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A Methodology for Understanding the Differences Between Perceived and Observed Road Safety: A Montreal Case Study

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Abstract

Planners and municipal officials contemplating road infrastructure changes, including traffic calming measures or pedestrian/bicycle infrastructure to encourage active transportation, may struggle to evaluate competing claims about the safety of existing facilities. In particular, anecdotal accounts of road safety in specific locations may seem to conflict with observed accident rates. The purpose of this study is to explore the discrepancies between perceived and observed safety of intersections in a Montreal, Canada neighbourhood and to present a “meta-methodology” analyzing the usefulness of our multi-method approach. We use surveys of local residents, visual observations and traffic counts at intersections, GIS analysis of traffic injury data, and interviews with key community informants to explore why perceptions of risk differ from accident patterns. Our results suggest that city planners seeking to encourage active transportation should not disregard residents’ perceptions, and that a multi-method approach can help integrate these perceptions into the broader analysis of a transportation policy issue.

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Introduction

Despite falling crash fatality rates over the past 30 years (Ramage-Morin, 2008), traffic safety remains a concern in Canadian urban neighbourhoods. This is particularly true in light of recent environmentally- and health-motivated efforts to promote human-powered modes, such as walking and cycling, as utilitarian forms of transportation. Those who are reluctant to use these modes often cite safety concerns as a barrier (Reynolds et al., 2009), but it can be difficult to objectively evaluate the severity of safety concerns and the appropriate policy responses. This paper analyzes the methodology of a study comparing perceived pedestrian and bicycle safety with observed collision data in an urban Montreal neighbourhood. The study used four main data sources to explore where and why gaps might exist between residents' concerns and the observed risks of being injured as a cyclist or a pedestrian, and to provide a basis for policymaking with respect to active transportation. This paper takes a step backward from that study to produce a “meta-methodology”, examining the contributions of each of the study's data sources to its overall conclusions. It highlights the role of synthesizing multiple types of data, from multiple sources, to gain a broad understanding appropriate for policy formulation. Not only does a mixed-method approach provide a basis for comparing perception and observation, its flexibility and minimal need for resources makes it a feasible research option for small municipalities seeking to improve their walking and cycling environments.

Why perception matters

Considerable research has argued that for cyclists and pedestrians in particular, perceived safety is a more important factor than “actual” safety—as defined by accident rates—in evaluating the ability of road environments to serve the needs of users. As noted by Landis et al. (2001), Jacobsen, Racioppi and Rutter (2009) and Reynolds et al. (2009), vehicle drivers and passengers are more protected from other road users and less subject to environmental conditions than pedestrians and cyclists are. Pedestrians and cyclists are therefore likely to choose routes—or even to choose to walk or bike at all—not due to simple efficiency calculations but to a wider range of factors relating to time, efficiency, safety and aesthetics (Klobucar and Fricker, 2007; Harkey et al., 1998). The implication, as noted by Hillman et al. (1990), is that

[R]oad accident statistics are a very bad, and often misleading, measure of safety or danger. Where danger is perceived, the perception is acted upon [I]f certain areas or situations are seen as dangerous they are avoided, or entered with a high level of vigilance, with the result that the danger is not reflected in the accident statistics. Yet, the only proof that many highway authorities will accept that a road is dangerous, and

merits measures to slow or divert traffic, is a large number of accidents. (4)

The ecological fallacy highlighted here has also been observed by Cho, Rodriguez and Khattak (2009), who find some evidence of a correlation between individuals' risk perception and behaviour, but who stress that the reasons and mechanisms for these behaviour changes are not well understood. They cite several bodies of research suggesting that behaviour changes in response to perceived risk may be influenced by people's ability to accurately or rationally evaluate environmental cues.

For example, Noland (1995) writes that behaviour changes may also be partly explained by the theory of risk compensation (Peltzman 1975, cited in Noland) or risk homeostasis (Wilde 1982). A contested concept in transportation literature, risk homeostasis proposes that "people compensate for risk reductions by being more careless" (Noland, 1995, 506).¹ Noland evaluated commuters' risk perception and found that bicycling was perceived to be the riskiest commuting mode (compared to walking, driving, and transit). He also found, however, that biking has a high elasticity—that is, small reductions in perceived risk will lead to comparatively larger increases in the share of bike commuting.

This could have adverse consequences on net transportation system risk, if bicycling is riskier than other modes and the perceived risk reductions do not correspond with reductions in objective risk. For example, if people perceive bike paths (separated from streets) to be safer, but they actually are not, this could increase the total accident rate by increasing the level of bicycle transportation. (514)

Noland notes that these relationships are relatively small, as people do not necessarily choose the mode they think is safest; many other economic and social factors play into mode choice. Nonetheless, these findings highlight two major considerations: first, perceived risk is the key variable affecting behaviour; and second, changes in travel behaviour may have unexpected or counterintuitive effects on observed risk.

