CITY OF VANCOUVER

Engineering Services
Transportation Design

MEMORANDUM

October 21, 2019

TO: 10th Avenue Evaluation Committee

CC: Paul Storer, Sarah Power, Vania Tse

FROM: Dylan Passmore
Senior Transportation Designer Engineer

SUBJECT: 10th Avenue Evaluation Committee Update

Background

Following extensive public and stakeholder engagement, the City developed a recommended design for street improvements for the 10th Avenue Hospital Zone. On May 17, 2017 City Council approved the "10th Avenue Health Precinct Street Improvements" (see Council Report link below).

Given the scale of changes proposed to 10th Avenue between Oak and Cambie Streets, it was difficult to predict all possible outcomes and some adjustments were required, as is common with all street design projects. In January 2018, City staff formally setup the 10th Avenue Evaluation Committee to meet the following commitment to Council:

> "Action 10: Commit to ongoing improvements and issue resolution, including establishing a 10th Avenue Health Precinct Evaluation Committee to evaluate the project's impacts following implementation and recommend spot improvements"

The intent of creating the evaluation committee is to provide a channel for City staff to continue to receive valuable feedback from key stakeholders on the functioning of the 10th Avenue Hospital Zone following construction of the approved improvements. Work with the committee builds off past engagement efforts made with stakeholder groups, advisory committees, and other organizations through the previous phases of 10th Avenue consultation leading up to Council approval. Since the Committee's inception, staff collaborated with the Committee to develop a monitoring plan, which was executed by City of Vancouver staff with support from researchers at UBC and SFU as well as NRG Research Group.

This report is a summary of all findings following the completion of Phase 1 construction of 10th Avenue, which comprised rebuilding 10th Avenue between Spruce St and Willow St in its final form as well as converting the operation of the block between Ash St and Cambie St to one-way westbound except bicycles using interim treatments. The second and final phase of construction is currently scheduled to begin in the first quarter of 2020. Although the overall design concept for Phase 2 has been approved by Council, details of the design are being informed by the results of this study.

Analysis Method

Based on suggestions from the Committee, staff developed a plan to collect data and report back on the following aspects of the project:

1. Comfort and safety of people using 10th Avenue
2. Interactions between people crossing the street and people cycling or driving
3. Interactions between vehicles accessing the VGH Emergency Department (ED) Entrance and people cycling eastbound
4. Changes in vehicle volumes
5. Amount of cycling volumes diverted to alternate routes
6. Performance of passenger loading zone outside the Arthritis Centre
7. Parking availability for people with disabilities and at key destinations

Our analysis method seeks to gain a thorough understanding of the impacts by applying a variety of both quantitative (e.g. vehicle counts) and qualitative (e.g. exploratory walks) data collection methods. Whenever possible, data collected after the implementation of the Phase 1 street improvements has been compared with data collected prior to implementation.

Study Findings

1. Comfort and Safety of People Using 10th Avenue

Many of the project's central goals aim to improve the comfort and safety of people using 10th Avenue. The analyses described below aimed to gain insight into whether 10th Avenue now functions more safely and how the experience of walking and cycling has changed following the implementation of Phase 1 of the 10th Avenue street improvements.

Frequency of Collisions

The City often uses the ICBC Collision database as the most comprehensive City-wide source of safety data, which also contains a brief description of incidents that can be used for a more details analysis of collisions in corridor studies. Unfortunately, the 2018/2019 collision data will not likely be available until 2020 and therefore we were not able to apply this data source to this analysis. However, Vancouver Coastal Health (VCH) has shared triage data from 2011 to the present of the total number of VGH Emergency (VGH ED) admissions associated with vehicle-pedestrian, vehicle-bicycle, bicycle-pedestrian, vehicle-vehicle and "bicycle alone" traffic-related incidents on areas of 10th Ave that changed as part of Phase 1. VCH staff have been very helpful in continuing to share this data on a monthly basis on request with a short turnaround time, which has allowed us to keep a close eye on the collision rates following construction. Although this dataset does not contain details describing the incidents other than the approximate location, it acts as a good barometer for this project given the proximity of VGH ED. This data tends to be somewhat sporadic, so it is easiest to interpret if aggregated to an annual rate.

Based on 7 years of VGH ED before data and 14 months of data following construction, to date we have seen a significant 60% reduction in traffic-related incidents on the corridor. Over the period since construction completed there have only been six incidents[1].

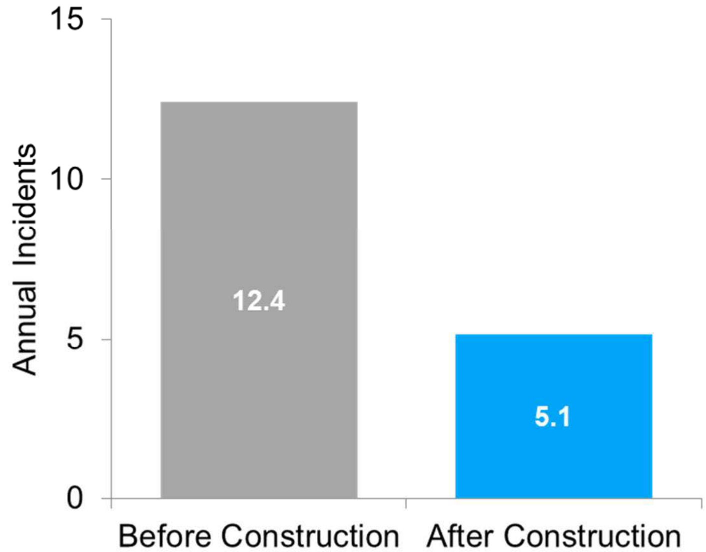


Figure 1: Average annual traffic-related incidents in the upgraded portion of 10th Ave that resulted in admission to VGH Emergency Department (Jan, 2011 to Aug, 2019)

[1] Only incidents in the segments of 10th Ave that were upgraded in Phase 1 were included. That is, the 500, 800, and 900 blocks of 10th Ave as well as the Cambie St, Ash St, Willow St, Laurel St, and Oak St intersections with 10th Ave. Given the relatively short timeframe, monthly incident rates were extrapolated to form annual rates.

Unfortunately, two incidents happened at Oak St and 10th Ave soon after the corridor opened for regular operation following construction. Staff and the contractor received details on the nature of these incidents the following day and immediately took action to install additional paint and signage to mitigate the potential for such incidents to repeat. To date, we are unaware of any similar incidents having occurred following the installation of the additional paint and signage. As such, those two incidents do not reflect the current "after condition" of the corridor and were not included in the 'after' results.

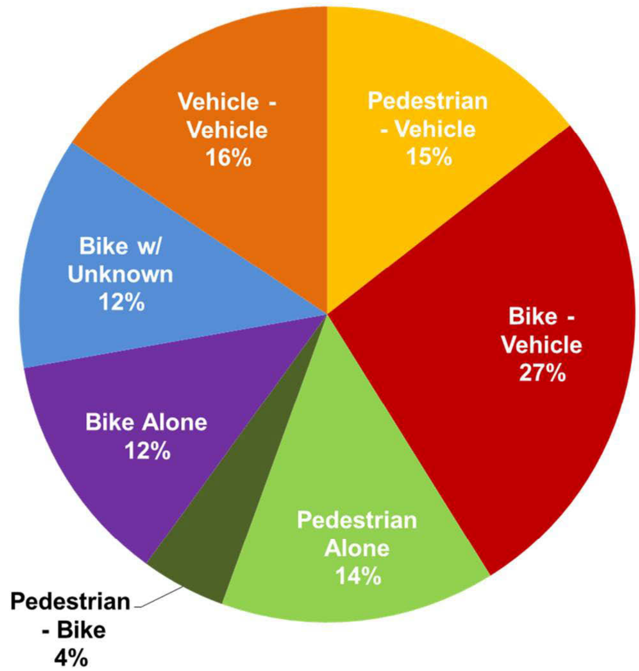
Without ICBC data, we have little information on the details of these six incidents although it is worth noting that to date there have been no incidents involving seniors while previously there was an average of two per year. As well, there have been no recorded incidents of bicycle-pedestrian collisions nor have there been any vehicle collisions with pedestrians.

Comfort of Road Users

Staff hired consulting firm NRG Research Group to conduct an intercept survey of pedestrians and cyclists using the corridor following construction of Phase 1. This complemented a similar intercept survey done by Mustel Group in 2016 before construction had started.[2]

When these people using the corridor were specifically asked to compare walking and cycling conditions before and after construction, overall the feedback was quite positive from those who felt informed enough to answer the question. Nearly 60% indicated feeling that walking conditions had improved versus 12% who felt they had worsened, while a similar proportion specifically felt that walking in the corridor was more comfortable than before.

Before Construction:



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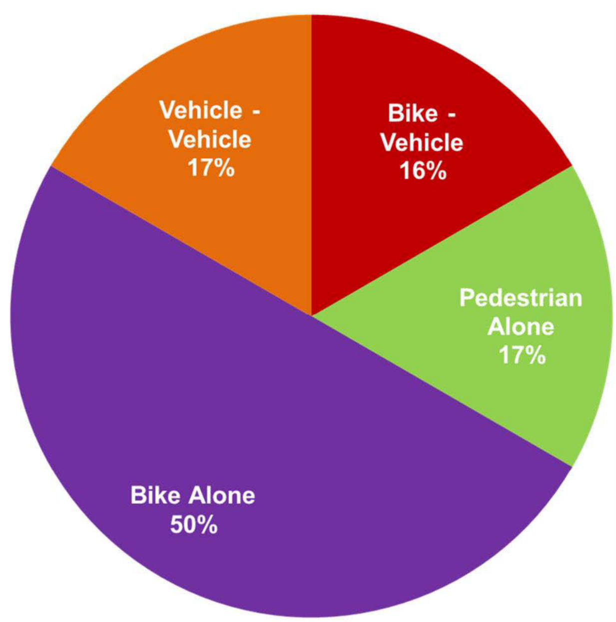


Figure 2: Type of traffic-related incidents in the upgraded portion of 10th Ave that resulted in admission to VGH Emergency Department (Jan, 2011 to Aug, 2019)

[2] The "after" survey was an intercept survey of a random sample of people intercepted on foot (449) and biking (159) on 10th Ave. conducted on weekdays by NRG Research Group April 3, 4 & 9, 2019 between 8am and 6pm. Similarly, the "before" survey was an intercept survey of a random sample of pedestrians (282) and people biking (46) on 10th Ave. conducted on weekdays by Mustel Group September 27, 28, 29, 2016 over the same time period (weekend data was filtered out of the 2016 results given the relatively quiet conditions in the Hospital Zone outside regular business hours).

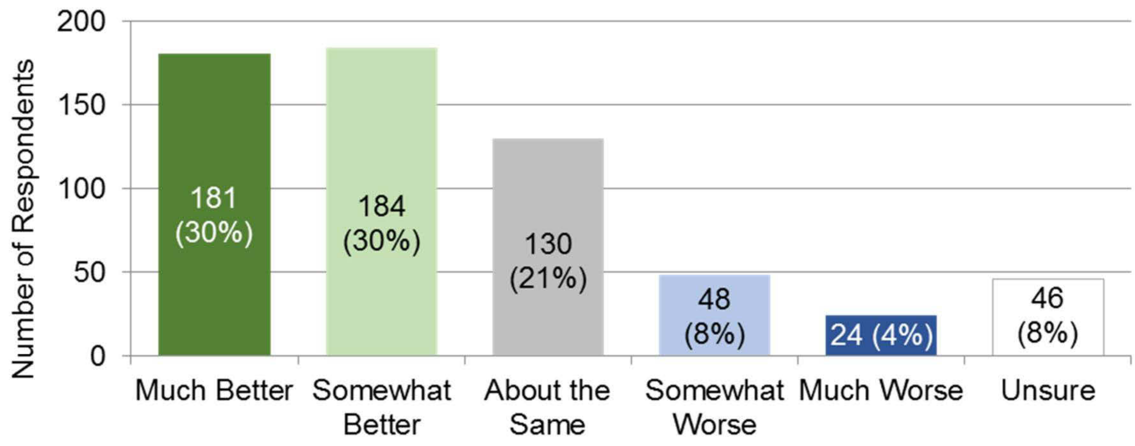


Figure 3: Do you feel the upgrades have improved conditions for walking?[3]

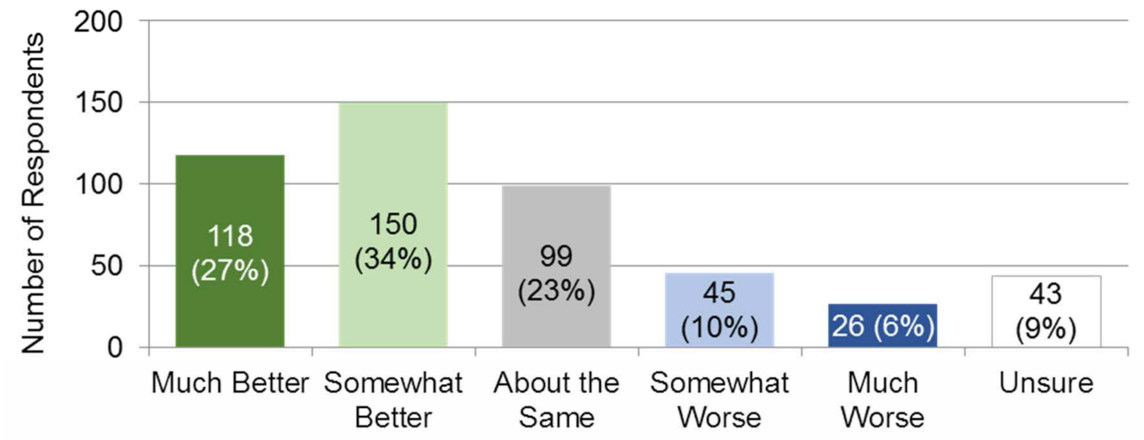
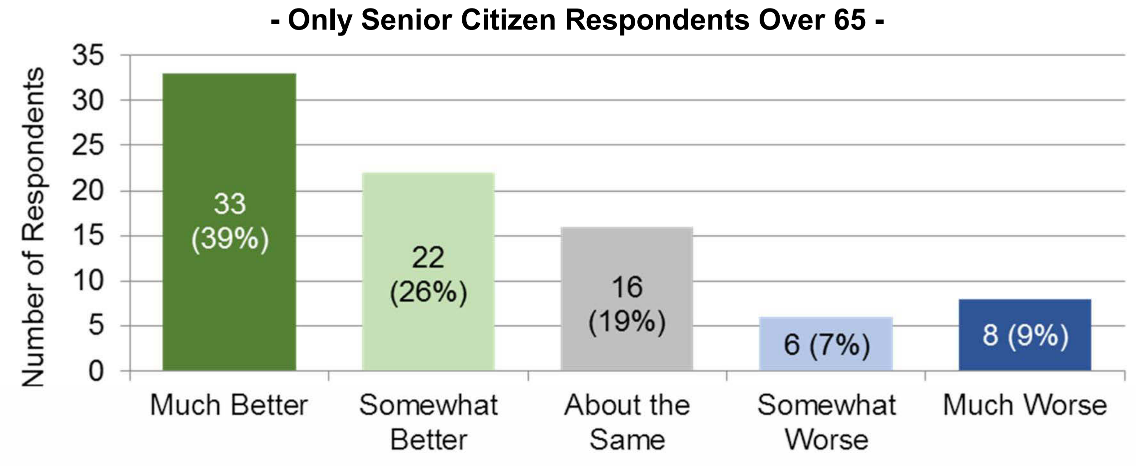


Figure 4: How comfortable is it walking through the new portion of 10th Ave compared to conditions before?[4]

Given the projects emphasis on addressing the needs of seniors and people with disabilities, staff also looked at demographics to see whether these priority respondents had significantly different perspectives. When asked generally if they felt the upgrades had improved conditions for walking, those using mobility aids and seniors indicated support similar to that of the general population (the seniors felt particularly strongly about it).

[3] Interviewers asked: "Do you feel the upgrades have improved conditions for walking on 10th Ave?" Interviewees were then prompted with "much Better, somewhat better, about the same, somewhat worse, much worse, or unsure/new to the area."

[4] Interviewers asked: "How comfortable is it walking through the newly constructed portion of 10th Ave west of Willow compared to conditions before construction?" Interviewees were then prompted with "much more comfortable, somewhat more comfortable, about the same, somewhat less comfortable, much less comfortable, unsure/new to the area."



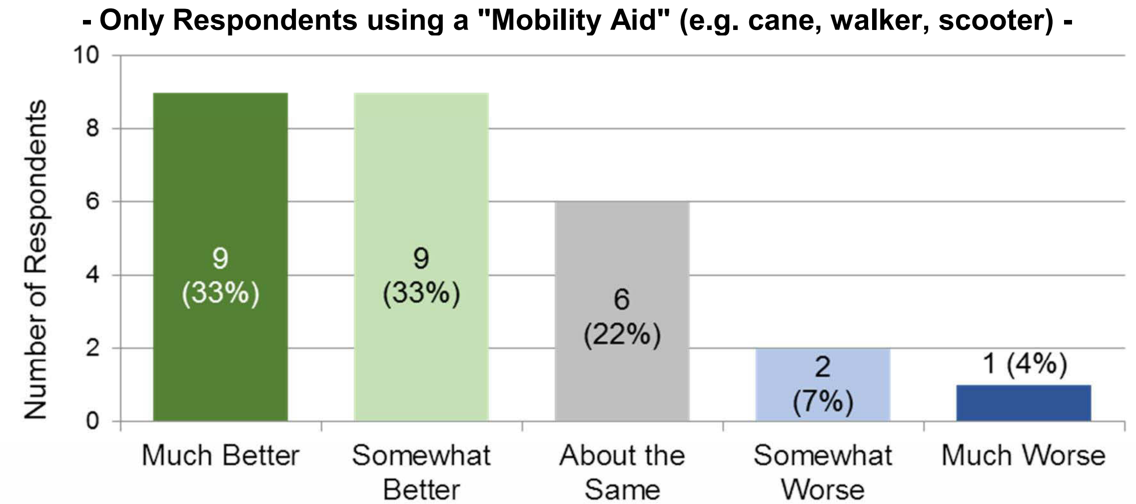


Figure 5: Do you feel the upgrades have improved conditions for walking?[5]

Opinions were even more supportive of the new cycling conditions in the corridor, where 80% felt conditions had improved while just 5% felt they had worsened. Opinions were nearly identical when evaluating the comfort of cycling on 10th Ave compared to conditions prior to construction. It perhaps should not be surprising that the assessment of the improvement to cycling conditions was so positive. Although much of the project's design efforts were focused on pedestrian improvements, as a minimum accommodation there had always been sidewalks on both sides of 10th Avenue whereas previously there was no space to cycle separately from vehicle traffic.

[5] Interviewers asked: "Do you feel the upgrades have improved conditions for walking on 10th Ave?" Interviewees were then prompted with "much Better, somewhat better, about the same, somewhat worse, much worse, or unsure/new to the area."

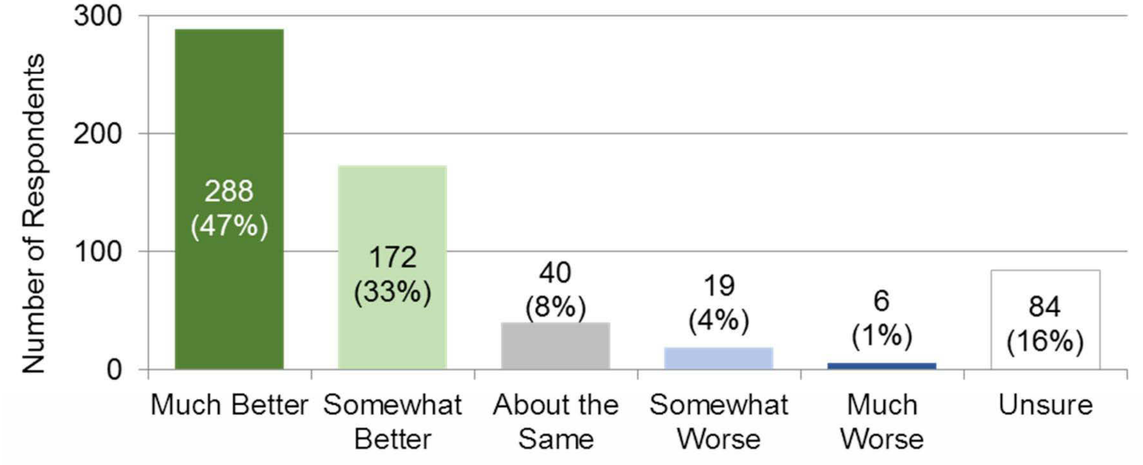


Figure 6: Do you feel the upgrades have improved conditions for cycling?[6]

The before and after intercept surveys also sought to understand people's primary concerns with walking and cycling in the corridor. Unfortunately the before survey contained a more limited set of categories to code responses, which complicates comparing a shift in opinions. However, the primary concerns for both walking and cycling in the corridor prior to the Phase 1 changes were clearly **high vehicle and bike volumes**. Following construction, the primary concerns of people biking shifted to bicycles not yielding, vehicle and bicycle speeds, and the lack of a barrier between the bike lane and the sidewalk. The primary concerns of cycling in the corridor were pedestrians in the bike lane (ironically), pedestrians crossing the street, and drivers pulling in/out of driveways.

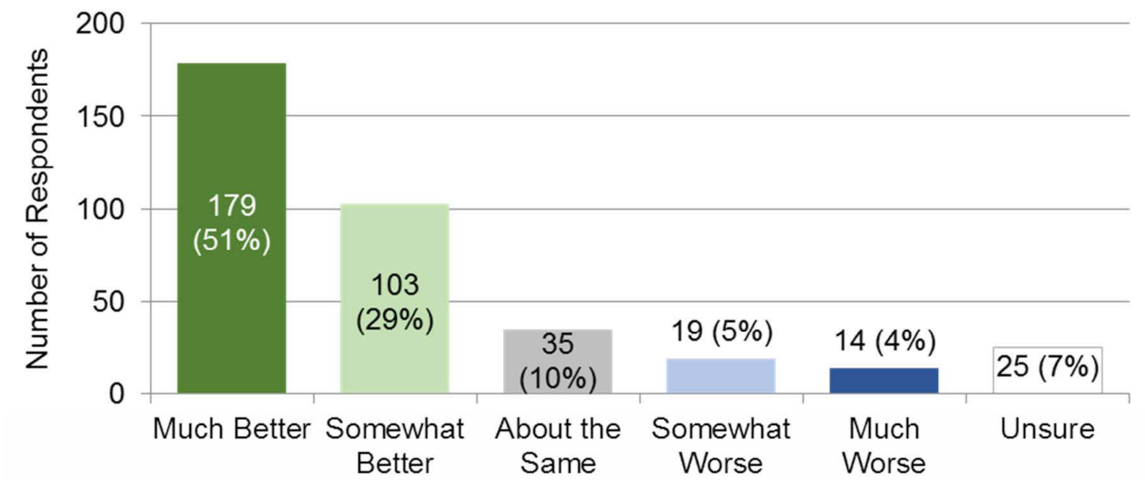


Figure 7: How comfortable do you feel biking on the new portion of 10th Ave compared to conditions before?[7]

6 Interviewers asked: "Do you feel the upgrades have improved conditions for walking on 10th Ave?" Interviewees were then prompted with "much Better, somewhat better, about the same, somewhat worse, much worse, or unsure/new to the area."

7 Interviewers asked people intercepted on foot and by bike: "How comfortable do/would you feel biking on the newly constructed portion of 10th Ave west of Willow compared to conditions before construction?", followed by the prompts "much more comfortable, somewhat more comfortable, about the same, somewhat less comfortable, much less comfortable, unsure/new to the area."

When it comes to driving conditions, opinions are somewhat evenly split with three in ten (29%) believing that conditions are worse than before while 23% think that driving conditions have improved. About one-quarter (24%) believe that driving conditions are about the same and a similar proportion (23%) were unsure about the changes to driving conditions. Staff were particularly interested to know more about how the driving experience has changed for those attending medical appointments. Result indicated that 30% of those respondents felt conditions had worsened versus 23% who felt it had improved. Unfortunately the survey did not solicit people's concerns with driving in the area, so we could only speculate. Staff will continue to work with the area's health partners to find solutions to parking concerns, better facilitate alternate modes of travel to the Hospital Zone for those who do not need to rely on driving, and complete the implementation of the area's new wayfinding signage. Informal feedback from BC EHS representatives suggests that paramedics' driving access to the VGH Emergency driveway has improved significantly.

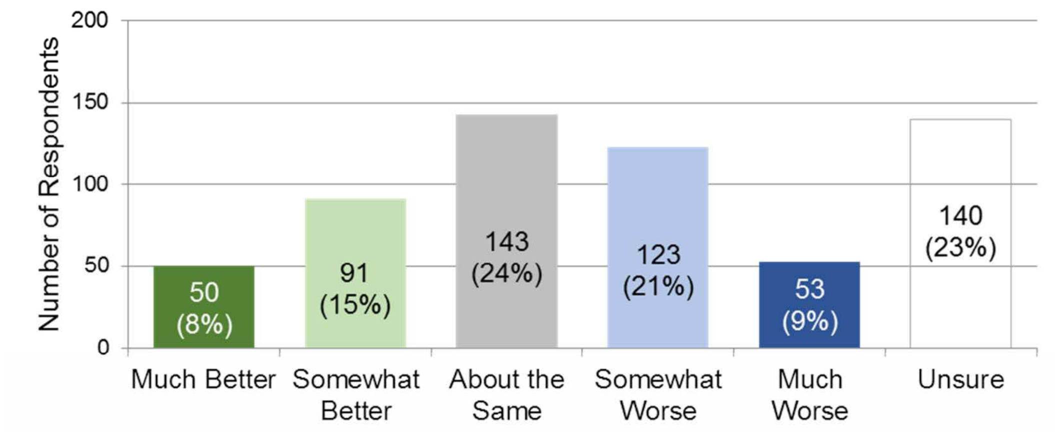


Figure 8: Do you feel the upgrades have improved conditions for driving?[8]

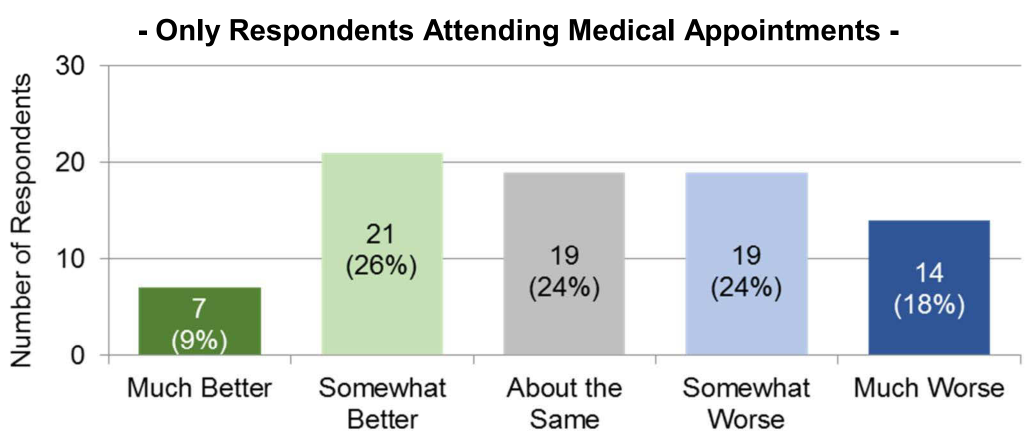


Figure 9: Do you feel the upgrades have improved conditions for driving?

[8] Interviewers asked people intercepted both on foot and by bike: "How comfortable do/would you feel biking on the newly constructed portion of 10th Ave west of Willow compared to conditions before construction?" Interviewees were then prompted with "much more comfortable, somewhat more comfortable, about the same, somewhat less comfortable, much less comfortable, unsure/new to the area."

