Compendium of errors and omissions, or: What is not in this article

Lusk et al. [1] ask whether cycling in (what they describe as) two-way, one side of the street, physically separated bicycle paths in Montreal is as safe as cycling in comparable streets. Short articles, such as are required by Injury Prevention, tend to leave out much that is important and sometimes even crucial. The following comments concern crucial missing items that readers must be aware of in order to sensibly evaluate the author's claims; as well as numerous other problems with the work.

All epidemiological studies are made or broken by the details of how the authors obtained their intervention group, how they chose the comparisons, and how they constructed their statistics. This study by Lusk et al. is marked by at least the following: incorrect and inadequate descriptions of the bicycle paths and their associated streets; no descriptions of the comparison streets; an unsound selection of comparison streets, which the authors went up to 10 blocks away to find; reliance on an untested indicator of danger to cyclists, one whose usefulness is refuted by the authors' own data; methods that are in conflict with the authors' own concurrent findings published elsewhere; inappropriate statistical analysis; incorrect representation of statistical results; lack of any sensitivity analysis on the major sources of uncertainty in their indicators of exposure and effect; lack of consideration of divergences between the cycling populations that use the paths or the streets; lack of consideration of how the presence of the bicycle paths has changed traffic flows on the comparison streets; avoidance of nearly all of the pre-existing literature that came to opposing conclusions; and the drawing of policy implications despite failure to use a systemic approach that would have considered in addition, if nothing else, harm to pedestrians.

1. Incorrect descriptions of the intervention group sample

The authors describe their intervention group sample as consisting of six cycle tracks in Montreal that are all two-way on one side of the street. This is incorrect, as are further details of the individual path segments as follows.

(a) de Maisonneuve between Claremont and Wood
Authors' description: street level, separated from traffic by delineator posts.

Approximately 16% of this path segment is neither separated from traffic by delineator posts nor even on any street: instead it traverses the entire width of a large park, where there are no streets and no intersections and there is no motor vehicle traffic. The comparison streets do not traverse any park.

During almost the entirety of the authors' 1 Apr 1999 – 15 Nov 2008 study period, this path ran only from Claremont to Greene, two blocks short of Wood, for a distance of approximately 1.56 km instead of the 1.9 (which in reality is closer to 1.75) listed by the authors. The incident rates for crashes and injuries per kilometre along this segment are therefore approximately 22% higher than as listed by the authors (see also section 1(c)). The path extension to downtown, and so to Wood, was opened only in the late summer of 2007.

Moreover the entire segment studied is not in the City of Montreal, but is instead in the City of Westmount (Westmount was a borough of Montreal only from 1 Jan 2002 to 31 Dec 2006). Westmount is one of only two places in the province of Quebec with an all-ages bicycle helmet law. The existence of this law, allowing for fines of up to $2,000 and nominally in effect since 1994, is not evident except in one place, namely along the de Maisonneuve path, where there is signage specifying that helmets must be used on the path (see photos at end). Even though in reality violators are no longer ticketed anywhere in Westmount, and perhaps never were anywhere but the path, this is not publicized and the signage may change the characteristics of the population that chooses to use that path rather than the parallel streets where there is no signage.

The authors need to explain how they obtained the cyclist count data for this path, what their nature is and what their period of collection was. Unlike the City of Montreal, the City of Westmount does not maintain automatic counters as described by the authors [1, 2], nor does the City of Montreal maintain such counters on Westmount territory.

(b) Christophe Colomb between Gouin and Jarry
Authors' description: sidewalk level, separated from traffic by virtue of being on the sidewalk, and additionally in some sections by a "planting strip".

No more than about one-quarter of this path is well pictured by the authors' description. Approximately one-third traverses what is, from a cyclist's point of view, more like a park or a park-like setting, having no interaction with Christophe Colomb and often above sidewalk level, and with hardly

any intersections; slightly more is on-street, separated from parallel traffic by raised medians with delineator posts and a parking lane; a short section has one direction on the sidewalk and the other on-street with delineator posts; while another short section is entirely on-street, separated from parallel traffic (of which in that section there is almost none) by delineator posts (see photos at end, and also complementary photos and analysis as linked in the earlier response to Lusk et al. by W. Pein [3]).

(c) Rachel between St Urban and Marquette

The authors list this path segment as being 3.5 km long. In fact it is approximately 1.7 - 1.8 km long, and thus has approximately twice the rates of injuries and crashes per kilometre given by Lusk et al. The authors should explain for all their path segments how they obtained the lengths they list.

As an aside, in order to obtain incident rates per kilometre, the authors assign subjective correction factors to the lengths of their segments. These subjective factors, ranging from 60 to 90%, were determined by "expert judgement". No indication of how one might become expert at judging such things is provided by the authors. Nor do they provide any expert judgement of the error distribution of these expert judgements. The resulting overall incident rates per kilometre are therefore not only incorrectly calculated, by fault of at least the de Maisonneuve and Rachel path length errors— the latter an expert error of approximately 100%— but also are fundamentally of no scientific value.

(d) Berri between Viger and Sherbrooke

One of the study authors has said on local television that two intersections on this path, Berri at Viger and Berri at Ontario, are respectively the second and third-worst bicycling injury blackspots for the entire island of Montreal. (The worst, Mount Royal at Park Avenue, is a short distance outside the Mount Royal segment studied by the authors, because Rachel, the corresponding path street, does not reach Park Avenue. The fourth-worst is on the Christophe Colomb path segment.) Given the short length and small number of intersections of the path segment studied here, the authors should explain why nevertheless the injury totals they give here do not seem to reflect this, and why they do not mention the blackspot record of this path.

2. Inadequate characterizations of the intervention and comparison streets.

The only description of the intervention streets given by the authors is whether they are one-way or two-way, and the only description of the comparison streets is that they are parallel to, and begin and end at the same cross streets as, their respective intervention streets. In particular the authors give no information on characteristics that have been studied in the literature or that cyclists pay attention to, such as posted speed limits, actual motor vehicle and bicycle speeds, numbers and widths of lanes, traffic volumes, condition of the pavement, neighbourhood type, and presence of heavy vehicles, bus routes, or metered parking. Even though accidents at intersections, both crashes and crushes, are the biggest safety problem with physically separated bicycle paths, the authors do not tell us the numbers and natures of the intersections traversed by the reference and intervention streets: they say (wrongly, see tables and photos) that they are similar, by virtue of the overall segments beginning and ending at the same cross streets.