Cho, Rodriguez and Khattak (2009) tested the mediating impacts of perceived and observed crash risk on each other using a path analysis, controlling for variables such as neighbourhood density, socio-economic status and respondent age. They found that while high observed crash rates tended to increase perceived risk among nearby residents, high perceived risk among residents tended also to be associated with lower actual crash rates. They suggest that the significance of these findings is different in different types of neighbourhoods: in higher-density, mixed-use areas, traffic safety efforts should focus on bringing users' relatively low perceived risk into line with the neighbourhoods' relatively high observed risk. In low-density, single-use neighbourhoods where perceived risk is higher than observed risk (perhaps due to the speed of vehicles), traffic safety efforts may need to encourage more people to walk or bike by reassuring them that their neighbourhoods are safe for these pursuits.² McGinn et al. (2007) have also found a poor correlation between perceived or observed

built-environment characteristics and walking behaviours, but a much stronger correlation when perceived and observed characteristics were considered together. The overall research findings in this area suggest that neither perceived nor observed risk factors can be considered in isolation when formulating design or policy interventions.

Understanding the relationship between perceived and observed risk is important in light of the potential societal impacts of the changes in travel behaviour associated with changes in perceived risk. Hillman et al. (1990) found that one effect of road environments that are viewed as unsafe for children has been a decrease in children's autonomy: British and German children were permitted to walk or bike to school without an adult at significantly later ages in 1989 than in 1971. Traffic danger was cited by English parents as the most important reason for not letting their children return from school alone.³ Due to lower exposure to potentially dangerous traffic situations, the authors argue, road death rates among children plummeted between 1922 and 1986 but were transferred to the adolescent "new driver" age group, where rates rose fourfold during the same period. They note that limiting children's independence may contribute to delaying their development into mature decision-makers, reducing their physical fitness, and increasing traffic, lost time and greenhouse gas emissions as their parents escort them by car.

In a similar vein, Grow et al. (2008) found that parents who perceived a high level of traffic safety in their neighbourhoods were more likely to permit their teenage children to walk or bike to recreation sites, permitting adolescents to access physical activity (through both the journey and the destination) without the supervision of a parent. The authors argue that the perception of traffic safety may therefore have a significant impact on public health issues such as childhood obesity.

Other authors have been careful not to overstate the impact of perceived traffic risk on travel behaviour and, in turn, on public health: Giles-Corti and Donovan (2002) write that individual and social factors play a greater role in decisions to use public spaces than the design of the spaces themselves, while Leslie et al. (2005), in a comparison of two Australian residential neighbourhoods, found that built-environment factors such as density, land-use mix and street connectivity had a major influence on walking behaviour in two neighbourhoods with similar perceptions of traffic safety. Still other authors have examined the impact on children's mobility of general neighbourhood safety, without separating perceptions of traffic safety from perceptions of crime (see, for example, Loukaitou-Sideris & Sideris, 2010); these studies have found that lower perceived safety is associated with lower use of public spaces, particularly parks.

Overall, the Westmount road safety study examined in this article aimed to address concerns that have a basis in existing planning literature, as discussed above; namely, that perceived safety affects behaviour in ways that are not easily understood, and that behaviour, in turn, is likely to affect

broader community health and social outcomes. Finding and implementing straightforward, cost-effective and accurate ways to evaluate safety concerns is therefore an important element of policy-making for small municipalities.

Methodology

This study focused on perceived and observed safety in Westmount, Quebec, Canada. Westmount (pop. 20,827 in 2010) is a 3.9-square-kilometre, independent municipality located near downtown Montreal, and is fully surrounded by the City of Montreal. Incorporated as a town in 1890 and built up most rapidly in the ensuing 20 years, most of its land contains single-family or low-rise residential uses or parks (City of Westmount, 2005). It has several mixed-use commercial main streets and some large-scale office developments at its southeastern edge. Westmount is notable for its generally high socio-economic status; census tracts in the northern portion, in particular, have a median income several times the Montreal average (Statistics Canada, 2006). Family incomes in the southern portion of the municipality, where most commercial streets and high-traffic arterials are located, are also above the Montreal average. Westmount's topography is relevant to active transportation patterns: while fairly flat between its southern edge and Sherbrooke Street, its north-south streets become significantly steeper as they approach the summit of Westmount [need a figure—will add in final version].

In 1993, Westmount implemented a dedicated cycling path along de Maisonneuve Boulevard, just south of Sherbrooke Street, its main arterial and commercial strip. In response to concerns that the path was unsafe for pedestrians, and that other areas of Westmount continued to be unsafe for cyclists, this study was undertaken to examine the relationship between the concerns being identified and any locations or broader urban factors that were observed to pose a risk.

Data gathering for this study consisted of four separate activities: direct traffic counts and observations, a paper-based survey, interviews with key community informants, and GIS analysis of crash data collected from emergency response units.

Early in the study, following preliminary discussions with local police officers who identified problematic intersections, six intersections were selected for direct observation. Each intersection was observed twice in the late afternoon for an hour at a time. Observers recorded the total number of bicycles and pedestrians passing through the intersection during the hour, as well as the number and nature (car-bike, pedestrian-bike, etc.) of any conflicts⁴ observed. Finally, observers recorded general notes about what they observed to be the key sources of risk at the intersection in question. The data

for each location were tabulated and conflict rates⁵ were calculated. Intersection counts that took place near schools after the end of the school year may have recorded fewer users than usual, but all counts allowed the researchers to observe basic usage patterns and conflict mechanisms.

