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Breaking into bicycle theft: Insights from Montreal, Canada

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ABSTRACT

Currently, bicycle theft often goes unnoticed and is largely unchallenged, negatively impacting the use of this sustainable transportation mode. The present research brings attention to this issue by analyzing the multifaceted problem of bicycle theft in Montreal, Quebec, Canada. A bilingual online bicycle theft survey was designed for this purpose and answered by 2,039 Greater Montreal residents, yielding 1,922 usable responses. This paper tries to understand bicycle theft through answering the questions of ‘who’, ‘what’, ‘where’, ‘how’, and ‘when.’ Findings from this study are useful to better understand and ultimately decrease bicycle theft in Montreal, but can also be beneficial for cyclists, police, and policy makers in other cities aiming to decrease bicycle theft.

Key words: cycling – theft – victimization – Montreal – bicycle parking – logit – cycling facilities

INTRODUCTION

Planners and transportation specialists are aiming to improve pedestrian and cycling infrastructure in an attempt to promote sustainable urban futures that are not heavily reliant on the personal automobile. Many cities have adopted policies that promote active modes of transportation such as walking and cycling due to their positive environmental, economic, health and social benefits (Gordon-Larsen, Nelson et al. 2005; Dill 2009). Some national governments are also proving commitment to the promotion of these active modes (Heinen and Handy 2012). While much of the recent research in active transportation aims to understand cyclists' behavior, experience and satisfaction with the built environment (Larsen and El-Geneidy 2011; Broach, Dill et al. 2012; Larsen, Patterson et al. 2013; Willis, Manaugh et al. 2013), few studies evaluate their opinions about the security and availability of bicycle parking facilities. Facilitating an increase in bicycle mode share requires planning both terminals (parking facilities) and cycling networks (paths and lanes). This research aims to better understand bicycle theft and tries to fill the gap concerning the safety and availability of bicycle parking facilities. As bicycles become a more popular form of transportation, planners and transportation researchers will need to consider how to create urban spaces that encourage cycling and discourage bicycle theft.

This paper recognizes that a major concern for cyclists is bicycle theft and therefore seeks to answer five basic questions: 1) *who* are the victims of bicycle theft; 2) *where* does bicycle theft occur most frequently, and where is it perceived to occur most frequently; 3) *what* kinds of bicycles are most commonly stolen; 4) *how* are bicycles most commonly stolen; and 5) *when* are bicycles most likely to be stolen; as well as examining trends. The data for this research is a result of a detailed online survey conducted in Montreal, Quebec, Canada specifically for this purpose. The survey included demographic, travel and parking behavior, theft history, and spatial questions to better understand the factors influencing bicycle theft in Montreal. Although the paper answers specific questions in relation to bicycle theft in the Montreal region, transportation planners and engineers in other cities can benefit from the findings as it gives some insights about the nature of bicycle theft as well as the attitudes of cyclists towards this issue.

LITERATURE REVIEW

As cities continue to propose transportation plans that encourage the use of bicycles as a sustainable alternative to the automobile, and bicycles become an increasingly popular form of transportation, planners and transportation researchers need to be aware of the growing opportunities for bicycle theft. The monetary value, availability, and utility of the bicycle have made it become a popular target for theft. Findings from the International Crime Victim Survey (ICVS) indicate that bicycle theft is the highest per bicycle owner in cities where bicycles are most popular and that from the 30 cities included in the study, cyclist are (slightly more than) four times as likely to be victims of bicycle theft than are automobile owners to be victims of automobile theft (van Dijk, van Kesteren et al. 2007).

Gamman, Thorpe, and Willcocks (2004) claim that thefts are not properly recorded to the police because they are often seen as being a low crime priority. Johnson, Sidebottom, and Thorpe (2008) state that bicycle theft is a crime that frequently goes unnoticed and is largely unchallenged by authorities. Although no academic attention has been given to the underreporting of bicycle theft in the literature, many respondents in the Montreal Bicycle Theft Survey indicate that they did not report the crimes due to doubt that police would act on these instances of crime. Within the field of criminology, Routine Activity Theory explains that for most criminal acts to be committed likely offenders, suitable targets, and a lack of a capable guardian is required. This theory provides temporal predictions about when crime rates could be higher (Cohen and Felson 1979). Survey participants made clear in their responses that bicycles are indeed suitable targets, and that police do not act as suitable guardians who actively protect against bicycle theft. A clear disconnect exists between cyclists' individual efforts to decrease instances of theft (i.e. by using strong locks, parking in well-lit areas, always taking their bicycle inside, etc.), and the apparently minimal effort by local police. While there is little academic research about bicycle-related crime, several studies have identified that bicycle theft is a problem for cycling communities (Gamman, Thorpe et al. 2004; Zhang, Messner et al. 2007; Sidebottom, Thorpe et al. 2009; Bachand-Marleau, Larsen et al. 2011).

Within a Chinese context, Zhang et al. (2007) used data collected in the city of Tianjin to explore social and legal aspects of bicycle theft victimization. The authors focused on neighborhood deviance and crime levels, and found that neighborhood poverty level is a significant risk factor in bicycle theft victimization. Gamman et al. (2004) focused on the need for bicycle-specific and theft-preventing urban design in the UK and elsewhere in Europe. These authors suggested best practice policies to increase the security of bicycle parking facilities. Meanwhile, Sidebottom et al. (2009) conducted a study in London and Brighton, UK, aiming to understand whether instructional stickers placed on bicycle parking facilities would encourage cyclists to park and lock their bicycles more securely in public spaces. Bachand-Marleau et al. (2011), in their research on bicycle and transit integration in Montreal, found that 20% of surveyed Montreal cyclists reported a lack of appropriate parking facilities or mentioned fears about theft.

Many studies have assessed cycling behavior and cyclists' preferences of bicycle specific infrastructure (such as bicycle lanes, boulevards, and paths) (Aultman-Hall, Hall et al. 1997; Handy, Boarnet et al. 2002; Dill and Carr 2003; Tilahun, Levinson et al. 2007; Winters, Brauer et al. 2010; Larsen, Patterson et al. 2013). However, the abovementioned studies are unique in identifying that with a rise in bicycle mode share comes and increase in the opportunity for bicycle theft, thereby increasing the need for secure bicycle parking facilities. This study specifically contributes to the literature by providing an analysis of the multifaceted problem of bicycle theft in Montreal and by evaluating cyclists' opinions about the security and availability of bicycle parking facilities in the region.

DATA AND METHODOLOGY

The City of Montreal endeavors to increase cycling mode share in the region by developing bicycle facilities throughout the area (Division du Développement des Transports 2008). According to the 2008 *Origine-Destination* (OD) survey, which is a regional transportation survey that is conducted every five years, the mode share for cycling in the region of Montreal is 1.2% of all trips (Agence Metropolitaine de Transport (AMT) 2008). This mode share resembles the national average (Pucher and Buehler 2005; Canada 2010). To increase the overall mode share of bicycle trips, Montreal's 2008 Transportation Plan encourages cycling for basic transportation as a part of the development program for reinventing Montreal within the next ten years (Division du Développement des Transports 2008). The city's transportation plan includes goals that involve interventions for both increasing the bicycle path network and improving bicycle parking facilities. These goals include doubling the length of the cities' bicycle paths, updating the existing cycling network, and increasing the number of bicycle racks by 500% by means of public-private partnerships. According to the *Service de police de la Ville de Montreal* (SPVM), the city's police department, an average of approximately 2,500 bicycles are reported stolen every year. The SPVM believes this number represents only a small proportion of all bicycle thefts taking place in the region (Tremblay and Letendre 2011).

