
City of North Vancouver, 2017 (*22*)	1.5
City of New Westminster, 2001 (*23*)	1.25
City of Surrey, 2017 (*24*)	1.2 (if 30+ motor vehicle parking spaces)
City of Coquitlam, 2016 (*25*)	1.25
District of North Vancouver, 2017 (*26*)	0.2
District of Squamish, 2012 (*27*)	2.0
City of Portland, Oregon, 2017 (*28*)	1.5
Canada LEED for Homes (Mid-rise Buildings) (*29*)	0.3 per studio & 1 bedroom, +0.15 per bedroom
U.S. LEED (*30*)	0.3 per resident (minimum 1 per unit)
Association of Pedestrian and Bicycle Professionals (*31*)	0.5 per bedroom (minimum 2 per unit)

5 Conclusion

To increase the utility of bicycle parking rooms, developers, municipalities, and green-building organizations should consider not just parking capacity and security, but also location and quality. Storage that accommodates different usage and bicycle types should be considered. The study method presented here provides new evidence on rates of bicycle storage and usage in residential buildings, but should be validated in future studies. The method is vulnerable to several potential errors, including the tape being removed without the bicycle being used, or the tape being incorrectly placed so that the bicycle could have been used without disturbing the tape.

Not all bicycles that are stored in the room were present during marking, and so the marked bicycles are a (high-proportion) sample of the population of bicycles. Given that 2/3rd of respondents who have bicycles regularly store them in other locations within the property, it would be difficult to mark all bicycles stored in the room at any point over a 9-week period by this method, even with multiple marking sessions. Still, the method provides data on usage of this sample of bicycles over time. If the sample is not representative of the population of bicycles parked in the room, it likely contains the less-used bicycles, and so is conservative (underestimates) with respect to utilization.

For future work, definitions of bicycle parking utilization might be explored in more detail. For example, in-use bicycles in storage could be defined based on a certain duration in a lock marking study (e.g., 2 or 4 weeks). Development of utilization targets may improve designs and increase the effectiveness of bicycle parking rooms in serving cycling activity. Separate regulatory standards could be defined for high-use and low-use storage, for example. Further research is required to evaluate the effects of various design options (aisle width, spacing and orientation of racks, etc.) on distribution of utilization. Broader questions remain for researchers, residents, and urban professionals to consider: for what types of cycling should residential bicycle parking be built, and can it effectively accommodate all users?