2. Interactions between People Crossing the Street and People Cycling or Driving

Speed of Road Users

Early in the project there was concern expressed about the speeds of people cycling and much speculation about the influence of a protected bike lane on the speeds of people biking. On the one hand, by providing protected space for cycling instead of sharing with motor vehicles it may enable people to cycle faster. On the other hand, with everyone cycling now in a narrower space than on the street, people cycling more slowly may result in everyone slowing down. Using a LiDAR speed gun, staff were able to gather accurate data on both bicycle and vehicle speeds, which were recorded on a mid-weekday in 2016 & 2018 on 10th Ave, sampling approx. 50 bikes and 50 vehicles in each direction near the VGH Cycling Centre.

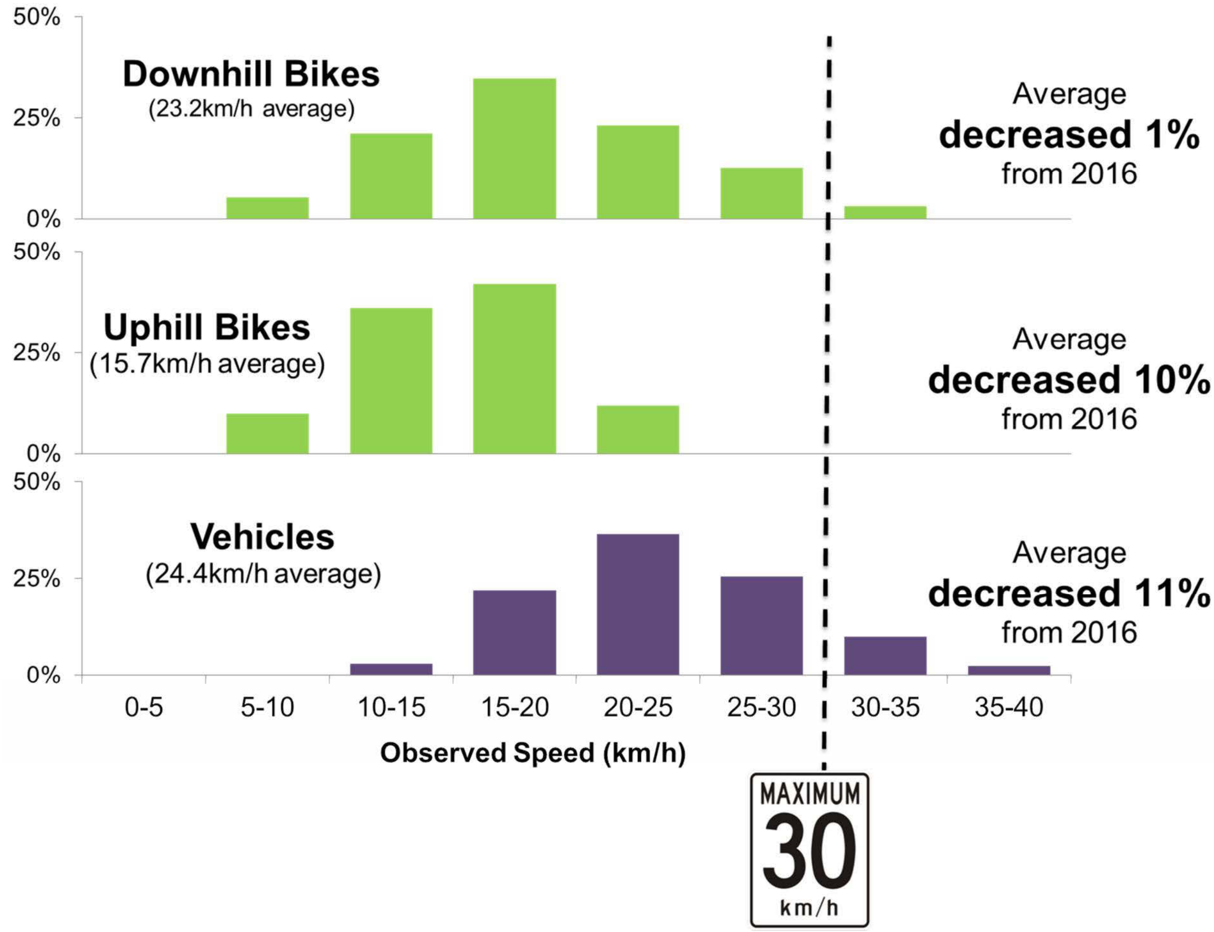


Figure 10: Bicycle and vehicle speeds on 10th Ave after phase 1 of construction
(note, the posted 30km/h speed limit is indicated with a dashed line)

The vehicle speeds on 10th Ave decreased by roughly 10%, likely due to several traffic calming features added to the corridor. In terms of people cycling, the speed of those travelling downhill was essentially the same as when they were sharing the street with motor vehicles, with an average speed of 23.2km/h, which is well below the 30km/h speed limit. Interestingly, the speed of people biking uphill (westbound) decreased by roughly 10%. Perhaps it is a case of the slower cyclists travelling downhill are coasting like everyone else with little influence on the speeds of others, but when travelling uphill the slower cyclists are harder to pass and therefore resulting in a slower average speed. Regardless of the cause, this is a fairly positive outcome especially given that the uphill direction and that with bike lane crossings at both passenger loading zones.

Pedestrian Interaction with People Driving and Cycling through Unsignalized Crossings on 10th Avenue

It remains unclear whether the observed speeds themselves are problematic or not. Through discussions with the Committee, the concerns raised with speeds were often rooted in concerns over the interactions between crossing pedestrians and people driving or biking on 10th Ave. In the 10th Avenue Evaluation Committee's April 2018 meeting, Committee members expressed that one of their primary concerns was the interaction with bikes and vehicles when crossing the bike lane or roadway at unsignalized crosswalks (painted with zebra stripes), which includes the bike lane crossing at the passenger loading zone in front of the Arthritis Centre. This is a concern that has also been raised by some stakeholders and members of the public about other projects in the city. In response, staff partnered with local researchers from the University of British Columbia (UBC) and Simon Fraser University (SFU) with expertise in this field to investigate those interactions. This project's objectives were to (a) determine the frequency of road user interactions in the 10th Ave project area and at other sites in the city with similar characteristics; (b) investigate the perceptions of different groups of stakeholders on non-compliant, uncomfortable, and unsafe interactions; and (c) examine systematic differences in perceptions of interactions among stakeholders.

Video data, collected between September and December of 2018, were used to capture road user volumes and interactions between road users at 7 crosswalks along 10th Ave, and at 4 comparison sites[9]. Video clips of 84 sample pedestrian crossings were rated in a web survey by three pools of participants: the general public, 10th Avenue Evaluation Committee members, and traffic safety experts. Video data and survey results were combined to understand broad perceptions of typical crossing experiences. On-site interviews with Committee members were used to qualitatively characterize perceptions of safety in further depth and inform the rating scales used in the web survey.

A full report detailing the findings of this research effort is included in Appendix B. The following is a summary of the key points related to the 10th Ave project:

- A quarter of crossing pedestrians experience a negative interaction from the perspective of yielding, while 10% experience an interaction that was not comfortable and 6% that was not low risk (see Figure 11).
- With high volumes of people walking, driving, and cycling, 10th Ave has high interaction rates during weekdays. Just over half of pedestrian crossings involved an interaction.
- Most crossings were perceived as "low risk" (94%) and "comfortable" (90%), although 25% of crossings involved "inadequate yielding".
- The observation sites along 10th Ave. have higher yielding rates and lower risk than the comparison sites. However, these effects are partially offset by wider crossings, higher volumes, and closer interactions along 10th Ave.

[9] Unfortunately, due to data privacy restrictions, we were unable to retain video data shot before construction of Phase 1 began. Therefore, this study was limited to using control sites to contextualize findings on 10th Ave as opposed to "before" data.

- There are no significant differences in perceptions of yielding, comfort, and safety between members of the public and Committee members who participated in the survey. The traffic safety experts have similar views of yielding and comfort to the Public and Committee pools, but a consistently lower assessment of risk for pedestrians in interactions with motor vehicles and bicycles.

- Pedestrian interactions with bicycles are more comfortable and lower risk than interactions with motor vehicles. This finding may be explained by the size difference between bicycles and motor vehicles and easier visual communication between pedestrians and cyclists. Rates of inadequate yielding are similar in pedestrian interactions with either motor vehicles or bicycles. In otherwise similar interactions, cyclists are much more likely to be perceived as not needing to yield than drivers.

- Interactions involving more vulnerable pedestrians (children, mobility impaired) are perceived as higher risk but there were no significant differences for the other severity outcomes of comfort or yielding. This finding is supported by the interview result that comfort and safety are distinct constructs and mobility aids may not affect assessed comfort.

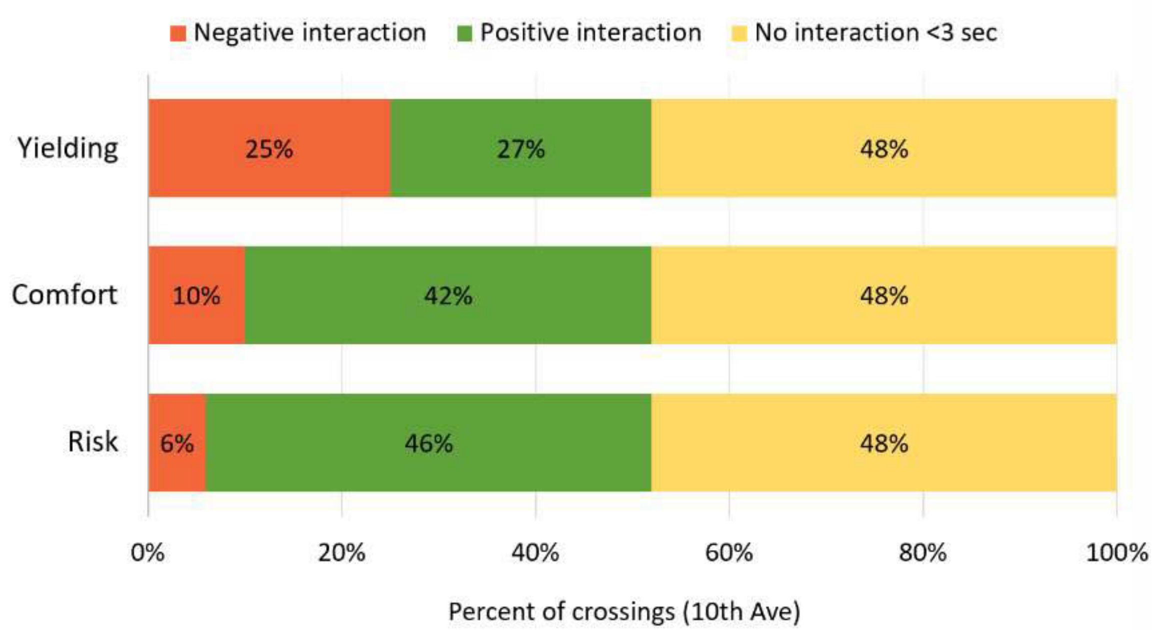


Figure 11: Overall pedestrian crossing experience at 10th Ave crosswalks[10]

Sidewalk Cycling

Lastly, concerns were raised that the beveled curb separating the sidewalk from the bike lane would result in an increase in sidewalk cycling. Based on 12-hour demographic counts of people cycling, which also note whether people were using the sidewalk or the roadway, incidents of sidewalk cycling appear to have decreased from roughly 2% of cycling trips to

[10] Negative/positive interactions indicate predicted disagreement/agreement that there was adequate yielding, that the pedestrian was comfortable, and that there was low risk of injury for the pedestrian.

below 0.5%[11], which roughly equated to an average of one incident every 15 - 20 minutes to one every 1 - 2 hours. Incidents of sidewalk cycling were not high to begin with, but now appear even lower and in line with the low sidewalk cycling rates seen on other streets where protected bike lanes were introduced.

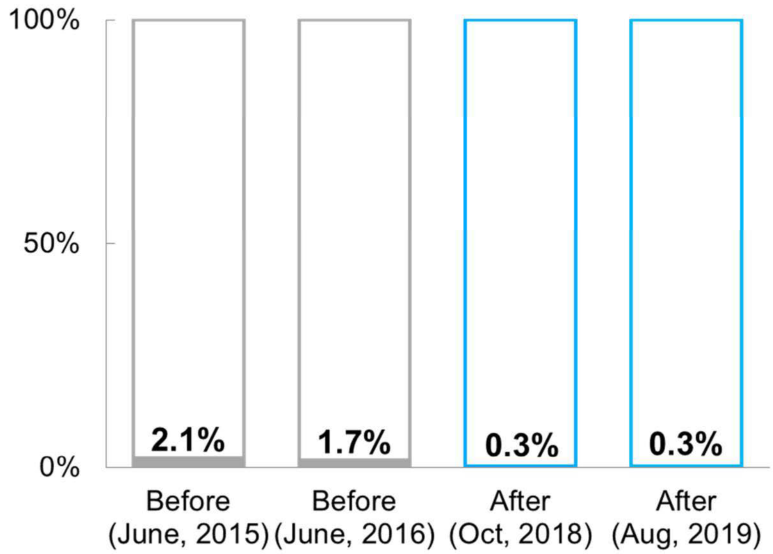


Figure 12: Proportion of sidewalk cycling observed at the middle of the 800 block of 10th Ave (near the Skin Care Centre driveway)

[11] The latest count in August, 2019 was done using video analysis to ensure accuracy.

3. Interactions Between Vehicles Accessing the VGH Emergency Entrance and People Cycling Eastbound

Representatives from BC Emergency Health Services expressed concerns about conflicts between people cycling in the protected bike lane and vehicles turning in the driveway to access the VGH Emergency Department (ED) entrance. A video camera was setup to observe these interactions (see Figure 13) mid-week between 8am and 5pm over two days (20 hours total).

Figure 13: Camera perspective for observing interactions between drivers turning into VGH ED and people cycling east

We found that interactions between right-turning ambulances and eastbound cyclists were relatively rare, with only 4 of the 109 ambulances observed encountering a cyclist. It is worth noting that not all vehicles accessing the VGH ED driveway are BC EHS ambulances, which accounted for only 37% of traffic during the observation period.

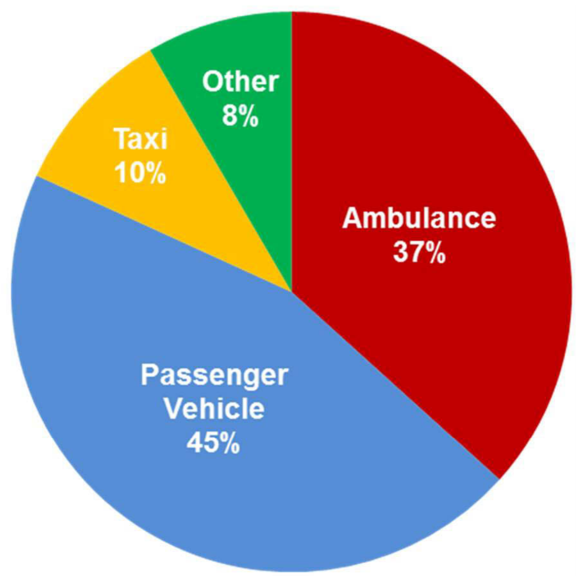


Figure 14: Type of vehicles accessing VGH ED

Based on observations of all vehicle types, behaviour of all road users, people driving and cycling alike, was not always ideal. However, right turns were generally slow and the offset bike lane approach appears to give people cycling enough of an advance warning that the driver intends to turn right in cases where drivers do not yield to people cycling.

Some concerns were raised about people cycling north on Laurel and turning right onto 10th Ave being difficult for people driving to see and anticipate. Some cases of this movement were observed and in all cases, the person cycling was traveling slowly both due to the stop sign on Laurel St and making a relatively tight right turn. As such, these particular interactions appeared to be safe although it may have been an uncomfortable surprise for the driver to encounter someone biking in the bike lane when they had thought it was clear.

The throat of the driveway was rebuilt as wide as it had been previously, which is wider than would typically be required for a one-way driveway. This decision was deliberate as City staff wanted to be sure vehicles would not have trouble accessing VGH Emergency due to someone accidentally exiting using the entrance driveway. However, despite the wide throat, the video showed some eastbound drivers approaching the driveway pulling into the opposing lane to make an (unnecessarily) wide turn, which unfortunately means the bike lane in is their blind spot as they cannot easily use mirrors to check for oncoming cyclists. Measures to help avoid this behaviour are proposed in the 'Follow-up Actions' section of this report.

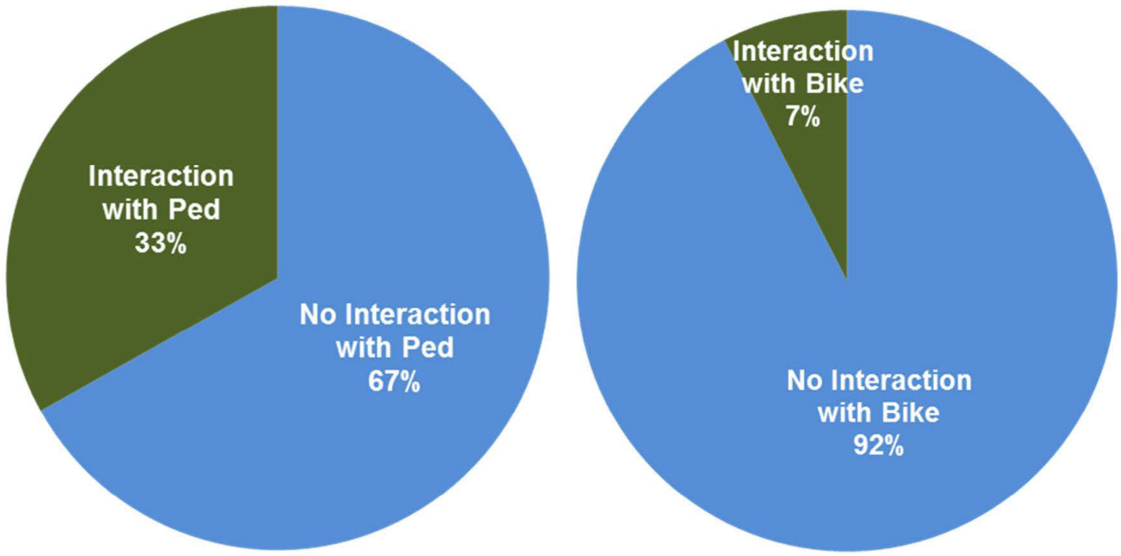


Figure 15: Pedestrian and cyclist interactions with people driving eastbound and turning right into VGH ED driveway[12]

Note, a Lidar gun was used to record cyclist speeds to the east and west of the driveway. However, this method was too imprecise with respect to the cyclists' location to conclude whether the jog in the bike lane design was successful at encouraging people cycling to slow down.

4. Changes in Vehicle Volumes

Although this project ended up including fairly minimal changes to traffic circulation, some Committee members were interested in understanding the impacts of the project on vehicle volumes in the Hospital Zone. Of particular interest was whether the removal of some on-street parking from 10th Avenue or conversion of 10th Ave between Ash and Cambie Streets to one-way westbound for vehicle traffic has influenced vehicle volumes.

Based on portable hose data gathered on mid-weekdays over 1-2 weeks in each location[13] it appears that vehicle traffic on 10th Ave may have actually increased slightly by 5%. Oddly, counts on Laurel show a significant decrease in vehicle volumes on that street of 10-20%, which may be the result of on-going temporary traffic control on Laurel St just south of 10th Ave. The only other noteworthy change in vehicle volumes is the laneway north of 10th Ave between Ash

[12] Turns with interactions are somewhat subjectively defined as those involving either the pedestrian or the driver changing their "pace" to avoid a collision with the other.

[13] As is typical practice at the City, vehicle counts were collected using temporary pneumatic hoses laid across the streets in the Hospital Zone and applying simple methods to filter out bicycle traffic. Most "before" data was gathered in 2015 & 2016, while all "after" data was gathered the 1st week of Dec, 2018.

St and Cambie St, which has seen vehicle volumes double, likely due to the one-way conversion of 10th Ave for the same block.

Figure 16: Average daily vehicle volumes following construction (with change relative to pre-construction conditions noted in green)

City staff were also keen to understand if the conversion of 10th Ave to one-way westbound from Cambie St to Ash St had resulted in a significant increase in turning vehicle volumes at Ash St / 10th Ave since people driving could no longer head straight east through the intersection. Although eastbound turn volumes increased at Ash St / 10th Ave, the impact has been fairly minor since there appear to be fewer eastbound vehicles arriving at the intersection that previously (see Figure 17).[14] It would appear that with time many people have adapted to the new traffic circulation and are choosing other routes to leave the Hospital Zone rather than using Ash St.

[14] Results are based on 4-hour manual intersection counts collected mid-week from 7am – 9am & 4pm – 6pm in 2014, 2016 & 2019.

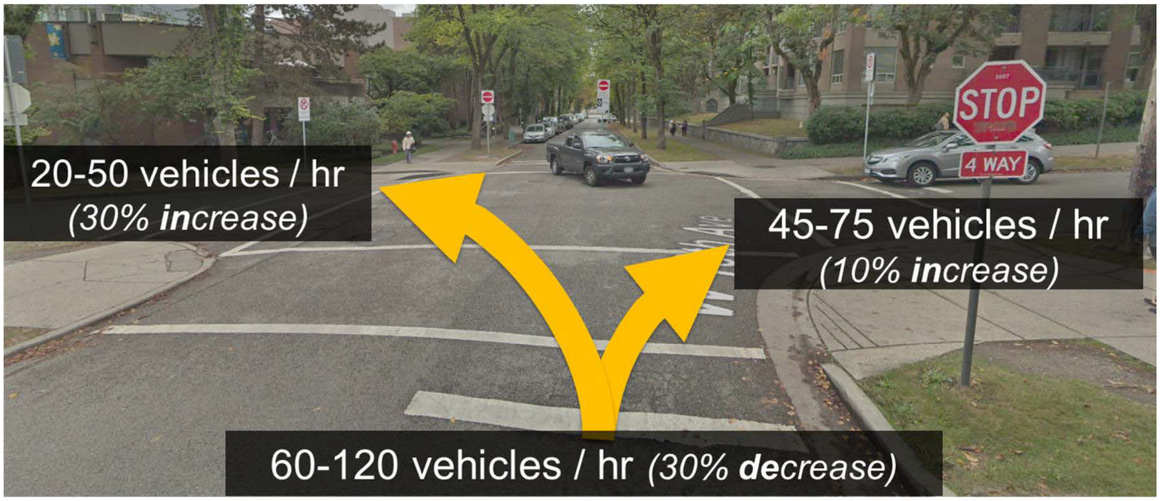


Figure 17: Change in eastbound peak-hour vehicle turn volumes at Ash St and 10th Ave

The Committee also expressed concern about a potential increase in the number of northbound vehicles on Ash St turning right onto West Broadway, and whether that would make it more difficult for pedestrians to cross West Broadway at Ash St.

Manual vehicle counts suggest that right-turn volumes did initially increase significantly soon after construction, but have since settled to a fairly modest increase that represents 20% more vehicles than staff had previously observed (see Figure 18). Although northbound traffic on Ash St at Broadway appears to have only marginally increased (approx. +5%), even prior to the 10th Ave work traffic tended to occasionally back up at this location.

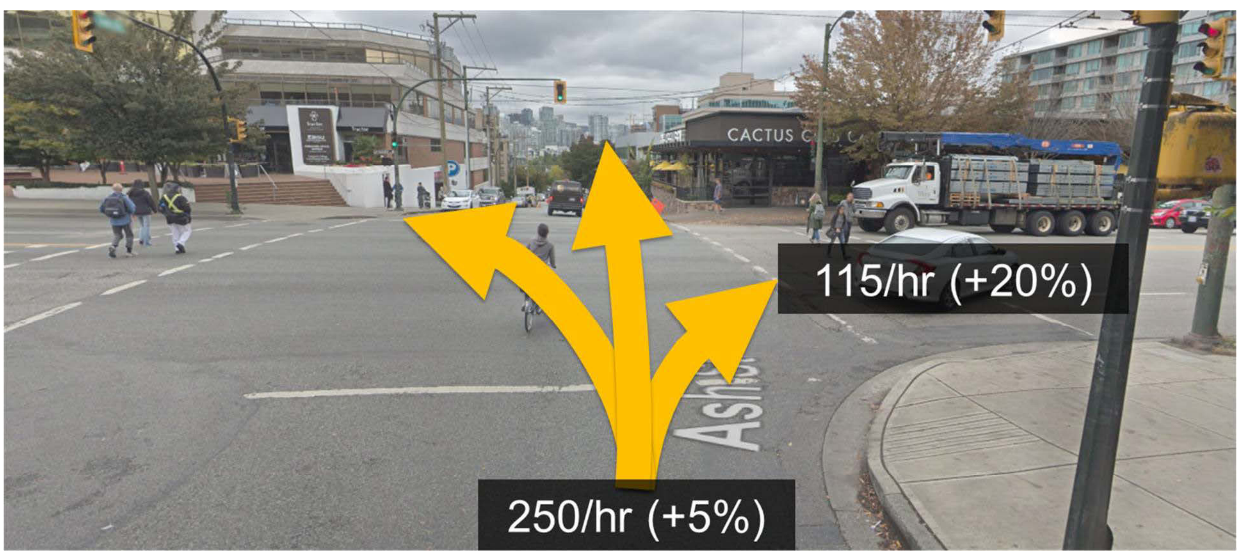


Figure 18: Change in northbound peak-hour vehicle right-turn volumes at Broadway and Ash St[15]

[15] Results are based on 4-hour manual intersection counts collected mid-week from 7am – 9am & 4pm – 6pm in 2016 & 2018.

5. Amount of Cycling Trips Using Alternate Routes

Based on a 2019 intercept survey conducted on 10th Ave in the Hospital Zone, 51% of the bicycle traffic on 10th Ave represents trips to/from/within the Hospital Zone itself.[16] In other words, of the 2,300 bicycle trips on 10th Ave in the Hospital Zone that were observed in June, 2019, approximately 1,160 were trips to/from/within the Hospital Zone itself. However, as part of Phase 1, a portion of both 14th Avenue and Alder Street were designated new bike routes to offer cycling alternatives to riding through the Hospital Zone for the other 49% of bike trips on 10th Ave (see map of alternate routes in Figure 19).[17]

For both new bike routes, the designation as a bike route meant that speed limits in these segments of 14th Ave and Alder St were reduced to 30km/h, standard bike route wayfinding signage was installed, and corresponding pavement markings were also installed. Both routes were also recently added to the City's official bike map (see Figure 19). Some Committee members were interested in knowing whether the measures associated with the creation of these new bike routes have succeeded in encouraging some people cycling to choose these alternate routes.

Annual bicycle volumes on 10th Ave appear to be roughly 10% lower in 2017 and 2018 relative to 2015 and 2016. However, that is likely partially the result of construction activities on 10th Ave in the Hospital Zone as well as near Kingsway.

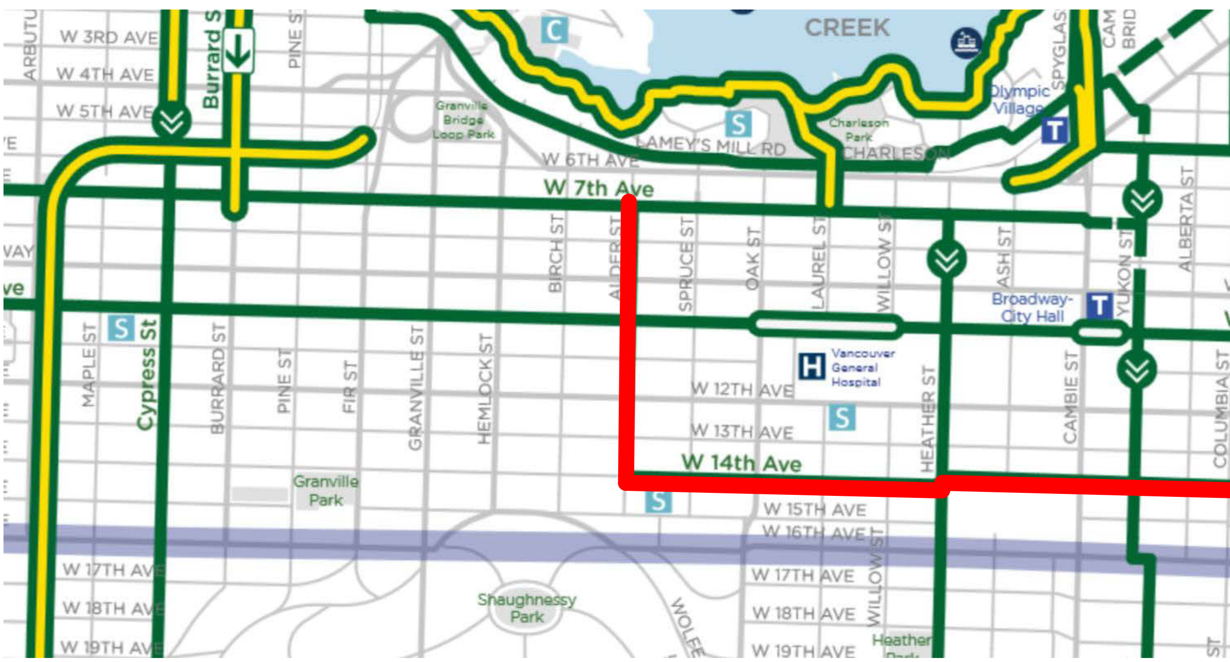


Figure 19: City of Vancouver bike map showing new routes (in red)

[16] Of the 201 people intercepted on bike, 102 had origins or destinations (or both) within the Hospital Zone.