To better understand bicycle theft in and around Montreal, a bilingual online survey was conducted in the region.⁴ Given the limitations of online surveys, particularly for overrepresentation of certain groups, a variety of media were used to ensure a broad cross-section of the public was reached. The survey was publicized through a combination of email newsletters, mailing lists, several newspaper articles in French and English, a radio interview, and various social networking media. Flyers advertising the survey were distributed to several bicycle shops throughout the region. These measures, as recommended by Dillman, Smyth & Christian (2009), allowed for a broader exposure and presumably reduced sample bias that can be associated with online surveys. Due to the title of the survey, the Montreal Bicycle Theft Survey, the survey may have attracted more victims than non-victims of bicycle theft (50% of the respondents had at least one bicycle stolen). However, previous research, unrelated to theft, also found that 50% of cyclists had been victims of bicycle theft (Bachand-Marleau, Lee et al. 2011). The survey was available online for approximately one month in the late spring of 2012, and it yielded a total sample of 1,922 usable responses from 2,039 individuals. This is slightly higher than the count of bicycle-riding adults in the regional travel survey, which samples 5% of the region's population (Agence Metropolitaine de Transport (AMT) 2008). Table 1 highlights the demographic characteristics of participants both in the Montreal Bicycle Theft Survey and the OD survey and includes both percentage and count figures. In this table, the total number per

⁴ A copy of the survey is available online at: <http://tram.mcgill.ca/Teaching/srp/documents/Dea.pdf>

cell does not always add up to the total number because participants always had the option of leaving the question blank.

TABLE 1: Montreal Bicycle Theft Survey and Origin-Destination Survey Participants

	2012 Bicycle Theft Survey				2008 Origin-Destination Survey (Adult)					
	All Survey Respondents		Logit		Bicyclists		All			
			Victims	All						
GENDER										
Male	58%	(1,037)	60%	(233)	60%	(612)	65%	(1,029)	47%	(58,890)
Female	42%	(738)	40%	(155)	40%	(400)	35%	(548)	53%	(65,563)
AGE										
Average Age	37		38		38		42		48	
18-29	30%	(542)	27%	(104)	29%	(290)	24%	(372)	16%	(19,750)
30-39	37%	(658)	37%	(143)	36%	(362)	22%	(343)	16%	(20,182)
40-49	17%	(301)	16%	(64)	17%	(167)	25%	(395)	21%	(25,929)
50-64	14%	(254)	18%	(68)	17%	(167)	24%	(371)	28%	(34,983)
65+	2%	(41)	2%	(9)	2%	(25)	6%	(96)	19%	(23,609)
HOUSEHOLD SIZE										
One	21%	(369)	22%	(82)	19%	(190)	22%	(346)	15%	(18,203)
Two	43%	(755)	40%	(153)	44%	(433)	34%	(539)	38%	(47,008)
Three	19%	(335)	18%	(70)	19%	(184)	20%	(310)	19%	(24,121)
Four	12%	(213)	14%	(55)	13%	(130)	17%	(270)	19%	(23,788)
Five or More	6%	(100)	5%	(20)	6%	(56)	7%	(112)	9%	(11,333)
OCCUPATION										
Employed Full-time	64%	(1,133)	66%	(253)	65%	(653)	59%	(935)	52%	(64,439)
Employed Part-time	7%	(130)	9%	(33)	7%	(71)	9%	(135)	6%	(7,105)
Student	21%	(370)	18%	(68)	20%	(202)	13%	(200)	8%	(9,872)
Retired	3%	(50)	2%	(9)	3%	(29)	11%	(181)	25%	(31,057)
Other	6%	(100)	5%	(21)	5%	(47)	8%	(126)	10%	(11,936)
INCOME (household)										
<\$20,000	14%	(245)	10%	(38)	12%	(118)	15%	(186)	12%	(10,217)
\$20,000 - \$40,000	18%	(305)	19%	(69)	17%	(157)	24%	(310)	22%	(19,849)
\$40,000 - \$60,000	18%	(313)	18%	(68)	17%	(164)	22%	(278)	21%	(18,877)
\$60,000 - \$80,000	14%	(234)	16%	(58)	15%	(138)	16%	(203)	16%	(14,502)
\$80,000 - \$100,000	13%	(216)	13%	(47)	13%	(126)	10%	(131)	11%	(10,186)
>\$100,000	23%	(391)	24%	(90)	26%	(245)	13%	(166)	17%	(15,009)
<i>N*</i>	1,922		388		1,012		1,577		124,453 (all modes)	

*The total number of survey participants was 2,039. Of these responses 1,922 were usable. Almost all of the usable responses came from current cyclists. The total number of current cyclists was 1,896.

As mentioned earlier, this paper tries to answer several questions in relation to bicycle theft. The first question asks *who* the victims of bicycle theft are. This question is answered through a description of the survey participants and the differences between cycling theft victims and non-victims. Basic socio-demographic information about the survey participants is presented through a series of summary statistics. This is followed by a binary logit model, which incorporates variables pertaining to socio-demographic status, commuting habits, and bicycle and lock characteristics, and which is used to demonstrate which of these factors most influence survey participants' likeliness to have had their bicycle stolen. Similarly to Zhang et al. (2007), this logit model helps to better understand the risk and protective factors for bicycle theft.

The second question concerns *where* bicycle theft occurs most frequently, and *where* is it perceived to occur most frequently. Answering this question involves using a geographic information system (GIS) software to highlight experienced and expected bicycle theft locations on the Island of Montreal. Details about the methodology that was used to better understand where bicycle theft occurred and where it is perceived to occur more frequently is further explained in the section titled ‘Where’. This is followed by a short discussion about the differences between actual and perceived instances of theft. Cyclists’ perceptions and preferences about bicycle parking facilities are also analyzed.

The third, fourth and fifth questions attempt to understand *what* kinds of bicycles are most commonly stolen, *how* bicycles are most commonly stolen, and *when* bicycles are most likely to be stolen, respectively. These questions are answered through a series of descriptive statistics. Figures are used to highlight key findings and to better understand relationships between variables. Also, a brief examination of bicycle recovery is included as are suggestions to improve the security and availability of bicycle parking. The paper concludes with recommendations and suggestions for further research.

WHO: *Who are the victims of bicycle theft?*

Montreal bicycle theft survey participants

The respondents’ ages range from 18 to 85. However 68.9% are 40 years old or younger. Men, accounting for 58% of the respondents, are slightly *underrepresented*, compared to OD survey figures (see Table 1 for more details). Most of the respondents are employed full-time and have completed at least an undergraduate degree. Participants generally live in two person households and 82.3% of participants live in households with fewer than four people. Almost all survey participants (98.6%) have made at least one commuting trip by bicycle in Montreal during the last year. Around 50% of the participants in the survey were subjected to a bicycle theft in their life time as active cyclists. This finding resembles previous studies’ (Bachand-Marleau, Lee et al. 2011).