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7 References

1. Celis, P., and E. Bølling-Ladegaard. *Bicycle Parking Manual*. The Dutch Federation of Cyclists, 2008.
2. Pucher, J. R., and R. Buehler. *City Cycling*. MIT Press, Cambridge, MA, USA, 2012.
3. Arbis, D., T. H. Rashidi, V. V. Dixit, and U. Vandebona. Analysis and Planning of Bicycle Parking for Public Transport Stations. *International Journal of Sustainable Transportation*, Vol. 10, No. 6, 2016, pp. 495–504. https://doi.org/10.1080/15568318.2015.1010668.
4. Buehler, R. Determinants of Bicycle Commuting in the Washington, DC Region: The Role of Bicycle Parking, Cyclist Showers, and Free Car Parking at Work. *Transportation Research Part D: Transport and Environment*, Vol. 17, No. 7, 2012, pp. 525–531. https://doi.org/10.1016/j.trd.2012.06.003.
5. Rose, G., H. Weliwitiya, B. Tablet, M. Johnson, and A. Subasinghe. Bicycle Access to Melbourne Metropolitan Rail Stations. Presented at the Australasian Transport Research Forum (ATRF), 38th, 2016, Melbourne, Victoria, Australia, 2016.
6. Akar, G., and K. Clifton. Influence of Individual Perceptions and Bicycle Infrastructure on Decision to Bike. *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2140, 2009, pp. 165–172. https://doi.org/10.3141/2140-18.
7. Lusk, A. C., X. Wen, and L. Zhou. Gender and Used/Preferred Differences of Bicycle Routes, Parking, Intersection Signals, and Bicycle Type: Professional Middle Class Preferences in Hangzhou, China. *Journal of Transport & Health*, Vol. 1, No. 2, 2014, pp. 124–133. https://doi.org/10.1016/j.jth.2014.04.001.
8. Yuan, C., Y. Sun, J. Lv, and A. C. Lusk. Cycle Tracks and Parking Environments in China: Learning from College Students at Peking University. *International Journal of Environmental Research and Public Health*, Vol. 14, No. 8, 2017. https://doi.org/10.3390/ijerph14080930.
9. Statistics Canada. *2016 Census Profile*. Ottawa, Ontario, Canada, 2017.
10. Moskovitz, D., and N. Wheeler. Bicycle Parking Analysis with Time Series Photography. *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2247, 2011, pp. 64–71. https://doi.org/10.3141/2247-08.
11. University of Washington Transportation Services. *Bicycle Parking Inventory & Utilization Study Report*. University of Washington, 2012.
12. Metro Vancouver. *The Metro Vancouver Apartment Parking Study: Revised Technical Report*. 2012, p. 98.
13. San Francisco Municipal Transportation Agency. *Strategy for Long-Term Bicycle Parking in San Francisco*. San Francisco, California, USA, 2013, p. 86.
14. Lierop, D. V., M. Grimsrud, and A. El-Geneidy. Breaking into Bicycle Theft: Insights from Montreal, Canada. *International Journal of Sustainable Transportation*, Vol. 9, No. 7, 2015, pp. 490–501. https://doi.org/10.1080/15568318.2013.811332.
15. Nettle, D., K. Nott, and M. Bateson. 'Cycle Thieves, We Are Watching You': Impact of a Simple Signage Intervention against Bicycle Theft. *PLOS ONE*, Vol. 7, No. 12, 2012, p. e51738. https://doi.org/10.1371/journal.pone.0051738.
16. Sidebottom, A., A. Thorpe, and S. D. Johnson. Using Targeted Publicity to Reduce Opportunities for Bicycle Theft , Using Targeted Publicity to Reduce Opportunities for Bicycle Theft: A Demonstration and Replication , A Demonstration and Replication. *European Journal of Criminology*, Vol. 6, No. 3, 2009, pp. 267–286. https://doi.org/10.1177/1477370809102168.
17. Heinen, E., B. van Wee, and K. Maat. Commuting by Bicycle: An Overview of the Literature. *Transport Reviews*, Vol. 30, No. 1, 2010, pp. 59–96. https://doi.org/10.1080/01441640903187001.

18. Buehler, R., and J. Dill. Bikeway Networks: A Review of Effects on Cycling. *Transport Reviews*, Vol. 36, No. 1, 2016, pp. 9–27. https://doi.org/10.1080/01441647.2015.1069908.
19. Pucher, J., and R. Buehler. Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. *Transport Reviews*, Vol. 28, No. 4, 2008, pp. 495–528. https://doi.org/10.1080/01441640701806612.
20. City of Vancouver. Parking Bylaw 6059. Bylaw 6059, 2014.
21. City of Richmond. Zoning Bylaw 8500. 2009.
22. City of North Vancouver. Zoning Bylaw 6700. 2017.
23. City of New Westminster. Zoning Bylaw 6680. 2001.
24. City of Surrey. Zoning Bylaw 12000 1993. 2017.
25. City of Coquitlam. Zoning Bylaw 3000, 1996. 2016.
26. District of North Vancouver. Zoning Bylaw, 1965. 2017.
27. District of Squamish. Zoning Bylaw 2200 2011. 2012.
28. City of Portland. Zoning Code 33.266. 2017.
29. Canada Green Building Council. *LEED Canada for New Construction and Major Renovations 2009*. 2009.
30. U.S. Green Building Council. *LEED BD+C: New Construction V4*. 2017.
31. Broom, N., E. Anderson, V. Caristo, R. Dodge, J. Donlon-Wyant, S. Figliozzi, E. Gauw, D. Jatres, D. Loutzenheiser, H. Maddox, B. Patterson, and C. Seiderman. *Essentials of Bike Parking: Selecting and Installing Bicycle Parking That Works*. Association of Pedestrian and Bicycle Professionals, Cedarburg, WI United States, 2015.