Rather than detailing these or other cycling-crucial features, the authors index only the numbers of injuries to motor vehicle occupants on the respective streets: they say that "MVO injury counts are considered a surrogate for traffic danger a bicyclist might face on a given street apart from any treatment." This statement is dubious for at least the following reasons:

1. Although phrased as if they were routinely used in this way, the authors provide no citation to show it.
2. The authors' own data refute it: a scatter plot of their bicyclist injury rates versus MVO injury counts on non-treatment streets shows a cloud with only a vague overall association, giving an r^2 of only 0.58.
3. There are entire categories of incidents, such as dooring, or being crushed beneath the wheels of an adjacent same initial direction turning vehicle, which are of grave injury danger to bicyclists, but which are of little if any injury concern to motor vehicle occupants. In narrow-laned streets during urban gridlock, danger to the traffic-weaving cyclist is omnipresent, while motorists instead are concerned mostly either with fender-benders or with hitting cyclists and pedestrians.
4. The concept of comparing reference and intervention streets via an indicator, measured after the bicycle path is in place, of "traffic danger... apart from any treatment" has not been well thought out. The creation and persistence of a bicycle path changes the characteristics of cyclist and motor

vehicle traffic on both streets. For example:

–In the downtown area, previously de Maisonneuve, as one-way westbound, was an ideal artery for westbound motorists turning in the major direction, southbound. Now they must turn into a two-way bicycle path with unpredictable, sometimes high speed, nearly continuous traffic, to which they are required to yield. This has made Sherbrooke street, despite its two-way automobile traffic, a relatively more attractive option. But this diversion of the traffic flow has made Sherbrooke less safe for cyclists. Similarly, Berri is a preferred north-south route for car traffic because of its much simpler flow, and the underpass that avoids the intersection at Sherbrooke; but west-turning vehicles must now contend with difficult bicycle traffic, thus making St Denis relatively more attractive to drivers, and less safe for cyclists.
–Posted speed limits are sometimes lowered, and in other jurisdictions sometimes raised, when paths are installed. Thus the posted speed limit for Brebeuf is 30 km/hr, while the posted speed limit on the nearly identical adjacent streets is 40 km/hr (the authors instead went 10 blocks away to find their comparison street, where the posted speed limit is 50 km/hr). This again encourages diversions of traffic flow and thus reduced safety for cyclists on the non-path streets.
–High-speed cyclists such as couriers avoid the clogged bicycle paths during rush hours and tend to adjacent streets.

3. Divergent characteristics of the intervention and comparison streets.

This study cannot be sensibly evaluated without at least some basic photographic and cartographic comparison of the reference and intervention streets. Likewise the authors should have detailed standard characteristics such as number of lanes, posted speed limits, actual speeds, condition of the pavement, and number and nature of intersections. Since the authors provide no such documentation, I take the opportunity to supply some of it here. Tables 1 to 4 provide missing relevant characteristics in the five (out of eight) comparisons where Lusk et al. found the paths to be safer. Table 5 does the same for one comparison (out of three) where the reference street had a better record. The figures document in photographs and the associated captions other cycling-crucial variances between the intervention and comparision streets. Further photographs and a corroborating analysis may be found as linked in the earlier response by W. Pein [3].

4. Lack of any sensitivity analyses of sweeping assumptions, and methods that conflict with the authors' own results published elsewhere

(a) Exposure

The authors state that they "measured bicycle exposure directly". In fact for their 1999-2008 study period they used short (no more than 20 to 64 days over 5 months out of 229 days in 7-month seasons) non-random sample counts for 2000 and 2008 only, for the intervention streets only, and used interpolation and back-extrapolation for the rest of the intervention data. This means they took into account only a growth trend, and did not account for year to year fluctuations. On the other hand their injury data seem to cover each year for the complete season, with all the inherent fluctuations.

For the comparison streets no such exposure time series are available, and instead the authors used counts from apparently a single 2-hour period sometime in 2009, made simultaneously with a count on the intervention street. This was then used to establish a single fixed ratio of intervention to comparison street exposure that was used for the entire 1999 - 2008 study period. The authors state that "Using a ratio of simultaneous counts eliminates systematic effects on bicycle use such as weather, time and day." The authors provide no sensitivity analysis for this sweeping assumption, which is dubious on the face of it:

–The cyclist's choice to use a path or an alternative street, and so the overall distribution of ridership between the two, depends on conditions which may vary from hour to hour, day to day, and year to year. This especially in a city such as Montreal with severe pothole problems, extensive summer roadwork, and frequent gridlock. Thus for example the present writer recently wanted to ride along Sherbrooke street during rush hour, but because of road construction particular to this summer and gridlock particular to that time and date detoured onto the cycle paths and then onto a distant street.

–The method conflicts with the authors' own results published elsewhere [2]. There they found that exposures on even nearby paths in Montreal do not vary in lockstep: on the contrary they found that "the variability of the magnitudes and significance of certain coefficients [in their fitted models of exposure] confirms the need for path-specific models." Considering that the reference-intervention pairs of the current study may be up to 10 blocks apart, or separated by features of the urban geography that bifurcate the respective cycling populations and their destinations, the onus is entirely on the authors to demonstrate that a result similar to what they found in

similar circumstances, for some reason does not hold similarly.

(b) Injury

The authors want to count injuries that occur to cyclists travelling specifically along their chosen segments, and not crossing them at intersections. Yet their ambulance services data do not contain this information. The authors used instead an overlapping dataset, police reports, to get for each intersection a ratio of through to cross-traffic injuries, which they then applied as a correction factor to the ambulance data.

Intersections represent the primary safety problem for physically separated bicycle paths. Therefore these correction factors must be key to all of the authors' results. Given the low rates of injuries overall, and the very low rates of reporting to the police, the data from which the correction factors are constructed must be very sparse and the reliability of the factors entirely uncertain. Yet, as with all their assumptions, the authors provide no sensitivity analysis. Nor do they give any idea of the distributions or quantities of these data.

Furthermore the entire concept of excluding injuries to cyclists coming from or going to cross streets is questionable, because some of these injuries occur specifically because of the presence of the path. This in at least three ways:

First, some cyclists are going out of their way along the cross-street precisely in order to get to or from the path. In so doing they have exposed themselves to extra risk from not just the path intersection, but also any others along the way.

Second, because cyclists ride opportunistically, and thus their crossing behaviours are affected by constraints. For example, to turn left onto a cross street, an unconstrained cyclist who knows how to deal with traffic will want to move to the left of the through street before arriving at the intersection, while a cyclist constrained to the path will have to use the cross street for the entirety of the crossing. Even though in both cases the end result is the same, the authors' procedure— to the extent it actually works as claimed— would count injuries occurring in the first crossing manoeuvre against the through street, but not count against the path any injuries from the second manoeuvre, for having occurred along the cross street.

Third, because the paths themselves do occasionally cross from one side of the street to the other. For example, the Rene Levesque path studied by the authors crosses from the south side to the north side precisely at the street chosen by the authors (de Lorimier) to terminate the

path segment, thus excluding from their analysis all the resulting injuries (see photos).