Factors associated with theft

The binary logit model below is used to further understand how individuals’ habits, choices, and socio-demographic status relate to the likeliness of having been a victim of a bicycle theft. Although the model can be helpful to better understand questions about the ‘who’, ‘what’, ‘where’, ‘how’, and ‘when’ of bicycle theft, it is presented in the section ‘who’ because it measures an individual’s odds of having had his or her bicycle stolen. The output of the logit is reported in Table 2.

TABLE 2: Binary Logit Model

Parameters		Coefficient	<i>t</i> -stat	Odds Ratio
Bicycle:	Used bicycle	-.227	-.873	.797
	New bicycle (reference)	---	---	---
	Value between \$500-\$1500	-2.491 **	-9.223	.083
	Value more than \$1500	-2.251 **	-4.671	.105
	Less than \$500 (reference)	---	---	---
Registration:	Chose not to register	-.816 *	-2.007	.442
	Did not know about registering	.142	.380	1.152
	Registered (reference)	---	---	---
Lock:	U-lock	-5.385 **	-10.381	.005
	Cable lock	-2.122 **	-4.351	.120
	Chain lock	-2.579 **	-4.668	.076
	Bicycle kept inside	-2.243 **	-6.302	.106
	Other locks	-3.974 **	-6.007	.019
	No lock (reference)	---	---	---
Exposure:	Year round cyclist	.643 *	2.068	1.903
	Cycle less than 12 months of the year (reference)	---	---	---
	Commuting for 4-6 yrs	.070	.227	1.072
	Commuting for 7-10 yrs	.534	1.416	1.706
	Commuting for more than 10 yrs	.662 *	2.284	1.939
	Commuting less than 4 yrs (reference)	---	---	---
Socio-demographic:	Female	-.506 *	-2.135	.603
	Male (reference)	---	---	---
	Age	.000	.000	1.000
	Constant	4.761	6.262	116.883

All values in
Canadian Dollars

Dependent variable: stolen bicycle
*95% significance **99% significance

Cox & Snell R square = 0.54, Nagelkerke R square = 0.73

Since participants were not obliged to answer all questions in the survey, for the purpose of the logit model, the original data had to be scaled down to a final sample size of 1012 cyclists. Demographic information about the participants who are included in the logit model is highlighted in Table 1. If a participant's bicycle had been stolen, the value of the *stolen* bicycle or the lock used to lock the stolen bicycle was input into the database; if a participant had not been a victim of bicycle theft, the value of their *current* bicycle or the lock currently used was input into the database. By using commensurate data describing both participants who have and have not been subject to bicycle theft, including the bicycles (and locks) that were or were not

stolen (or overcome), the model is able to determine how the different factors influence a cyclist's likelihood to have had their bicycle stolen.

The model possesses a reasonable amount of explanatory power (Cox & Snell R square = 0.54, Nagelkerke R square = 0.73), and its variable coefficients show the expected relationship directionality (positive or negative). It indicates that bicycle value, awareness about registration, lock type, exposure, and gender are statistically significant. High value bicycles are less likely to have been stolen. This is further illuminated in Figure 1. Participants were asked whether they registered their bicycles, both stolen and current.

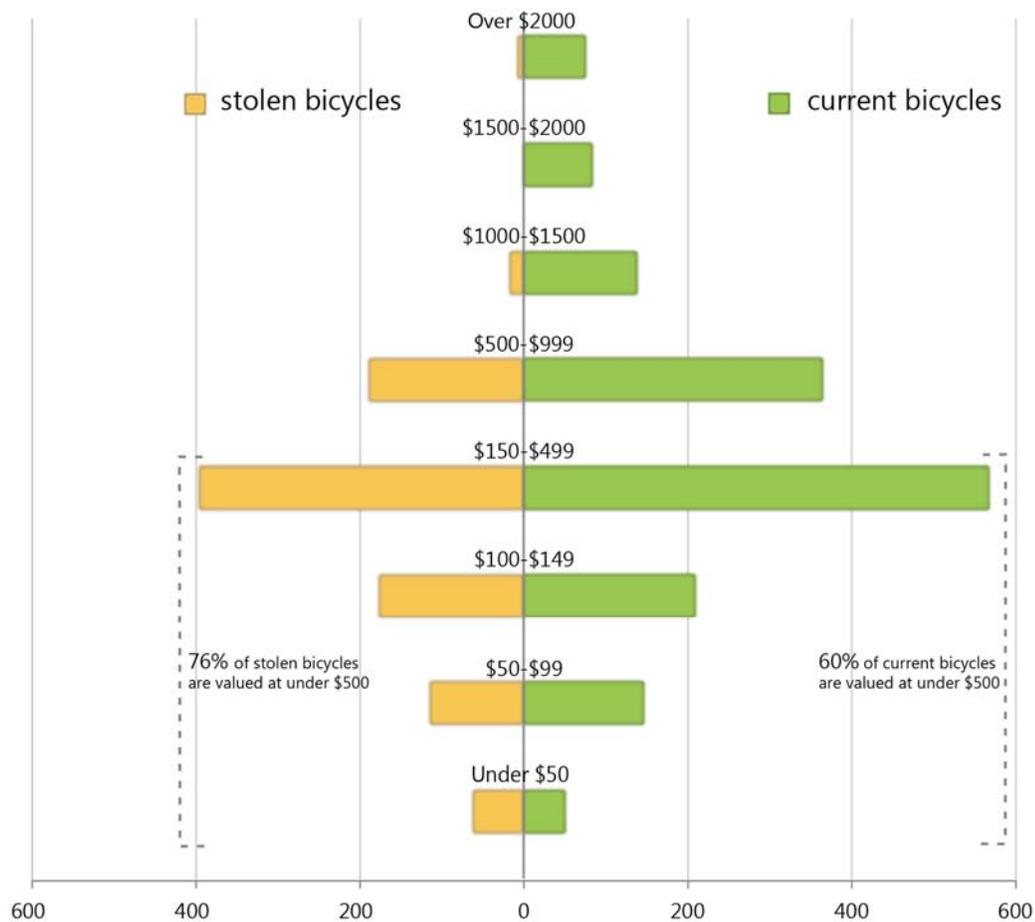


Figure 1: Difference in values between stolen and current bicycles

The model reports that cyclists who did not register their bicycles were 55.8% less likely to have been victims of bicycle theft than cyclists who did register their bicycles. This could be due to cyclists who knew about registration but consciously chose not to register their bicycles being more aware of the risk of theft, bicycle security, and locking techniques. Another hypothesis is that cyclists who did register their bicycles experienced a false sense of invulnerability and became more careless with bicycle security after registration.

The model compares cyclists who use U-locks, cable locks, chain locks, other types of locks, and cyclists who always keep their bicycles inside to cyclists who do choose to not take

security measures. The category “other locks” accounts for the many different types of locks cyclists used, such as wheel and combination locks, not specifically named in the logit model. The output of the model makes very clear that using a lock significantly decreases a cyclist’s likeliness to have been a victim of bicycle theft compared to not using a bicycle lock. Of the different kinds of locks, U-locks are found to decrease the likeliness of bicycle theft more than other lock types. Figure 2 shows use frequencies for common types of locks on stolen and current bicycles.