The paper-based survey was designed to assemble both qualitative and quantitative information about perceived safety in Westmount. In a three-page survey consisting of 12 questions, respondents were asked to provide information about their trip frequencies and mode choices, any specific Westmount locations they believed to be dangerous for various road users (including pedestrians, cyclists and vehicle drivers), and any groups of road users that made them feel unsafe as pedestrians or cyclists. The survey was administered in part by in-person surveyors at several of the key intersections previously used for direct observation, and in part through community organizations and institutions (specifically, the local arena, library, seniors' drop-in centre, bike shops and walk-in clinics) that agreed to act as pick-up and drop-off points for the survey form. Data from the 165 returned surveys was coded in SPSS and used to generate frequency tables and graphs. The small sample size limited the statistical analyses that could be performed, and was disproportionately female and non-cyclist; certain questions also had low response rates. Nonetheless, the survey allowed the researchers to prepare basic frequency tables to identify issues and intersections of concern.

The researchers then obtained crash data from the Société de l'assurance automobile du Québec and compared them with the number of trips taken according to the Montreal Origin-Destination survey. The comparison provided an estimate of the number of crashes per trip taken in each area of Montreal. They also obtained ambulance pick-up data from the Direction de la santé publique (DSP) and mapped the locations with the most frequent pick-ups as compared to the locations most often identified as dangerous by survey respondents. Unlike Cho, Rodriguez and Khattak (2009), who measured perceived safety at the individual level and observed crash risk at the neighbourhood level, this study has attempted to present results at the intersection level, to observe the relationship between perceived and observed risk on a smaller scale. The researchers subsequently used the same data to create graphs comparing pedestrian and cyclist accident rates with estimated traffic volumes in each borough or municipality on the island of Montreal.

Interviews with key community informants took place during the later portion of the study period. These semi-structured interviews gathered qualitative information on what community leaders or officials perceived to be the most significant road safety hazards and the most effective possible solutions. Informants included the director of a seniors' activity centre, the director of children's programming at a local recreation centre, the presidents of two local cycling and pedestrian advocacy organizations, a Montreal police officer in charge of bicycle safety for the neighbourhood, and a Westmount Public Security officer who has been documenting cycling-related complaints and viola-

tions. Interviews took place in person at respondents' workplaces and lasted approximately half an hour. The interviewer took detailed notes but did not tape-record the interviews.

Informants were asked to describe what they perceived to be the key sources of cycling and pedestrian risk that they encountered in their work or for the demographic group they worked with. They were asked to specify whether particular locations, circumstances, times of day, or times of year were problematic, and to describe whether any of the sources of risk constituted a barrier to people's mobility. They were also asked how they found out about these risks (that is, whether they observed them directly or whether they heard about them from clients or members of the public), what they currently do to mitigate them, and what else they thought should be done about the sources of risk they identified. Interview notes were coded and recurring themes identified.

Results

The key findings of the original study were communicated in a research report to the City of Westmount. These were as follows:

- In general, Westmount is a safe environment for pedestrians and cyclists;
- When prompted, people easily identify factors they believe contribute to risk, and these perceptions are important to consider;
- Nonetheless, there is a gap between perceived safety and observed accident data at particular locations;
- Certain risk factors were identified that Westmount may be able to influence, including traffic speed and volume, non-compliance with traffic signals, poor signalization at intersections, and poor infrastructure design;
- Other risk factors are those that Westmount will be less able to influence, including road user inattention, seasonal hazards (such as ice and snowplows), and topography;
- The de Maisonneuve bicycle path is quite safe, but its perceived safety could be improved.

Westmount was generally perceived to be safe: as shown in Figure 1, most survey respondents were "not concerned" or "a little concerned" about their safety as pedestrians. Pedestrians were most concerned about cyclists (Figure 2), while cyclists were most concerned about vehicles (Figure 3). Nine per cent had been in a collision in Westmount as a pedestrian, cyclist or driver during the previous five years.