[17] New bike routes were installed on 14th Ave (initially between Ontario St and Alder St, later extended east to Prince Edward St) and on Alder St (between 14th Ave and 7th Ave).

Considering bicycle volumes on 14th Ave and Alder St, based on manual summer counts[18] both before and after construction of Phase 1, it appears bicycle volumes on both routes have increased significantly, particularly 14th Ave which is nearly 110% higher than prior to being designated a bike route (see Figure 20).

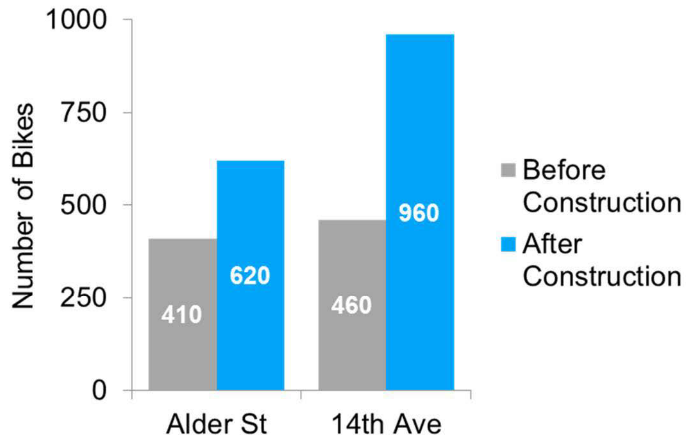


Figure 20: Change in Daily June Cycling Volumes on New Bike Routes

Staff were also able to use manual intersection counts collected before and after construction at Alder St and 10th Ave to assess the proportion of people choosing to ride east vs. south at that decision point. Results suggest there has been little change in the proportion of eastbound cyclists turning left to head north (see Figure 21). However, the proportion of people cycling eastbound and turning right has increased from 10% to 18% of the total eastbound bike traffic, which suggests that several people are taking advantage of these new bike routes. In terms of actual numbers, this represents an 80% increase in people biking eastbound and making a right turn south on Alder.

Figure 21: Change in volume of people cycling eastbound that choose to bike outside the Hospital Zone

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[18] 12-hour demographic counts and intersection turning movement counts were manually collected in summer months of 2017 and 2019, which were expanded to a typical June day for their respective years using the permanent counter at Clark Dr & 10th Ave to account for seasonal variation.

6. Passenger Loading Zone Performance

Committee members expressed concern that the removal of most of the on-street metered parking from 10th Avenue in the Hospital Zone might place additional pressure on passenger loading zones. Similarly, although the Arthritis Centre loading zone was increased in Phase 1 from 2 to 5 spaces, concerns were raised about whether increasing the passenger loading zone time limit from 3 minutes to 10 minutes would reduce the availability of passenger loading space for those who need it. Lastly, there were general concerns about the compliance and orderly use of the new design and configuration of passenger loading zones.

To gain insight on the performance of the loading zones, City staff gathered loading occupancy data through manual analysis of video shot over 2 days in November, 2015, 2 days in July 2018, and 2 days in May, 2019 during the hours the zones are in effect (7am to 6pm). Note, only the Arthritis Centre loading zone was rebuilt as part of Phase 1, while the Eye Care Centre loading zone is slotted to be rebuilt as part of Phase 2.

Loading Zone Occupancy and Vehicle Dwell Times

As Committee members had suspected, the data suggests that indeed both loading zones are busier than they were prior to Phase 1 construction, with the Eye Care Centre being quite a bit busier (see Figure 22).

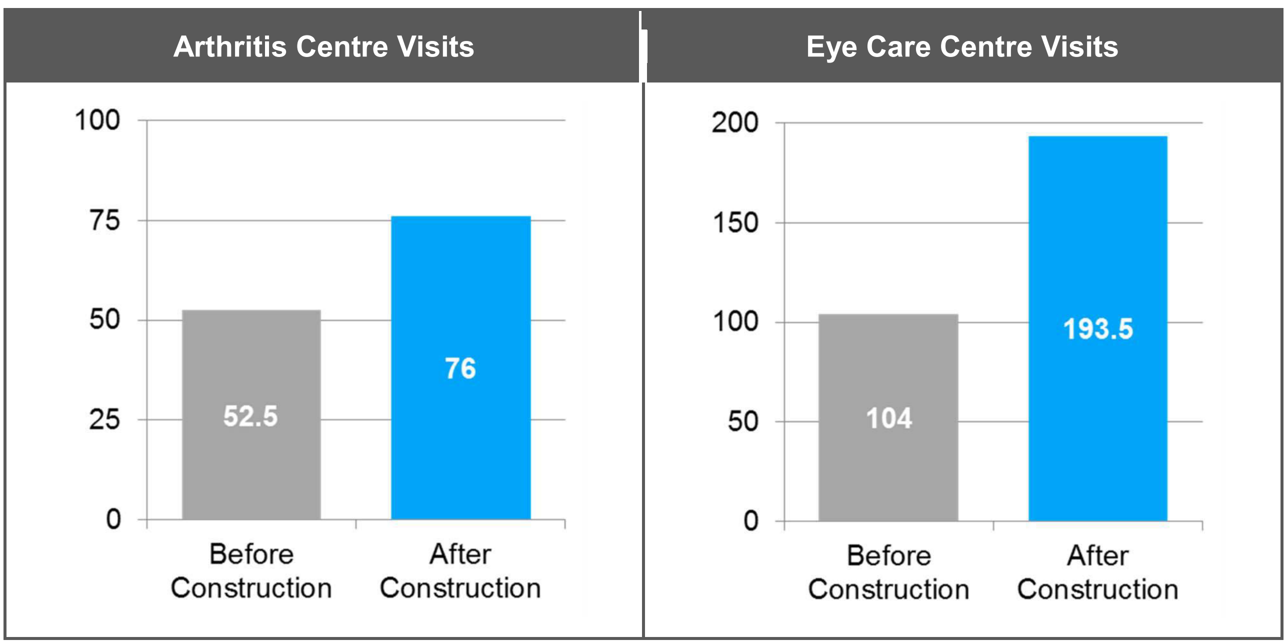

Figure 22: Average number of daily visits to 10th Ave passenger loading zones

Furthermore, with the increase in allowable dwell time in the passenger loading zone from 3 minutes to 10 minutes, we also observed an increase in the median dwell time in front of the Arthritis Centre (see Figure 23). Interesting, the dwell time in front of the Eye Care Centre decreased, although this loading zone has not yet been rebuilt.

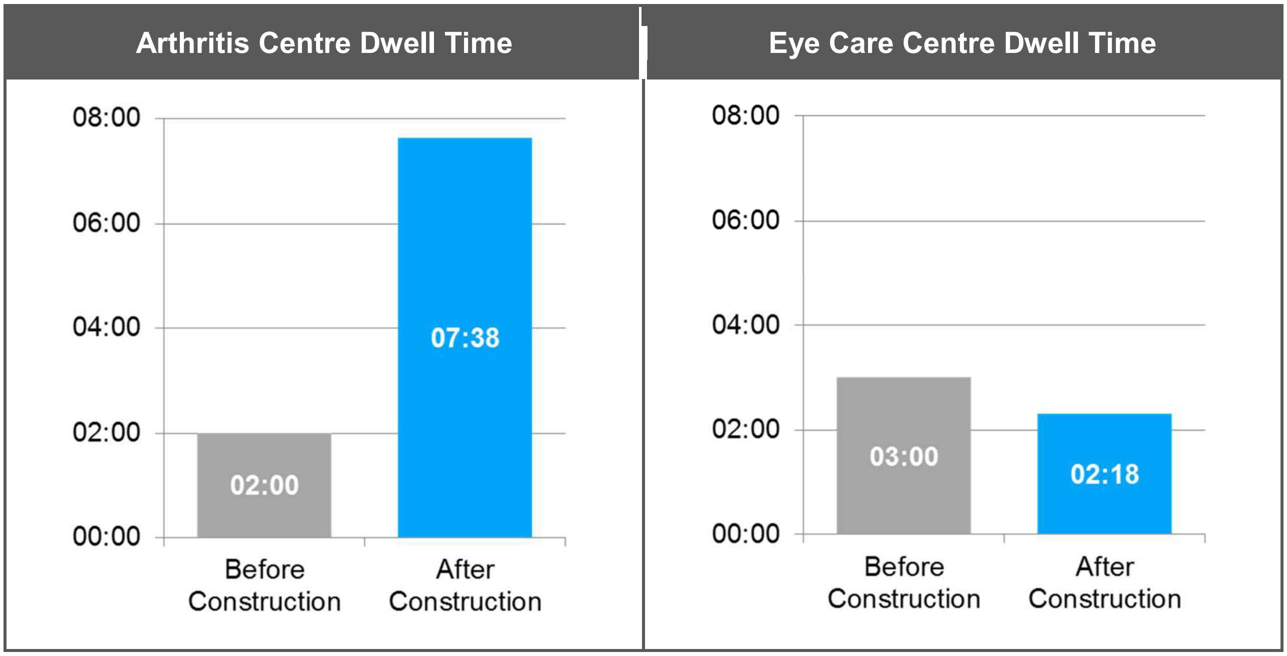

Figure 23: Median dwell times in 10th Ave passenger loading zones

However, despite the increase in demand and an increase in dwell time next to the Arthritis Centre, our monitoring suggests this passenger loading zone is better serving visitors after Phase 1 completed. Figure 24 shows that on average the loading zone was observed to be full only 20 minutes per day (3% of the time it was in operation), whereas previously it was full 2.5 hours per day (22% of the time). As such, we expect people are now able to spend more time escorting visitors to their appointments while also feeling less pressure to rush.

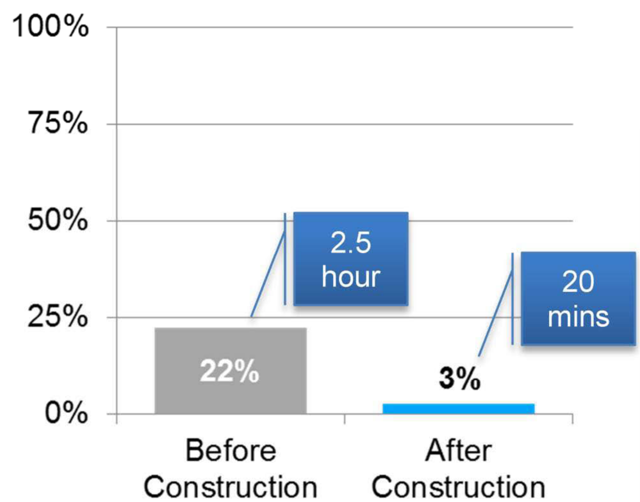

Figure 24: Proportion of operating hours the passenger loading zone adjacent to the Arthritis Centre is full

The passenger loading zone adjacent to the Eye Care Centre has not yet been rebuilt (this is part of Phase 2). Since the time limit was increased but the numbers of spaces hasn't yet increased, we did observe that it is full somewhat more often, despite the observed decrease in median dwell time (see Figure 25).

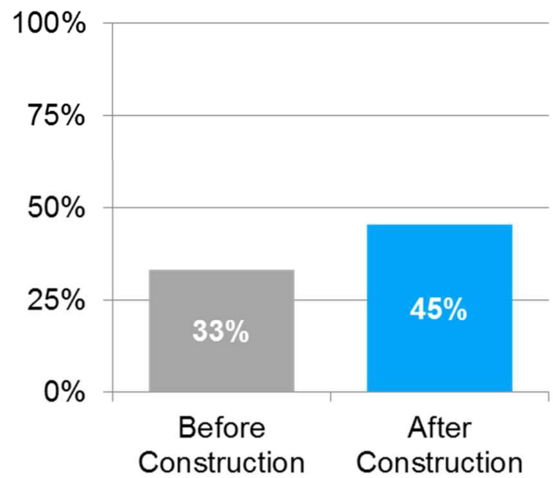

Figure 25: Proportion of operating hours that the passenger loading zone adjacent to the Eye Care Centre is full

We were also able to observe the degree of compliance with the loading zones' time limits. Although the compliance record changed little following construction, there is still a high proportion of people (42%) who stay longer than allowed (see Figure 26). In fact, over the 2 days observed in 2018, we noted 7 cases per day of people parking in the loading zone for roughly 1 hour (sometimes 2-4 hours). Parking enforcement has been notified.

City staff also recently spoke with contacts at both HandyDART and SN Transport (Hospital Transfers), and both indicated there have been no issues they are aware of with the loading zones. Hospital Transfers staff in particular expressed that "it is now more convenient and safe for our crew to load and unload their patients. The vehicle space that they have provided helps us separate from the two way vehicle traffic along W. 10th avenue. I appreciate this loading zone particularity at the Skin Care Centre as the entrance for this facility has a low ceiling and can only be access by minivan The only thing though that I had to watch out for are the cyclist coming from right side before heading/ walking towards these centres."

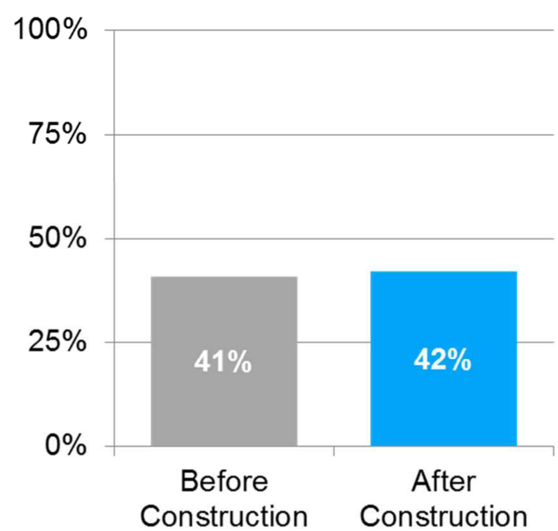

Figure 26: Proportion of visitors that stayed over the 10-minute limit in either passenger loading zone

Rubber Sidewalk in the Arthritis Passenger Loading Zone Area

We were unable to ascertain through video footage if there were any issues with the rubber sidewalk putting people off balance. Our contacts at SN Transport indicated they have not received any concern from the field crew. To solicit further feedback regarding the rubber sidewalk, City staff will be installing a small information sign next to the sidewalk to explain why it was installed and also solicit feedback.

7. Availability of High-Priority Parking Spaces

Throughout this project, there was a general sense that many people with low mobility were relying on the on-street parking on 10th Avenue in order to park near front entrances and access their medical appointments. As such, there was concern expressed by the Committee as well as the general public that the removal of most on-street parking from 10th Avenue within the Hospital Zone would place additional pressure on nearby high-priority parking, such as disability parking spaces and off-street visitor parking at nearby health services with a low parking supply.

Disability Parking Vacancy

Staff manually surveyed all 115 off-street disability parking spaces scattered through the Hospital Zone before and after construction[19]. Overall the occupancy of disability parking in the Hospital Zone is not unreasonably high. We did observe a slightly higher demand for these parking spaces following construction (see Figure 27), although the difference is small enough that it may fall within day-to-day fluctuations in parking demand. Results suggest the disability parking in several key parkades continues to be quite busy, all of which are relatively far from the study corridor: 12th Ave parkade (89%), Diamond Centre parkade (96%), and Jim Pattison at 12th Ave (90%).

Parking Vacancy in Nearby Small Parkades

Staff also manually gathered some parking vacancy data every hour between 9am and 4pm at the Arthritis Centre and the Eye Care Centre[20]. Both buildings were flagged throughout engagement as older buildings with a limited supply of visitor parking on-site. As such, there was concern over the removal of on-street parking from 10th Ave as there was a sense that many visitors had been using nearby on-street parking to access their appointments. To help mitigate this, the changes in Phase 1 included adding 3 on-street disability parking spaces on 10th Ave near the Arthritis Centre and also converted 5 meter parking spaces on Laurel St north of 10th Ave to residential permit parking, which SPARC permit holders can also access. In light of all of these changes, City staff and Committee members decided it was important to monitor this parking demand in this building to ensure problems of undersupply did not result from the Phase 1 changes.

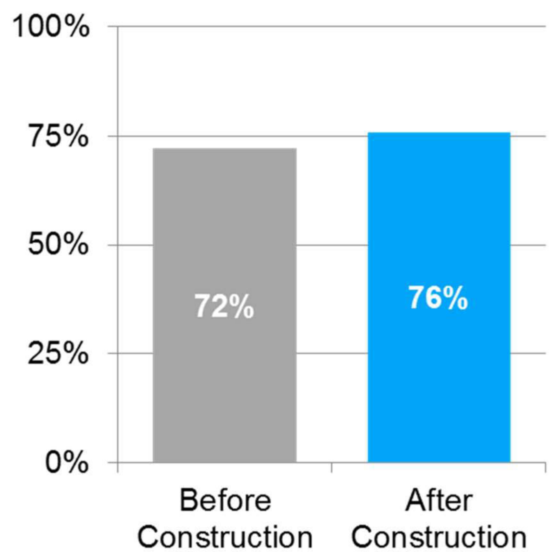

Figure 27: Occupancy of all 115 off-street disability parking spaces in the Hospital Zone

19 Off-street disability parking occupancy data was collected manually every hour between 9am and 4pm on a Tuesday in January, 2017 and a Tuesday in April, 2019.

20 Before parking occupancy data at the Arthritis Centre and Eye Care Centre was gathered every hour between 9am and 4pm on Wednesday, December 9th, 2015 and Tuesday, January 26th, 2016. The corresponding "after" data was gathered for the same times of the day on Tuesday, April 16th, 2019 once all disability parking meters had been installed for the new 10th Avenue spaces.

Visitor parking demand at the Arthritis Centre appears to be slightly higher following Phase 1 (see Figure 28). The location appears to be busiest after 2pm and it was observed to be full on 1 site visit (out of 7). However, on average staff observed 8 vacant visitor parking spaces free (prior to construction the average was 10). It's possible that the parkade may be full from time to time, but our observations to date suggest there is a very high possibility that visitors to the building will find a vacant parking space even with the observed increase in parking demand.

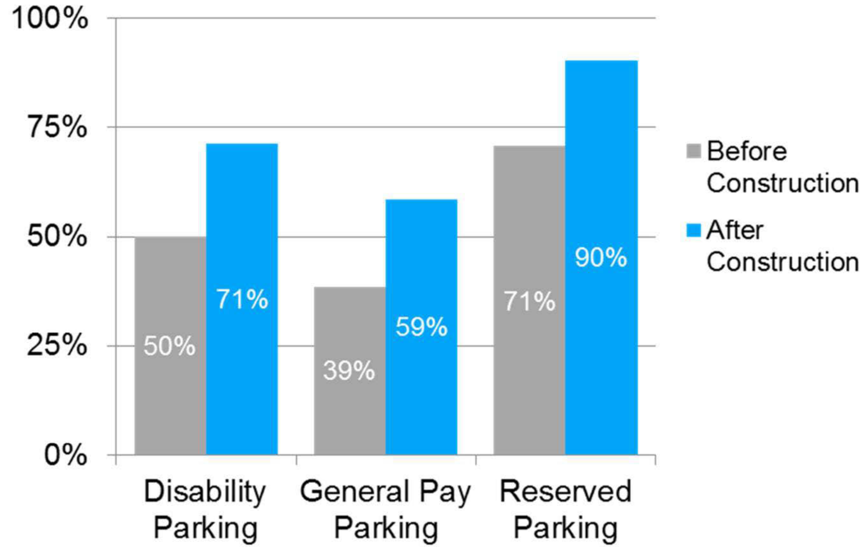

Figure 28: Arthritis Centre parking occupancy before and after phase 1 of construction

Interestingly, visitor parking demand at the Eye Care Centre was observed to be lower than previously. This parkade currently only contains 9 visitor parking spaces. It appears to be busiest before noon, but in the most recent round of data collection it was never observed to be full whereas prior to Phase 1 it was quite often full. Although major parking supply issues were not observed after construction, given the size of the Eye Care Centre, the parkade is quite small. Similar to the area surrounding the Arthritis Centre, Phase 2 will introduce approximately 8 disability parking spaces on 10th Ave near the Eye Care Centre to help ensure those with low mobility have easier access to this building.

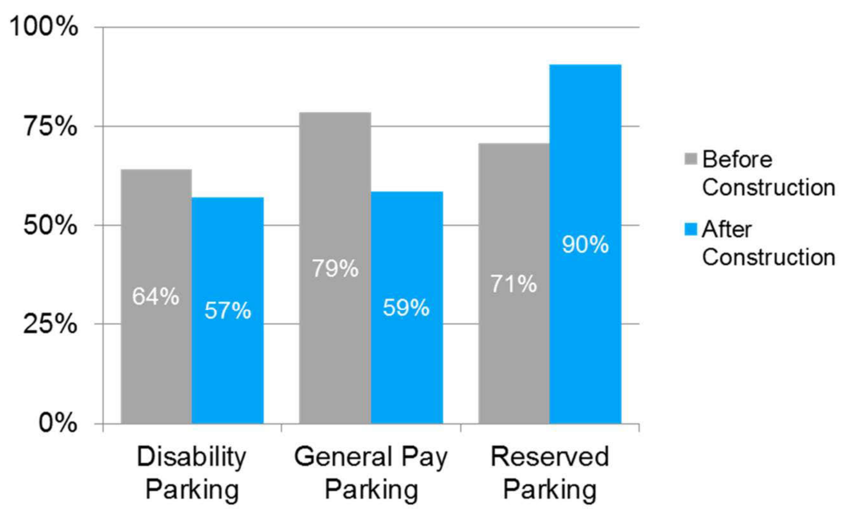

Figure 29: Eye Care Centre parking occupancy before and after phase 1 of construction

On-street Parking Occupancy

To better understand changes in demand for on-street parking, staff manually collected parking data every hour between 9am and 4pm on weekdays both before and after construction of Phase 1.[21] As expected, parking demand for the remaining metered parking spaces on 10th Ave within the Phase 1 area continues to be quite high (see Figure 30).

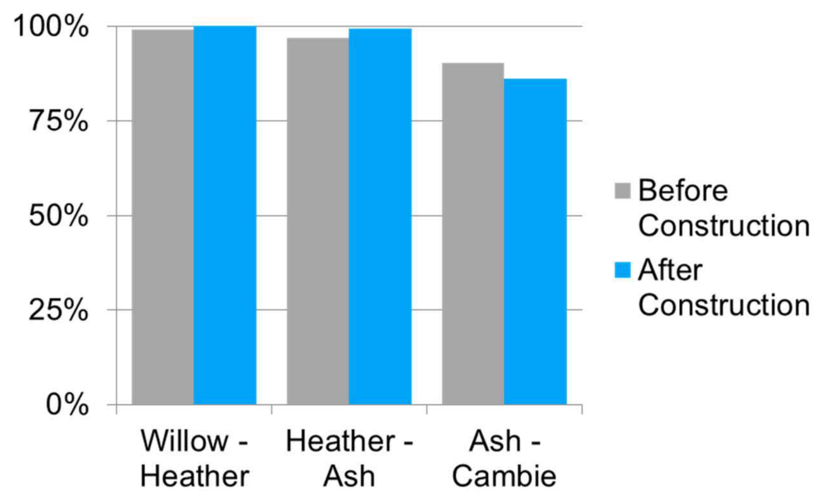

Figure 30: Parking occupancy of remaining 10th Ave on-street metered parking

However, much of the discussion throughout this project has been on ensuring that with the removal of some on-street parking from 10th Ave, that those with low mobility who need nearby access to health facilities as accommodated. Prior to the changes to 10th Avenue, there was only one dedicated on-street disability parking space (across from BC Cancer). Following the implementation of Phase 1, there are now 9 such spaces:

- 1 space on 10th Ave across from BC Cancer
- 3 spaces on 10th Ave near the Eye Care Centre
- 3 spaces on 10th Ave near the Arthritis Centre
- 2 spaces on Laurel St next to VGH Emergency

[21] On-street parking occupancy was manually observed prior to construction of Phase 1 every hour between 9am and 4pm on Wednesday, December 9th, 2015 and Tuesday, January 16th, 2016. The corresponding "after" data was gathered for the same times of the day on Tuesday, April 16th, 2019 and Wednesday, June 19th, 2019.

Prior to Phase 1, staff had observed many SPARC permit holders using the general meter parking within the hospital zone. Given how busy this on-street meter parking is and how difficult it can be to find a free space, this suggested to City staff there was latent demand for disability parking in the area. Considering only at these new on-street disability parking spaces, the data suggests they are in fact well used (see Figure 31). Furthermore, we are still seeing some SPARC permit holders using general meter parking on 10th Ave (see Figure 32), which suggests there remains latent demand and the new spaces that will come with Phase 2 will likely also be well used.

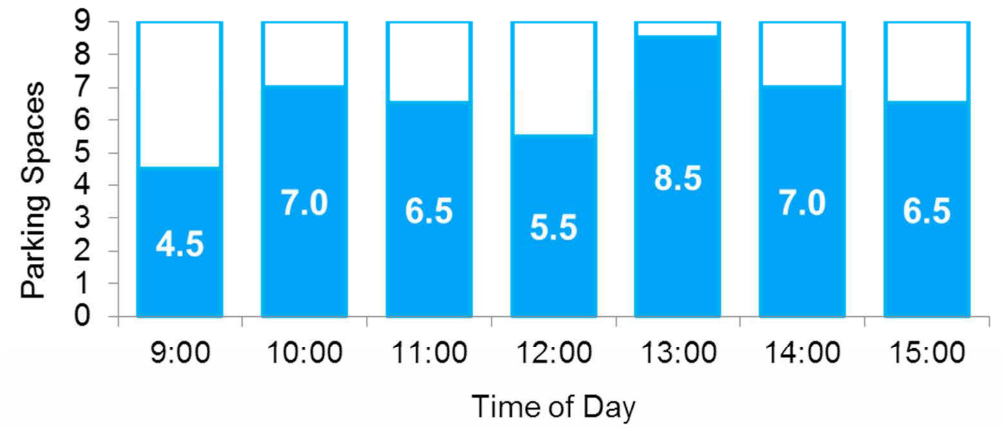

Figure 31: Parking occupancy of on-street disability parking in the Hospital Zone after phase 1 of construction

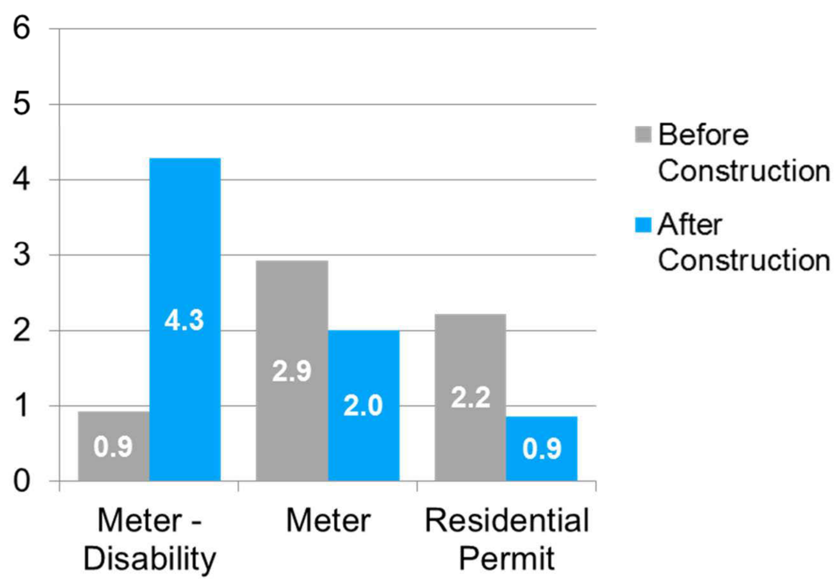

Figure 32: Distribution of parked vehicles displaying SPARC permits on 10th Ave by parking type[22]

[22] SPARC permit holders can access residential permit parking for up to 3 hours.