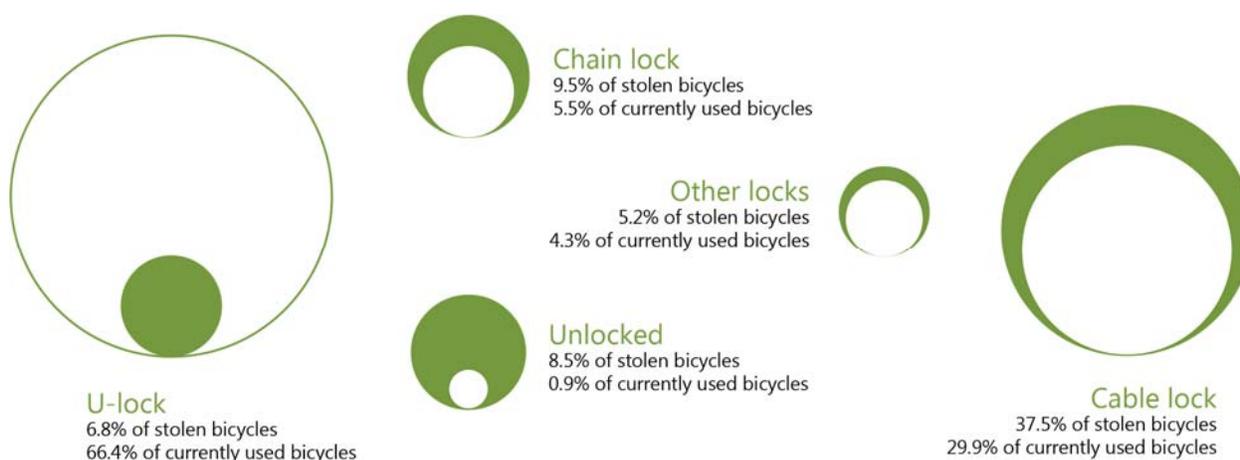


Figure 2: Comparison of locks used on stolen bicycles and locks used on current bicycles

Surprisingly, around 8.5% of the surveyed theft victims neither used a lock nor keep their bicycles inside or on their porch at the time when their bicycle was stolen. In other words, these bicycles were unprotected and unlocked. Also, 10% of all surveyed theft victims did not have a lock at the time when their bicycle was stolen. The difference lies in the fact that some cyclists, although not using a lock, became victims of theft despite taking their bicycle indoors.

Although the model ranks bicycle value and lock types, it is important to understand that the likeliness for a cyclist to have had their bicycle stolen depends not only on the variables presented in the model, but also on factors not expressed by the model. Factors such as bicycle parking location, the duration that the bicycle was left unattended, and how the bicycle was locked, are not included in the model but might influence bicycle theft. Data about these factors is only available for the stolen bicycle from the 2012 Montreal Bicycle Theft Survey, and therefore cannot be included in the logit model.

Exposure is controlled for in two manners: by comparing participants who cycle twelve months of the year to participants who do not, and by comparing long-time bicycle commuters to those who have been doing so for under four years. Year-round cyclists’ likeliness to have been a victim of bicycle theft is 90.3% higher than that of cyclists who do not cycle every month of the year. Similarly, as the number of years that a cyclist has regularly been commuting increases, so does his or her likeliness to have been a victim of bicycle theft. These factors indicate, as expected, that the longer a bicycle is exposed, the more likely it is to be stolen.

Most notable among socio-demographic characteristics, females are found less likely to have had a bicycle stolen. Although the male-female ratio, 60%-40%, is nearly the same for survey participants generally and theft victims, being female is shown in the model to significantly reduce the likelihood of bicycle theft. Females seem to be, then, disproportionately represented in other higher-likelihood factors, such as riding an inexpensive bicycle or using no lock. Several survey respondents wrote of women's bicycles seeming less attractive to thieves. "*Un remeur urbaine affirme que les velos pout femmes se font moins voles*" (English translation by author: An urban legend claims that women's bicycles are less frequently stolen).

Other variables that were available for both stolen and non-stolen bicycles that were not included in the model either were not theoretically meaningful, tested to be insignificant in the model, or had high levels of correlation with the existing variables in the model. While only including a small number of variables, the model does make clear that bicycle value, lock type, and exposure time are the most significant factors in determining a cyclist's likeliness to have been a victim of bicycle theft.

WHERE: *Where does bicycle theft occur most frequently, and where is it perceived to occur most frequently?*

Experienced and perceived theft

Data about Montreal cyclists' home-based bicycle trips from the 2008 *Origine-Destination* (OD) survey helps establish cycling frequencies that are needed in order to determine where on the Island of Montreal bicycle theft is most prevalent (Agence Metropolitaine de Transport (AMT) 2008). This data provides the origin locations of 2719 cycling trips and the destination locations of 2742 cycling trips on the Island of Montreal. The difference between origin and destination counts is explained by cyclists commuting from areas that are located off island to the Island of Montreal.

The Montreal Bicycle Theft Survey (MBTS) provides data about participants' home location and bicycle theft location. It does not, however, provide information about where participants usually park their bicycles on a daily basis. To understand the destination points of cyclists in the Montreal Bicycle Theft Survey, the ratio between the origin and destination points of cyclists in the OD survey is applied to calculate the ratio between home location and destination points of cyclists in the Montreal Bicycle Theft Survey at the police district level of analysis.

Although it is most common to collect and analyze data at the borough level, police districts have been used to analyze instances of theft because they are both smaller than boroughs and represented by SPVM stations that are responsible for handling crime within their respective police districts. While 49 police districts exist on the Island of Montreal, there are only 19 boroughs. Police districts can therefore more closely describe theft trends at the neighborhood level. To standardize the number of thefts per police district, accounting for differences in theft opportunity, the z-score of the total number of thefts per police district (from MBTS) is divided

by the sum of participants' home locations (from MBTS) and expected destinations (from OD) per police district.