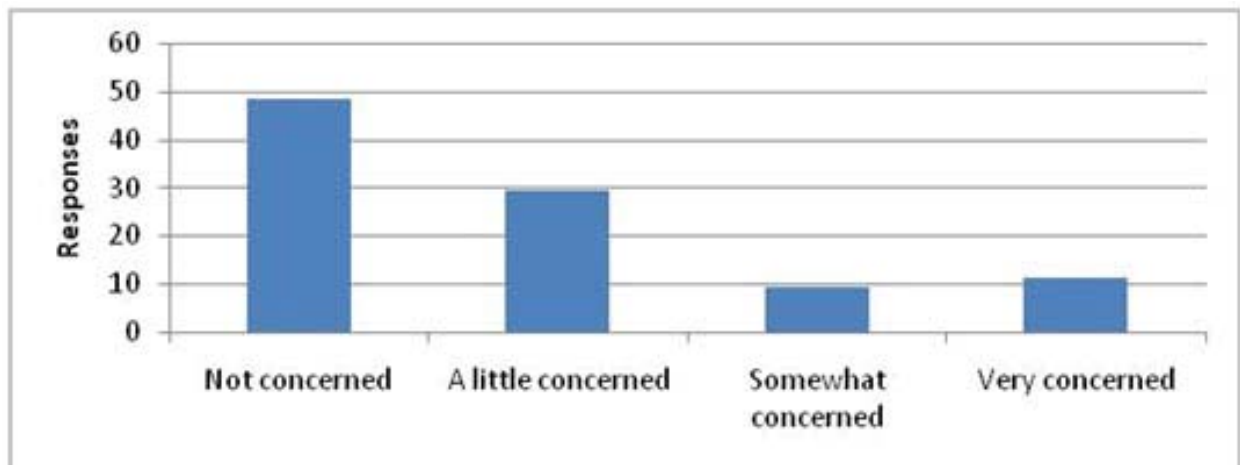


Figure 1: Survey respondents' concern with safety as pedestrians in Westmount

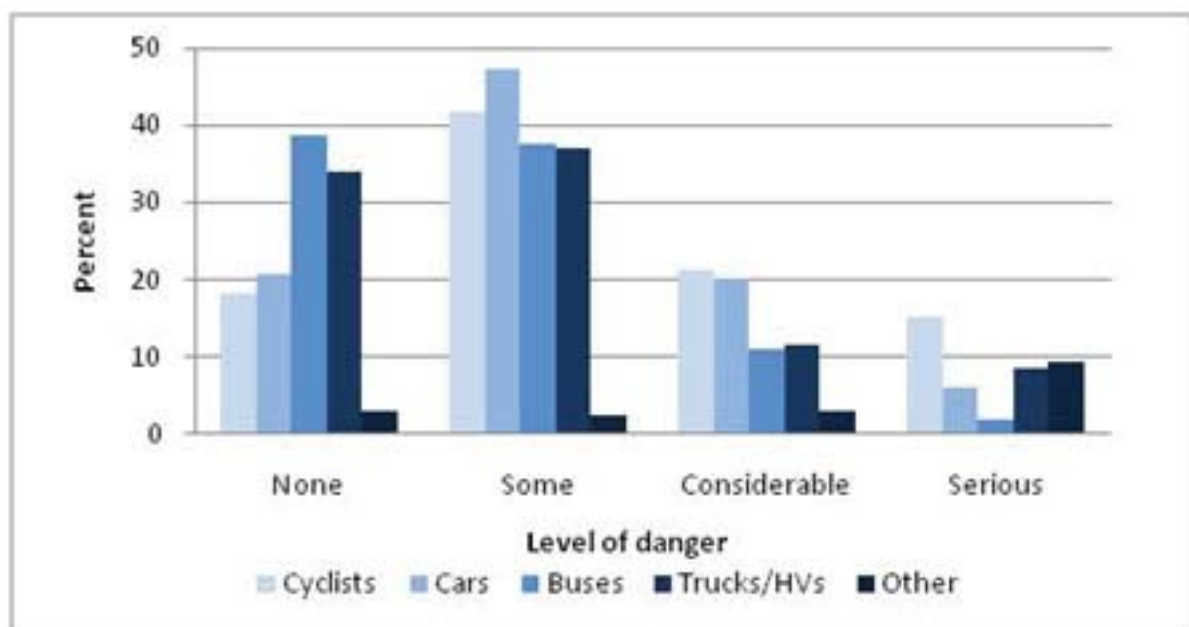


Figure 2: Survey respondents' perceived sources of danger as pedestrians

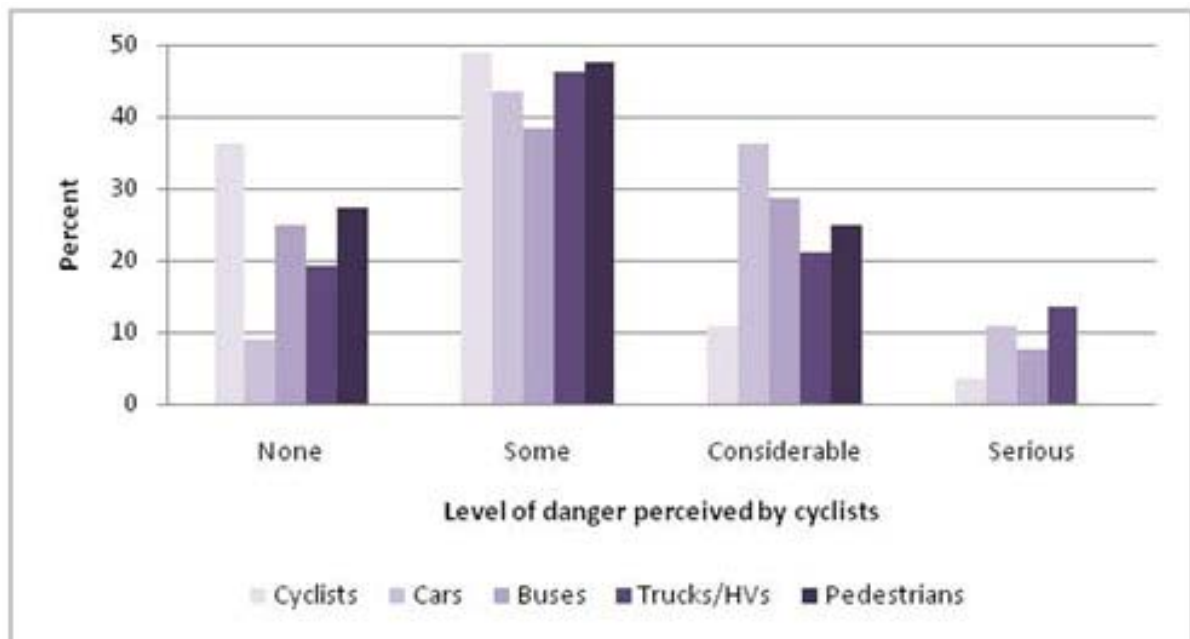


Figure 3: Survey respondents' perceived sources of danger as cyclists

Municipal accident data supported the finding that Westmount is generally safe, showing a lower rate of pedestrian and cyclist collisions relative to estimated kilometres driven in Westmount than in most other Montreal-island boroughs (Figure 4).

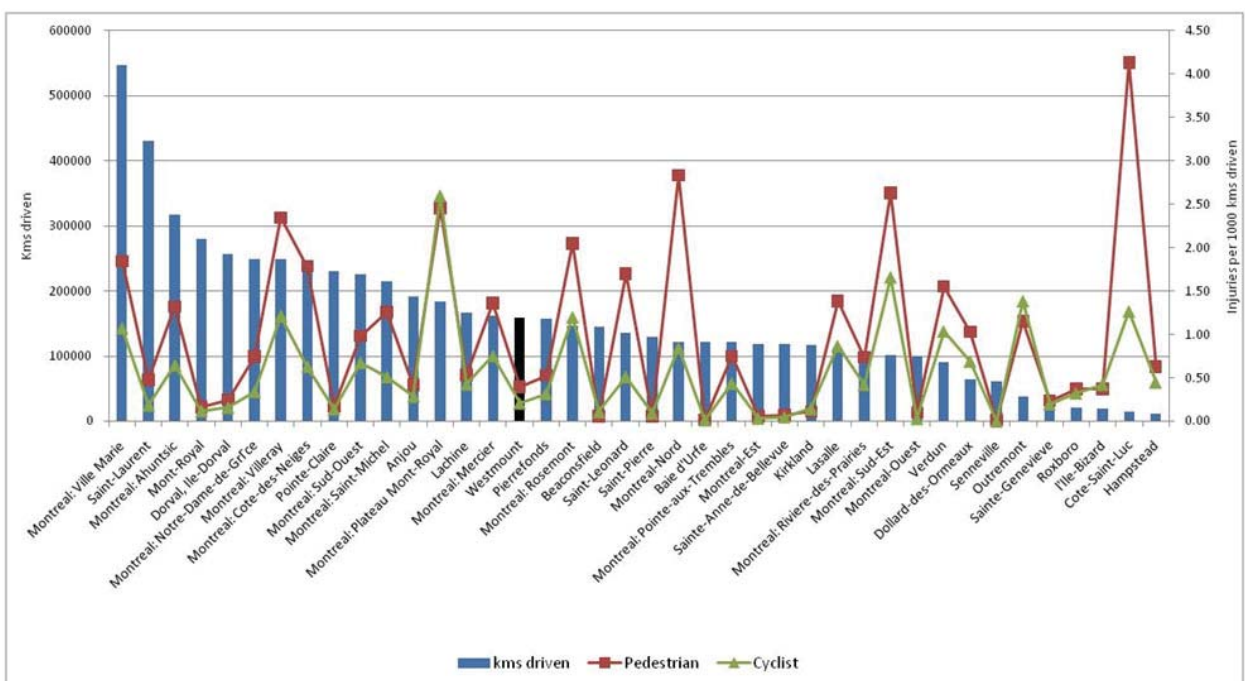


Figure 4: Estimated pedestrian and cyclist injuries per 1,000 km driven (Sources: 5% of population sampled, 2003 AMT Origin-Destination survey; SAAQ records 2003-2008). Note that this figure is for comparative purposes only, as kilometres driven are estimated based on the origins and destinations reported in the regional travel behaviour survey, representing only 5% of daily weekday volumes.

Nonetheless, a map comparing intersections identified as dangerous by survey respondents with intersections recording high collision rates (Figure 5) demonstrates a clear gap between perceived and observed safety at particular locations. In particular, intersections close to highway on- and off-ramps were viewed as less risky than their collision rates would suggest, as were intersections along Atwater Street, an arterial road with an adjacent major shopping centre and a significant slope. At the same time, the bike path along de Maisonneuve Boulevard was perceived as riskier for all three modes than its collision rates indicate.

Traffic speed and volume were identified as a concern by intersection observers, survey respondents and almost every key informant. Speed along Westmount's east-west thoroughfares (especially Sherbrooke, Westmount Avenue and The Boulevard) was a source of particular concern. High volumes contributed to safety concerns when large numbers of vehicles and pedestrians could not clear an intersection after a traffic signal change.