8. Other Miscellaneous Findings

Through walking tours and site visits with Committee members, a few additional observations were raised:

- Staff conducted a site visit with guide dog users to help understand issues that have arisen in the past with navigating the area following Phase 1 construction:
  - The guide dogs responded well to the beveled curb in that they recognized it was an edge to follow, which matches previous staff observations of guide dog behaviour elsewhere that beveled curbs had been installed on Pacific St. However, in cases where guide dogs guide people around an obstruction and into the bike lane, such as around people loitering, it's unclear whether the beveled curb as constructed is enough of a cue underfoot for guide dog users to catch that they have left the sidewalk.
  - The current approach of only installing truncated domes in street crossings where there is no pedestrian ramp with a change in grade is a difficult design logic for fully blind pedestrians to work with while navigating their environment, especially for those who are new to the area and won't know in advance whether to be scanning for truncated domes or a change in grade, which are two very different cues.
  - To someone new to the area who is fully blind, the stretches of rubber sidewalk could be confusing since underfoot it feels like softscape and therefore it feels like one has left the sidewalk and walked onto a grass boulevard.
  - Ironically, the entrance to the Eye Care Centre seems to be particularly challenging to navigate for someone who is fully blind.

- The tread pattern on the City's water meter covers underfoot feels indistinguishable to a standard truncated dome pattern.

Summary of Findings

Comfort and Safety of People Using 10th Ave

Results suggest the comfort and safety of pedestrians and people cycling on 10th Ave has improved significantly:

- Data to date suggests there has been a significant improvement in overall traffic safety in the Phase 1 portion of the corridor with collision rates down by 60% and there have not yet been any traffic-related incidents involving seniors, bicycle-pedestrian collisions, or vehicle collisions with a pedestrian that resulted in someone being admitted to VGH ER. Staff continue to monitor safety data on a monthly basis.

- Generally speaking, people using the corridor felt the upgrades in the Phase 1 have greatly improved conditions for walking and cycling in the area compared to pre-construction conditions. However, 30% of respondents felt that conditions for driving are somewhat or much worse versus 23% who feel it is somewhat or much better. We do not know which aspect of the changes resulted in this assessment of how driving conditions have changed. Informal feedback from BC EHS representatives suggests that paramedics' driving access to the VGH Emergency driveway has improved significantly.

Interactions between People Crossing the Street and People Cycling or Driving

- Downhill bicycle speeds have not changed, while the speeds of uphill cyclists travelling past the Eye Care Centre and the Arthritis Centre have reduced by 10%. Furthermore, the traffic calming measures added to 10th Ave appear to have also reduced vehicle speeds by approximately 10%.

- The observation sites along 10th Ave were assessed by the public to have higher yielding rates and lower risk than the comparison sites. Most pedestrian crossings were perceived as "low risk" (94%) and "comfortable" (90%), despite 25% of crossings involving "inadequate yielding". Pedestrian interactions with bicycles were evaluated to be more comfortable and lower risk than interactions with motor vehicles.

- Mid-block sidewalk cycling rates were not high to begin with, but now appear even lower and in line with the low sidewalk cycling rates seen on other streets where protected bike lanes were introduced.

Interactions between Vehicles Accessing the VGH ED Entrance and People Cycling Eastbound

- Yielding behaviour at VGH ED driveway was not always ideal, but right-turning traffic was generally slow and the road user interactions did not appear to result in unsafe circumstances. To date City staff are unaware of any collisions resulting in admittance to VGH ED, however staff will continue to monitor this priority location.

- Some eastbound drivers pulled into the opposing lane to make an unnecessarily wide turn, which places the bike lane in the driver's blind spot.

Changes in Vehicle Volumes

- The one-way conversion of 10th Ave between Cambie St and Laurel St did not result in concerning increases in traffic turning onto Ash, although we have noticed a doubling of the traffic in the lane between Ash St and Cambie St south of Broadway which may warrant additional traffic calming on the laneway. Due to the narrow width of Ash St south of Broadway, northbound traffic can sometimes backup at Broadway. Although this has not changed much with Phase 1 of the project, staff also plan to explore adjustments to Ash St.

Passenger Loading Zone Performance

- The increase in size of the Arthritis Centre passenger loading zone has significantly improved the level of service for visitors, despite it being busier. It is now rarely full and people are spending more time escorting visitors to appointments. The Eye Care Centre loading zone is over-subscribed as it has not yet been rebuilt.

Availability of High-Priority Parking Spaces

- The removal of on-street parking from 10th Ave does not appear to have had a significant impact on parking access to the Arthritis Centre and Eye Care Centre.

- SPARC permit holders are taking advantage of the 8 new disability parking spaces installed in Phase 1, and it appears that there is still latent demand for the 6 new spaces that will be installed as part of Phase 2.

Amount of Cycling Trips Using Alternate Routes

- Since becoming new bike routes as part of Phase 1, 14^{th} Ave and Alder St have seen a significant increase in cycling volumes. Furthermore, some people appear to be taking advantage of these routes to bypass the hospital zone (mostly to the south).

Other Miscellaneous Observations

- To blind or low-vision travelers unfamiliar with the area, the rubber sidewalk might feel like they have stepped off the sidewalk.

- The current design approach of only installing truncated domes in level crossings is challenging for the blind or low-vision end user.

- Guide dogs responded well to the beveled curb. However, in cases where guide dogs are travelling around obstructions in the sidewalk, it is still unclear if the grade different is sufficient communicate to their owner that they have left the sidewalk.

Follow-up Actions

The following is a concise list of on-going and completed follow-up actions that City staff are currently working to wrap up. Some of the items below arose outside of the official 10th Avenue Evaluation Committee work, but are included for completeness.

Action	Status	Details
1. Add TWSIs to all pedestrian ramps	Part of Phase 2 construction	Truncated domes will be installed in all pedestrian ramps in the corridor. This is based on feedback that the current practice of only installing truncated domes where grades are level is causing some confusion for people with vision impairment. We are still resolving internally whether we will switch to yellow polycarbonate tiles instead of the cast iron tiles that were installed in Phase 1.
2. Replace all water covers with new non-slip pattern	In progress	Unfortunately the standard covers for the City's water meters have a tread pattern that underfoot can feel very similar to the truncated dome pattern. Transportation staff are coordinating with staff in the City's Waterworks Design branch to trial a new pattern in the hospital zone, replacing all covers with a different non-slip pattern. If successful, this could serve as a template for a new tread pattern for all new water meter covers City-wide.
3. Adjust Phase 2 layout of TWSIs in front of the Eye Care Centre	Done	Through observations of blind and low-vision pedestrians navigating the sidewalk around the passenger loading zone adjacent to the Arthritis Centre, adjustments have been made to the design of the sidewalk around the Eye Care Centre to more closely match that around the Arthritis Centre.
4. Schedule site visits with cane users & possibly O&M (orientation and mobility) specialists	In progress	Site visits with guide dogs users proved to be quite informative. Staff hope to conduct similar visits with cane users to further inform any adjustments to the Phase 2 design.

<table>
<tr><th>Action</th><th>Status</th><th>Details</th></tr>
<tr>
<td>5. Make spot improvements to VGH ED driveway

a. Add yellow centre line on 10th Ave in front of the driveway

b. Add custom additional VGH ED driveway warning sign

c. Add “Caution Emergency Entrance Ahead” paint to bike lane.</td>
<td>In progress</td>
<td>To help alleviate the tendency of some drivers to pull out and make a wide right turn into the driveway, which puts the bike lane in their blind spot, staff will paint a yellow directional dividing line down the middle of 10th Ave from Oak St as far as the VGH ED entrance driveway.

To further help emphasize to road users the uniqueness of this driveway and encourage caution, an additional warning sign will be added in advance of the driveway as well as paint in the bike lane. The images below are conceptual – the exact placement and wording is still in progress.

</td>
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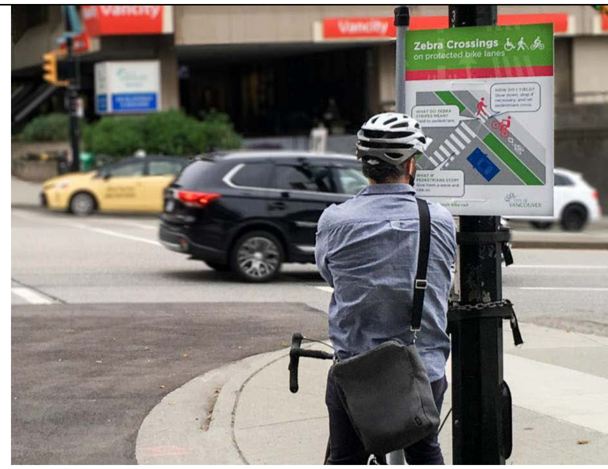
Action	Status	Details
6. Expand education campaign a. Update educational signage b. Engage in person with people travelling on 10th Ave. (with BC EHS participation) c. Social media campaign d. Continue to provide posters to VCH Cycling Centre as needed.	Currently in the planning phase	 In 2018, staff ran events on site to intercept people cycling in the corridor and remind people of the significance of the hospital zone as well as respectful yielding behaviour. Through this, education signage was installed at both the Oak/10th and Cambie/10th traffic signals, where people biking are frequently waiting. Sandwich boards with messaging to encourage yielding at zebra crossings which is directed at both people driving and cycling has also been temporarily deployed on a few occasions. Planning is currently underway to expand this campaign to encourage cautious behaviour at the emergency driveway, yielding to people walking, and greater consideration for people with disabilities or mobility challenges.
7. Continue to extend and improve the 14th Ave bike route	Granville/14th and Hemlock/14th traffic signal designs in progress	Staff are continuing to work to extend the 14th Ave bike route further west. Ideally a connection to the Arbutus Greenway could be achieved before the Broadway Construction begins, which will require that a detour be in place for a few years. The main challenges to completing this extension are installing new traffic signals at the Hemlock St and Granville St crossings. Completing this extension to the west is likely to dramatically increase the utility (and use) of the 14th Ave bike route.

Action	Status	Details
8. Install temporary signs beside rubber sidewalk	Signs were installed early September, 2019.	Staff installed small signs, similar to those used for the Green Streets program, to both explain the purpose of the rubber sidewalk while also soliciting feedback as it has been difficult to ascertain through observation whether the sidewalk has been challenging for those with low mobility or if there have been other unintended consequences. 
9. Upgrade existing traffic signals a. APS pushbuttons at Cambie/10th and Oak/10th (N-S) b. Explore ways to improve navigability & reduce non-compliance at Oak St / 10th Ave	Part of Phase 2 construction	As part of Phase 2 construction, City staff will be converting the Cambie St / 10th Ave traffic signal to use accessible pedestrian signal pushbuttons, and also install accessible pedestrian signal pushbuttons for the north-south direction at Oak St / 10th Ave. Staff continue to work with the Traffic and Data Management branch to develop a solution to the non-compliance issues at Oak St / 10th Ave.
10. Explore installation of new protected left-turn phases for vehicles into Hospital Zone	Staff are exploring the possibility.	To help alleviate concerns of a protected left-turn phase at Cambie St / 10th Ave and Ash St / 12th Ave encouraging more shortcutting, staff are considering installing signal equipment such that this protected phase would only trigger when a queue is detected. Note that traffic management for Broadway Subway construction may significantly impact the ability for a protected phase to operate at Cambie St / 10th Ave based on the available lanes and alignment on Cambie. However, staff are considering adding the necessary signal equipment with the signal upgrades to enable the possibility in the future.

Action	Status	Details
11. Add yellow paint to some concrete islands	Monitoring	Staff installed yellow paint on concrete islands at Oak St / 10th Ave to enhance their visibility to people cycling. Staff aren't aware of visibility concerns with any of the remaining concrete islands in the corridor, but are monitoring the situation.
12. Adjust the dimensions of the banner ID signs to match BIA signs	Part of Phase 2 construction	As part of the Phase 2 construction, the dimensions of the banner ID signs will be increased to match those of a typical BIA street sign, with consideration for potentially changing the material should wind loading be a problem with continuing to use aluminum.
13. Explore means of firming up the rubber sidewalk while maintaining permeability	In progress	To help address concerns of blind pedestrians, staff are exploring either a thin permeable alternative material to rubber or a means of making the rubber more rigid while maintaining permeability.
14. Facilitate passenger loading zone at Blusson building	In progress	Unfortunately both the Blusson and Segal buildings were built without any on-site parking. Staff have been coordinating with VCH support the installation of a passenger loading space as well as a dedicated HandyDART space in the VCH-owned surface parking to the east of the Blusson building to provide an accessible loading zone to the building that does not require crossing the street.
15. Adjust the location of the bench in the new pedestrian shelter	Completed	In order to accommodate wheelchair users within the shelter, the location of the shelter's bench was shifted off centre.
16. Install additional one-way signage between Cambie St and Ash St	Completed	The new one-way configuration of the block between Cambie St and Ash St was not clearly understood by many drivers who were parking facing east in the south side on-street parking, often performing awkward u-turns in the middle of the block to get to the spaces. More one-way signage was added next to the spaces to clarify which direction to face.
17. Remove low-hanging tree	Completed	Staff coordinated with Park Board to remove problematic trees and shrubs encroaching on the sidewalk.

Action	Status	Details
18. Adjust passenger zone time-of-day restrictions	Completed	In response to a physician request, City staff adjusted the passenger loading zone 10-minute limit to be in effect only from 7am to 6pm, Mon-Fri. Thus anyone would have access to the spaces evenings and weekends. This reflects the same time-of-day restrictions that were in place prior to Phase 1 construction.
19. Add permanent disability parking to Laurel St next to VGH ED	Completed	To help alleviate some of the parking concerns that arose during Phase 1 construction, staff added 2 temporary disability parking spaces to Laurel St, south of 10th Ave. The spaces have been well used and, as such, staff have since made the spaces permanent.

Lastly, the 10th Avenue project brought many of the area's parking challenges to the fore. Staff will continue to work with health partners to find solutions to parking concerns, better facilitate alternates modes of travel to the Hospital Zone for those who do not need to rely on driving, and complete the implementation of the area's new parking wayfinding signage.

Reference Material

- 10th Avenue project website: http://vancouver.ca/10th-avenue/
- '10th Avenue Health Precinct Street Improvement Council Report', May 2017: http://council.vancouver.ca/20170516/documents/rr4.pdf
- The 10th Avenue Evaluation Committee Terms of Reference along with this report will be posted on the project website, pending a significant update to the website which is currently under review.

Appendix A: 10th Avenue Evaluation Committee Role, Membership and Meeting Dates

Committee Role

The role of the 10th Avenue Evaluation Committee was to review the performance of the Hospital Zone portion of the 10th Avenue project for 1 year after the completion of Phase 1 construction.

The intent of creating the evaluation committee was to monitor and continue to receive valuable feedback from key stakeholders on the functioning of the 10th Avenue Hospital Zone following construction of the approved improvements. Work with the committee built on engagement efforts made with stakeholder groups, advisory committees, and other organizations through the previous phases of 10th Avenue consultation leading up to Council approval.

Input received from the committee was considered by City staff in tandem with other technical and financial considerations to identify which, if any, additional changes to the 10th Avenue Hospital Zone are warranted.

Membership

The 10th Avenue Evaluation Committee includes representatives from key 10th Avenue Hospital Zone stakeholders for a **total of approximately 20 members.**

Membership on the committee was by invitation only, and organizations selected their representative(s) to attend and provide input on their behalf. One (1) representative (except where otherwise indicated) from the key stakeholder groups are invited to participate. Representatives from the following stakeholder categories will be included:

- Health Precinct Partners and Emergency Services
    - Vancouver Coastal Health [3 representatives]
    - Lower Mainland Facilities Management [1 representative]
    - BC Cancer [2 representatives]
    - BC Emergency Health Services [1 representative]
    - Vancouver Fire and Rescue Services [1 representative]
    - SFU Health and Transportation Researcher [1 representative]
- Civic Advisory Committees and Councils
    - Active Transportation Policy Council [2 representatives]
    - Persons with Disabilities Advisory Committee [2 representatives]
    - Seniors' Advisory Committee [2 representatives]

- Other organizations and groups
    - Arthritis Patient Advisory Committee [1 representative]
    - Rick Hansen Foundation [1 representative]
    - Canadian Institute for the Blind (CNIB) [1 representative]
    - HUB Cycling [1 representative]
    - Arthritis Society [1 representative]
    - BC Barrier Free Design [1 representative]

Meetings Held

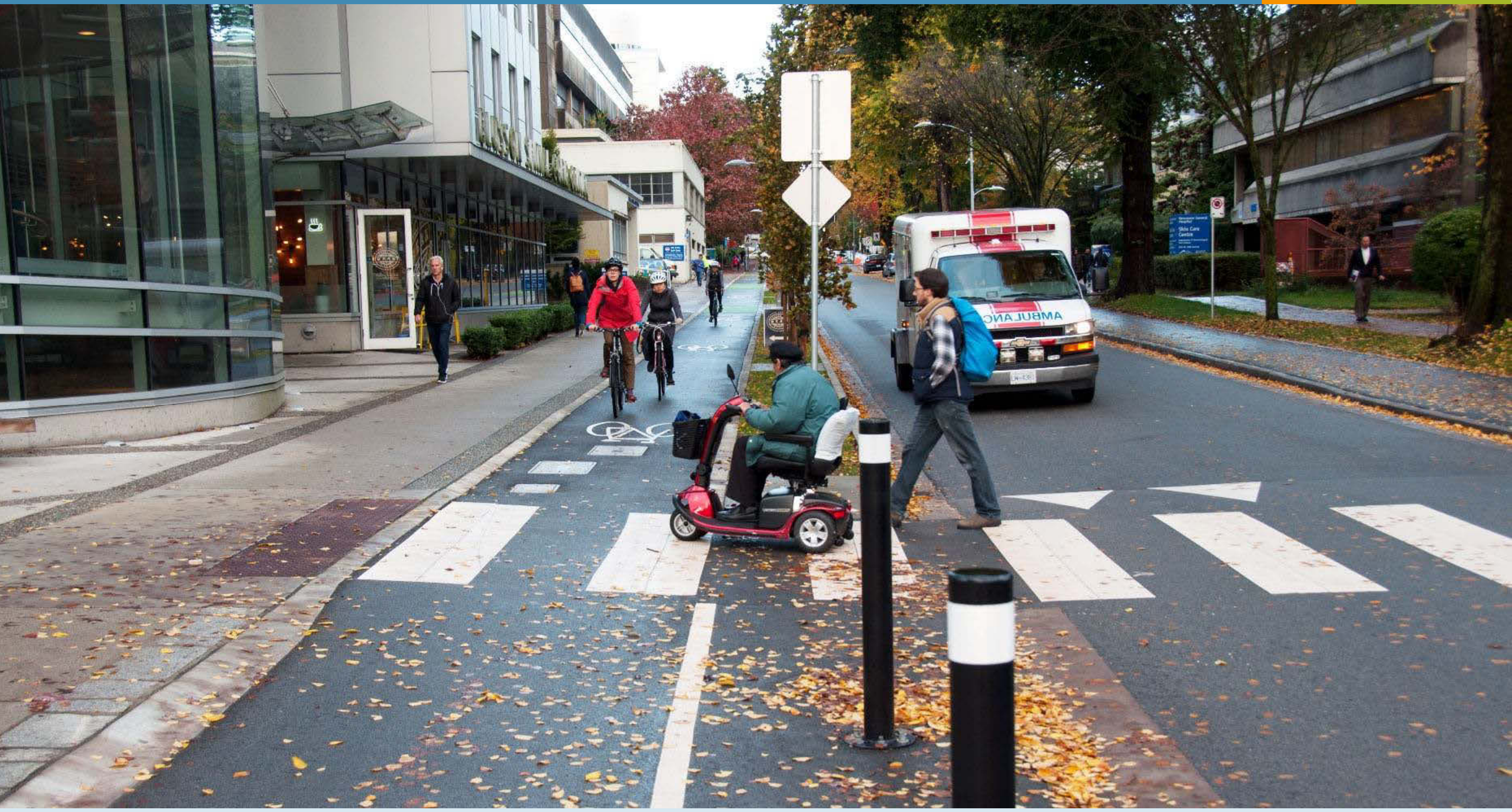
Evaluation Committees meetings were held on the following dates:

- April 23, 2018
- April 17, 2019
- June 21, 2019

Staff also led walking tours to the Committee on:

- October 25, 2019
- January 17, 2019

Appendix B: Joint UBC & SFU Study on Perceptions of Pedestrian Comfort and Safety at Unsignalized Crossings



Perceptions of Comfort and Safety for Non-Motorized Road User Interactions in Vancouver

Report prepared for City of Vancouver

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Executive Summary

Background and objectives

The City of Vancouver recently completed the implementation of Phase 1 of the 10th Avenue Health Precinct Street Improvements. City staff held meetings with the 10th Avenue Evaluation Committee members to establish the scope of follow up analysis to evaluate the project's impacts. During these meetings, several Committee members raised the issue of interactions between people walking and people using different modes of transportation, particularly seniors and persons with disabilities, while navigating the recently rebuilt portion of 10th Ave. between Willow Street and Oak Street. City staff partnered with local researchers with expertise in this field to investigate those interactions. This project's objectives were to (a) determine the frequency of road user interactions in the 10th Ave. project area and at other sites in the city with similar characteristics; (b) investigate the perceptions of different groups of stakeholders on non-compliant, uncomfortable, and unsafe interactions; and (c) examine systematic differences in perceptions of interactions among stakeholders.

Overview of methods

The study framework is summarized in Figure 1. Video data, collected between September and December of 2019, were used to capture road user volumes and interactions between road users at 7 crosswalks along 10th Ave, and at 4 comparison sites. Video clips of 84 sample pedestrian crossings were rated in a web survey by three pools of participants: the general public, 10th Avenue Evaluation Committee members, and traffic safety experts. Video data and survey results were combined to understand broad perceptions of typical crossing experiences. On-site interviews with Committee members were used to qualitatively characterize perceptions of safety in further depth and inform the rating scales used in the web survey.

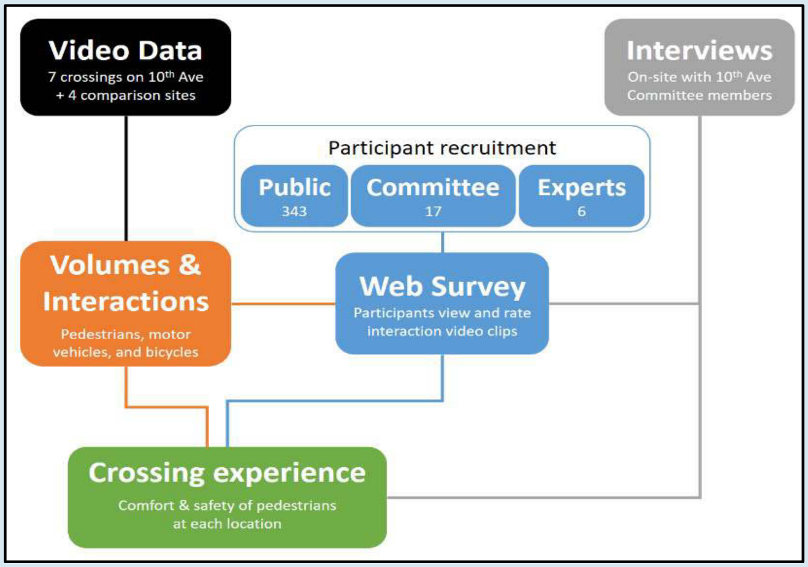

Figure 1. Study methods

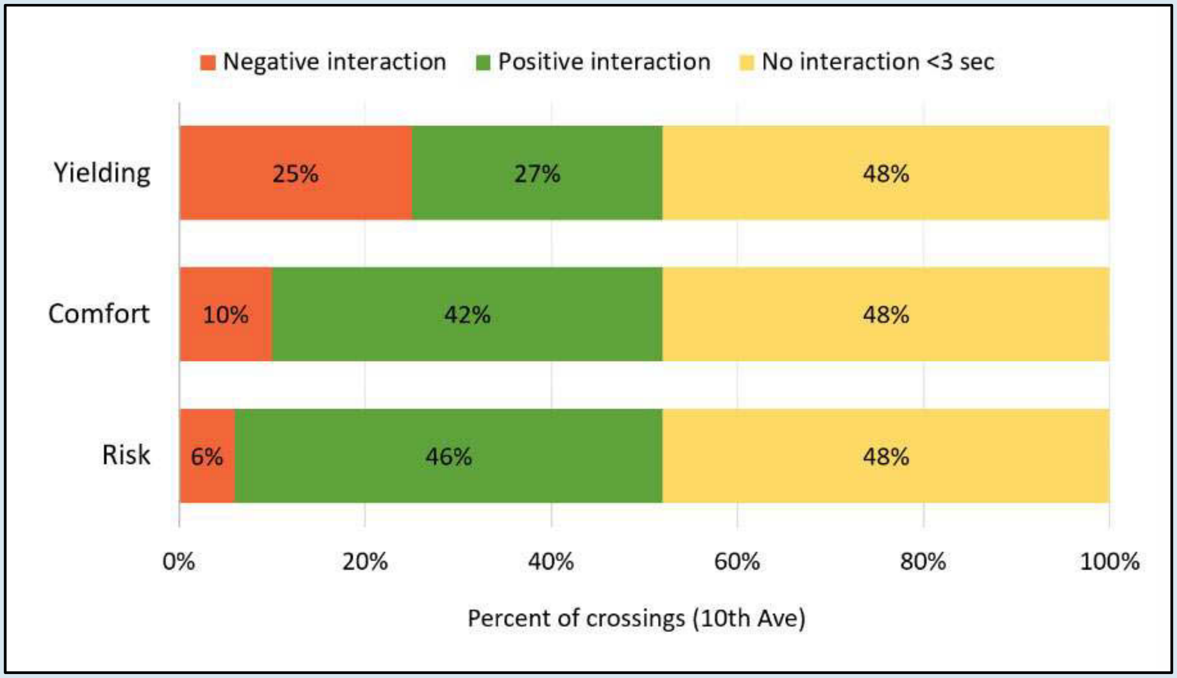

Figure 2. Overall pedestrian crossing experience at 10th Ave. crosswalks (negative/positive interactions indicate predicted disagreement/agreement that there was adequate yielding, that the pedestrian was comfortable, and that there was low risk of injury for the pedestrian);
A quarter of crossing pedestrians experience a negative interaction from the perspective of yielding, while 10% experience an interaction that was not comfortable and 6% that was not low risk.

Key findings

- **Most crossings were perceived as "low risk" (94%) and "comfortable" (90%)**, although 25% of crossings involved inadequate yielding (rated as "should have yielded", but did not) – see Figure 2.
- Pedestrian **interactions with bicycles are more comfortable and lower risk** than interactions with motor vehicles. This finding may be explained by the size difference between bicycles and motor vehicles and easier visual communication between pedestrians and cyclists. Rates of inadequate yielding are similar in pedestrian interactions with either motor vehicles or bicycles. In otherwise similar interactions, cyclists are much more likely to be perceived as not needing to yield than drivers.
- With high volumes of people walking, driving, and cycling, 10th Ave has **high interaction rates** during weekdays. Just over half of pedestrian crossings involved an interaction (defined from the survey results as another road user passing within 3 seconds before or after a crossing pedestrian).