$$st = \frac{\left(\frac{x - \mu}{\sigma}\right)}{y + z}$$

st = standardized thefts per police district

x = score of thefts per police district

μ = mean

σ = standard deviation

y = survey participants' home location

z = survey participants' expected destination

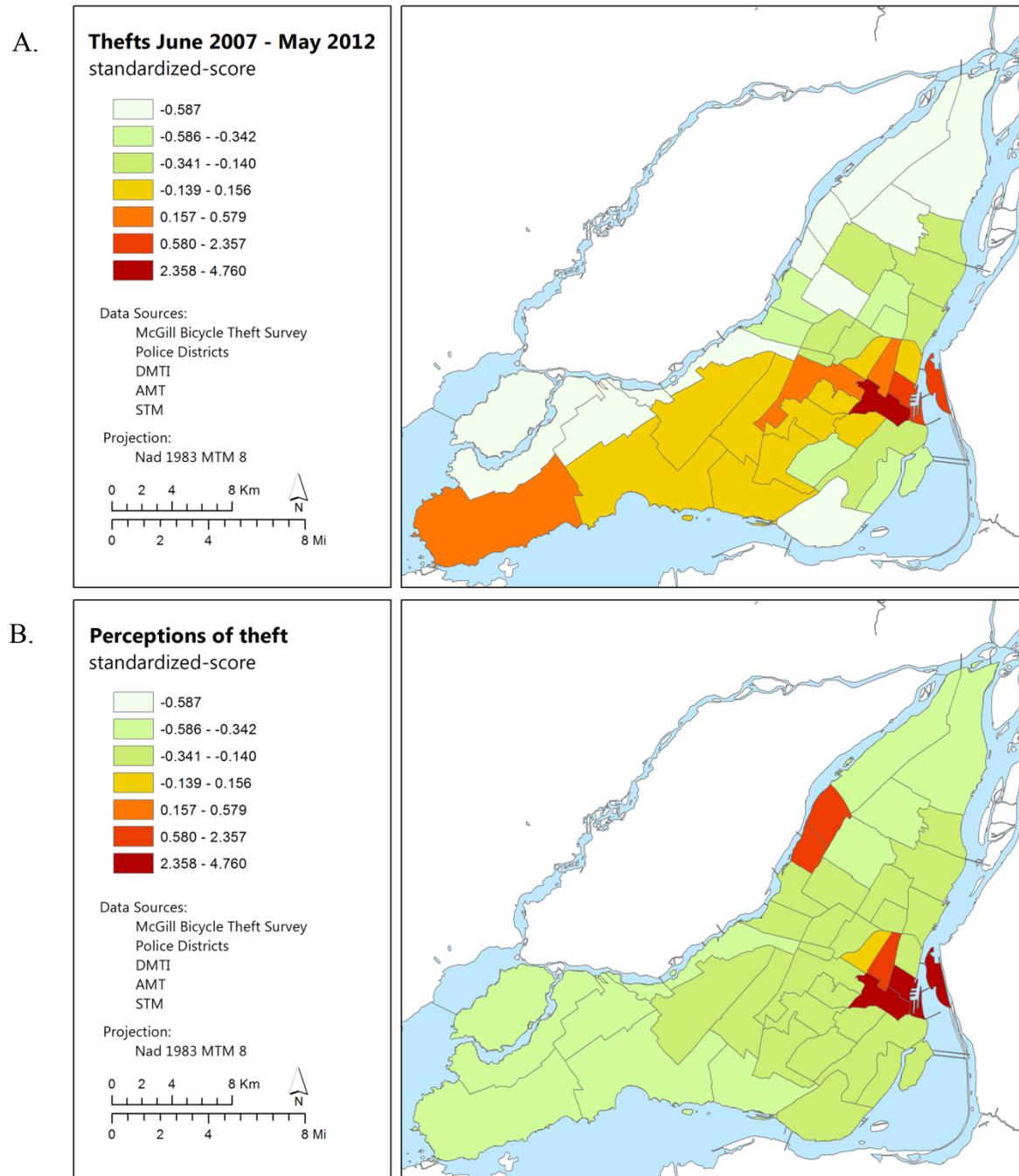


Figure 3: (a) Bicycle thefts within the five-year period between June 2007 and May 2012 and (b) areas on the Island of Montreal known for having high instances of theft

The standardized thefts per police district are mapped by standardized score (Figure 3). These maps represent bicycle theft on the Island of Montreal within the five-year period between June 2007 and May 2012 as well as the areas that survey participants identified as being known for having high instances of theft (similarly standardized to expose differences between infrequently bicycled districts).

The highest standardized score is observed in the downtown police district. This is followed by neighboring police districts and the southwestern end of the island. Actual theft counts were over twice as high in the Lower Plateau, a trendy and densely populated neighborhood bordering downtown to the north, as anywhere else, but were tempered by very high rates of bicycle use. Conversely, the high rates featured for sprawling West Island neighborhoods largely reflect very low ridership.

When asked to identify which areas of the city were known to have high instances of bicycle theft by placing a pin on a map, cyclists' responses broadly matched the measured reality, showing a degree of theft awareness, but there were some notable differences. Perceptions of theft were calculated similarly to actual theft; the same formula was applied, but the variable *st* was replaced with standardized perceived thefts per police district. Results of the analysis show that Old Montreal, to the downtown's east, was perceived as having incidences as high as the downtown, but suffered fewer actual thefts, both in absolute and standardized terms. This pattern of imagined theft occurring farther east (and north) than actual theft can be seen on a larger scale across the island and might reflect conceptions of higher density or lower income areas (similarly situated) as being less safe than wealthier suburbs. Most dramatically, Montréal Nord, a traditional immigrant neighborhood far north of downtown, is perceived as a high instance area (after standardization), despite a total absence of thefts reported in that district.

The apparent disconnect between actual and perceived theft locations suggest that some cyclists might underestimate risk of theft in their own neighborhoods. In general, survey participants perceive bicycle theft to occur most frequently at least 5.5 kilometers from their home location. The actual average distance from participants' home locations to the reported theft locations, however, is 3.2km (for thefts that occurred between June 2007 and May 2012).

Bicycle Parking

Johnson et al. (2008) claim that parking and locking habits are closely related to risk of bicycle theft. According to their report, lock type and application, as well as where and to what a bicycle is locked, are the key factors most likely to influence bicycle theft. With regard to bicycle parking, Sidebottom et al. (2009) claim that there is a need for increased locking facilities based on the observation that nearly half of the parked bicycles in their study were 'fly-parked'. Fly-parking, a term coined by Adam Thorpe, refers to the securing of bicycles to street furniture not intended to function as parking facilities (Gamman, Thorpe et al. 2004). It reflects the appeal of being able to move through the city freely and experience parking near destinations, eliminating the spatial restrictions that are often attributed to the automobile. The data in our survey corroborates Sidebottom et al.'s (Sidebottom, Thorpe et al. 2009) finding that nearly half of all stolen bicycles were stolen from fly-parking locations. There appears to be, therefore, a need for an increase in bicycle locking facilities in Montreal.

The Montreal Bicycle Theft Survey asked participants to evaluate six different types of bicycle racks with regard to security (Figure 4). While racks one to five are found in Montreal,

rack six is not publically available in the city. Rack four has the lowest ranking; it has visibly thinner metal bars and is not secured to the sidewalk. Rack six has the highest ranking; it functions as a bicycle locker in which the entire bicycle is stored. In response to a question about which factors cyclists look for when they are locking their bicycle, ease of locking and proximity to destination point are the most highly regarded factors. A place being officially designated as bicycle parking is also deemed important. Cyclists who value parking places that are well lit so that their bicycle is easy to see tend to rank racks two and three higher than the other available rack types in terms of security. In Montreal, these racks tend to be located on the sidewalks of commercial streets, in areas with high levels of pedestrian and cyclist movement.

