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 *under*represented, compared to O-D 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	*t*-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)	---	---	---

Parameters		Coefficient	*t*-stat	Odds Ratio
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, Nalgelkerke 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 likeliness to have had their bicycle stolen.

The model possesses a reasonable amount of explanatory power (Cox & Snell R square = 0.54, Nalgelkerke 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.

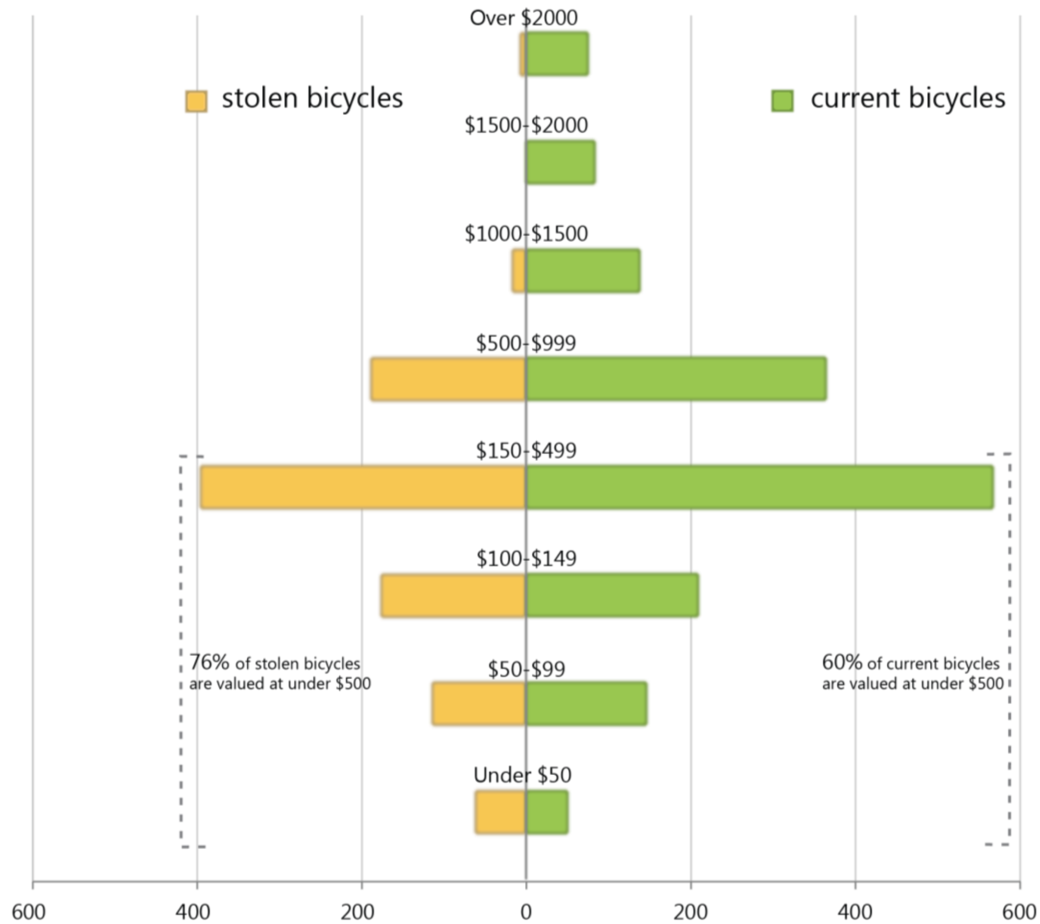


Figure 1: Difference in values between stolen and current bicycles

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.

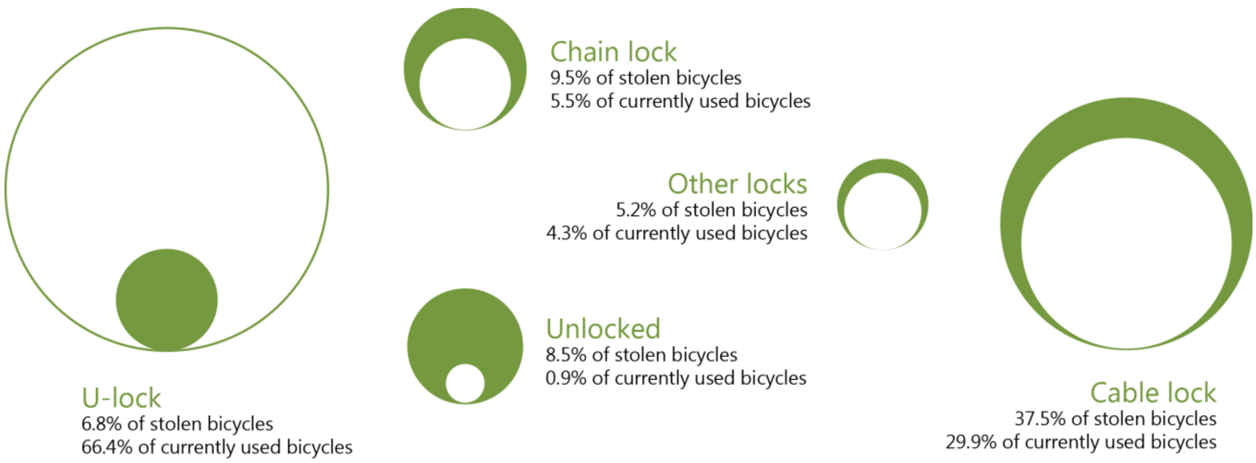


FIGURE 2: COMPARISON OF LOCKS USED ON STOLEN BICYCLES AND LOCKS USED ON CURRENT BICYCLES

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 partially 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* (O-D) 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 O-D 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