- The observation sites along 10th Ave. have **higher yielding rates and lower risk** than the comparison sites. However, these effects are partially offset by longer crossings, higher volumes, and closer interactions along 10th Ave.
- Perceptions of yielding, comfort, and safety **do not vary significantly with a rater's socio-demographics** (age, gender, income, education), but perceptions do vary with a rater's travel habits. People who walk more frequently rate pedestrian comfort as lower. People who cycle more frequently rate risk as lower (including for pedestrian interactions with motor vehicles).
- There are no significant differences in perceptions of yielding, comfort, and safety between members of the public and Committee members who participated in the survey. The traffic safety experts have similar views of yielding and comfort to the Public and Committee pools, but a consistently **lower assessment of risk for pedestrians** in interactions with motor vehicles and bicycles.
- Interactions involving **more vulnerable pedestrians (children, mobility impaired) are perceived as higher risk** but there were no significant differences for the other severity outcomes of comfort or yielding. This finding is supported by the interview result that comfort and safety are distinct constructs and mobility aids may not affect assessed comfort.
- Perceptions of yielding are most strongly based on whether the pedestrian passed first, rather than specific manoeuvres by the other road user (i.e., visible slowing). Legal definitions of right-of-way and yielding are neither well-known nor considered of main importance, based on the interview results.

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1 Introduction

1.1 Background

The City of Vancouver recently completed the implementation of Phase 1 of the 10th Avenue Health Precinct Street Improvements (see Council report[1] for full background). Based on significant public and stakeholder feedback since the project began, City staff are confident that the final recommended design is a significant improvement over existing conditions. However, given the scale of changes being made to the street, it is difficult to predict all possible outcomes and inevitably some adjustments may be required. As part of the execution of the 10th Avenue Health Precinct Street Improvements, City of Vancouver staff committed before Council to "ongoing improvements and issue resolution, including establishing a 10th Avenue Evaluation Committee to evaluate the project's impact following implementation and recommend spot improvements" (identified as "Action 10" in the Council report). Following Council approval of the project, staff finalized Terms of Reference for an Evaluation Committee and held meetings with Committee members to establish the scope of follow up analysis. Through this engagement with Committee members, several raised the issue of interactions between people walking and cycling as a particular concern. As such, City staff sought to give special attention to this issue in a transparent manner by working with local researchers with expertise in this field.

1.2 Objectives

The objectives of this project were to:

1. Determine the concerns of pedestrians, particularly seniors and persons with disabilities, in navigating the recently rebuilt portion of 10th Ave. between Willow Street and Oak Street, hereafter the 10th Avenue Hospital Zone (TAHZ)
2. Determine the frequency of road user (pedestrian, cyclist, and motorist) interactions in the TAHZ, as well as at comparable sites in the city,
3. Determine the frequency of non-compliant, uncomfortable, and unsafe interactions, as perceived by different groups of stakeholders, and
4. Examine systematic differences in the perceptions of interactions among stakeholders.

1.3 Overview of study methods

The project objectives required a unique analysis approach. Traditional traffic safety analysis has limited application in this context due to a reliance on crash data or vehicle-oriented conflict approaches. In addition, expert evaluations of comfort and safety may not reflect public perspectives on road-user interactions. Even within the traffic professional context, there are unclear and inconsistent definitions of when road users have interacted and yielded. The study methods were developed with the intention of understanding a broad range of perspectives, recognizing the subjective nature of comfort and safety perception.

The study framework is summarized in Figure 3 – more detailed information is given in the subsequent sections of this report. Video data were used to gather information on traveller volumes and interactions at seven pedestrian crosswalks in the study area and four nearby comparison sites. Volumes and interactions were recorded for six hours (8-10hr, 11-13hr, 16-18hr) on one mid-week day at each

[1] https://council.vancouver.ca/20170516/documents/rr4.pdf

location. Video data from second and third days (over the same hours) were added if the number of recorded pedestrian crossings at any site was less than 200.

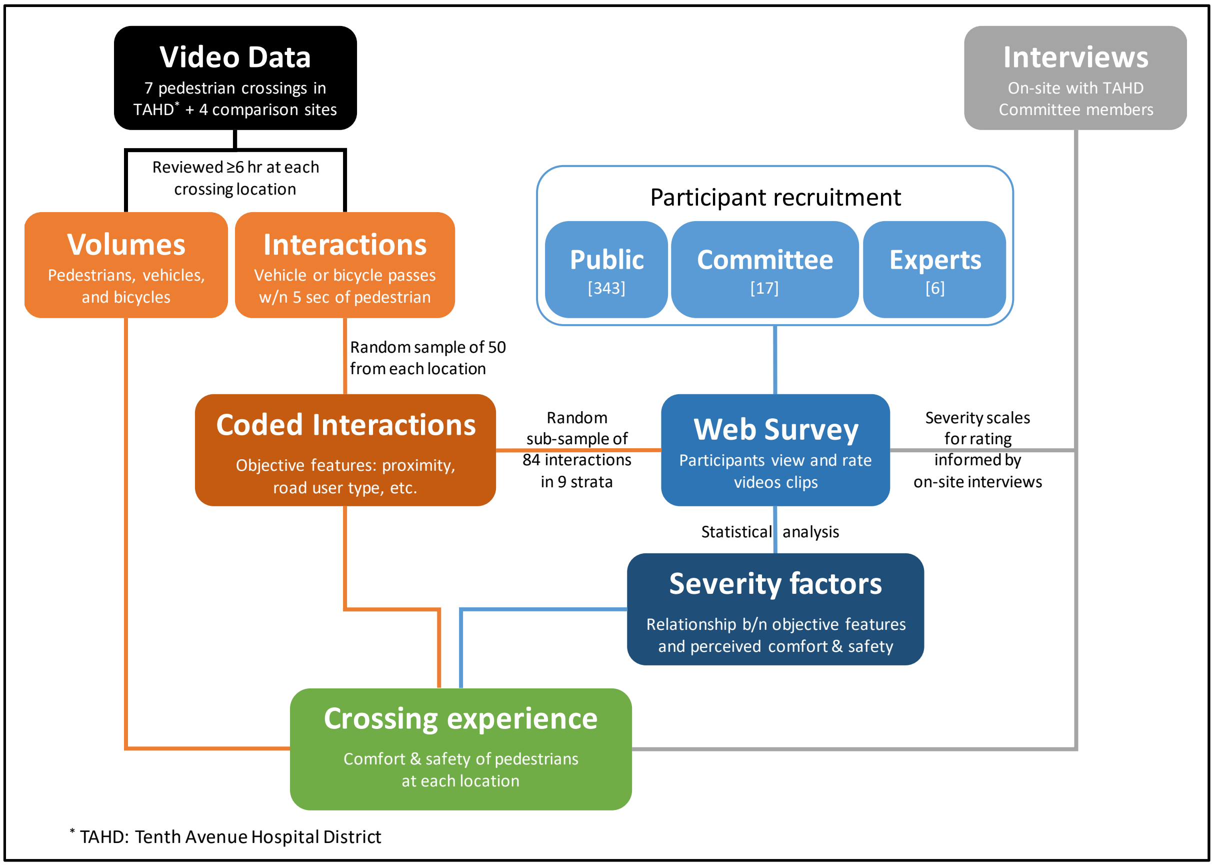

Figure 3. Study framework

Identification of interacting road users was based on passing time[2], as illustrated in Figure 4. For two road users on intersecting paths that cross at a conflict point, the passing time is the time gap between when the first road user exits the conflict point and when the second road user enters it. ***Potential interactions*** were initially defined using a conservative threshold of under 5-seconds passing time. As described in subsequent sections, that initial threshold was later refined to a data-driven 3-seconds interaction threshold based on the survey results.

Objective features (passing time, whether the pedestrian or other road users passed the conflict point first, the pedestrian location when the other road users entered the crosswalk, etc.) were coded for 50 randomly-selected sample crossings from each location (if available – fewer than 50 crossings were recorded at one location). The 536 sample crossings were then separated into nine strata based on passing time and interacting road user type (vehicle/bicycle), and 84 were extracted (randomly by strata) for use in the web survey.

[2] Referred to as "Post Encroachment Time" in the traffic safety literature

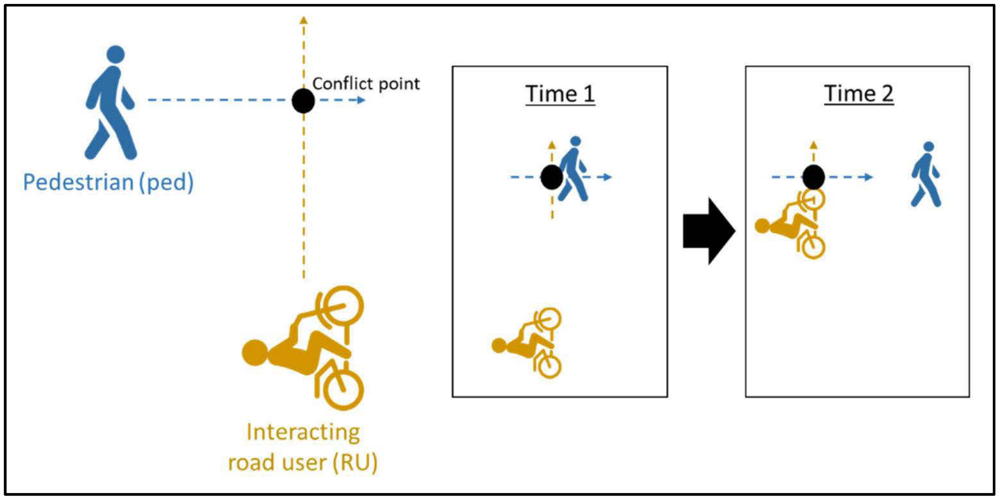

Figure 4. Illustration of passing time for identification of road user interactions

Three pools of participants were recruited for the web survey: 343 from the general public, 17 from the 10th Avenue Evaluation Committee, and six traffic safety experts from outside of British Columbia. The survey participants viewed a stratified sample of 15 of the 84 videos (except for the Experts, who viewed all 84), and rated them on four scales of severity[3] using the questions:

1. The [driver/cyclist] yielded to the pedestrian.
2. The [driver/cyclist] ***should*** have yielded to the pedestrian.
3. The pedestrian felt comfortable in this crossing.
4. The risk of injury for the pedestrian in this crossing was low.

Statistical analysis was then used to investigate: 1) agreement on interaction severity within and between the participant pools, and 2) objective determinants of perceived severity levels. Statistical models were generated from the survey data to predict interaction severity from the coded interaction features. These severity prediction models were then applied to characterize the interaction severity at each location (based on the ~50 sample interactions by location). Finally, the full set of volume and interaction data were combined with the severity information to assess the crossing experience of pedestrians at each location. The assessment gave the expected fraction of pedestrians experiencing no interaction, a positive interaction, or a negative interaction (meaning most people would disagree that it was comfortable or low risk).

On-site interviews with nine members of the 10th Avenue Evaluation Committee were used to 1) characterize perceptions of safety in the TAHZ, 2) inform the wording of the severity scales used in the web survey, and 3) verify the findings of the statistical analysis with qualitative information. The research methods were approved by the Behavioural Research Ethics Boards of the University of British Columbia and Simon Fraser University, under approval H18-03637.

[3] As “Strongly disagree”, “Somewhat disagree”, “Somewhat agree”, “Strongly agree”, or “I don’t know”

2 On-site interviews

The entire 10th Avenue Evaluation Committee was invited to take part in on-site interviews in February and March, 2019. The 30-45 minute semi-structured interviews were led by two study team members (M. Winters and K. Hosford) and took place on-site[4] in the TAHZ. First, the interviewee's general concerns about street activity in the area were examined with the prompt: "What are your general concerns along the corridor?" Second, locations with perceived conflicts among road users were identified with the prompt: "Are there specific areas that you have concerns about?" The interviewers and interviewees then watched and discussed some interactions, and interviewees were prompted to evaluate the interactions in terms of a set of draft severity scales (see Appendix C: Interaction Severity Scales for a description of the draft scales). Comprehension and clarity of the draft scales were explored with the prompt: "Were these easy to understand? Did you have any challenges in answering them?" Nine Committee members took part in the interviews (seven on-site and two by phone/e-mail).

2.1 Summary of observations

The general comments on safety in the redesigned portion of the 10th Ave. Hospital Zone can be summarized as below. Location-specific results are summarized in Appendix H: Location-specific on-site interview results. Overall points:

- There is an **overall improvement** in the area, with more awareness and delineation of where people should be, and a perception of slower speeds.
- **Wayfinding** is good in the redesigned corridor, and especially helpful for out-of-town visitors.
- **Complexity**: there is a lot of activity in the street area, but changes are an improvement and for the most part it is clear where people are supposed to go.
- **Many of the existing challenges are inherited** (Hospital emergency access, street geometry at Laurel St., etc.), and the new design is an improvement.
- During **construction,** traffic control personnel (i.e. "flaggers") were exceptional and a model for future city projects (with the exception of a comment about smoking).
- **Inherent conflicts** in the design features that accommodate users with different needs is a continuing challenge (e.g., people using wheelchairs and people with guide dogs).
- The **phased approach** taken by the City created problems in terms of infrastructure discontinuity at the edges.
- Pedestrian jaywalking may suggest the need for **mid-block crosswalks**. Additional crosswalks for pedestrians with mobility limitations may also be needed.
- Significant numbers of users are not familiar with the corridor (e.g., **visitors to the area**), which creates additional challenges.

[4] Members were also able to respond to the interview prompts with written or verbal answers off-site.

The in-the-field interviews also enabled observation of specific crossing and interactions. The following points are a summary of the discussion of interactions observed during interviews, from the perspectives of the interviewees:

- **Eye contact and non-verbal communication** are important in negotiating the complex road user environment. This may be easier between pedestrians and people bicycling, rather than people in cars.
- Many pedestrians **gave way** to bikes and cars at crosswalks, even if they have the legal right-of-way.
- Virtually all the observed interactions were **considerate.**
- The **travel speeds** at mid-day time periods were very slow.
- **Pick-up/drop-off** zones were perceived to be working well, with minimal conflicts.
- **Driveways** are interaction zones of concern (in addition to the intersections and marked crosswalks), based on field observations and past experience of interviewees.

2.2 Evaluation of draft severity scales

The interviews provided an opportunity to test question wording for the online survey, and concepts of yielding, comfort, and safety. In rich conversations with the Committee members, we learned:

- The strict legal requirements for right-of-way and yielding were not well known and not considered highly important.
- The simple yielding question (i.e., “Did the cyclist yield to the pedestrian?”) was clear and easy to answer. It included multiple dimensions of a complex social interaction and was not perceived as law-based but more behavioural (slowed, went around, allowed to pass, etc.).
- “Careful”, “Respectful”, and “Considerate” were considered too subjective of terms.
- Comfort and Safety were distinct constructs: comfort was perceived as a subjective characteristic and in the mind of the pedestrian, whereas safety was an external/objective characteristic of an interaction; mobility aids did not seem to affect 3rd-person assessed comfort.
- The wording of the Comfort scale was important – particularly whether they were meant to try to empathize with or infer an observed pedestrian’s personal experience.
- Risk of collision and risk of injury were both perceived as equivalent to safety.
- Some interviewees felt the researchers were “over-thinking” the wording.

3 Video data collection and coding

Video data were collected at 11 locations (camera scenes) for three days each, and provided by the City to the research team: seven crosswalks in the recently redesigned portion of the TAHZ and four crosswalks at comparison sites. Recorded video dates ranged from September 25 to December 5, 2019. The names of all 11 crosswalks and their still images from the video data are given in Appendix A: City coding of volumes and interactions in video data. Video data were reviewed, and volume and interaction counts were recorded in 15-minute intervals by the City for six hours (8-10hr, 11-13hr, 16-18hr) per location on a single weekday. A target sample of 200 pedestrian[5] crossings at each location was established. Validity tests conducted by the research team for the City-coded video data are described in Appendix A: City coding of volumes and interactions in video data.

Table 1 gives the data extent and mean hourly counts and interactions by location. Because the approach from only one direction was visible in each video scene, only interactions from that traffic were recorded and considered for further analysis. The same traffic directions were used for counts. Pedestrians crossing in both directions were included in the counts and interactions. In total, in 80 hours of coded video data, almost 14,000 road users were counted at 10th Ave. sites and 5,000 at comparison sites. The overall road user mix counted at the 10th Ave. sites was 37% pedestrians, 39% vehicles, and 24% bicycles - although the comparison is imprecise because not all movements were recorded. The volumes varied substantially by time of day, travel mode, and location (see Appendix A: City coding of volumes and interactions in video data for details).

Table 1. Summary of volume and interaction counts

Location	Number of (15-min) intervals	Crossing pedestrians	Vehicle counts	Bicycle counts	Interactions with vehicles	Interactions with bicycles
		(mean, per hour)				
Main 10th Ave sites (x6)	144	116	162	71	70	28
Laurel North & 10th (East)	24	98	168	77	72	26
Laurel North & 10th (West)	24	144	139	79	75	43
Laurel South & 10th (East)	24	40	139	77	27	14
Laurel South & 10th (West)	24	84	180	63	40	13
Willow & 10th (West)	24	161	173	67	138	37
Willow & 10th (East)	24	169	171	67	70	35
Arthritis Centre	72	13	0	77	0	5
Comparison sites (x4)	105	109	58	21	25	6
Heather & 11th	24	49	147	22	31	8
Laurel & 7th	24	69	24	29	6	9
Haro & Bute	24	298	41	5	66	6
Lakewood & Adanac	33	19	21	30	3	3
All 11 locations	**321**	**104**	**109**	**54**	**40**	**16**

[5] Pedestrians included persons in wheelchairs or using mobility devices

In total, 2529 vehicle interactions and 1090 bike interactions were recorded at the seven 10th Ave. locations, and 647 vehicle interactions and 162 bike interactions were recorded at the four comparison crosswalks, for a grand total of 3176 vehicle interactions and 1252 bike interactions recorded at all 11 crosswalks (see Appendix A: City coding of volumes and interactions in video data for mean hourly potential interactions distributed by the time of day). As described previously, these recorded interactions are based on a conservative definition of under 5-seconds passing time.

To examine the interactions in further detail, 50 potential interactions were randomly selected from each location. One location (Lakewood & Adanac) did not have 50 potential interactions, yielding 536 total sample interactions at all 11 locations. The following objective features were coded for each of the sample interactions: 1) passing time (defined above), 2) whether the pedestrian passed the conflict point before the interacting road user or after, 3) pedestrian location when the road user entered the crosswalk, 4) interactions with road users from the opposing direction, and 5) interacting road user types.

Figure 5 summarizes the passing times at the seven TAHZ locations, separated by interacting road user types (N=185, 51, and 110 for Vehicles only, Vehicles + Bikes, and Bikes only, respectively). Interactions with bicycles had shorter passing times than interactions with vehicles, and all three distributions are statistically significant based on Chi-squared tests at $p<0.05$. There were no significant differences in whether the pedestrian passed first in interactions with vehicles versus bicycles, or in the pedestrian location when the interacting road users entered the crosswalk.

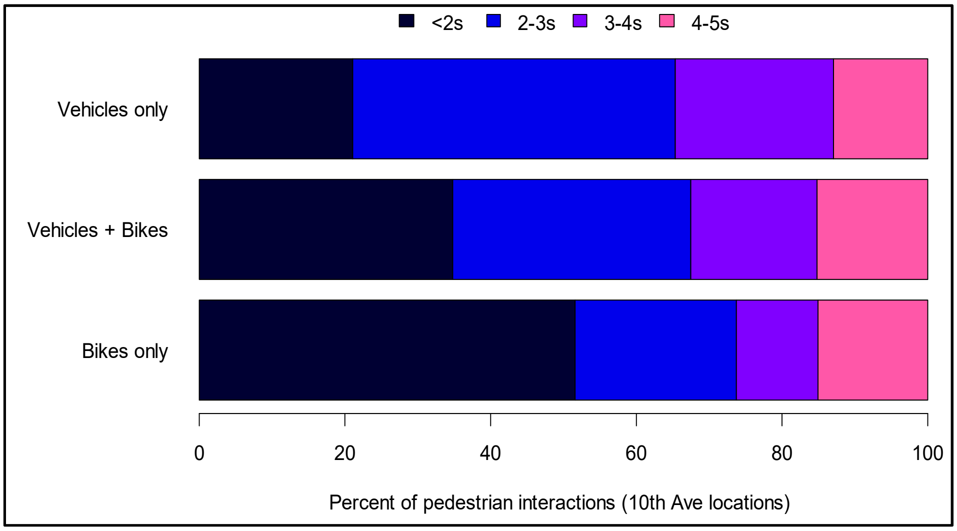

Figure 5. Passing times for sample interactions at TAHZ locations by interacting road user type

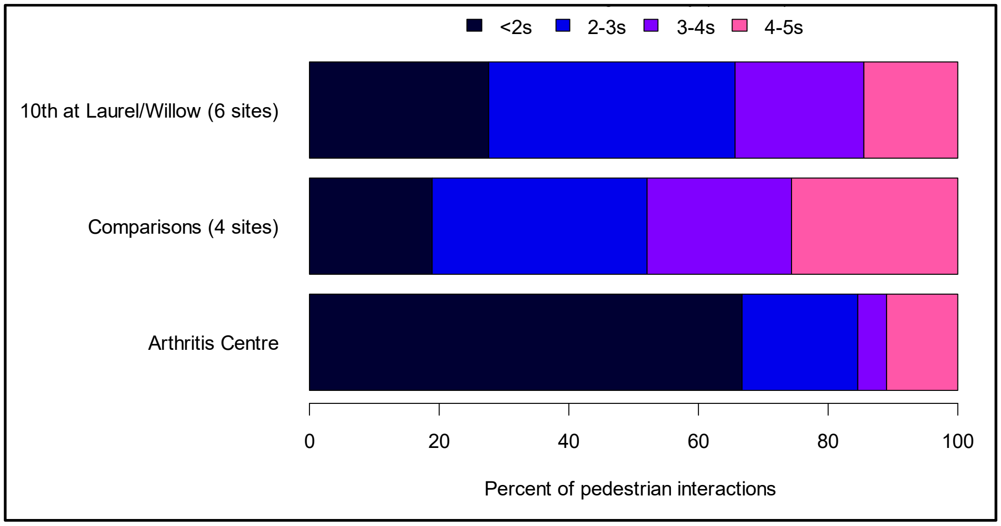

Figure 6. Passing times for sample interactions by location

Figure 6 summarizes the passing times by location. There were no significant differences among the 6 main 10th Ave locations, or among the 4 comparison sites, but the Arthritis Centre had significantly closer interactions than the other sites, and the TAHZ sites together had closer interactions than the comparison sites. The Arthritis Centre location is unique because it is a much shorter crossing than the other locations (hence the closer passing times). There were no significant differences in whether the pedestrian passed first by location (on average 60%), but there were significant differences by location in the pedestrian location when the interacting road user entered the crosswalk (the pedestrian was on-street 51% of the time for the main 10th Ave sites, 37% at Arthritis Centre, and 31% at comparison sites).

4 Web survey to investigate perceptions of interaction severity

4.1 Survey methods

After extracting the sample interactions and coding their objective features, the next step was to conduct an online survey to elicit severity ratings from a variety of participants for a sub-sample of interactions. The survey sub-sample of 84 interactions was taken from the set of 536 sample interactions by randomly sampling within nine strata based on interacting road user type and passing time. The nine strata are given in Table 2, along with the number of videos in the survey from each stratum. Additional objective features were then coded for the survey sub-sample of interactions: whether the pedestrian and road user adjusted speed or course, vehicle type, number of pedestrians and other road users in the scene, whether the pedestrian and other road user were in a group or isolated, and others (see Appendix B: Coding of interaction characteristics for survey sample).

Table 2. Nine strata for interactions shown in web survey video clips

Stratum	Interacting road users	Passing time gap	Videos in survey (& shown to Expert pool)	Videos shown to Community and Public pools	Total ratings
1	1 bicycle	<2 sec	12	3	1080
2	1 bicycle	2-3 sec	10	2	734
3	1 bicycle	3-4 sec	8	1	381
4	1 vehicle	<2 sec	12	3	1081
5	1 vehicle	2-3 sec	10	2	728
6	1 vehicle	3-4 sec	8	1	383
7	2 or more vehicles	<4 sec	8	1	380
8	1+ vehicles and 1+ bicycles	<4 sec	8	1	381
9	2 or more bicycles	<4 sec	8	1	381

An online questionnaire was implemented in Qualtrics survey software. It began with a consent form, followed by a one-page set of travel habit and demographic questions: frequency of travel by different modes, frequency of travel in the TAHZ, age, gender, home postal code, education, household income, and level of comfort taking risks (based on Glanz et al.[1]). Next, participants were shown a series of short video clips in random order, each on a different page, with the prompt to indicate their agreement with the following statements regarding the interaction shown in the video (see Figure 7). The four statements were:

1. The [driver/cyclist] yielded to the pedestrian.
2. The [driver/cyclist] ***should*** have yielded to the pedestrian.
3. The pedestrian felt comfortable in this crossing.
4. The risk of injury for the pedestrian in this crossing was low.

The response options were: “Strongly disagree”, “Somewhat disagree”, “Somewhat agree”, “Strongly agree”, or “I don’t know”. The wording of the severity scales was selected after extensive consideration using input from the scientific literature, on-site interviews with Committee members, pilot testing, and input from professional and academic colleagues (see Appendix C: Interaction Severity Scales). Each video page also included an open comment text box for survey participants to offer clarification of their ratings if needed.

Regarding the interaction between the crossing **pedestrian** and the closest **vehicle** shown in the video, please indicate your level of agreement with the statements below:

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	I don't know
The driver yielded to the pedestrian.	O	O	O	O	O
The driver ***should*** have yielded to the pedestrian.	O	O	O	O	O
The pedestrian felt comfortable in this crossing.	O	O	O	O	O
The risk of injury for the pedestrian in this crossing was low.	O	O	O	O	O

Figure 7. Video rating in the questionnaire

Three participant pools were recruited for the survey:

1. Members of the **Public** in Vancouver, recruited through online posts by the City and researchers and Facebook ads,
2. Engaged community stakeholders, defined as the 10th Ave Advisory **Committee**, recruited through email from the City, and
3. Transportation safety **Experts**, defined as transportation professionals from North America but not British Columbia who have previously taken part in professional safety evaluations involving pedestrians or cyclists, recruited through email from the researchers.

As incentives, participants in the first two pools were entered into a draw for four gift cards of $25 each; the third pool was offered an honorarium of $300.

4.2 Survey results

Survey data processing, response rates, and sample characteristics are described in the Appendix D: Survey data processing. After processing and filtering, 343 complete responses were received from the Public pool, 17 from the Committee pool, and 6 from the Expert pool. Socio-demographic and travel characteristics of each pool and the City's census data are summarized in Figure 8. Missing bars represent no available data (not in Census data or not asked of participants). The sample was younger and better educated than the city's average, and so sampling weights were applied to represent the age, gender, income, and education distributions from the 2016 Census (see Appendix D: Survey data processing).