Non-compliance with traffic signals was repeatedly cited by survey respondents and key informants and observed at intersection counts. The most common complaints were about bicycles running stop signs and riding on sidewalks, although pedestrians jaywalking or walking in the bike path were also identified as a source of risk. Despite near-universal recognition of this issue as a problem, key informants were the least unanimous about this problem's causes and appropriate remedies: some recommended greater enforcement and education on the legal consequences of non-compliance, while others suggested re-examining signals that were most often disobeyed to find more appropriate methods of traffic calming for those locations.

Most problems with traffic signal and infrastructure design concerned the pedestrian scramble intersections located at several major intersections along Sherbrooke Street. Intersection observers and survey respondents both noted that the pedestrian signals were too short to permit people with mobility issues to make two crossings, particularly if they do not try to cross diagonally. Interviews with key informants revealed that these intersections remain a grey area in Quebec: although diagonal crossing is appears to be permitted, it is effectively illegal throughout the province.⁶ This misunderstanding contributes to confusion, traffic conflicts and tickets.

Survey respondents and key informants were the primary sources of information on factors beyond Westmount's control. Many of them felt that road user inattention and the presence of winter hazards such as ice and snowplows were significant contributors to risk. Information from these sources also revealed the extent to which Westmount's topography (a steep north-south slope) concentrates bicycle traffic on particular routes and may contribute to risk in those areas.

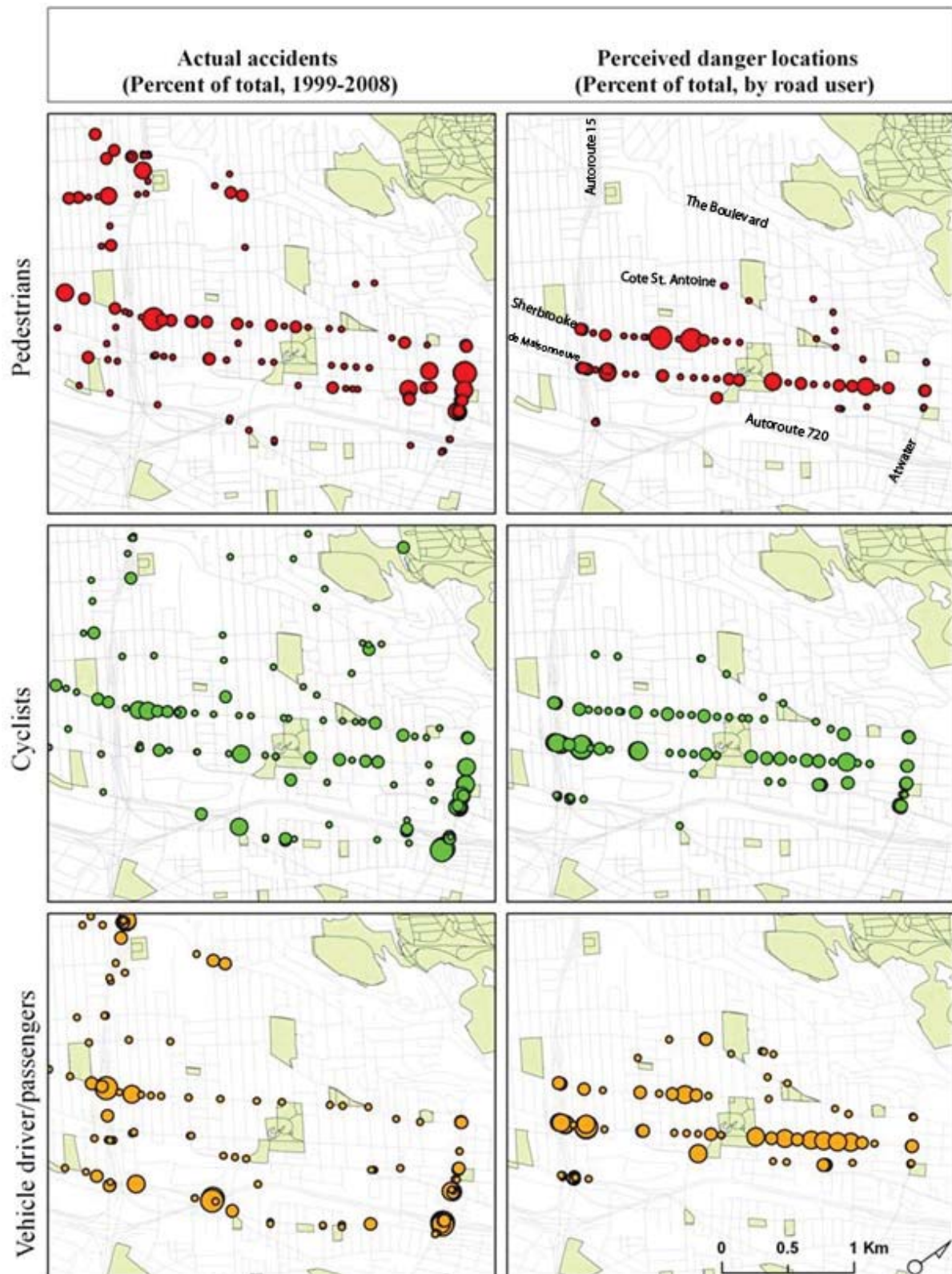


Figure 5: Comparisons of observed and perceived danger, across modes (Source: DSP, ambulance calls, 1999-2008)