5. Inappropriate or missing statistical analysis

(a) Confounding

Lusk et al. compared six paths with a total of eight reference streets, two of the intervention streets being compared with two reference streets each. They used MVO injury counts as an indicator of potential confounding, but performed no adjustment for the overall risk ratio because the overall average ratio of reference to intervention MVO injury counts was near 1. For reasons unexplained they also performed no adjustments on the individual risk ratios.

The MVO injury ratios of the individual reference to intervention comparisons are heterogeneous, varying by factors of up to 25. This seems to indicate only that the authors made a judicious selection of outliers to achieve the goal of a neutral average. Averaging selected outliers to arrive at an overall assessment is not a valid statistical procedure.

(b) Effect modification

The authors averaged the risk ratios for the two-street comparisons to obtain a single risk ratio for those paths, and averaged all eight comparisons to provide a single risk ratio for the entire group.

The pooling of results in this way is invalid in the presence of effect modification. The heterogeneous risk ratios obtained for the individual comparisons are standard evidence of effect modification. The authors provide no evidence or statistical tests to the contrary.

(c) Poisson distribution

The authors calculate their confidence intervals under the assumption that the event probability follows a Poisson distribution. In order for a Poisson distribution to be the case, the variance must equal the mean, and the event probability must be constant per unit time. The authors provide no data on the variances for the reader to check and provide no indication that they checked themselves. Given the tremendous changes in motor vehicle traffic flows and the cycling scene in Montreal over the decade of the study period, the assumption of time constancy also appears untenable.

Coincidentally, an article appearing in this journal shortly after the work of Lusk et al. showed that the Poisson distribution is not a good fit for falls count data that might be analogous [4].

(d) Construction of the reference and intervention samples
The authors state that the lengths of the path segments they studied "may be less tha[n] the entire cycle track length for comparability with reference streets." This explanation is nonsensical for each and every reference-intervention pair, because in every case the comparison street continues far beyond any early termination point chosen by the authors.

Thus the authors provide no information on how the intervention sample was chosen, either the particular paths, or the particular start and end points of the actually studied segments of them. These choices are particularly crucial because they avoided several high-volume or otherwise hazardous intersections, such as Papineau (one street after the early termination point) and Rachel, de Lorimier (the early termination point) and Rene Levesque, and the continuation of the Brebeuf path at St Gregoire (the first intersection after the termination point) and multiple further locations. Since presumably the authors do not count incidents occurring along the path segment but in the terminating intersections, using short path segments as the authors do also lowers the overall number of intersections per kilometre, making for a comparison more favourable to the paths. (Example: for block lengths of 200 m, a 1 km path without the terminating intersections would have incidents resulting from 4 intersections per kilometre, while a 5 km stretch of the same path would have incidents resulting from 4.8 intersections per kilometre— a 20% increase.)

The authors also do not tell us why two particular paths and these only were chosen to have two comparison streets. The authors need to explain whether the choice to include any second comparison was made before or after data from any first comparison were obtained.

6. Incorrect representation of statistical results

(a)
The authors prominently state that "Cycle tracks lessen, or at least do not increase, crash and injury rates compared to bicycling in the street." This is an incorrect representation of the authors' results, for two reasons.

First, the authors supply no crash data for their comparison streets, so there are no relevant study-specific results to support their crash claim. They can only make a non-statistical comparison to the few and divergent estimates that have previously made it into the literature, which are not always the same or higher than the ones obtained by the authors

(the latter by an incorrect and and also unsound calculation, as described previously in sections 1(a) and 1(c)): as cited by Lusk et al., instead they range from approximately one-third to six times the ones the authors come up with.

Second, by making this same claim for the injury rates, for which they do have statistical results, they make a well-known elementary statistical error, namely confounding clinical or public health significance, and the facts of the matter as well, with statistical significance [5].

In fact, out of eight comparisons, the authors found that in three of their decade-long cases the actually recorded injury rate was higher on the bicycle path than on the comparison street: respectively 1%, 18%, and 21% higher. That the authors found none of these figures to be statistically significant does not constitute an endorsement of the cycle paths, but rather a weakness of the authors' methods. Thus a major study of physically separated bicycle paths in Copenhagen [6] using methods superior to those of Lusk et al. found a statistically significant 12% increase in crash injuries after the installation of the paths, and a statistically significant 19% increase in injuries specifically to pedestrians, with the greatest burden of the increases being born by females.

(b)
The "What this study adds" box incorectly compares the (incorrectly calculated, see sections 1(a) and 1(c)) injury rate of 8.5 per km reported by the authors with a range of 3.75 to 67 supposedly reported elsewhere. In fact the latter figures are crash rates, not injury rates.

7. Body of literature that came to opposing conclusions.

The authors provide a detailed criticism of a single study from 1994 that came to a conclusion opposed to theirs. They refer to a recent study [6]—much larger, more comprehensive and detailed than theirs, that used a study design superior to their own and that also came to opposing conclusions— only with the remark "conflicting studies with warnings of increased crash rates". They omit all reference to the body of other literature, including further studies using methods superior to their own (e.g. before and after in combination with comparison streets), that also came to opposing conclusions. Overviews and examples of this literature can be found elsewhere [7, 8].

8. Drawing of policy implications despite failure to consider the problem systemically

Lusk et al. provide no information on standard characteristics of their streets, disabling any assessment of generalizability. The authors' study is unifactorial, considering only one aspect (ambulance calls) of harm only to cyclists. They consider no other possible harm, including harm to pedestrians, even though this and harm and inconvenience to other user groups have been found by larger studies using superior study designs [6, 8]. Nor did they consider costs or alternatives. Even discounting all the flaws with this study outlined in the preceding sections, to draw policy implications of any kind from such a limited basis is not serious.

It may be unfair though to blame the authors for this fault. "Implications for Policy" is a section specified by the journal, whose founding editor espoused a grandiose conception of epidemiology. Would the editors of Injury Prevention have accepted this article for publication if the correct policy implications were drawn, namely "none"?

9. Conclusion

The authors note that cycling on the paths is on average 2.5 times more popular than cycling on their comparison streets. It ought to be: the city has typically gone out of its way to select some combination of the most direct, the most convenient, the most scenic, the most pleasant, and sometimes even the safest routes. For their comparisons Lusk et al. selected streets featuring amongst other disadvantages some combination of higher speed limits, heavier and more chaotic traffic, less pleasant surroundings, less convenience, and more intersections than the intervention streets; and went up to 10 blocks out of the way to find them.