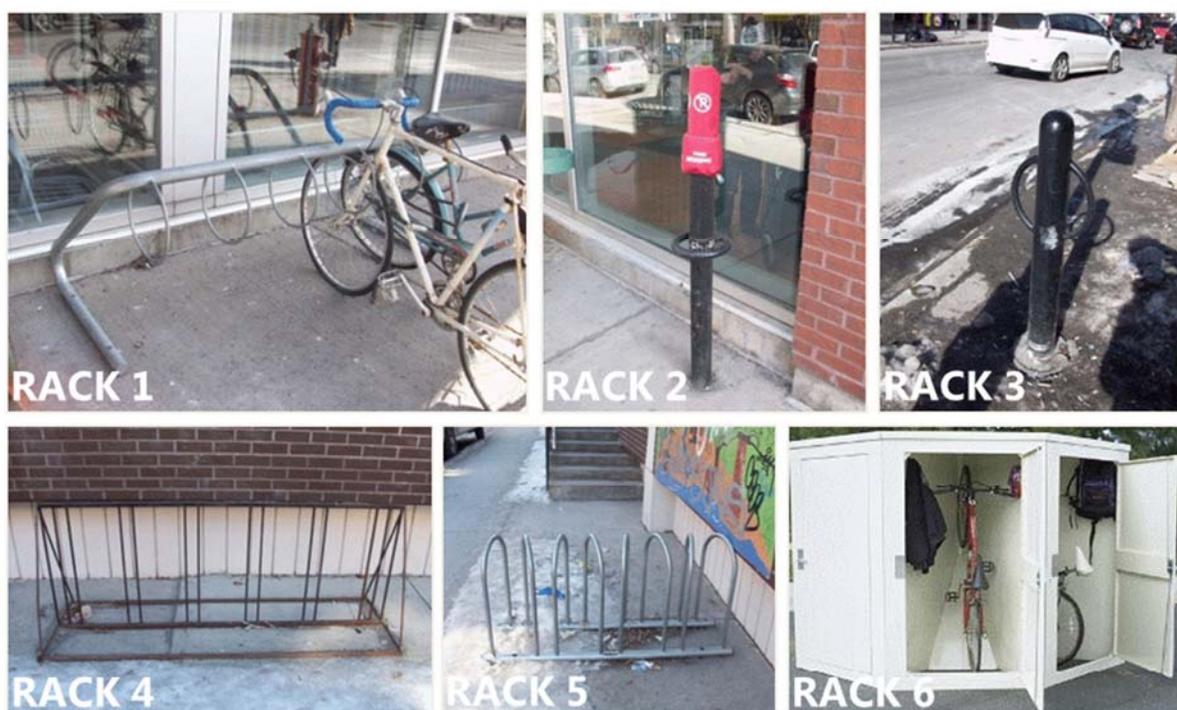


photo credit: rack 1- 5 courtesy of author, rack 6: <http://www.bikegard.net/photo1.gif>

Figure 4: Bicycle racks

As well as rating bicycle rack types, survey respondents characterized general bicycle parking security and availability at five types of locations: at metro stations, near home, near work or school, in the downtown area, and by grocery stores. Parking security near work or school appears relatively good, with 60% of all responses favorable (either “satisfied” or “very satisfied”), compared to rates around 30-35% for other location types. Even work or school locations, however, show room for improvement, with 20% “unsatisfied” or “very unsatisfied” responses. Parking availability, similarly, appears better at work and school than elsewhere: about 55% favorable compared to corresponding scores around 25-35%. As with security, work and school parking availability could be improved, though. Nearly 30% of respondents were “unsatisfied” or “very unsatisfied”.

Thirty-five percent of written suggestions at the end of the Montreal Bicycle Theft Survey involve parking racks. A factor that might inform decisions about new bicycle parking is cost, and relatedly, cost sharing. Many people were unwilling to pay for secure bicycle parking, for reasons such as cost (39.0% of those unwilling), unfelt necessity (34.9%), or principle (19.4%). “The goal of biking, among others, is to save money”, wrote one study participant. A large minority of respondents (37.2%), however, indicated that they would pay something for such improved facilities. Owners of high value bicycles (>\$500) are more often willing to pay for secured parking (57%) compared to owners of low value bicycles (32%). Responses suggest that either \$1.00 or \$2.00 would be ideal rates, at 29.8% and 16.0% acceptability, respectively. Popularity appears to drop off immediately as each dollar value is exceeded, at only 18.4% willing to pay \$1.25 and 7.0% at \$2.25. These rates are low in comparison to those paid for automobile parking, and secure bicycle parking, such as that pictured as Rack 6 in Figure 4 would likely require some subsidy. Compared to automobile parking, however, secure bicycle parking takes much less space per vehicle, and it encourages use of the preferred transportation mode, working to reduce costly traffic congestion while contributing to an active, healthy population and workforce.

WHAT: *What kinds of bicycles are most commonly stolen?*

Stolen bicycles and bicycle parts

The most frequently stolen bicycles are new bicycles that at the time of the theft were valued between \$150 and \$500 (27% or 256 of 961 total stolen bicycles). Used bicycles in the same price range (15%) and new bicycles valued between \$500 and \$1000 (16%) were the second most frequently stolen. Many more used bicycles priced at under \$150 (28%) were stolen compared to new bicycles (1%) in the same price range. Owners of high value bicycles more frequently increase protective measures. They use high value locks with 71% of high value bicycle owners using locks valued at more than \$40 compared to only 47% of low value bicycle owners. Similarly, users of high value bicycles also more frequently claim to always keep their bicycles inside as an action to avoid bicycle theft. Around 24% of high value bicycle owners took such protective measures compared to only 13% of low value bicycle owners.

After a theft, around 36% of participants claimed that they did report the crime to the police. Of the participants who did not report their theft, the majority reported that they did not think it was worth the effort. Only 8.5% of bicycle theft victims had registered their bicycle, and of these people 26.8% did not record the serial number (which would allow victims to positively identify their bicycle on sight). The survey asked participants if they had photos of their bicycle that they could give to the police to assist in an investigation; merely 27.8% of participants reported that they possessed photos for this purpose. Johnson et al. (2008) also report that the majority of bicycle owners cannot provide enough supporting documentation to support in an investigation. The proof-of-ownership problem must be addressed to improve the police’s

likeliness to recover stolen bicycles and return them to their legitimate owners. Only 2.5% of survey respondents' most recent stolen bicycles had been recovered.

Not only do victims rarely recover their bicycles, but they often have replacement bicycles stolen as well. While only 961 respondents (about 50%) had been victims of bicycle theft, the total number of bicycles stolen was at least 1890, owing to high numbers of multiple theft victims and of thefts from some victims. A majority (525 respondents) had only once lost a bicycle to theft, but nearly 20% had been victims three times or more. Theft of bicycle parts is about half as frequent overall, but displays a similar pattern of multiple theft victims. The most frequently stolen parts are accessories (40.3%), seats (30.1%), and wheels (20.1%), with handlebars, frames, pedals, breaks, and other parts each stolen in less than 5% of cases.

HOW: *How are bicycles most commonly stolen?*

Theft technique

Most bicycle theft victims surveyed (52.3%) do not know the means by which the most recent theft occurred (the cut off for most recent thefts was set at 1990). A sizeable minority (20.5%), however, report that their bicycle was simply picked up and moved, echoing the importance of locks evidenced by the logit model. Other commonly reported means include bolt cutters (10.3%), hacksaws (4.5%), and crowbars (2.3%). As was mentioned earlier, 8.5% of victims did not lock their bicycle.

The theft of bicycle parts can be more easily explained. Only 27.6% of responding victims of parts theft do not know how it happened. Screwdrivers (8.5%), wrenches and Allen keys (4.1% each) are the leading part theft tools reportedly used, but 51.5% of parts theft events described required only pulling the part(s) off. Unfortunately, 60.6% of respondents currently leave removable bicycle parts unlocked. Substantial reduction in theft of removable bicycle parts might be achieved if locking them becomes the norm.