The safety of the de Maisonneuve bicycle path is a longstanding concern in Westmount, particularly where it passes through a public park. Survey and interview responses indicated that pedestrians are concerned that they cannot hear cyclists coming and that cyclists frequently run stop signs. However, this study's comparative maps indicated a lower-than-expected risk for all road users along the bike path. Intersection observations in the park and elsewhere along the path did not reveal systematic conflicts or risky behaviour. These findings suggested that although safety along de Maisonneuve was observed to be high, interventions that would improve feelings of safety among pedestrians may be warranted.

Discussion

The results outlined above were of interest specifically to the City of Westmount, to help the municipality identify ways to improve its cycling and walking environment. This paper, however, is concerned with “meta-methodology”, discussing how the interaction between these four sources is crucial for producing valid findings.

A systematic look at the sources of each finding, as shown in Table 1, illustrates the contributions of each data type to the study's overall results. Each finding, with the exception of the risk posed by seasonal hazards that were not possible to observe during the summer study period, was supported by at least three of the data sources. This level of triangulation for all findings suggests an overall validity that provides an appropriate starting point for public policymaking.

One category of this study's findings (nos. 2 and 4-10) identified the key factors perceived to contribute to increased risk for pedestrians and cyclists in Westmount. These findings relied on surveys, interviews and intersection observations, and they could not have been made using an analysis of accident data. In most cases, the survey provided a sense of the scope of residents' concerns, while the intersection observations and interviews lent insight into their mechanisms. Finding 2 seems to confirm that, as discussed earlier in the paper, people perceive risk readily enough that it affects their walking and cycling behaviour. Findings 4 through 10, which identified sources of this perceived risk, could be explored in Westmount in further detail with quantitative studies investigating the relationship between any single finding and observed collision rates. Most, however, are examined in existing planning and safety literature.⁷ Overall, this category of findings suggests that interventions to improve the perceived safety of the walking and cycling environment in Westmount are warranted, and that the main safety concerns are consistent with those that have been documented in other cities.

Table 1: Sources of data contributing to each key finding

Finding	Survey	A c c i d e n t Data	O b s e r v a - tions	Interviews
1. Westmount is generally a safe environment for pedestrians and cyclists	X	X	X	X
2. When prompted, people easily identify factors they believe contribute to risk; these perceptions are important to consider	X		X	X
3. There is a gap between perceived safety and observed accident rates at particular locations	X	X	X	
Specific factors contribute to higher risk:				
Factors Westmount can influence:				
4. Traffic speed and volume	X		X	X
5. Non-compliance with traffic signals	X		X	X
6. Poor signalization at intersections	X		X	X
7. Infrastructure design	X		X	X
Broader issues:				
8. Road user inattention	X		X	X
9. Seasonal hazards	X			X
10. Topography	X		X	X
11. The de Maisonneuve bicycle path is quite safe, but its perceived safety could be improved	X	X	X	X

A second major category of this study's findings (nos. 1, 3 and 11) presented a more concrete picture of observed risk factors and locations in Westmount. While they required the type of quantitative information on observed road safety that could only have been provided by the SAAQ and DSP data, they were greatly enhanced by the information on the location and scope of risk provided by the survey and on the sources of risk provided by the intersection observations and interviews. Unlike the previous category of findings related to perceived risk, which identified factors common to many communities, these "observed risk" findings provide insight into the specific context in which interventions to improve road safety in Westmount may take place. Overall, this category of findings suggests that observed risks to pedestrians and cyclists are relatively low for Westmount as a whole, so interventions to improve perceived and observed safety are likely to focus on particular locations.

Overall, then, the study's multi-method approach was central to the types of findings that could be made. The survey data were necessary to provide the systematic information on risk percep-

tions that have been found to be relevant in understanding pedestrian and cycling safety, as discussed earlier in this paper. The accident data were necessary to provide a quantitative counterpart to the perception data and establish where there were gaps between the two. The observational data were necessary to provide a concrete description of the rates and mechanisms of conflicts identified by the surveys. Finally, the interview data were necessary to corroborate findings in other areas and gain more qualitative insight into their causes and importance. Without any single source, the researchers' ability to effectively triangulate data to arrive at valid findings would have been compromised. Given the particular community concerns around the safety of the de Maisonneuve bike path, the fact that all four sources could contribute useful information to the finding in this area lends it strength for policymaking purposes.

A multi-method approach also helps address concerns surrounding data quality. For example, comments from community members on this study's report to Westmount noted that our accident data cannot capture bicycle-pedestrian collisions that do not involve insurance claims or emergency responders, but that may still contribute to feelings of insecurity along bike paths. This study's ability to examine overall risk perceptions (via the survey) and specific intersection dynamics (via the observations) allows us to draw conclusions despite this weakness in our quantitative data.