Lusk et al. began their article with an apparent truism, that most bicyclists would prefer to ride separated from motor vehicle traffic. They neglect that most motorists would also like to drive separated from other motor vehicle traffic, most bicyclists would prefer to ride separated from other bicyclists narrowly overtaking them from behind, blocking the way in front, wobbling around them, whizzing by immediately adjacent in the opposite direction, and likewise from roller bladers, skateboarders, wheelchairers, electric scooters, perambulator joggers, pedestrians making the mad dash from the sidewalk to their parked cars on the other side of the path, or lollygagging unpredictably immediately adjacent on the sidewalk. On the other hand the pedestrians, especially the elderly, find the two-way

traffic of the bicycle paths right next to the sidewalk difficult to contend with and hazardous (see Figure 12, Figure 14, and the associated captions). Meanwhile on crowded sidewalks fast and slow walkers come into conflict [9], and on quiet ones both can get their nerves jangled by runners, who in turn have to weave around them, sometimes stepping into the roadway to do so. Even fast and slow runners on eight-lane purpose-built tracks tangle their rights of way, in both competition and training.

The authors' vision is one where every user type is relegated to their own path and given their own signal at intersections. Unfortunately the more ways 100% is divided, the smaller everyone's share becomes [10]. Already at an intersection with two equal rights of way, half the users must spend the signal cycle waiting; add just one more, and the duty cycles are reduced from one-half to one-third while two-thirds of the users must sit idle, the motorized among them spewing greenhouse gases all the while.

10. Tables and photographs

Tables 1-4 describe various relevant characteristics of the intervention and reference streets in the five cases where the authors found the intervention to be safer. Table 5 does the same for the Rachel – Mount Royal comparison, an example of one of the three cases where the comparison street had a lower injury rate. Numbers of intersections estimated from a 2003 (middle of the study period) map [11] or counted on-site, and do not include driveways or the delimiting cross-streets. Distances either as given by Lusk et al. or in the case of large errors on their part (de Maisonneuve group and Rachel group; to a lesser extent St Hubert) as measured from the map.

The photographs depict further relevant characteristics of these and other path segments and their comparison streets.

Table 1. Brebeuf path, Rachel to Laurier (Barrette)

	Brebeuf (intervention)	St Denis (used as comparison; located 10 blocks away from intervention street)	Streets adjacent Brebeuf: Chambord, de Lanaudiere (not used by authors)
Posted Speed Limit	30 km/hr (typically respected)	50 km/hr (routinely exceeded)	40 km/hr
Traffic Lanes	1-2	2 North, 2 South	1-2
Intersections per km	5	6-7 (one an offset diagonal)	5-6
Parking Lanes	2	2	2
Comments	Entirely residential, low traffic, no heavy vehicles or bus routes, one driveway (laneway) per block	Heavily commericial, heavy traffic, heavy vehicles, bus routes, metered parking length of route, numerous places serving alcohol, narrow parking and first lanes; is also a numbered Quebec provincial highway (Route 335) [12, 13; see also photos at end]	Essentially identical in character to intervention street

Table 2. de Maisonneuve path, Claremont to Greene, two streets short of Wood. (Authors claimed to have studied path from Claremont to Wood, but for almost the entirety of their study period the segment from Greene to Wood did not exist.)

	de Maisonneuve (intervention)	Sherbrooke (used as comparison)	Ste Catherine (used as comparison)
Approximate Length	1.56 km	1.59 km	1.66 km
Intersections per km	9.0	12.6	11.4
Posted Speed Limit	30 km/hr (typically respected)	40 km/hr (routinely exceeded)	30 km/hr (routinely exceeded)
Traffic Lanes	0-1 (one-way traffic)	4-5 (two-way traffic)	4-5 (two-way traffic)
Parking Lanes	0, or 1 on opposite side of street	2	0-2
Comments	Very low traffic, no major intersections, entirely residential, no heavy vehicles, motorcycles or bus routes, no metered parking (2-hour limit); no motor vehicle traffic through Westmount Park; signage for helmet use	Heavy traffic, commercial activity, major intersections, numerous bus routes and heavy vehicles, narrow parking and first lanes, some metered parking; no signage for helmet use	Heavy traffic, commercial activity, major intersections (one at bottom of hill), numerous bus routes and heavy vehicles, some metered parking, one section divided four-lane with no parking; no signage for helmet use

Table 3. Berri path, Viger to Cherrier

	Berri (intervention)	St Denis (used as comparison)
Intersections per km	3.6	7.9
Traffic Lanes	2 North, 2 South, separated for much of length by raised medians or wide marking	2-4 southbound only from Viger to Sherbrooke; 2 North, 2 South undivided from Sherbrooke to Cherrier
Parking Lanes	1	0-2
Comments	Dominated by large institutions whose entrances on St Denis tend to route cross traffic away; underpass avoids major intersection at Sherbrooke; relatively simple overall traffic flow. Has second and third-worst bicycle injury blackspots of entire island of Montreal (intersections at Viger and Ontario).	Part heavily commercial, with metered parking, numerous places serving alcohol; part dominated by heavy traffic to major institutions, including emergency room entrance to major hospital; no underpass at Sherbrooke; chaotic traffic flow Authors index this street as being safer for cyclists than Berri, for having had a lower MVO injury count.

Table 4. Christophe Colomb path, Jarry to Gouin

	Christophe Colomb (intervention)	St Hubert (used as comparison; for most of its length located 7 blocks away from intervention street)
Approximate length	3.7 km as given by Lusk et al. (follows in part a curved trajectory)	3.52 km as measured from map (shorter because follows a straight trajectory)
Intersections per km	3.2	4.5
Posted Speed Limit	40-50 km/hr	50 km/hr
Traffic Lanes	0-5, in parts divided North/South by raised median	2-5
Parking Lanes	0-2	0-2; AM & PM rush hours, alternates between east and west side
Comments	Approximately one-third of segment is through a park or park-like setting, rest is mostly residential on at least path side.	This route essentially not used by bicyclists. The few riders and injuries recorded may be from only a limited subsection, or consist mainly of local children riding on the sidewalk. Other section of Christophe Colomb used as second comparison may similarly have counted mostly sidewalk riding.

Table 5. Various relevant characteristics of Rachel – Mount Royal comparison, one example of the three cases where the non-intervention street had a better record (path street had 18% higher injury rate over the decade of the study period).

	Rachel (intervention)	Mount Royal (used as comparison)
Bus Routes	1	2-3
Subway Stations	0	1 at middle of segment
Lanes	Wider	Narrower
Traffic Intensity	Lighter	Heavier
Eastern End	Residential area, parallel to a large park discouraging or blocking cross traffic	Heavily commercial area with northbound and southbound cross traffic
Western End	Rachel terminates as a dead end at a park approximately 75 m after St Urban boundary	Becomes major multi-lane road feeding from/to large complex of multiple major arteries, the worst cycling injury blackspot on entire island of Montreal (see photos). Authors index this street as being safer for cyclists than Rachel, for having had a lower MVO injury count. Motor vehicle traffic is often gridlocked, with few possibilities for injury to motorists, but many to bicyclists.