WHEN: *When are bicycles most likely to be stolen?*

Seasonality and time of day

Cycling and theft are both most frequent in summer months. Considering all bicycle thefts reported in the survey, findings illustrate that every calendar month between 2 – 10% of cyclists on the road had been victims of bicycle theft. Survey participants could report multiple months for riding, but they could not for theft, as detailed information was only collected on the most recent bicycle theft event and/or bicycle part theft event, as applicable. The actual rate for cyclists ever having had a bicycle stolen is about 50%, roughly double the rate for bicycle parts. Figure 5 makes clear that a greater number of bicycles are stolen in months when more bicycles are being used. Theft of bicycle parts shows a similar pattern. Thefts rates peak in July and drop significantly in August even though ridership levels remain similar from May to September.

While this drop cannot be explained by the data, it might represent a decrease in the demand of bicycle sales.

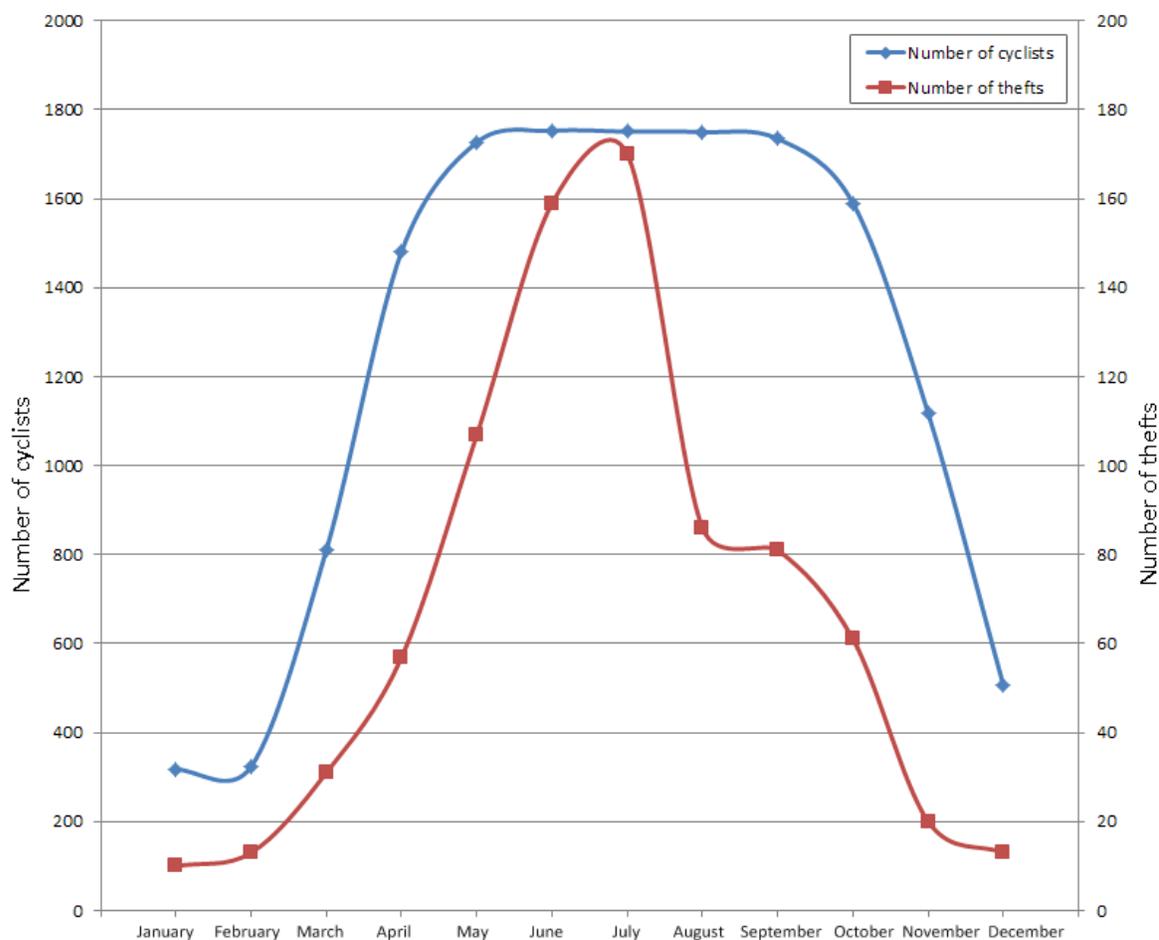


Figure 5: Number of cyclists and number of thefts per month

Bicycles are more frequently stolen during the night (37.0%) than in the morning (9.0%), afternoon (32.3%) or evening (21.7%). In the comment section at the end of the survey many people state that bicycles should not be left on the street at night. One participant claimed that her “last bike was locked to a bike rack outside [her] apartment with a high security U-lock, yet it was stolen overnight. [Now, she is] forced to bring [it] into [her] apartment every night, which is a nuisance”. Almost as frequent, however, is afternoon theft (the most frequent time for bicycle parts theft), and over three fifths of bicycle thefts happen at some point during the day, when bicycles are likely to be parked at a destination other than the rider’s home and are presumably visible to passers-by. There is, therefore, substantial potential for theft reduction by improving bicycle parking facility provision and locking habits.

Before and after bicycle theft

Many current cyclists have at one or more times been victims of bicycle theft, rarely to see their rides returned. While this fact is itself unsettling, it is possibly more problematic, for those attempting to increase regional bicycle commute mode share, that some victims do not replace their stolen bicycles (7.3%). An interesting counterpoint is that among those who do, or who have their stolen bicycle recovered, 24% report increased cycling, compared to 15.5% who cycle less and 60.5% who report no change. One explanation is that replacements for both new and used stolen bicycles are more often new than used, and are possibly better suited to riders' travel needs, enabling use for longer or more difficult trips. Unclear from this study (because the vast majority of respondents do commute by bicycle or have done so), is the degree to which theft discourages non-riders from attempting bicycle commuting.

Bicycle theft victims who continue cycling appear to make efforts to adapt and reduce their risk of further theft. Around 61.1% of theft victims subsequently change the type of lock that they use. Of bicycles that were replaced or recovered, only 3% are usually left unlocked and 71.1% are currently locked with U-locks. Less than a quarter of parts thefts motivate a lock type change, but this does not necessarily indicate irresponsiveness, as victims might improve technique, fastening some removable parts and taking others with them into destinations.

Bicycle registration, although shown in the logit model to relate positively with stolen bicycles, stays at 8.5% for both stolen bicycles and theft victims' current bicycles. However, only 40.2% of those who had registered their stolen bicycles chose also to register their current bicycles, evidencing a lack of faith among those who have had personal experience with registration.