When thoughtfully implemented, this methodology can also help minimize bias resulting from individual data sources. Our key informants, for instance, included police and bylaw officers whose responsibilities include enforcing a car-oriented Highway Safety Code and whose experiences include dealing with the aftermath of traffic accidents. Our informants also included cycling advocates with varying opinions about the appropriate rights and responsibilities of cyclists under road safety legislation. All these individuals can be expected to provide interview responses informed by their backgrounds and roles, and their responses must be considered accordingly. Interviews with other community leaders whose primary concern is not road safety helped us understand the relative local importance of many of the concerns raised by cycling advocates and law enforcement, even as we benefitted from the latter informants' more detailed opinions of the causes and severity of particular risks.

In addition to these theoretical advantages, this study had the practical benefit of requiring relatively little time and few materials. The survey was designed and data collected over a three-month period in midsummer, using the equivalent of one full-time graduate student position. The accident data analysis required GIS software and the survey was compiled in SPSS, a basic statistical analysis program; all other work was completed using an office software suite. These practical considerations make it possible for most or all of the work on a similar study to be carried out by a small municipality or neighbourhood organization.

It is important to note that the study's key findings, as outlined in Table 1, do not constitute everything that was observed at intersections, written on survey forms, or recorded in interviews. Instead, they are the portions of the data that could be triangulated. Areas of disagreement among survey respondents or key informants were almost always related to the appropriate ways of addressing road safety risks, rather than the nature of the risks themselves. As noted in this study's report to Westmount, the complexity and relatively low incidence of the risks identified make it unlikely that one or even several solutions will address all of them. Any further discussion of potential solutions is beyond the scope of this study; however, to identify a municipality's main road safety concerns as a first step in addressing them, this multi-method approach has both theoretical and practical advantages.

Conclusion

This study draws conclusions in two areas. First, from the point of view of pedestrian and cyclist safety, it identified sources and characteristics of risk in Westmount that can inform municipal policymaking in the areas of road safety and active transportation. Second, and more broadly, this study illustrates the ability of a low-resource, methodologically flexible study to help a small municipality identify appropriate approaches to improving perceived and observed safety for pedestrians and cyclists.

The results of this particular study were systematic and well-received by the community, despite some avoidable limitations associated with the timing of the project and the survey distribution methods. The results suggest that a triangulation methodology combining a survey, collision data, direct observations, and in-depth key informant interviews is an effective and reasonable approach for municipalities seeking to evaluate their active transportation environment in a way that is not resource-intensive.

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Endnotes

- 1 Hillman et al. (1990) cite literature that found an increase in pedestrian and cyclist fatalities after the introduction of mandatory seat belt laws in Western Europe, which was thought to have been due to more aggressive driving by motorists who suddenly felt safer.
- 2 There is some evidence that greater numbers of pedestrians and cyclists using the roads may lead to greater pedestrian and cyclist safety as drivers become accustomed to interacting with them; however, this body of research remains small and may have the additional effect of seeming to shift responsibility for collisions onto vulnerable road users, rather than promoting the use of accepted traffic-calming measures as a means to reduce collisions (Bhatia and Weir, 2010; Jacobsen, 2003).
- 3 Ahead of “child unreliable,” “fear of molestation,” “distance too great” and “bullying.”
- 4 A traffic conflict is a situation in which two road users move toward each other such that a collision is imminent unless one of them changes course or speed (Hyden, 1987).
- 5 These rates were expressed as the number of pedestrian conflicts per pedestrian and cyclist conflicts per cyclist.
- 6 In Quebec, “No pedestrian may cross diagonally at an intersection unless he is authorized to do so by a sign or by a peace officer or school crossing guard” (Highway Safety Code S.451). Four-way “walk” lights are not considered to be a sign.
- 7 For example, our finding (no. 4) that traffic speed and volume are associated with greater perceived risk is supported by a large body of evidence that it also increases collision rates (e.g., Turner, Binder and Roozenburg, 2009; Garder, 2004; LaScala, Johnson and Gruenewald, 2001). Finding 5 is supported by literature describing contexts in which non-compliance with signals can contribute to conflicts between road users (Clifton and Kremer-Fults, 2007). Findings 6 and 7 are supported by literature outlining pedestrian- and cyclist-oriented designs that can be used both to improve feelings of safety (Landis, 1997; Landis, 2001) and reduce crash rates (Lusk et al., 2011; Reynolds et al., 2009; Turner, Binder and Roozenburg, 2009); an additional body of work examines how pedestrian scrambles can be implemented for the greatest reductions in crashes (Kattan et al., 2009; Bechtel et al., 2003). Finding 8 is supported by research into the role of inattention in cyclist/driver collisions (Johnson et al., 2010; Schramm et al., 2008). Finding 9 is corroborated by literature quantifying the drop in mode share between summer and winter and identifying major barriers to winter cycling (Bergstrom and Magnusson, 2003; Pucher and Buehler, 2006). Finding 10 is discussed in literature concerning the relative influence of topography and safety on cyclists’ route choices and decision to cycle (Moudon, 2005; CTC, 1997).