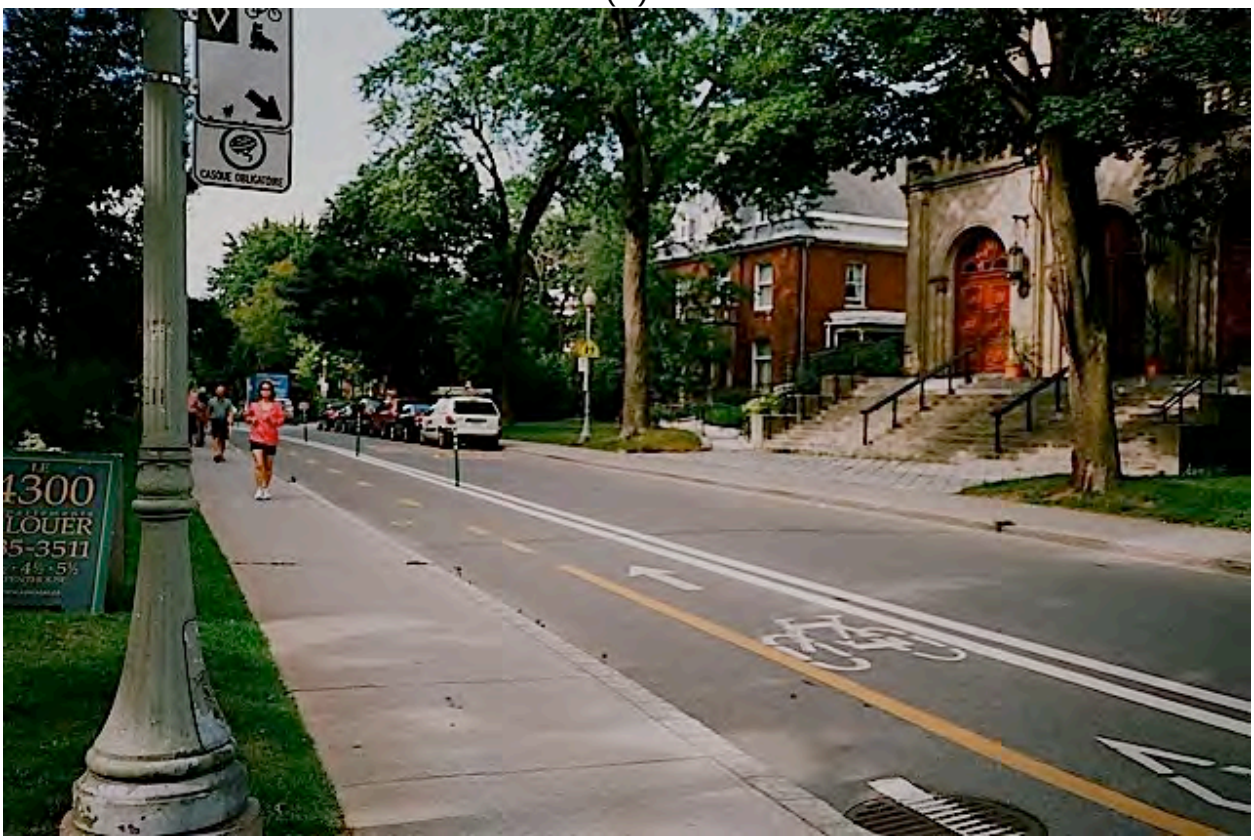
11. Comparison photographs of reference and intervention streets

(a) de Maisonneuve group

Figure 1. (A) de Maisonneuve at Clarke: one-way through unproblematic, low-speed, low-traffic intersection. (B) Signage for compulsory helmet use on path. (C) Ste Catherine at Clarke: two-way through problematic multi-lane high-traffic intersection. No signage for bicycle helmets.
(D) Sherbrooke at Clarke: two-way through another problematic high-traffic intersection. No signage for bicycle helmets.

(A)

(B)



(C)

(D)