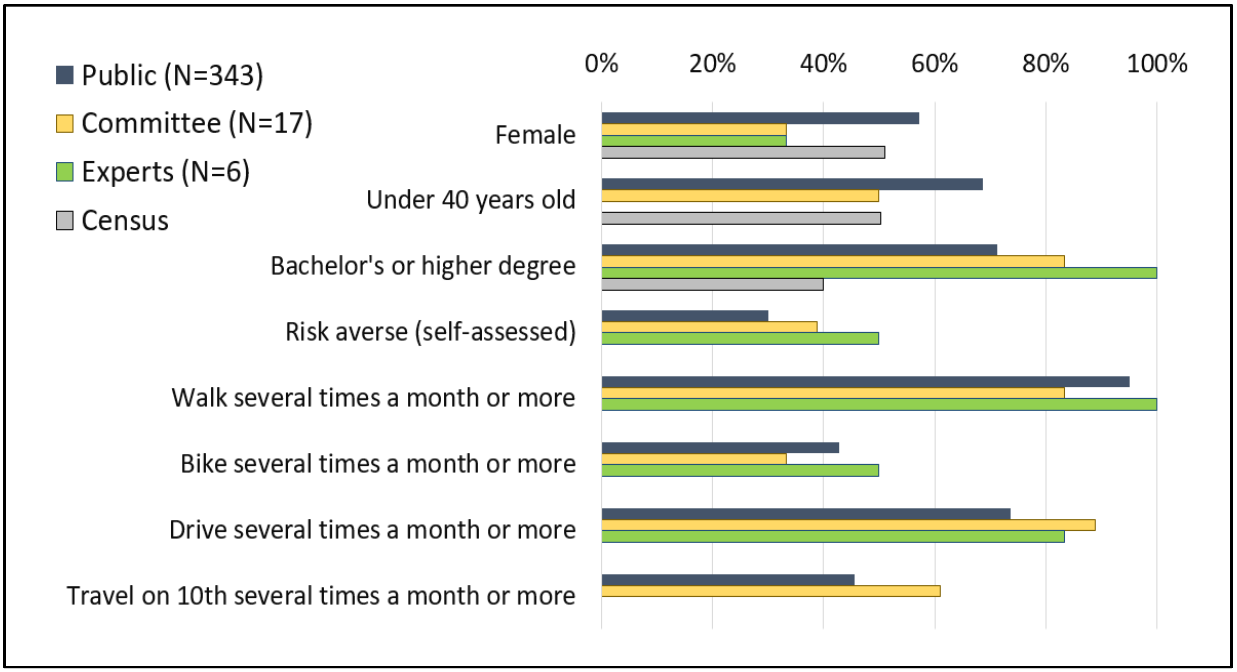

Figure 8. Sample characteristics (with 2016 City of Vancouver Census subdivision comparisons)

A summary of all the ratings is given in Figure 9. Note that these are *not* representative of all interactions because the rated videos were selected by strata, and had disproportionately short passing times. Overall, most responses disagreed that the pedestrians were yielded to, but agreed they should have been yielded to, they felt comfortable, and the interactions were low risk. Participants more frequently rated motor vehicle interactions as both yielded and should have yielded, compared to bicycle interactions. Interactions involving both motor vehicles and bicycles were rated as less comfortable and less low risk than interactions with just one type of interacting road user. Additional figures for all nine strata are given in Appendix E: Video Rating Results.

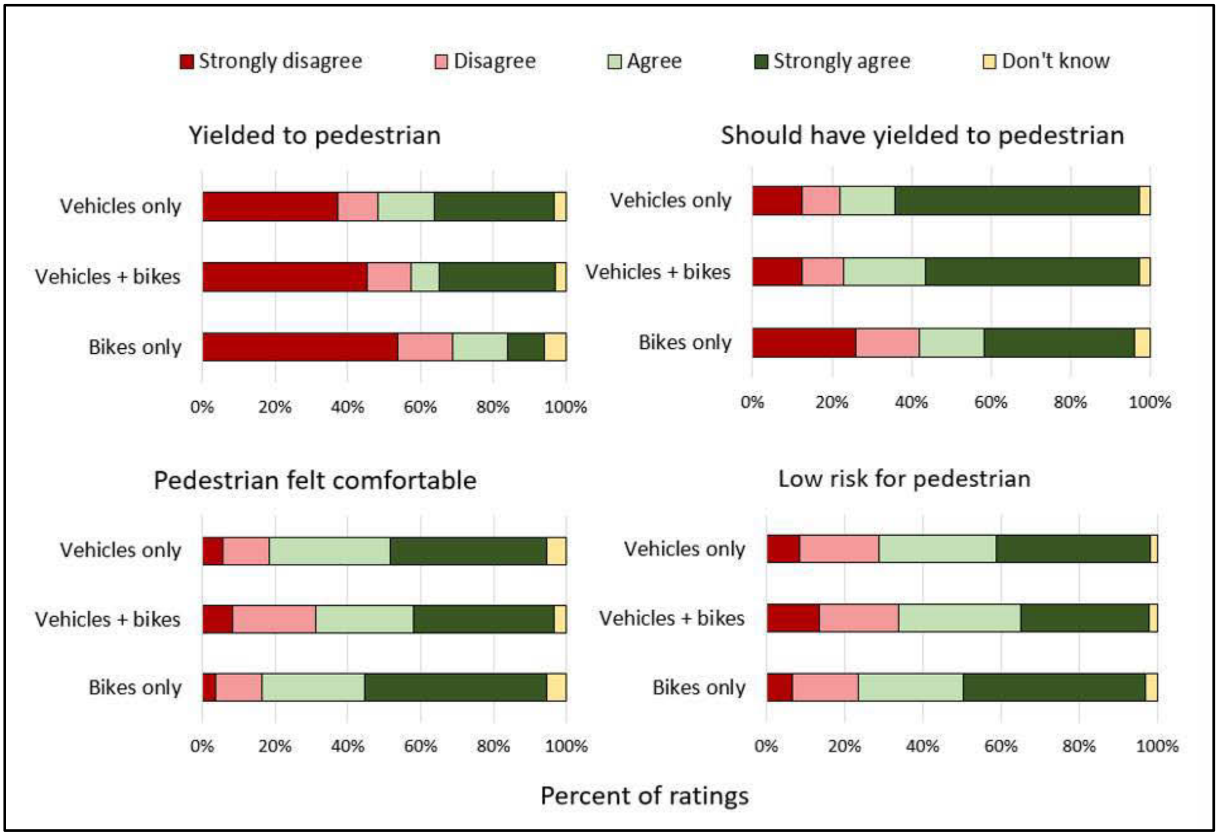

Figure 9. Summary of all 5529 video ratings in the web survey

The responses for "yielded" and "should have yielded" were combined to create a composite variable of "Adequate yielding", illustrated in Figure 10:

- No need to yield: Disagree or Strongly disagree to "should have yielded"
- Adequate yield: Agree or Strongly agree to both "yielded" and "should have yielded"
- Failed to yield: Agree or Strongly agree to "should have yielded", and Disagree or Strongly disagree to "yielded"

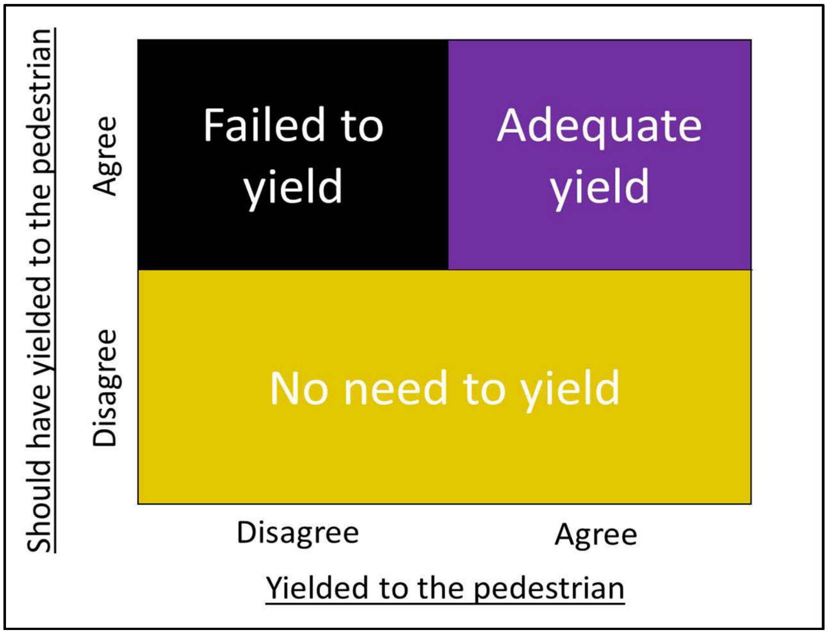

Figure 10. Illustration of "Adequate yielding" from the two questions on yielding

Figure 11 summarizes the "adequate yielding" variable for all survey responses, again as the percent of ratings (and not a representative distribution of all observed interactions). Here the proportion of interactions rated as a failure to yield is similar across road user types, but for interactions with bicycles there is a substantially larger share of "no need to yield", and smaller share of "adequate yield". Very few ratings indicated "yielded" but not "should have yielded" (i.e., the bottom right quadrant in Figure 10).

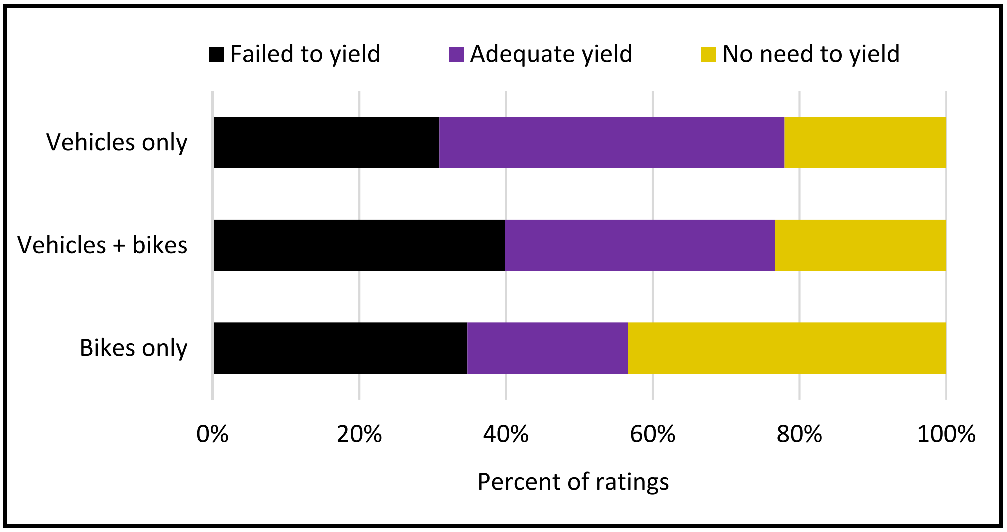

Figure 11. Adequate yielding for all 5529 video ratings in the web survey

The survey responses were used to estimate a weighted mixed ordered logistic regression model for each outcome: "yielded", "should have yielded", "comfortable", and "low risk". The models included random effects for each video (84) and each respondent (366). The best-fit[6] models for each outcome are given in Table 3. The model results show that after controlling for other factors (passing time, road user type, rater characteristics, etc.), yielding and risk were rated significantly better for interactions on 10th Ave than at control sites. Limited street design variables could be tested in the model due to video data coming from only eleven locations (which can lead to multicollinearity – a barrier to regression analysis). Alternative location variables were also tested (crosswalk length, path separation, uphill direction, near/far-side crossing, etc.), but the two in Table 3 (TAHZ location and number of lanes to cross) had the best statistical fits. The TAHZ variable likely includes the effects of the street design as well as other less tangible aspects of the Hospital Zone. To visualize the model results, Figure 12 shows an example of model-predicted percent agreement for all four outcomes, given a pedestrian in the ramp crossing a 2-lane road with 2.5 sec passing time and other average interaction features.

Model results in Table 3 indicate that perceptions of Comfort are hardest to predict (lowest pseudo R^2), followed by risk, obligation to yield, and yielding. Passing time was the only significant predictor of all four severity outcomes, supporting its use in defining interactions. Interactions with cyclists were rated as more comfortable than interactions with motor vehicles; cyclists were rated as yielding less, but there was also less agreement that they "should have yielded."

Table 3. Best-fit explanatory models of rater agreement with each outcome

<u>**Odds ratios**</u> (>1 increased odds of agreement, <1 decreased odds of agreement)	**Yielded**	**Should have yielded**	**Comfortable**	**Low risk**
Passing time (seconds)	1.71	0.52	2.17	2.35
Interaction with a bicycle (vs. vehicle)	0.25	0.21	1.46	-
Ped passed conflict point before interacting RU	24.12	6.03	1.68	-
Ped location when RU entered crosswalk: *Crosswalk/on-street*	-	2.99	0.36	0.32
Ped location when RU entered crosswalk: *Ped ramp/island*	-	3.76	0.42	0.48
Interacting RU was in a group (not isolated)	-	2.36	0.40	0.42
Uncommon pedestrian type (child, mobility-impaired, etc.)	-	-	-	0.44
Noticeable deviation of speed or path *by interacting RU*	4.67	2.27	-	2.01
Noticeable deviation of speed or path *by pedestrian*	4.01	2.49	-	-
Number of pedestrians in the scene	-	1.12	0.90	0.86
10th Ave Hospital Zone location	3.21	-	-	2.71
Total lanes to cross	0.58	-	-	0.74
Rater walking frequency (ordered factor, 1-5, never to daily)	-	1.16	0.80	-
Rater biking frequency (ordered factor, 1-5, never to daily)	-	-	-	1.13
Rater from Expert pool	-	-	-	3.76
Pseudo R^2	**0.582**	**0.516**	**0.330**	**0.410**

[6] Highest log-likelihood, with all independent variables significant at $p<0.05$

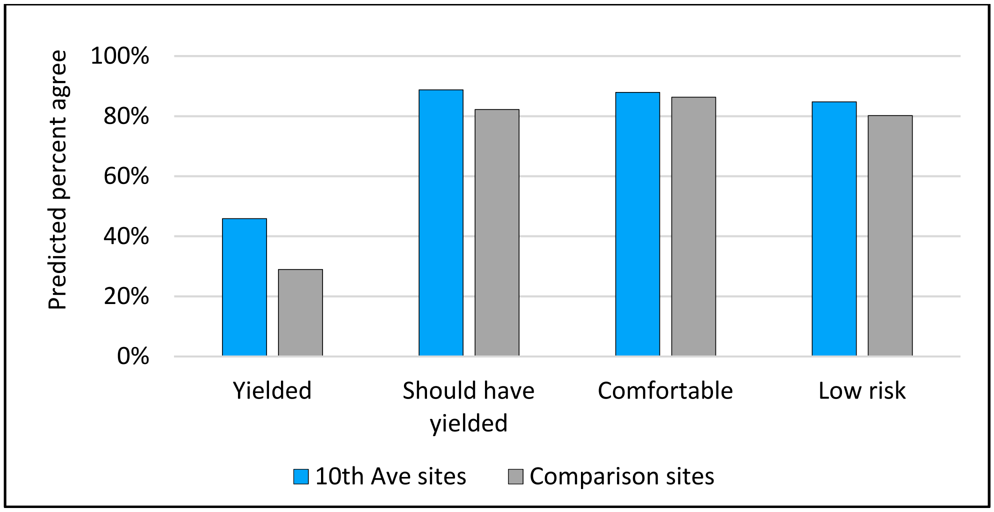

Figure 12. Modelled differences in severity between 10th Ave and Comparison sites, for a pedestrian crossing a 2-lane road with 2.5 sec passing time and other average features

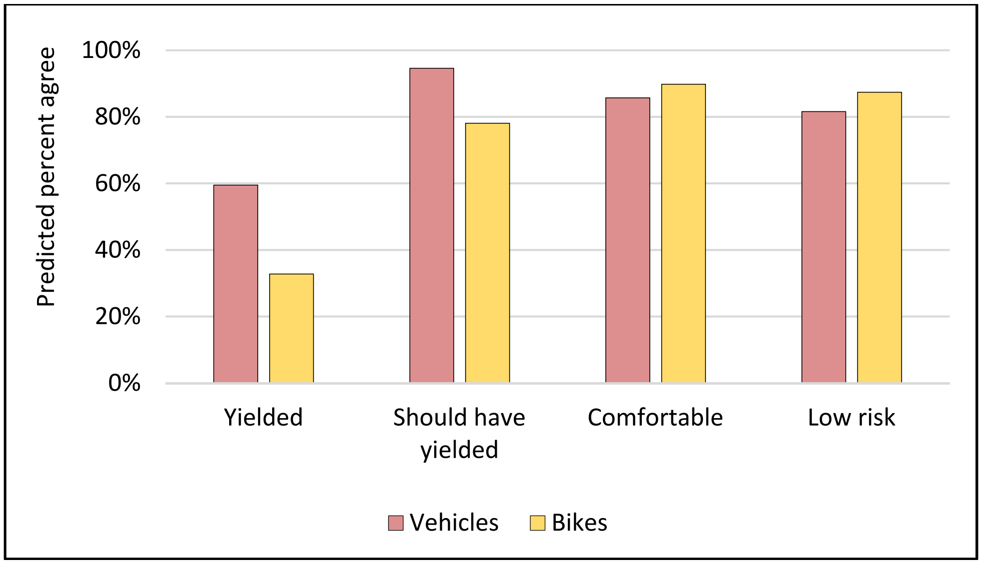

Figure 13. Modelled differences in severity between interactions with vehicles and bicycles, for a pedestrian crossing a 2-lane road in the TAHZ with 2.5 sec passing time and other average features

Figure 13 shows the model-predicted percent agreement for all four outcomes, given a pedestrian crossing a two-lane road in the TAHZ with 2.5 sec passing time and other average interaction features. Whether the pedestrian passed first was crucial for perceptions of yielding – more important than speed or path deviations, for example. Pedestrians passing first was perceived as more comfortable, but not necessarily lower risk. Interactions involving more vulnerable pedestrians (children, mobility impaired) were rated as higher risk, but there were no significant differences for the other severity outcomes. This finding corroborates the observation from Committee member interviews that Comfort and Safety are distinct constructs and mobility aids may not affect assessed comfort.

A statistical comparison of the responses among the participant pools is given in Appendix F: Comparisons among and between pools. The 'excellent' reliability of the combined (average) severity rating, contrary to the 'poor' reliability of *individual* ones, gives us confidence in applying the survey results to summarize the observed interactions. Rating agreement among individuals was highest for Yielding and lowest for Comfort and Risk.

There were no significant differences in the ratings of the Public and Committee pools. This finding shows that the Committee, whose members have higher average age, represents the younger-aged Public in terms of severity ratings of interactions. There were no significant differences between the Expert pool and the other two pools on the Yielding or Comfort questions, but Experts rated both vehicle and bicycle interactions as significantly lower risk. Hence, Experts align with the Public in assessing yielding and comfort, but not on what that behaviour implies for safety. This finding is reinforced by the fact that Experts expressed higher self-assessed risk aversion than the other two pools, meaning the lower risk ratings are likely not attributable to a higher threshold for risk in this pool. The Expert effect on risk rating in Table 3 was tested for differences between vehicle and bicycle interaction types, and found to be not significant ($p=0.61$); i.e., the systematic difference in risk perception between Experts and the Public was similar for interactions with vehicles and bicycles.

Somewhat surprisingly, there were no significant effects of socio-demographics or 10th Ave familiarity on the severity ratings. Model results in Table 3 show that raters who bicycle more also rate risk as lower (for all interaction types - vehicles and bicycles). Raters who walk more rate Comfort as lower for the pedestrians in interactions, and also more strongly agree that other road users "should have yielded".

4.3 Definition of interactions

Statistical models from the ratings data were used to refine the passing time threshold for defining when an interaction has occurred. Table 4 gives the derived passing time thresholds that yield at least 85% predicted agreement with each severity outcome for a pedestrian in the ramp crossing a two-lane road, interacting with a vehicle or bicycle. The 85th percentile is selected as a common threshold in transportation engineering practice.

For vehicle interactions, at least 85% agreement with "should have yielded" is expected for interactions with passing times under 3.3 seconds, and for bicycle interactions, it is expected for passing times under 1.2 seconds. Lower agreement levels are achieved at higher passing times. Based on the results in Table 4, the remainder of the analysis applies a 3-second passing time threshold to define interactions. The same threshold is used for interactions with motor vehicles and bicycles, for consistency. Previously identified potential interactions with passing times over three seconds are excluded from the interaction pool, which reduces the set of sample interactions from 536 to 277 (58% of potential interactions at 10th Ave locations and 41% at comparison sites were under 3 seconds).

Table 4. Passing time thresholds for ≥ 85% predicted agreement with severity outcomes (pedestrian in ramp, crossing a two-lane road)

Outcome	Interactions with vehicles	Interactions with bicycles
Should have yielded	≤ 3.3 s	≤ 1.2 s
Comfortable	≥ 2.7 s	≥ 2.1 s
Low risk (Public)	≥ 3.2 s	≥ 2.6 s
Low risk (Experts)	≥ 1.6 s	≥ 1.0 s

5 Evaluating comfort and safety

The process of evaluating crossing experiences at the 10th Ave and Comparison sites is illustrated in Figure 14. In the first step, 4400 interactions (at 5 seconds) were identified in 80 hours of video data from 11 locations. Then, 50 crossings with interactions were randomly selected for each location and objective features were coded (including passing time). In the third step, a web survey was used to investigate perceptions of the severity of a sub-sample of 84 interactions with a controlled mixture of passing times and road user types. In the final two steps of the analysis, statistical models from the web survey data were applied to predict the perceived severity of all the sample interactions, and then those sample interactions were combined with interaction rates to summarize the crossing experience by location.

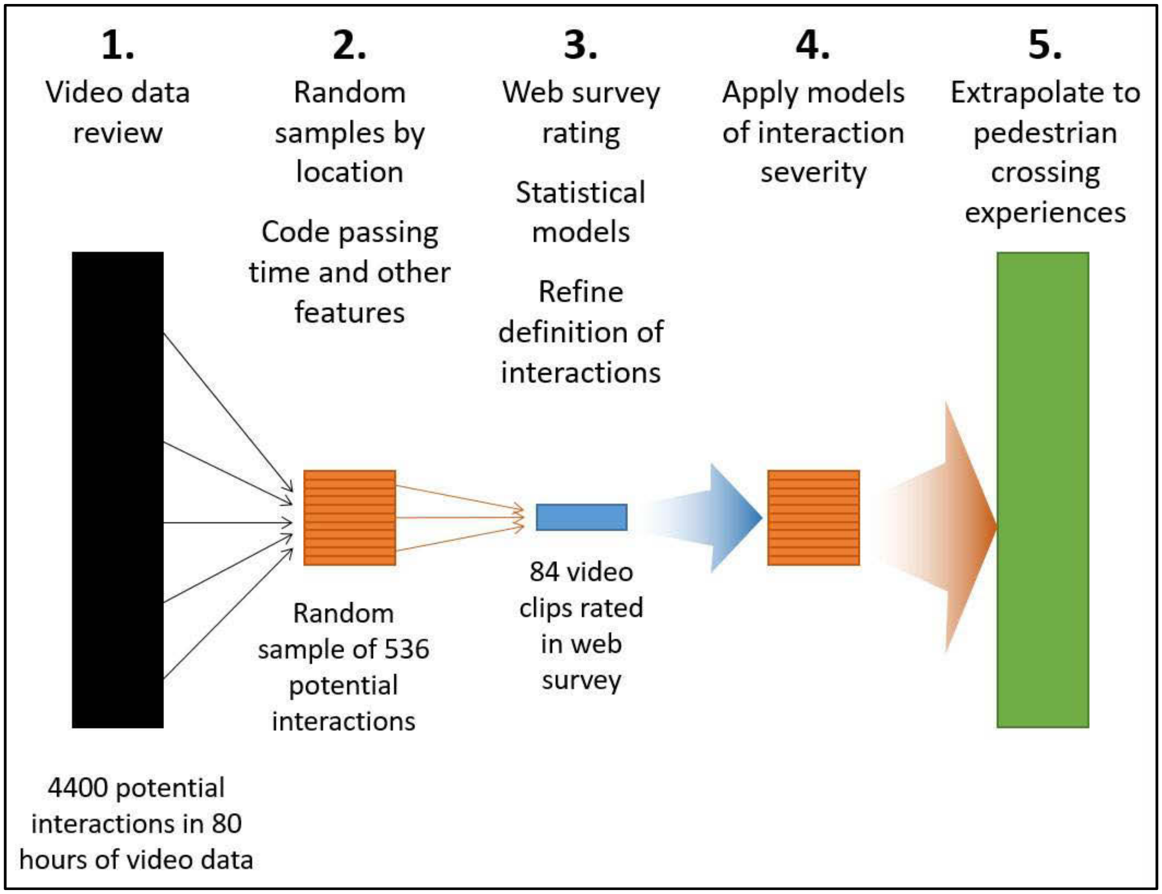

Figure 14. Summary of method for evaluating crossing experiences from sample interactions

5.1 Severity of interactions by location

To predict perceived severity by location, a reduced set of four regression models (one for each outcome) was estimated using only those independent variables that were coded for the sample interactions and significant ($p<0.05$) for at least one of the outcomes in the best-fit models. The same set of variables was used in all four models for consistency, other than the variable Expert, which was only included in the Risk model. The prediction models in Table 5 show that they have only a slightly poorer overall goodness-of-fit and the estimated parameters are similar to the best-fit models (see Table 3).

Table 5. Reduced-from models to predict perceived severity of sample interactions (limited to variables coded for all interactions)

Odds ratios (>1 increased odds of agreement, <1 decreased odds of agreement)	**Yielded**	**Should have yielded**	**Comfortable**	**Low Risk**
Passing time (seconds)	1.26	0.45	2.17	2.30
Interaction with a bicycle (vs. vehicle)	0.33	0.20	1.47	1.56
Ped passed conflict point before interacting RU	33.32	6.10	1.84	1.43
Ped location when RU entered crosswalk: *Crosswalk/on-street*	1.38	5.08	0.31	0.30
Ped location when RU entered crosswalk: *Ped ramp/island*	1.78	6.11	0.41	0.55
10th Ave Hospital Zone location	2.08	1.70	1.15	1.37
Total lanes to cross	0.71	0.95	0.91	0.90
Expert rater	NA	NA	NA	3.98
Pseudo-R^2	**0.579**	**0.513**	**0.327**	**0.406**

Results of applying the statistical models in Table 5 to the sample interactions by location and interacting road user type are summarized in Figure 15 (using Expert assessment of risk). The figure shows the expected percent of interactions which would be perceived as adequate yielding, comfortable, and low risk. Overall, the severity of interactions is roughly similar by type and location: 86-91% are low risk, 78-84% are comfortable, and 50-58% involve adequate yielding. Public perception of Low Risk is in line with the Comfort results. Although the 10th Ave sites had better severity outcomes *controlling for other interaction characteristics* in the modelling results above, those effects are offset by longer crosswalks, higher volumes, and closer interactions on 10th Ave than the Comparison sites. Thus, Figure 15 shows that the severity is slightly worse at the 10th Ave sites than the Comparison sites; the exception is cyclist yielding, which is higher on 10th Ave. Bicycle interactions are more comfortable and lower risk than vehicle interactions at each site.

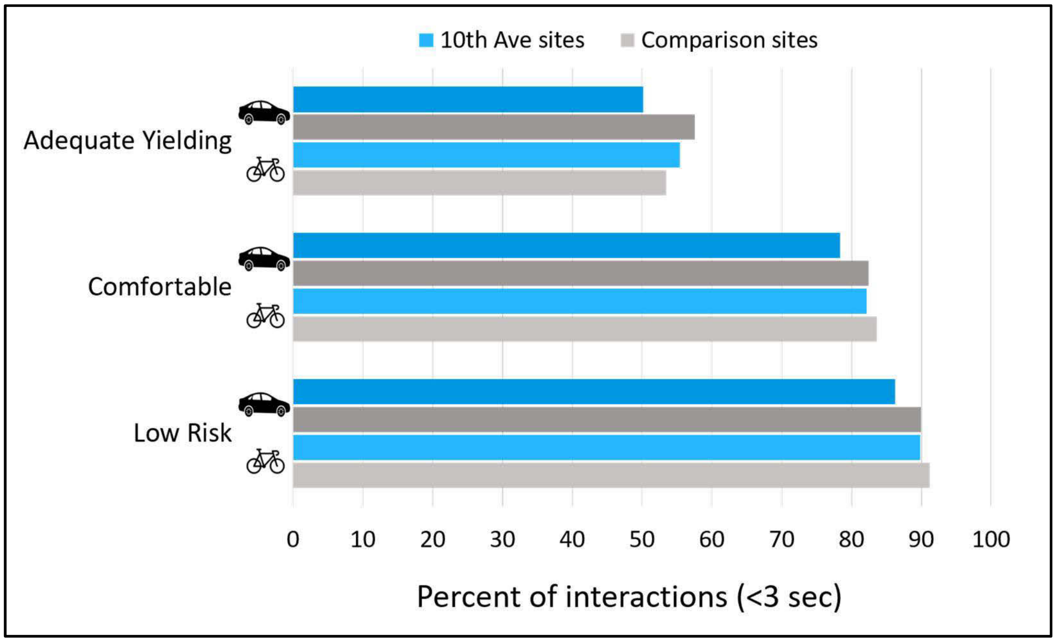

Figure 15. Predicted severity of interactions by location and type

5.2 Interaction rates

Volumes and interactions were only recorded for one direction of interacting traffic (due to the limited camera scenes). Hence, a two-way adjustment was made to the raw interaction rates. The statistical evidence from a subset of video data that was coded in both directions supports an assumption of independent likelihood of pedestrians experiencing interactions from each direction (see Appendix G: Bi-directional traffic adjustment). A further assumption is made of equal severity of interactions with traffic from each direction (by location).