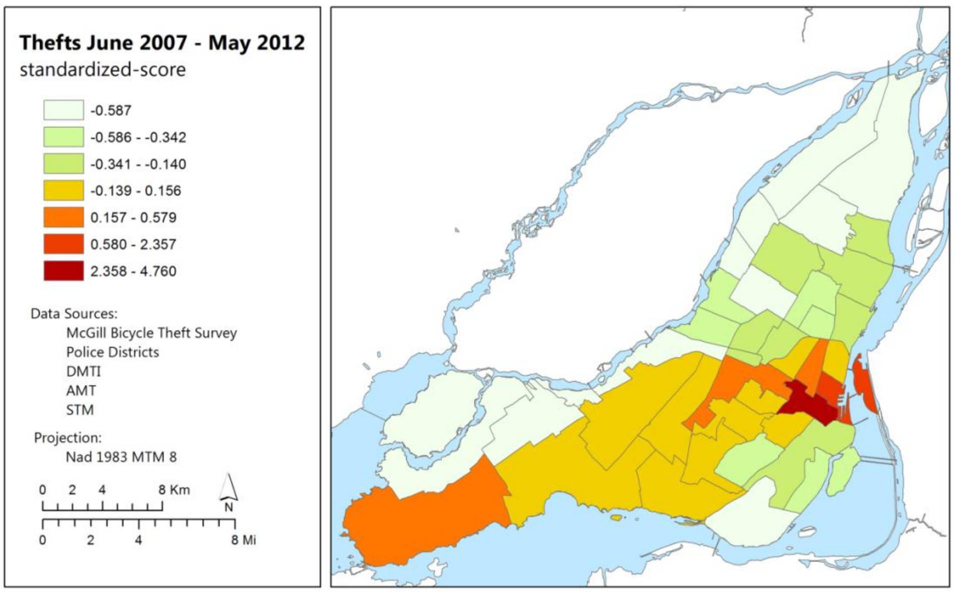
μ = mean

σ = standard deviation

y = survey participants' home location

z = survey participants' expected destination

A.



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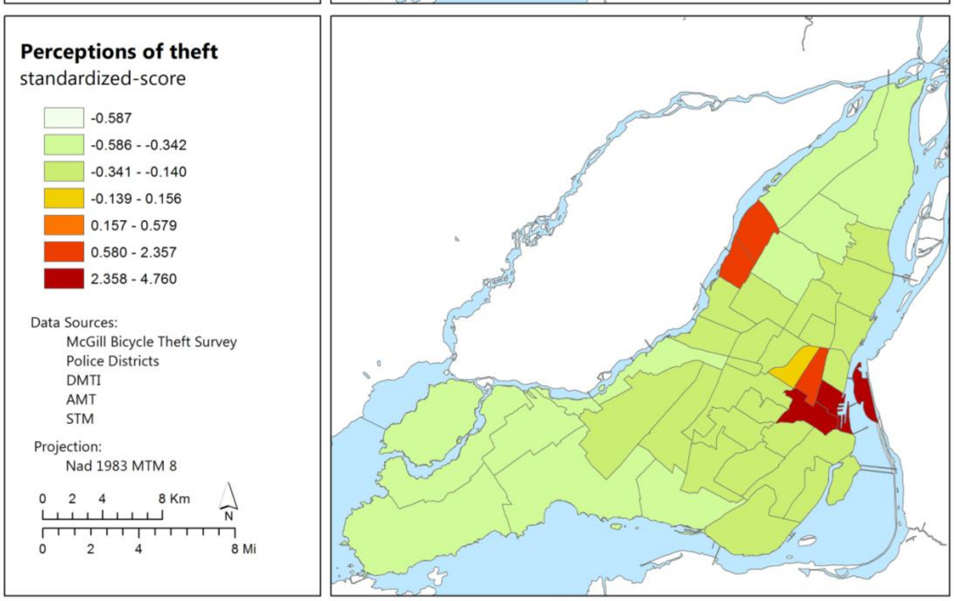

FIGURE 3: (A) BICYCLE THEFTS WITHIN THE FIVE-YEAR PERIOD BETWEEN JUNE 2007 AND MAY 2012 AND (B) AREAS ON THE ISLAND OF MONTREAL KNOWN FOR HAVING HIGH INSTANCES OF THEFT

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 and identified as the darkest police district on the maps. 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 both in their own neighborhoods as well as in others. 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, 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 (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 through 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.

FIGURE 4: BICYCLE RACKS *photo credit: rack 1- 5 courtesy of author, rack 6: http://www.bikegard.net/photo1.gif*

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. (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.