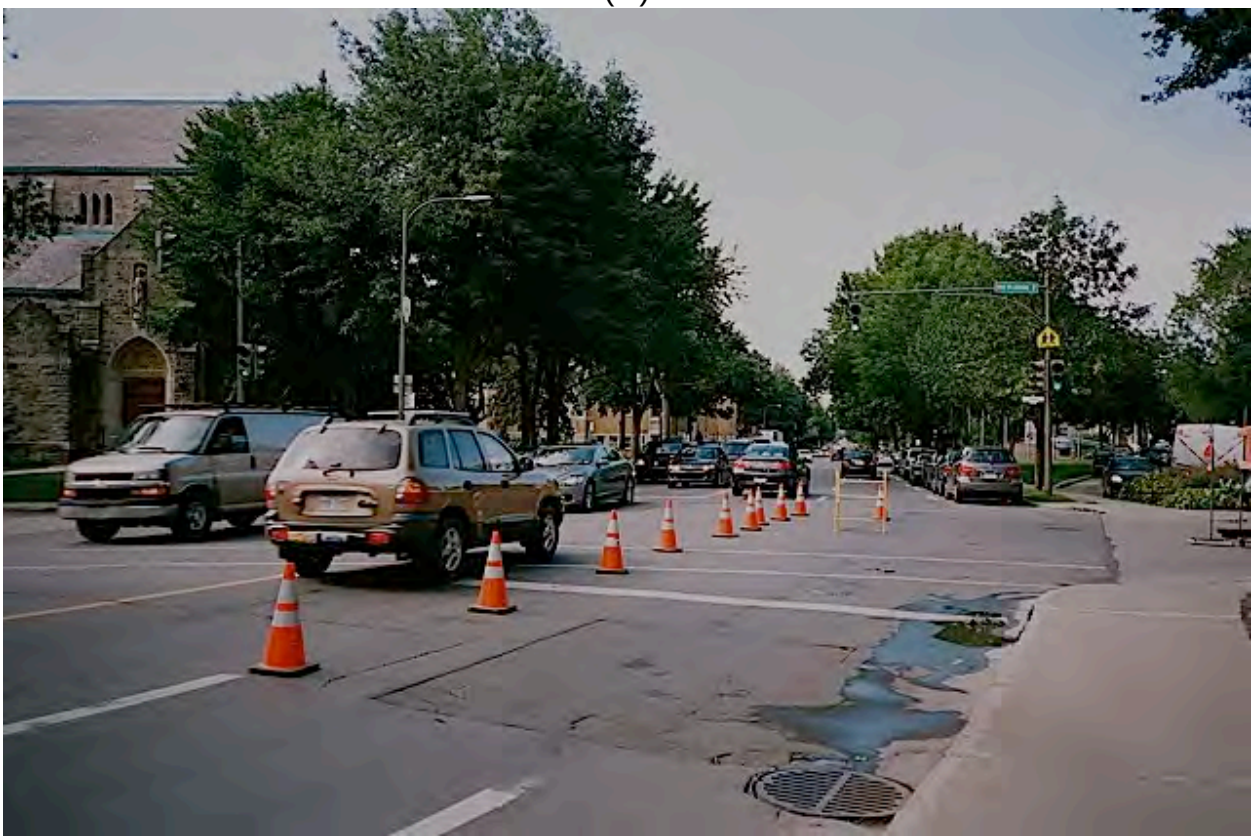


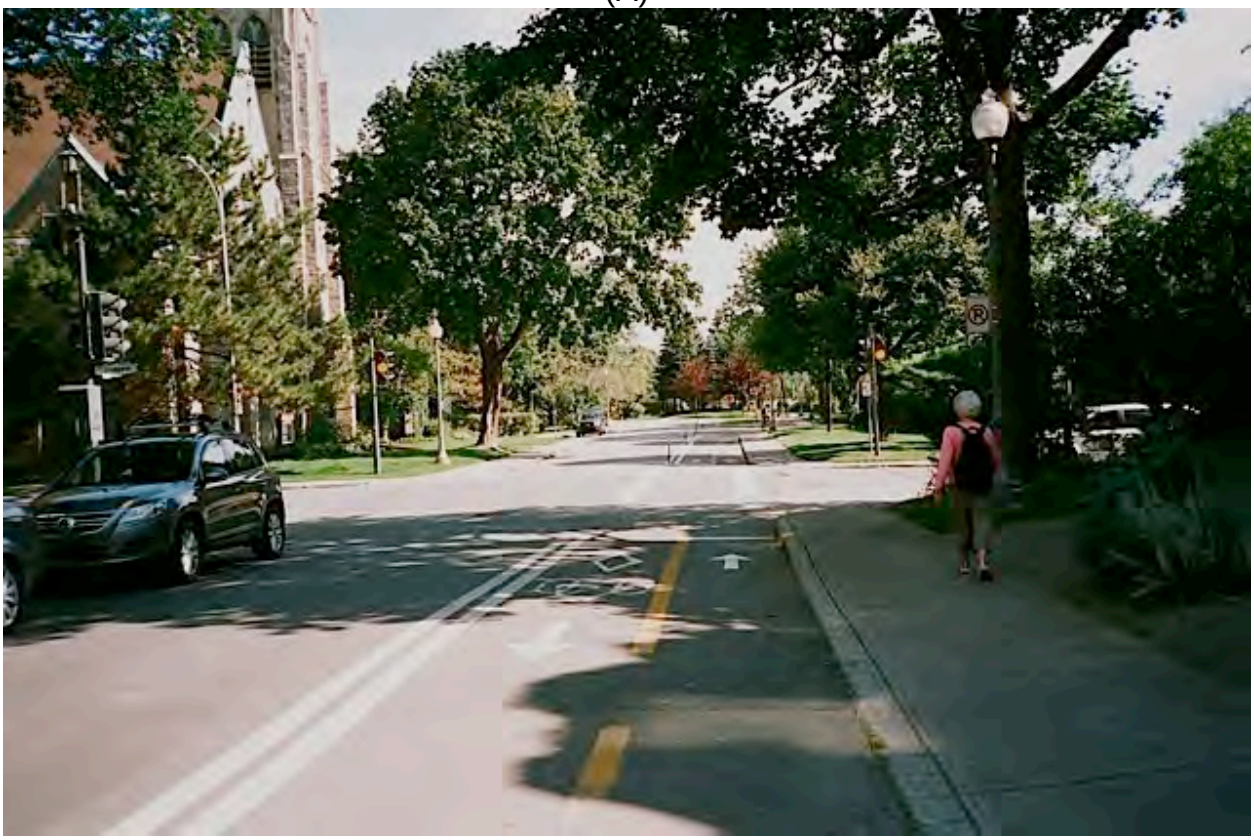
Figure 2. (A) de Maisonneuve at Claremont, facing east (western start of path is after the do not enter sign): residential, low traffic, one-way. This is also the intersection of Ste Catherine at Claremont— Ste Catherine is not parallel here, but is instead the high-traffic two-way 4-lane divided cross street running south of de Maisonneuve from this intersection and then turning eastward. (B) Sherbrooke at Claremont: commercial, high volume two-way traffic.

(A)

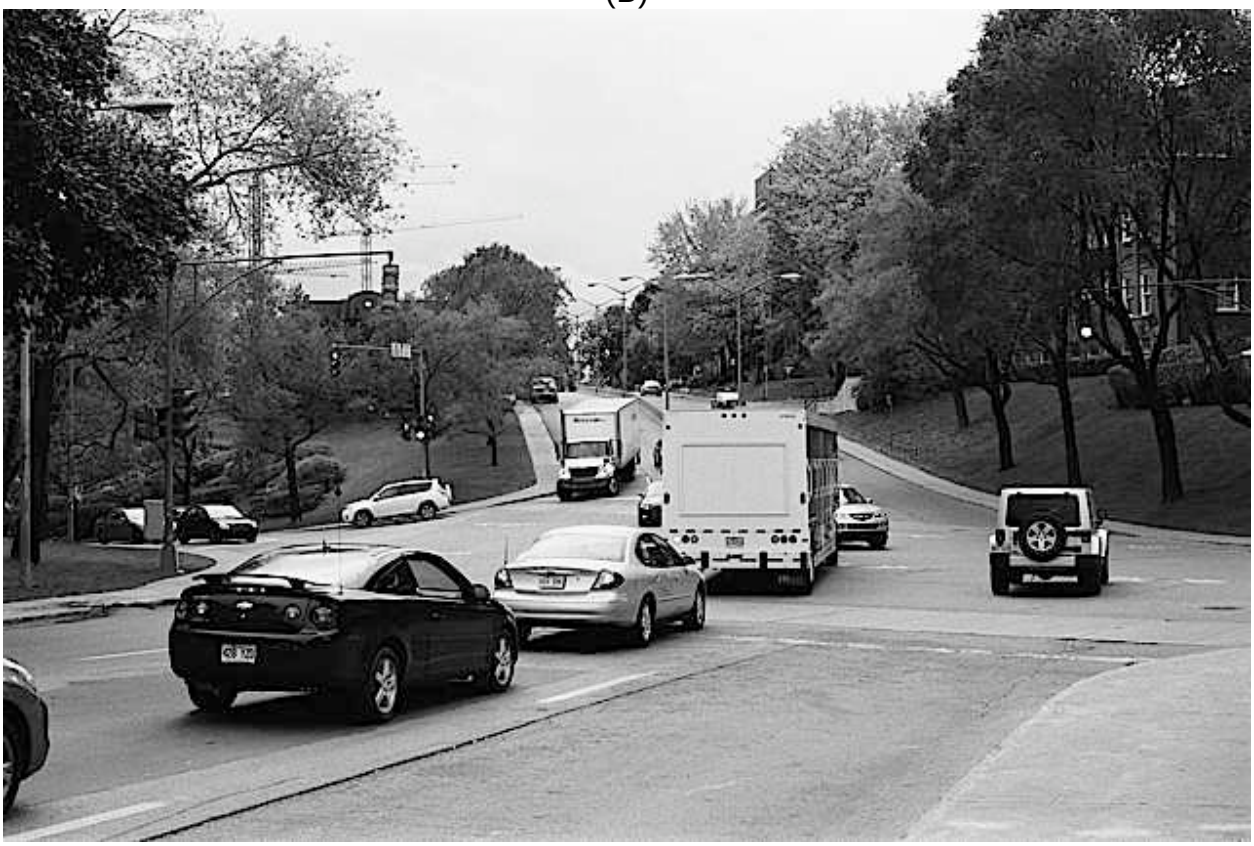
(B)