Figure 16 summarizes the frequency of two-way interactions by type and location. Due to the higher volumes on 10th Ave, pedestrians are much more likely to interact with a vehicle or bicycle while crossing than at the Comparison sites. Half of the pedestrians experience an interaction while crossing 10th Ave during weekday peak periods, compared to just 20% pedestrians crossing at the Comparison sites. This finding reinforces the perceptions expressed during the interviews that 10th Ave is a uniquely complex multi-modal street. The interaction rates by road user type are consistent with volume differences: 10th Ave had roughly two times higher vehicle volumes and 3.5 times higher bicycle volumes than the comparison sites. Also, vehicle volumes were two to three times higher than bicycle volumes.

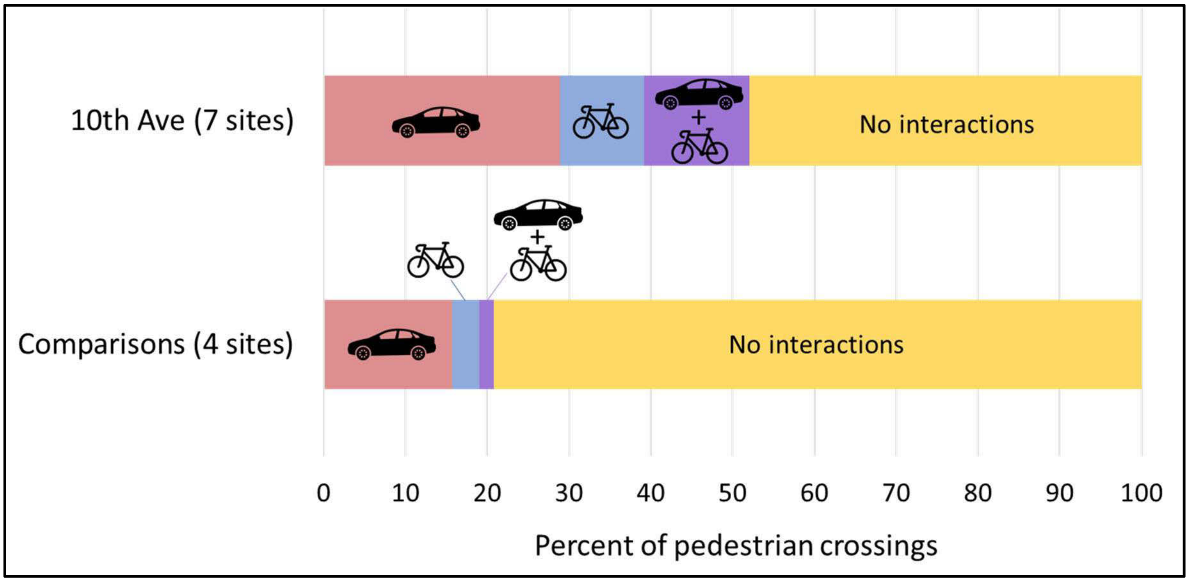

Figure 16. Frequency of interactions by type and location (including 2-way interactions, based on ±3 sec passing time)

5.3 Overall crossing experience

Combining the severity by location and type with interaction rates yields the crossing experiences shown in Figure 17 for 10th Ave during weekday peak periods. “Negative interactions” were those with predicted disagreement (strong or otherwise) that they involved adequate yielding, were comfortable, or were low risk, while “Positive interactions” were the opposite (predicted agreement). **A quarter of crossing pedestrians experience a negative interaction from the perspective of yielding, while 10% experience an interaction that was not comfortable and 6% that was not low risk.** Isolating the most problematic interactions as those responses predicted as “strongly disagree” rather than “somewhat disagree”, the numbers are much lower, with under 2% of crossings strongly negative for comfort and under 1% strongly negative for risk.

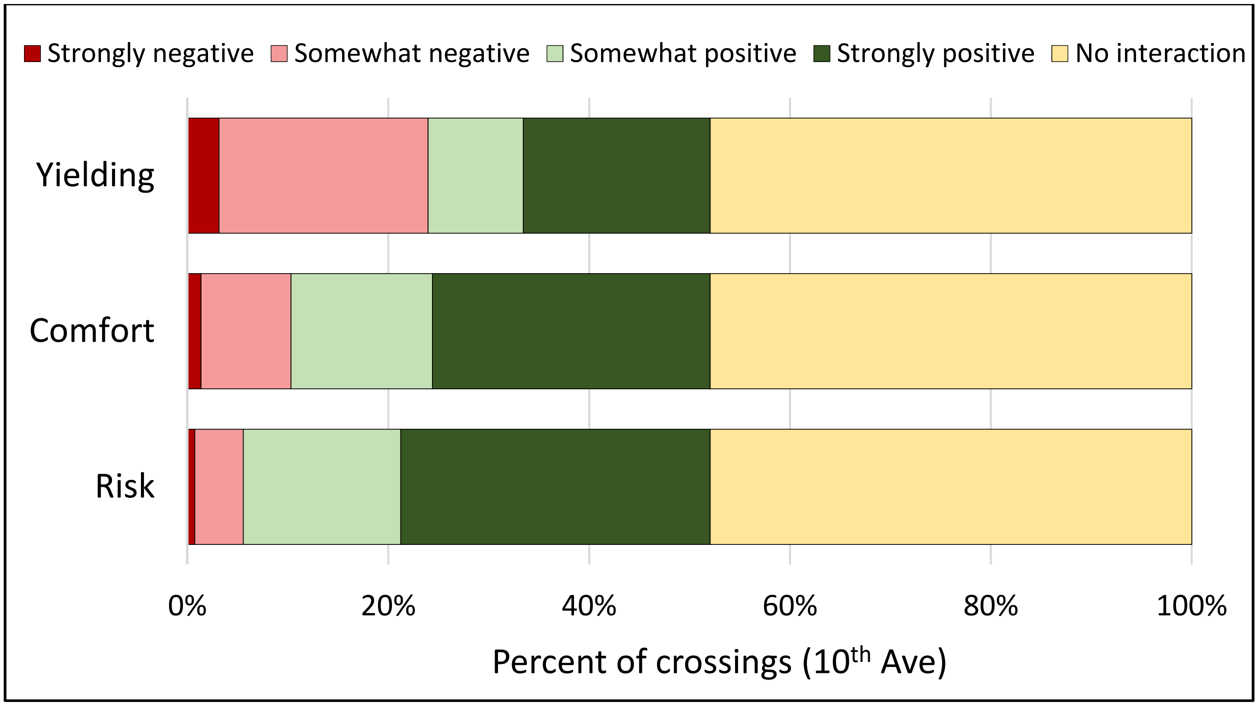

Figure 17. Overall crossing experience based on interaction frequency and perceived severity of sample interactions (negative/positive interactions indicate disagreement/agreement that there was adequate yielding, that the pedestrian was comfortable, and that there was low risk)

5.4 Summary of findings

- Most crossings are perceived as "low risk" (94%) and "comfortable" (90%), although 25% of crossings involve inadequate yielding (rated as "should have yielded", but did not).
- With high volumes of people walking, driving, and cycling, 10th Ave. has high interaction rates during weekdays. Just over half (52%) of pedestrian crossings involved an interaction (defined from the survey results as another road user passing within 3 seconds before or after a crossing pedestrian).
- The observation sites along 10th Ave. have higher yielding rates and lower risk than the comparison sites. However, these effects are partially offset by longer crossings, higher volumes, and closer interactions along 10th Ave. Overall severity of interactions are similar among the study locations, with around 50% adequate yielding, 80% comfortable, and 80-90% low risk (depending on perspective).
- Perceptions of yielding, comfort, and safety do not vary significantly with a rater's socio-demographics (age, gender, income, education), but perceptions do vary with a rater's travel habits. People who walk more frequently rate pedestrian comfort as lower, and are more likely to agree that road users "should have yielded". People who cycle more frequently rate risk as lower (for pedestrian interactions with both bicycles and motor vehicles).
- There are no significant differences in perceptions of yielding, comfort, and safety between members of the public and Committee members who participated in the survey. The traffic safety experts have similar views of yielding and comfort to the Public and Committee pools, but a consistently lower assessment of risk for pedestrians in interactions with motor vehicles and bicycles. This finding is reinforced by the fact that the experts expressed higher self-assessed risk aversion than the other two pools, suggesting that the lower risk ratings are likely not attributable to greater general risk acceptance.
- Pedestrian interactions with bicycles are more comfortable and lower risk than interactions with motor vehicles. This finding may be explained by the size difference between bicycles and motor vehicles and easier visual communication between pedestrians and cyclists. Rates of inadequate yielding are similar in pedestrian interactions with either motor vehicles or bicycles. In otherwise similar interactions, cyclists are much more likely to be perceived as not needing to yield than drivers.
- Interactions involving more vulnerable pedestrians (children, mobility impaired) are perceived as higher risk but there were no significant differences for the other severity outcomes of comfort or yielding. This finding is supported by the interview result that comfort and safety are distinct constructs and mobility aids may not affect assessed comfort.
- Perceptions of yielding are most strongly based on whether the pedestrian passed first, rather than specific manoeuvres by the other road user (i.e., visible slowing). Legal definitions of right-of-way and yielding are neither well-known nor considered of main importance, based on the interview results.

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Appendix A: City coding of volumes and interactions in video data

The City collected video data from 11 locations for three days each. Figure 18 and Figure 19 show the names and still images of the crosswalks from the video data. Seven crosswalks were selected in the recently redesigned portion of the TAHZ, based on the expectation of significant pedestrian, motor vehicle, and cycling activity. Only crosswalks at intersections were included (no mid-block crosswalks). Four comparison sites were selected based on similar operating characteristics (uncontrolled crosswalks) and high pedestrian volumes.

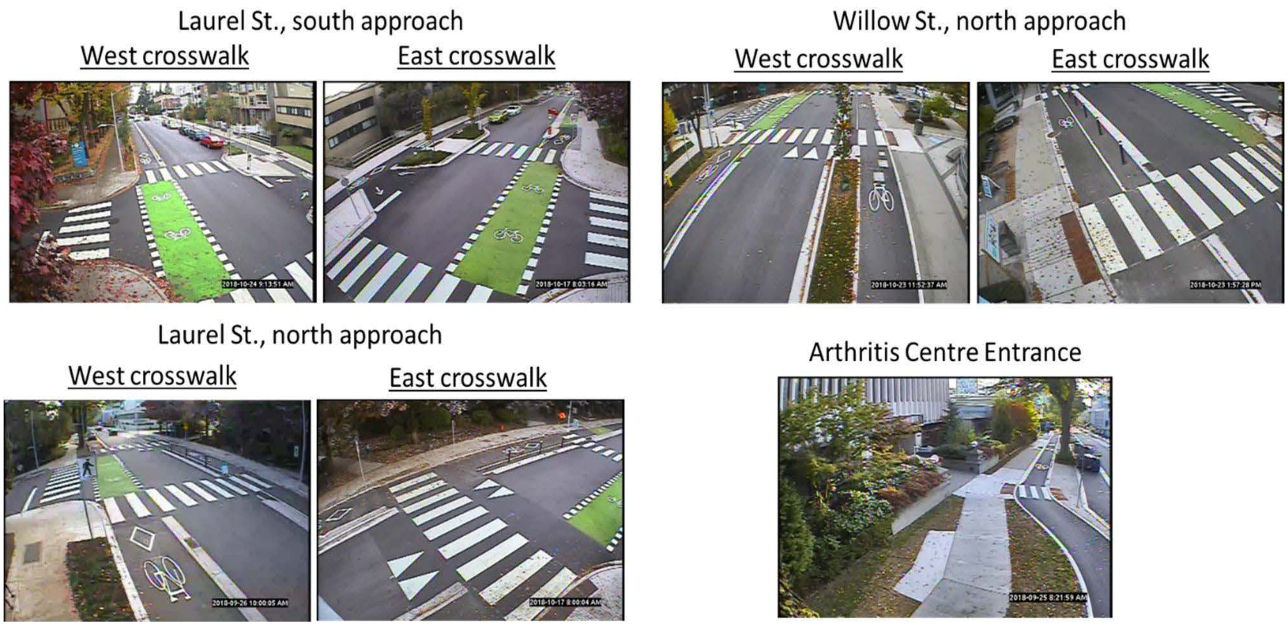

Figure 18. Video data from 10th Ave crosswalks

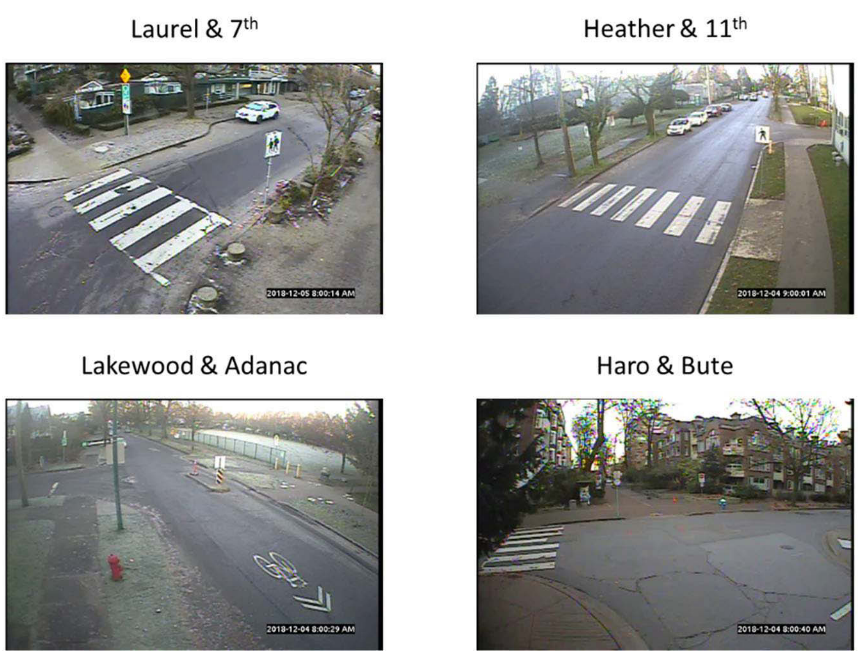

Figure 19. Video data from comparison crosswalks

The video data were reviewed and volume and interaction counts were recorded in 15-minute intervals by the City for six hours (8-10hr, 11-13hr, 16-18hr) per location on a single weekday. A target sample of 200 pedestrian crossings at each location was established, and two locations (Arthritis Centre Entrance and Lakewood & Adanac) failed to reach that target in a single day of data. Two additional days of video data from Arthritis Centre Entrance were reviewed to reach the target pedestrian volume in 18 hr of video data. Due to video data loss at Lakewood & Adanac, only 33 15-minute observation intervals were available for review, providing a final pedestrian sample volume of 157 crossings at that location.

The overall road user mix counted at 10th Ave sites was 37% pedestrians, 39% vehicles, and 24% bicycles – based on counts from one direction (see Table 1 for a summary of hourly volume). Figure 20 gives mean volumes for the six main 10th Ave sites by the time of day. The volumes varied substantially by time of day, travel mode, and location. Based on long-term monitoring data from the City, hourly bike volumes range 40-140 on 10th Ave. at Clark St. (several km east of the study area) for comparable hours over the course of the year. Hence, we are at the low end of the middle/shoulder season for bicycle volumes – and seeing a typical range over the course of the day. Figure 21 gives mean hourly potential interactions recorded for the six main 10th Ave sites by the time of day which resembles the hourly volumes from Figure 20, hence demonstrating their positive relationship with interactions.

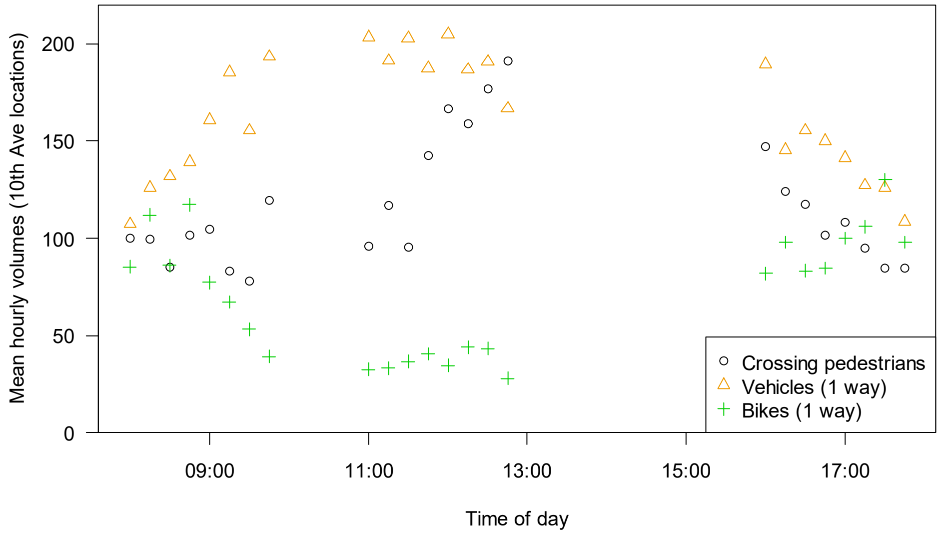

Figure 20. Mean hourly volumes over the course of the day at the 6 main 10th Ave. locations (based on 36 hours of video data)

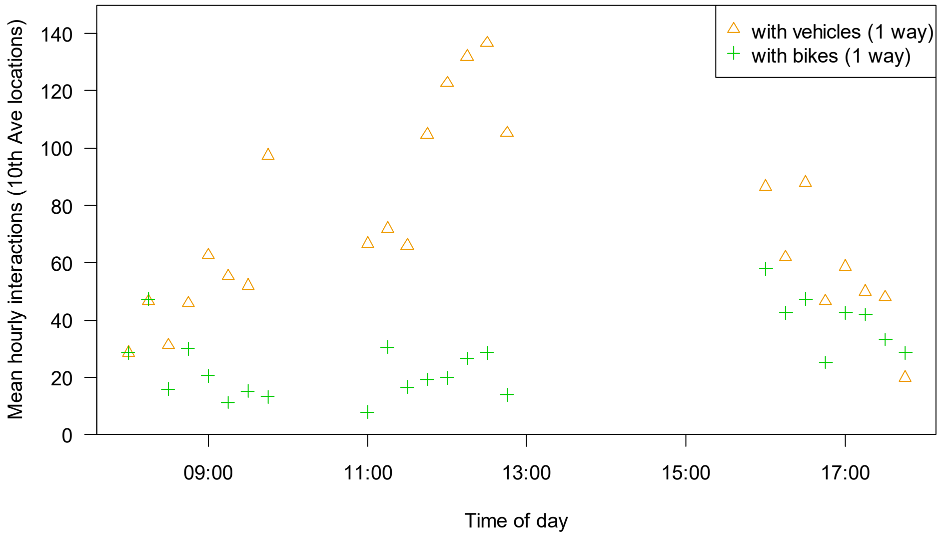

Figure 21. Mean hourly interactions (passing time <5 sec) over the course of the day at the 6 main 10th Ave. locations (based on 36 hours of video data)

The research team independently coded eleven 15-minute periods of video data (one randomly selected from each location) using the same methods as the City and compared with the City coding results. The results given in Table 6 show that the counts are very well validated, with correlations of at least 0.997 and mean errors of less than 1 per 15 minutes. The interaction coding was not as well validated, as expected, but still showed good agreement with correlations of 0.97 and 0.81 for vehicle and bicycle interactions, respectively. The discrepancies in the number of interactions are due to interactions with long passing times (around 5-seconds passing time), which gives more confidence that all of the <4s passing time interactions were recorded.

Table 6. Interaction Coding Validation Results (based on eleven 15-minute periods)

	Volumes			Number of interactions of crossing pedestrians with…	
	Pedestrians	**Bicycles**	**Vehicles**	**Vehicles**	**Bicycles**
Mean (standard deviation) in validation periods	23.9 (19.8)	14.2 (9.2)	26.1 (19.5)	10.7 (11.1)	3.3 (3.1)
Correlation	0.998	0.997	1.000	0.974	0.813
Mean difference	0.545	-0.091	0.000	-0.727	0.182
Mean absolute difference	0.909	0.273	0.182	1.455	1.273

Appendix B: Coding of interaction characteristics for survey sample

The survey was composed of 84 crossings, which were a sub-sample taken from the set of 536 sample crossings by randomly sampling within nine strata based on interacting road user type and passing time. After selecting the sub-sample, video clips of the selected interactions were reviewed and replaced with other random interactions from the same stratum if the interaction was not clear and dominant in the video scene. For example, a goose crossing the road or a conflict between road users in some other part of the scene.

Apart from the characteristics coded by the City for the video data, the research team further tested additional characteristics for the interactions in survey videos. To determine what additional interaction characteristics could be reliably extracted from the sample interaction videos, a draft set of 29 characteristics was first created, and then four raters on the research team independently coded 10 video clips of randomly selected interactions. Several features of interest were not coded because of unreliability, including distracted pedestrians, elderly pedestrians, whether the cyclists stopped pedaling. Based on those results, the following variables were coded for each of the 84 sample interactions included in the survey:

1. Total number of pedestrians in the scene
2. Total number of vehicles and bicycles in the scene
3. Motor vehicle type: passenger or not
4. Pedestrian type: mobility-assisted, cart/trolley, child, or none
5. Who passed the conflict point first: pedestrian or other road user
6. Vehicle in a group: influenced or isolated
7. Cycle in a group: influenced, isolated, or grouped
8. Pedestrian in a group: influenced, isolated, or grouped
9. Pedestrian position when road user enters crosswalk: parallel sidewalk, crosswalk/street, curb-cut/island, or off-street/off-screen
10. Yielding-related manoeuvres by vehicle: full stop or speed deviation
11. Yielding-related manoeuvres by bicycle: full stop, speed deviation, or path deviation
12. Yielding-related manoeuvres by pedestrian: full stop, speed deviation, or path deviation
13. Road user turning movement: yes or no
14. Cycle in a general purpose lane: yes or no
15. Low light: yes or no
16. Crosswalk marking: good, poor, or missing
17. General purpose lanes to cross: zero, one, or two
18. Bike lanes to cross: zero, one, or two.

Appendix C: Interaction Severity Scales

Rating scales were needed for three dimensions of severity: adequacy of compliance/yielding, comfort, and safety. Draft severity scales were developed from the literature to test during the interviews, before selecting the final wording for the web survey.

Objective safety: "Comfort", "safety" and "severity" are all widely used in safety and pedestrian/cycling literature. The traffic conflict literature, which aims to systematically evaluate objective risks, tends to frame risk as "conflict severity", where more severe conflicts represent a greater likelihood of a collision occurring [2]–[9]. The severity of the potential collisions (in terms of bodily injury/death given a collision occurs) is not generally included in conflict severity. The severity of a conflict is usually assessed as qualitative levels (e.g., low, medium, high) by human observers or quantitative bins based on objective conflict indicators such as Time to Collision (TTC) or Post Encroachment Time (PET). Both are accepted as valid methods, with expert observers suffering from consistency issues and objective measures from simplicity and lack of comprehensiveness. There is wide recognition that there is no one best objective conflict measure for all types of interactions and risks; PET has been used successfully and frequently in the past for ped and bike interactions [2], [5].

Perceived safety: Comfort and safety are sometimes used interchangeably in the pedestrian/cyclist literature, although the former tends to indicate subjective or perceived safety, while the latter may mean perceived risk in terms of crash or injury likelihood. Less often, comfort can refer to other factors such as weather or hills. A common phrasing to measure perceived safety is to ask travellers if they "would feel comfortable" in a certain situation or something similar. Comfort has also been evaluated as a safety concern, fear of traffic, and concern about traffic and conflicts with vehicles [10]–[14]. Two recent studies reported comfort and safety as essentially indistinguishable or interchangeable [15], [16]. Kaparias et al. [17] addressed perceived safety with a binary-response question of whether respondents "would be comfortable moving around as a pedestrian" in a specific shared-space area. Lord et al. [18] designed a questionnaire with a Likert scale response to evaluate perceived safety based on pedestrian crossing experience in different traffic conditions (jaywalking, crossing at an intersection without traffic lights, crossing without looking at traffic, etc.) Moody and Melia [19] assessed comfort as to whether travellers "feel safer" and "are…ever worried about sharing space in" a given location. Another study asked cyclists to "report all episodes in which they felt uncomfortable while riding (subjective risk perception)" [20].

Yielding and compliance: Definitions of yielding are similarly inconsistent and vague in the multi-modal road user literature; even compliance is not always strictly defined [21], [22]. Moody and Melia [19] asked whether pedestrians "feel [they] have more, less or equal priority" than other road users. They also assessed which road user "gave way" in conflicts, without clearer definition. Yielding is sometimes simply assessed as which road user passed first, and sometimes based on subjective indicators of slowing or avoidance manoeuvres.

Identifying interactions: A standard definition of a conflict in traffic conflict analysis is "an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remained unchanged" [23]. In a recent review, Mahmud et al. [5] state that a "standard value has not been determined yet to distinguish conflict and normal events". Tageldin and Sayed [8] suggest conflict thresholds of 1.5 to 3 sec, while others have used as high as 8.5 sec for "minimal" conflicts [2], [5]. There is no clear threshold for differentiating a conflict from a normal interaction; they are often presented as different areas on the same severity continuum

[3], [8]. Ismaili et al. [2] defined “exposure events” (interactions) as road users within 10m spatial proximity and a convergent path direction. Moody and Melia [19] described ‘conflicting movements’ simply as when the paths of two road users crossed. Beitel et al. [24] define an interaction as non-motorized road users with a PET under 5 sec, and a conflict as PET under 2 sec, without clear justification. Beitel et al. [9] manually identified “potentially dangerous events and potential conflicts” from video data, without clearer definitions. In contrast, Paschalidis et al. [25] take a perception approach and described conflicts as "a subjective procedure related to situations of competitiveness, stress, frustration and inconvenience", and asked cyclists "to report any incident they had experienced with pedestrians and/or car drivers, which caused them feelings similar to the aforementioned, and not including physical contact necessarily".

Draft scales: The draft severity questions in Table 7 were generated from the literature above and other sources. They were presented to interviewees and piloted with colleagues before selecting a final set for the web survey.

Table 7. Interaction Severity Draft Question[1] Bank

Set	Yielding	Comfort	Safety
1	The [cyclist/driver] yielded to the pedestrian.	The pedestrian felt comfortable in this crossing.	This crossing was safe for the pedestrian.
2	The [cyclist/driver] was considerate of the pedestrian.	The pedestrian felt safe in this crossing.	There was a low risk of injury for the pedestrian in this crossing.
3	The [cyclist/driver] was careful with respect to the pedestrian.	I would have felt comfortable as the pedestrian in this crossing.	There was a low risk of the pedestrian being hurt in this crossing.
4	The [cyclist/driver] obeyed the law.	I would have felt safe as the pedestrian in this crossing.	There was a low risk of collision for the pedestrian in this crossing.

[1] “Please indicate your level of agreement with each statement”

Appendix D: Survey data processing

The online survey was opened on 15-03-2019 and closed on 24/4/2019 (41 days). The numbers of raw responses were: 425 Public, 18 Committee, and six Experts. Based on the observed timing of responses (Figure 22), "low timing" ratings were flagged as those with under 12 seconds spent on the video page (which roughly aligns with the video lengths). Entire responses were excluded if more than one of a participant's rated videos were flagged as "low timing": this led to 11 exclusions (not highly sensitive to the low timing thresholds). Individual ratings were excluded for remaining participants with "low timing" ratings (five video ratings in total). Participants who rated fewer than four videos were also excluded, leading to another 72 exclusions. The exclusions were moderately sensitive to this threshold: 54 participants rated zero videos, 18 rated one to three videos, 18 rated four to six videos, 10 rated seven to nine videos, eight rated 12-14 videos, and 324 rated all 15 videos (excluding the six Expert participants who rated all 84 videos). The final sample size was 366 (343 Public, 17 Committee, and 6 Expert). Of the 427 submitted responses, 84 Public (71 incomplete, 11 low timing, and two declined consent) and one Committee (incomplete) response were excluded.