Bicycle recovery

Of all stolen bicycles, as mentioned above, only 2.4% had been recovered. This small sample size reduces the reliability of information that characterizes recovered bicycles in comparison to unrecovered bicycles. However, some statistics appear relevant and bear mention. Two thirds of recovered bicycles were reported stolen, compared to only 34.8% of unrecovered bicycles. In the open-ended questions at the end of the survey several respondents claimed that they had recovered their unregistered and unreported stolen bicycles by finding them again after a theft occurred. Recovered bicycles had been photographed 37.5% of the time and 12.5% were registered, in contrast to unrecovered bicycles (26.8% photographed and 8.2% registered). Reporting a bicycle theft should, and does, substantially improve the likelihood of recovery (testing significant at the 99% confidence interval [see Table 2]), if still to a very low rate. Photographing and registering bicycles also appear to have some positive effect, although the numbers involved are too low to make a strong claim. It is interesting that a third of recovered bicycles were not reported stolen: perhaps respondents recovered them on their own. Most compelling, however, is the evidence that, while measures such as reporting, photographing, and registering bicycles might improve chances of recovery, they offer little assurance that a bicycle

will be returned. While only 22 stolen bicycles (2.3% of most recent thefts) were reported stolen, registered, *and* photographed, indicating substantial room for improvement on the part of owners, *not one* of these bicycles had been recovered at the time of the survey, suggesting currently insufficient police attention to bicycle theft that is echoed in 24% of written comments.

DISCUSSION

This research can be helpful for different regions and not only the City of Montreal in their efforts to better understand bicycle theft and upgrade theft-preventing infrastructure as it attempts to increase bicycle mode share in their regions. It provides an account of bicycle theft that includes information and instances not available from official police reports. Results from this study have driven public policy and are currently being used by the City of Montreal to create an educational theft-preventing campaign in the borough of Rosemont-Petite-Patrie. The study makes clear that public agencies should act to prevent theft by adding bicycle parking capacity and ensuring that parking facilities are strong (thick metal well-anchored), easy to properly use (locking to bicycle frame and removable parts), visible, and located near destinations such as work, school, shopping, and recreation. Improvements to bicycle parking facilities should also include removing unsafe racks and installing alternative racks that are secured to the ground and feature thick metal bars at an appropriate height for easy and effectual locking. Other actions that public agencies can take to help reduce bicycle related crime, are to fit both new and existing racks with prominent signage showing proper locking technique, and to offer workshops or audio-visual materials to schools and other organizations that provide information about bicycle theft prevention, stolen bicycle recovery, and registration. Police districts, such as those located in the downtown core, that are most in need of bicycle parking improvements, were also the same areas that were known for having high rates of bicycle theft per rider. It is important to note that bicycle parking improvement should be determined based on field observations of existing rack quantity, quality, and vacancies, and not only based on theft statistics. Police departments need to be more transparent in the area of bicycle theft to report recovery rates and organize registration campaigns with local cycling agencies. Although bicycle registration had a little role in recovery, it is recommended to increase awareness of these services among cyclists and at bicycle shops.

Theft can likely be reduced by using better locks, securing removable parts, and practicing safe locking techniques. Although public agencies in cities are advised to take leading roles in bicycle theft prevention, cyclists must recognize that bicycles are likely targets of crime, and take preventative actions by always locking their bicycle and ensuring that frames, as well as easily removable parts, are secured. While the police should improve the transparency of bicycle theft investigation procedures, cyclists should register and photograph their bicycles, and report instances of theft to the police to improve the chance of recovery.

This study focuses on Montreal and many factors might be different in other cities or regions, but the magnitude both of the problem of bicycle theft and of the under-reporting seen

here are compelling. Information on bicycle theft available through official means in other cities might be similarly incomplete and insufficient so other cities might benefit from conducting similar surveys. Too, insight gained here about cyclists' parking facility preferences and locking habits and effectiveness might be broadly applicable elsewhere, and might be used to influence cities to promote specific types of bicycle racks and education programs. Findings about cyclists' opinions on police involvement can be useful to assist in policy changes that improve the transparency of theft investigation procedures in hopes of increasing recovery rates and bicycle mode share.

CONCLUSIONS

This research has attempted to understand bicycle theft by asking 1) *who* are the victims of bicycle theft; 2) *where* does bicycle theft occur most frequently, and where is it perceived to occur most frequently; 3) *what* kind of bicycles and bicycle parts are most commonly stolen; 4) *how* are bicycles and bicycle parts most commonly stolen; and 5) *when* are bicycles most likely to be stolen. With regard to understanding *who* the victims of bicycle theft are, the most striking finding is that over 50% of participants were subjected to a bicycle theft in their life time as active cyclists. The logit model makes clear that the monetary value of a bicycle, lock type, and a cyclist's gender influence his or her likeliness to have been a victim of bicycle theft. Thematic maps make clear *where* thefts occur, and *where* thefts are perceived to occur. The maps illustrate that theft rates are, and are perceived to be, most prominent in the downtown police districts. However, there appears to be a disconnect between actual and perceived theft locations in many regions, which suggests that some cyclists might underestimate risk of theft in their own neighborhoods.

The majority of theft victims had only once lost a bicycle to theft, but nearly 20% had been victims three times or more. Theft of bicycle parts is about half as frequent overall, but displays a similar pattern of multiple theft victims. Concerning *what* kinds of bicycles are mostly commonly stolen, the results show that the most frequently stolen bicycles are new bicycles, which at the time of the theft were valued between \$150 and \$500. Many more used bicycles priced at under \$150 were stolen compared to new bicycles in the same price range. Although cyclists are generally aware of *how* parts were stolen from their bicycles, the means by which the most recent theft of a whole bicycle occurred is unknown for the majority of victims.

With respect to understanding *when* bicycles are most likely to be stolen, theft evidently occurs most frequently in months when more bicycles are being used. Because the majority of thefts occur during the day, when bicycles are likely to be parked at a destination other than the rider's home and presumably visible to passers-by, there is substantial potential for theft reduction by improved bicycle parking facility provision and locking habits. Pertaining to bicycle parking facilities, respondents are largely unsatisfied with current parking facility security and availability at most destinations, and rack types such as racks 2, 3, and 6, in figure 4 are perceived as being more secure than others.

In future studies it would be interesting to track changes in theft frequency from year to year. In the current study, over a quarter of both complete bicycle thefts and partial bicycle thefts were reported to have occurred in 2011 and 2012, despite theft events being mentioned as long ago as 1990 or earlier. However, because respondents only detailed the most recent theft (as well as noting the number of thefts they have experienced), previous incidents for victims of multiple thefts are not dated and underrepresented. Additionally, people who had been bicycle theft victims in Montreal in the distant past are more likely than recent local victims to have since moved out of the region and not filled out the survey. Subsequent bicycle theft surveys might benefit by including questions for timing of all thefts, rather than just the most recent, as well as amount of time having lived in the chosen region and at the current address. Future research should also include putting the collected data to more extensive use, by modeling the relationships between the characteristics of the victims, as well the observed differences between the reported and perceived locations of bicycle theft.

This research, based on a survey of cyclists in Montreal, Quebec, Canada, provides new insights into bicycle theft. The main findings from this study can not only be useful to better understand and ultimately decrease bicycle theft in Montreal, but can also be beneficial for cyclists, police, and policy makers in any city aiming to decrease bicycle theft. The creation of urban spaces that encourage cycling and discourage theft nurtures Montreal's cycling culture and encourages the use of the preferred and sustainable transportation mode, working to reduce costly traffic congestion and greenhouse gas emissions while contributing to an active, healthy population and workforce.

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