Figure 3. (A) de Maisonneuve at Lansdowne, facing east. Road comes from a dead end at the park in the background. (B) Ste Catherine at Lansdowne, facing west: major intersection at bottom of hill. (C) Sherbrooke at Lansdowne, facing east: another high-volume intersection. Note non-standard, narrow parking and first traffic lanes. (D) De Maisonneuve path in Westmount Park, east of Lansdowne, facing west: no street and no intersections.

(A)



(B)



(C)

(D)

(b) Brebeuf group (all photos facing north)

Figure 4. (A) Brebeuf at Rachel. (B, C) Almost identical adjacent streets Chambord and de Lanaudiere at Rachel: not used by authors for comparison. (D) St Denis at Rachel: 10 blocks away, thoroughly different in character; chosen by the authors for the comparison. Note signage as a numbered Quebec provincial highway (Route 335) [12, 13].

(A)

(B)

(C)

(D)

(c) Berri group

Figure 5. (A) Berri at Viger, facing north. Mostly residential on path side in this area. Northbound side of roadway divided from southbound by raised medians at intersections and wide markings in between. (B) St Denis at Viger, facing north. Traffic lanes all one-way southbound. Large building in background is a major hospital, whose emergency room entrance is on St Denis, adjacent bicycle traffic keeping to the right in the direction of traffic flow.

(A)

(B)

Figure 6. (A) Overlooking Berri, just below Sherbrooke, facing south. Underpass bypasses major intersection at Sherbrooke. North and southbound lanes of roadway separated by raised median; path is on the west-side sidewalk. First cross street is Ontario, whose intersection with this path, along with Viger and this path, are the second and third worst bicycle injury blackspots on the entire island of Montreal. (B) St Denis at Sherbrooke, facing south: thoroughly different in character.

(A)

(B)

(d) Christophe Colomb group

Figure 7. (A) Christophe Colomb at Jarry, facing north. After the gas station, neighbourhood is residential on the path side, up until the elevated expressway in the background. That intersection is the fourth-worst bicycle injury blackspot on the entire island of Montreal. Thus three of the four island-wide worst bicycle injury blackspots are on the cycle paths.

During the authors' study period this section of the path was instead on the sidewalk, which was of a different width and construction at the time. (B) St Hubert at Jarry, facing north. Neighbourhood is instead commercial in this area.

(A)

(B)

Figure 8. (A) Christophe Colomb a short distance north of Emile Journault, facing north. The authors describe this as sidewalk level, separated from traffic by the curb and a "planting strip". (B) Further north, facing north. Parallel sidewalk is separate and to the right. Crossing path is a footpath. (C) St Hubert below Emile Journault, facing south. No parking on the right during morning rush hour.

(A)

(B)

(C)

Figure 9. (A) Christophe Colomb at Fleury, facing north. (B) St Hubert facing north to Fleury. No-parking side alternates morning and afternoon rush hours. Rush hour side appears to be a wide single lane suitable for bicycle riding, but during heavy traffic two cars drive side by side in what then becomes two narrow traffic lanes (this is the purpose of the parking change), with inadequate room for an adjacent bicyclist. Rider must either ride in line with one of the car lanes, which few are willing to do; use the sidewalk; or invite serious injury by riding adjacent to traffic. The solution most bicyclists adopt is to not use this route.

(A)

(B)

Figure 10. (A) Northern end of Christophe Colomb path at Gouin, facing south. (B) Northern end of comparison street St Hubert at Gouin, facing south. The authors index St Hubert as being safer for cyclists than Christophe Colomb, on the basis of a lower MVO injury count.

(A)

(B)

(e) Rene Levesque group

Figure 11. (A) Rene Levesque at de Lorimier, facing west. Path traverses from north to south at this complex crossing; any resulting injuries excluded by the authors. Bridge traffic (heavy) neither enters nor exits to Rene Levesque, but instead feeds to and from the comparision street, Sherbrooke. (B) Rene Levesque at the eastern start of the authors' path segment: from de Lorimier facing west, omitting the dangerous de Lorimier intersection. Geography of the area makes for few opportunities for cross-traffic. (C) Sherbrooke at de Lorimier, facing west. Sherbrooke in this area crossed by many major north-south routes.

(A)

(B)

(C)

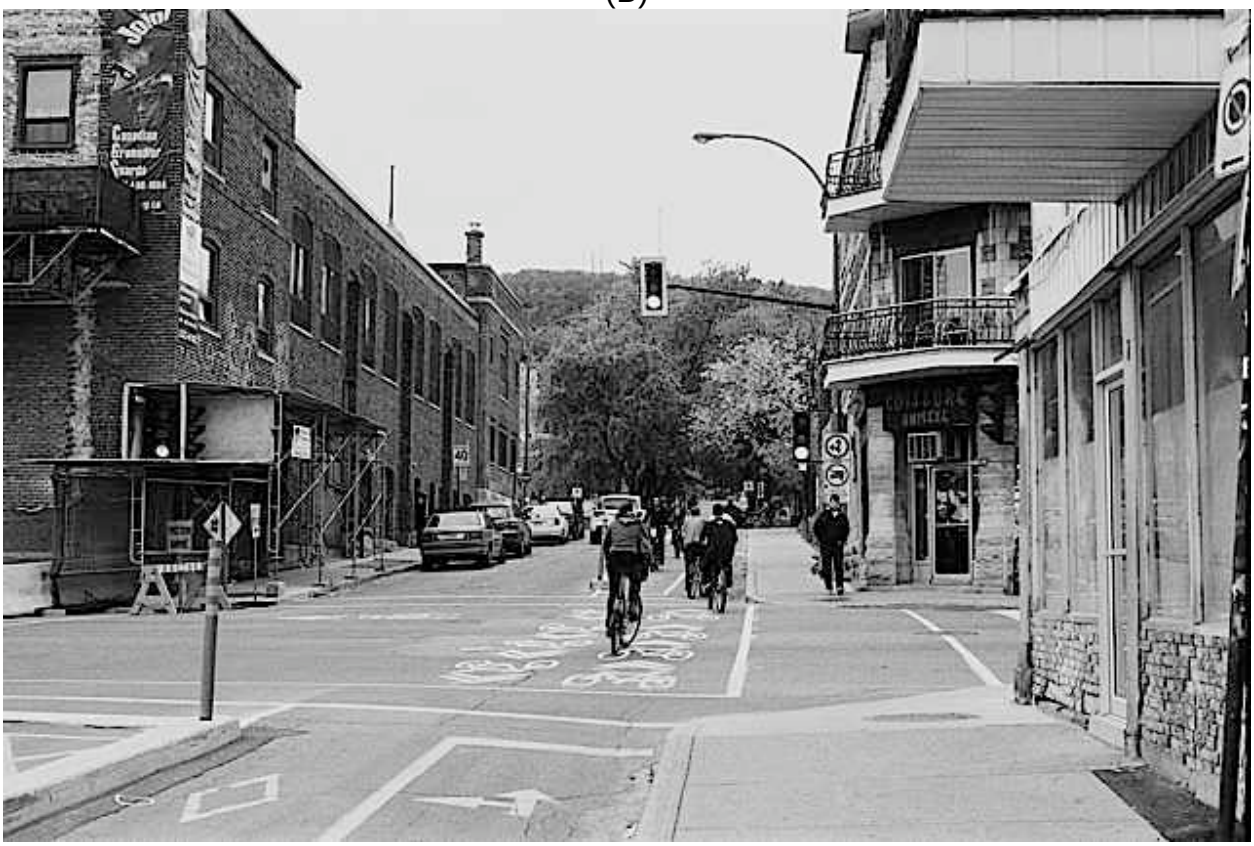
Figure 12. Rene Levesque facing east, near the mid-western part of the authors' path segment. Bridge in the background is at de Lorimier. Building on the right is the Montreal headquarters of the Canadian Broadcasting Corporation. In 1990, renowned CBC journalist and producer Joan Donaldson attempted to cross this two-way path to get a taxi, and was struck down by a cyclist coming from her right. Donaldson remained in coma for at least six months, was unable to speak at all for three years, and was left permanently brain damaged and quadriplegic. The cyclist was uninjured. Donaldson died in 2006 from extended complications of the accident [14, 15]. Authors' method does not count such injuries, for not being to a cyclist.

(f) Rachel group

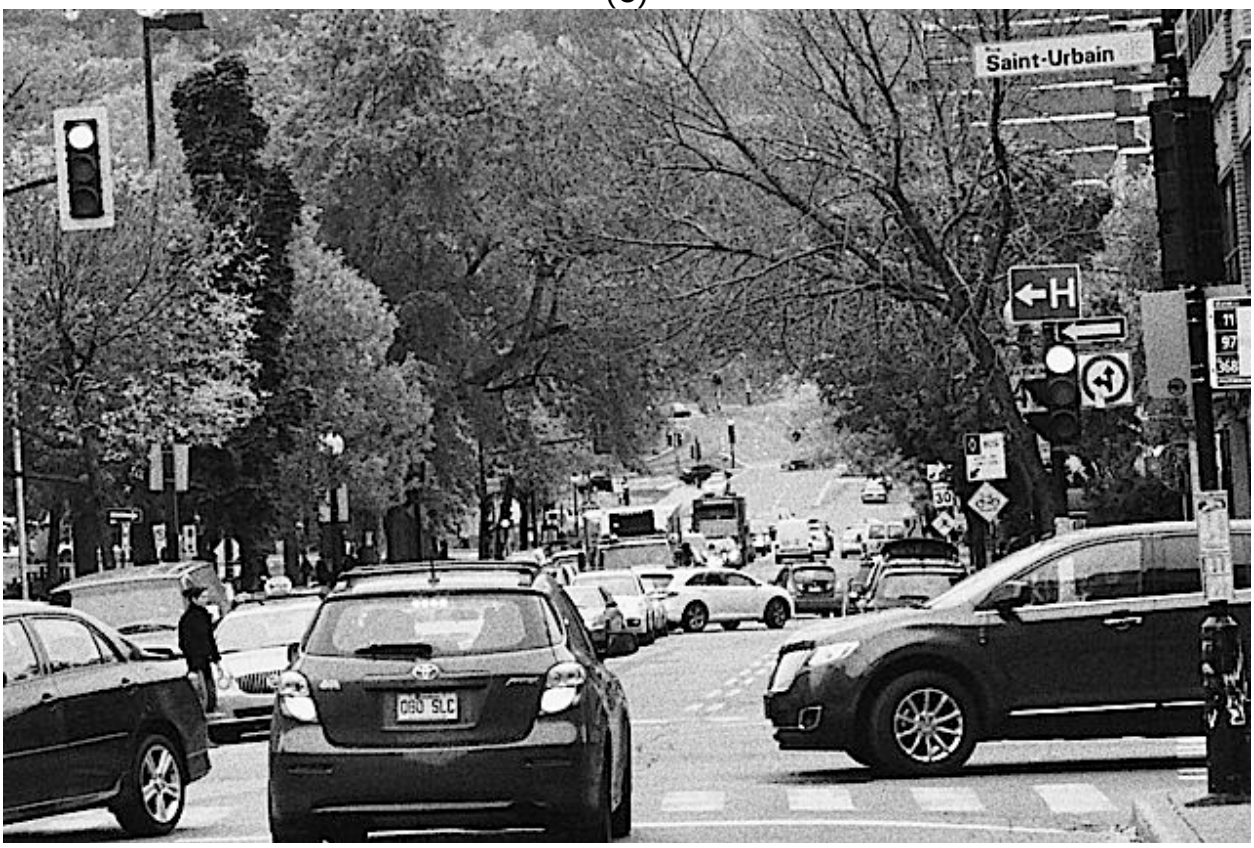
Figure 13. (A) Rachel at Marquette, facing west. Lafontaine park to the south blocks or discourages crossing traffic along most of its width. Comparison street Mount Royal at Marquette is in a heavily commercial area, with a fast food restaurant at each corner. (B) Rachel at St Urban, facing west: terminates in a dead end. (C) Mount Royal at St Urban, facing west: feeds to/from a major multi-way intersection complex, the worst bicycling injury blackspot on the entire island of Montreal. (D) Rachel at St Urban, facing east: traffic so minimal photographer can stand in middle of road without major concern. (E) Mount Royal at St Urban, facing east: photographer did not stand in the middle of the road. Time difference between this photo and the previous: about 5 minutes, or the time it took to walk from one to the other. The authors index Mount Royal as safer for cyclists than Rachel, on the basis of lower MVO injury counts.

(A)

(B)



(C)



(D)

(E)

(g) de Maisonneuve path, downtown section.

Figure 14. De Maisonneuve path in a section not studied by the authors: the reality of a downtown bicycle path in Montreal, or anywhere. Path is two-way, not one way or arbitrary way, as its users seem to indicate in this photo. Injuries occurring to pedestrians not counted by the authors, for not being to cyclists.

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