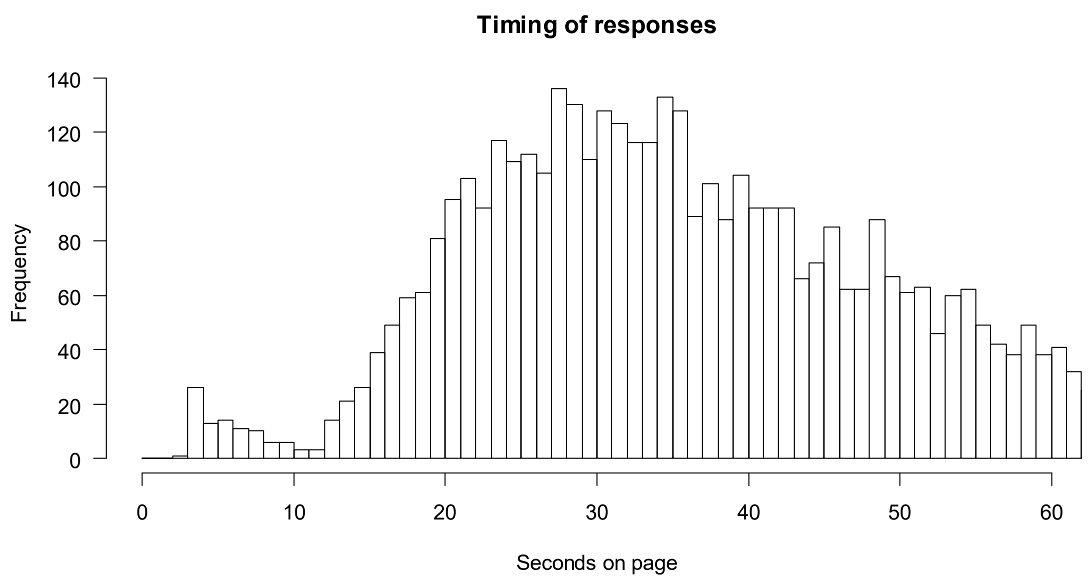

Figure 22. Distribution of response time on a page by survey participants

Response rates do not apply to the Public sample, due to the open recruitment method. For the Committee sample, 17 complete responses were received out of 59 invitations from the city (29% response rate). The sample characteristics cannot be compared because socio-demographics of the Committee population were not available. Of 11 invitations, six complete surveys were received from the Expert pool (55% response rate); one employed in Academics, three in Government, and two in Consulting. The completed responses were from four US cities (Boston, Corvallis, Portland, Seattle) and one Canadian city (Montreal).

Rating completions by video are consistent with expectations across strata, based on the Public and Committee samples rating one of eight videos in five strata, two of 10 videos in two strata, and three of 12 videos in two strata. Time spent on each video page was similar across pools, with median times of

43, 49, and 38 seconds for the Public, Committee, and Expert pools, respectively (no differences by pool are statistically significant at $p<0.05$ based on a two-tailed t-test).

The sample differs from the socio-demographic characteristics of the City and Region, based on a comparison to Census data. Figure 23 gives age, education, and income distributions for the survey, City, and Region. The sample overall is 54% female; 55%, 35%, and 33% for the Public, Committee, and Expert pools, respectively. Some of the sample bias is possibly due to the recruitment methods, and some to self-selection of those interested in non-motorized transportation in the city. The sample travel habits (other than the Expert pool) are given in Figure 24. The sample likely over-represents non-auto travellers and 10th Ave. travellers, compared to the City at large.

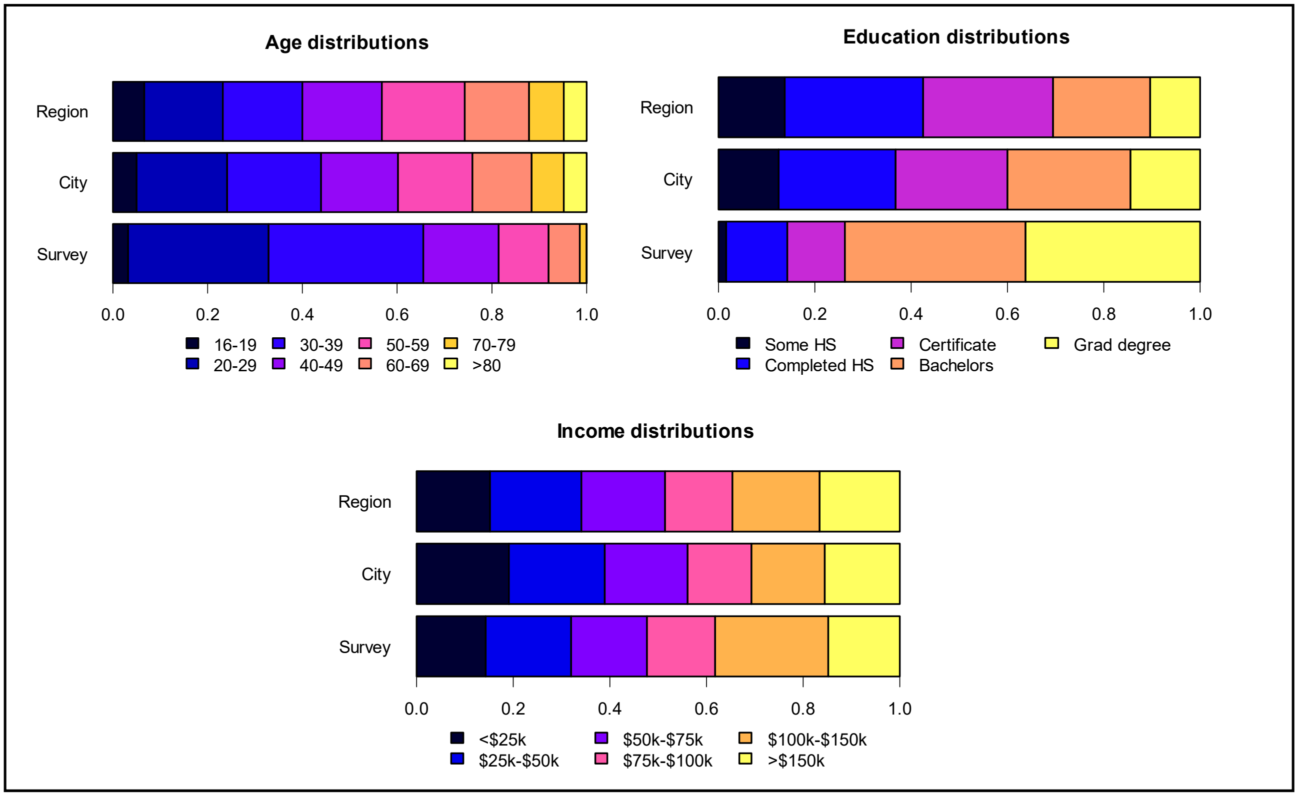

Figure 23. Sample socio-demographic statistics

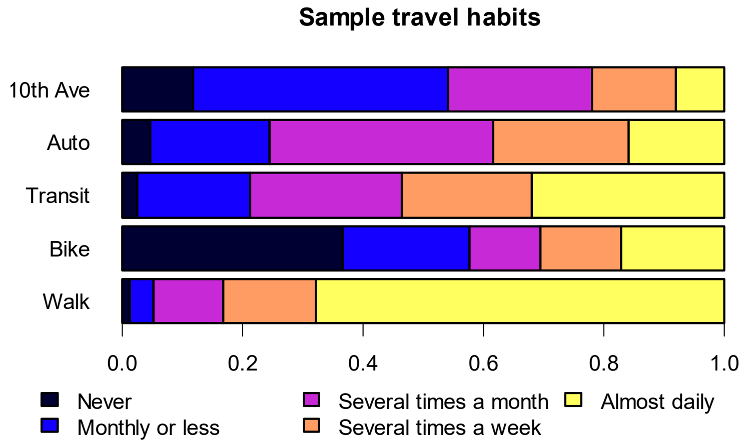

Figure 24. Sample travel statistics

All data analysis was performed in the statistical software package R [26]. Survey weights were created by raking [27], using the “survey” package in R [28]. Weights were created only for the Public sample, to match the age (9-level factor), gender (Female binary), education (5-level factor), and income (6-level factor) marginal distributions in census data for the City of Vancouver.[29] For raking, missing respondent socio-demographic data were maintained as a synthetic marginal category in the comparison population data [30]. Weights were trimmed (strictly) at lower and upper bounds of 0.3 and 3.0 times the median weight, respectively (0.14 and 1.36). This led to trimming of 102 (30%) of the weights and a final median weight of 0.997.

Appendix E: Video Rating Results

Summary rating results by video strata are given in Figure 25. The ratings for all nine strata show that with higher passing times there was more agreement of yielding, comfort, and low risk, and less agreement that the road user "should have yielded", as expected. Figure 26 illustrates how the two yielding questions relate to comfort assessment, again aggregated by strata. Low risk and Comfort were highly correlated.

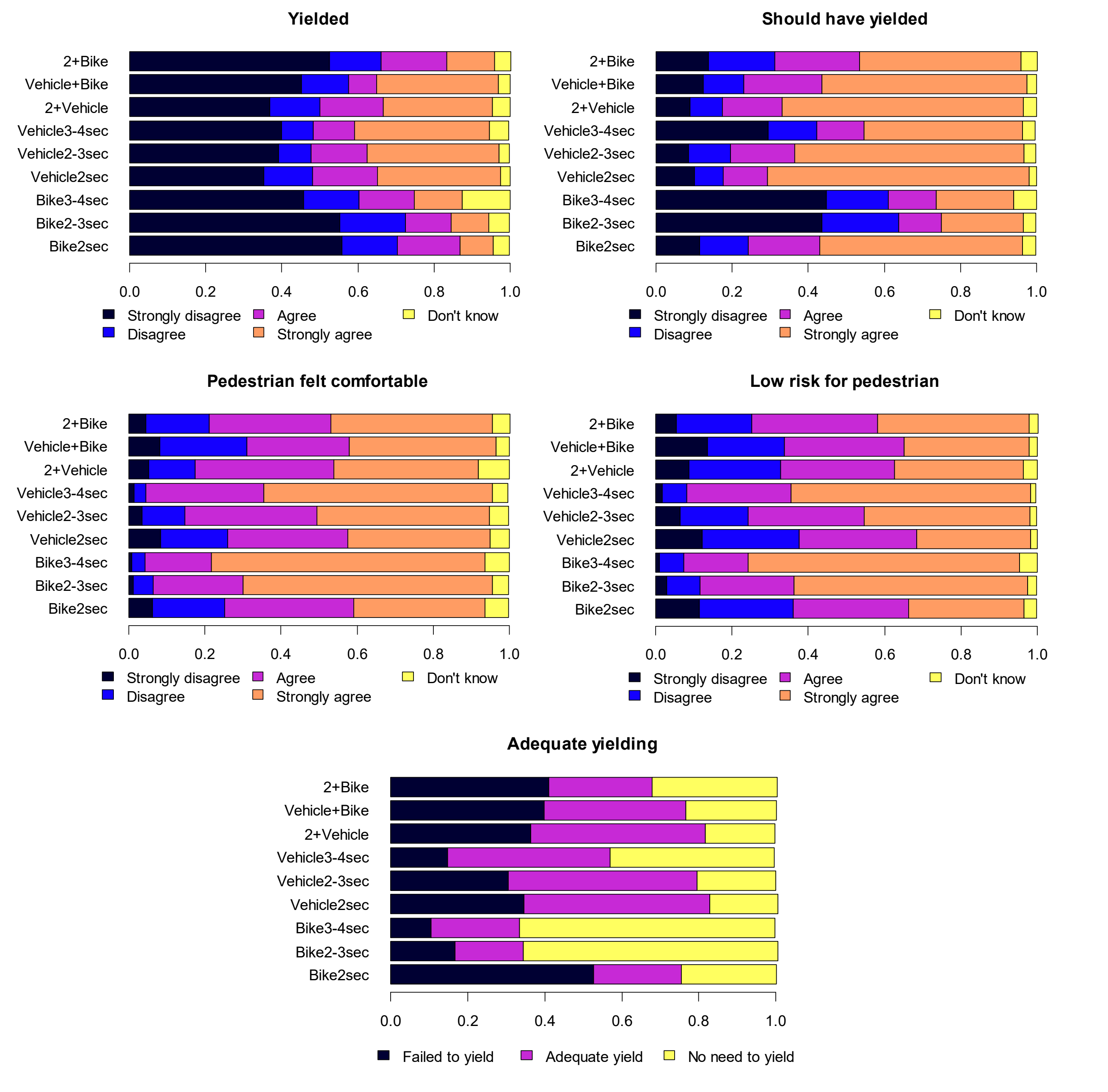

Figure 25. Summary of all video ratings by strata

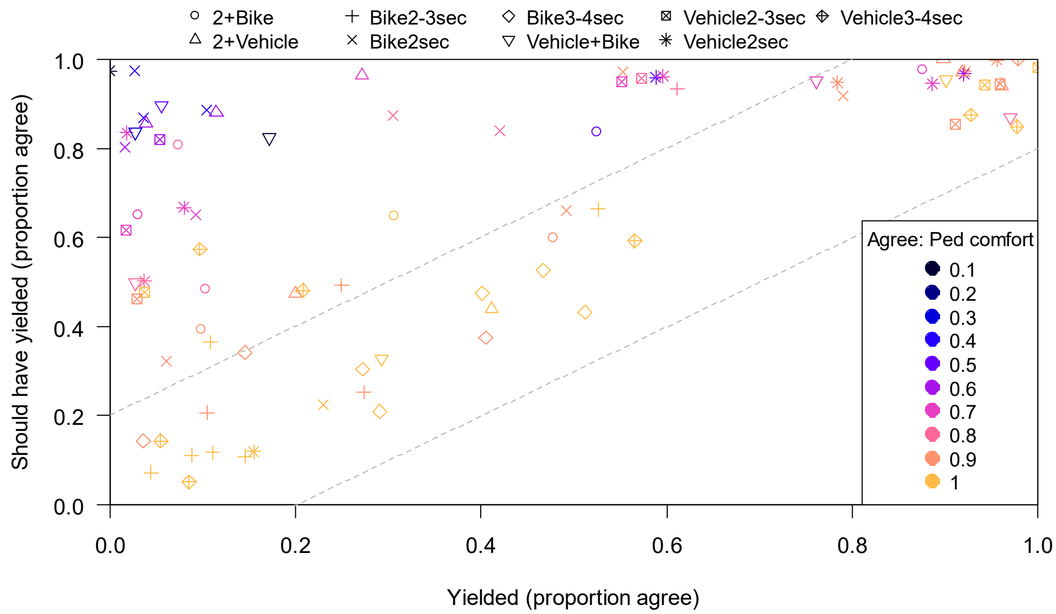

Figure 26. Relationship of yielding and comfort assessment

Appendix F: Comparisons among and between pools

Ratings distributions by respondent pool and strata are given in the following figures (Figure 27, Figure 28, Figure 29, Figure 30, and Figure 31). There is generally good agreement among the pools on the ratings. Interclass correlation coefficients (ICC) for *average ratings* are given in Table 8, all significant at p<0.01 (based on two-way effects) [31]. All the ICC are high, with typical good values of at least 0.60 and excellent values of at least 0.75. Yielding was most consistently rated, with comfort and risk less consistent across all pools.

Table 8. Interclass correlation coefficients for average ratings

Survey participants	Yielded	Should have yielded	Adequate yielding	Comfortable	Low risk
Experts	0.789	0.826	0.735	0.661	0.650
Committee	0.841	0.812	0.653	0.565	0.681
Public	0.978	0.978	0.970	0.940	0.955
All	0.981	0.981	0.974	0.949	0.961

Conversely, Interclass Correlation Coefficients (ICC) for *individual ratings* were lower, in the 'poor' range of 0.23 to 0.45, meaning substantial variability among respondents (even Experts). At least 85% of raters agreed or disagreed on 58% of videos for Yielded, 48% for Should have yielded, 52% for Comfortable, and 39% for Low Risk. Hence, the reliability of using individual ratings to represent population perspectives on the severity of interactions is low, but the combined ratings from the survey are reliable. This finding supports the approach taken in this research of gathering a range of perspectives on comfort and safety. In the future, we will continue to need pools of raters to assess severity (or infer from objective features).

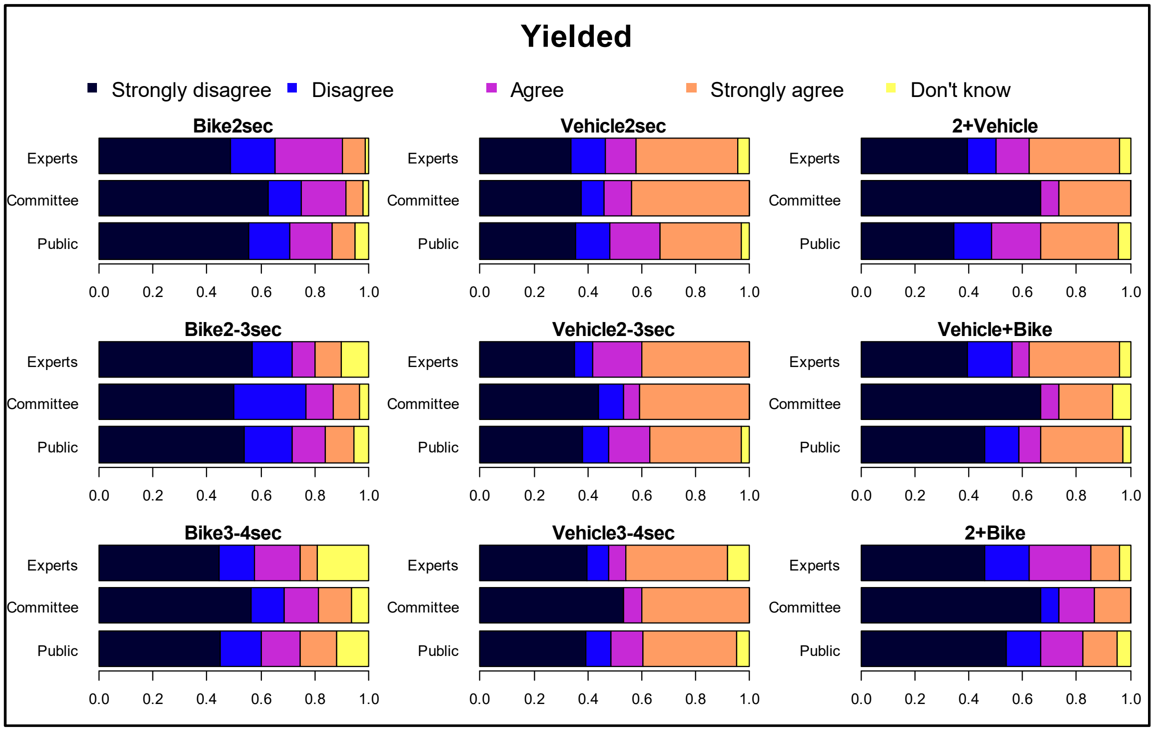

Figure 27. Ratings distributions by respondent pool and strata for yielding

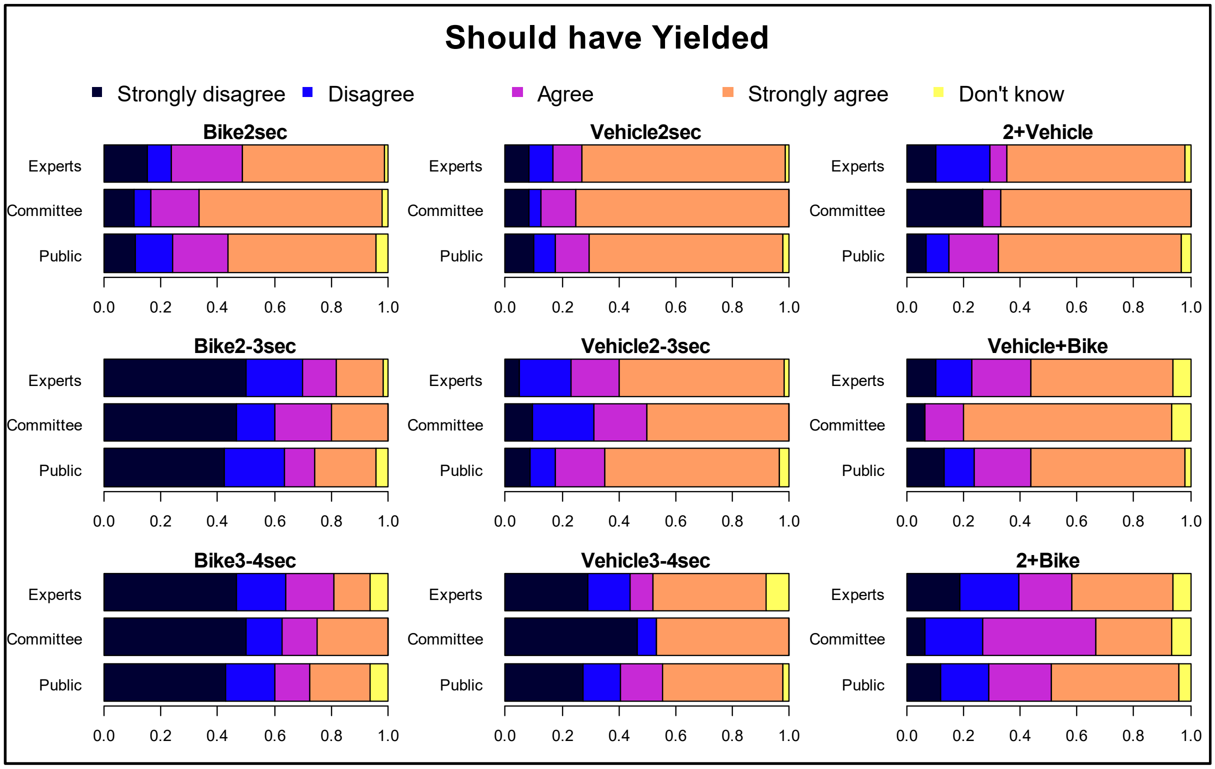

Figure 28. Ratings distributions by respondent pool and strata for should have yielded

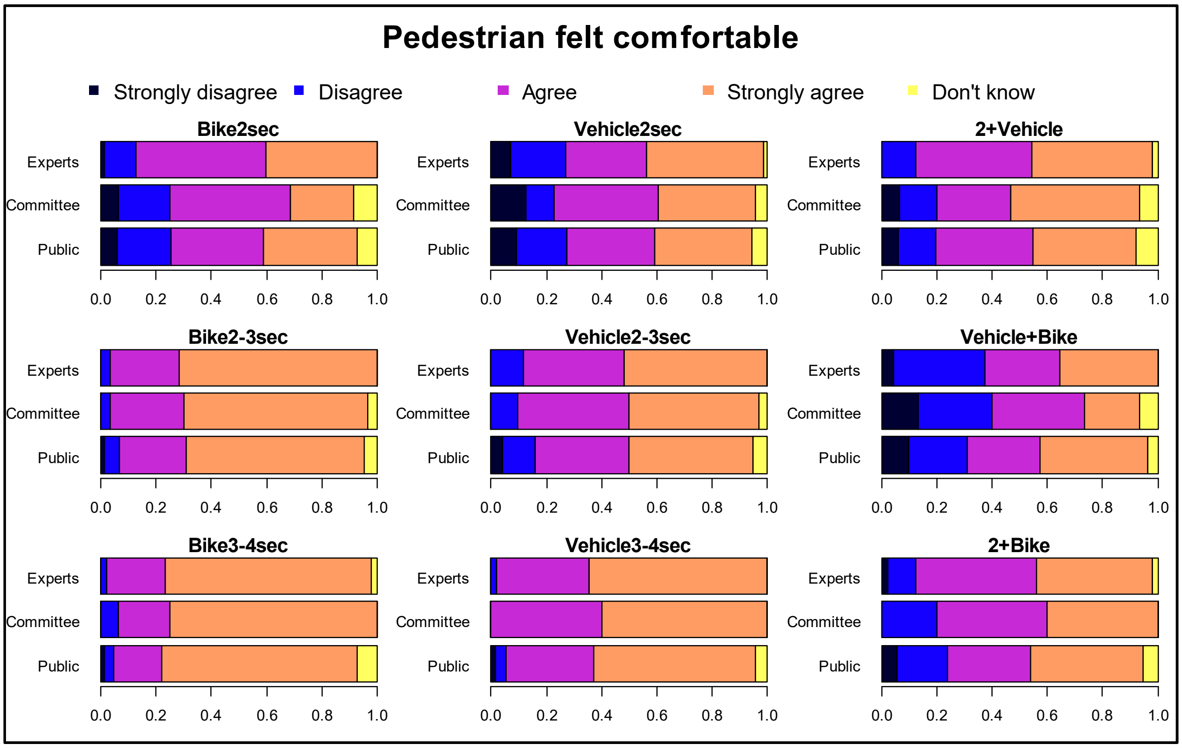

Figure 29. Ratings distributions by respondent pool and strata for comfortable

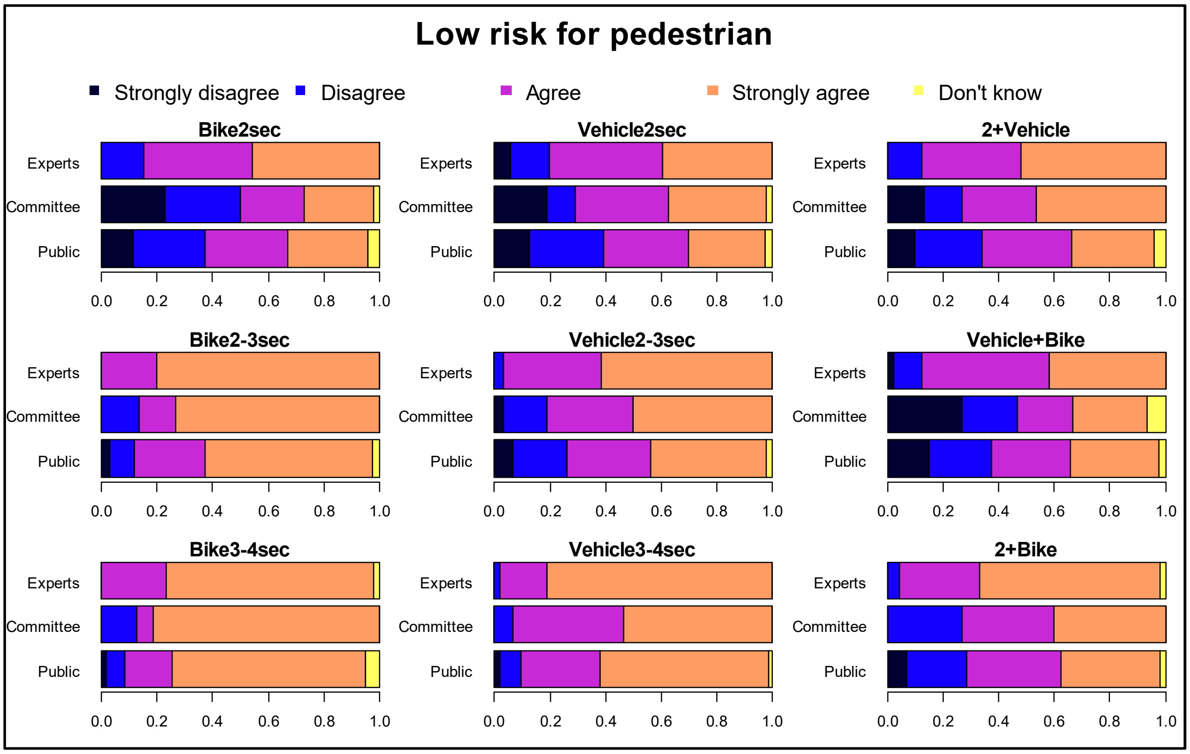

Figure 30. Ratings distributions by respondent pool and strata for low risk

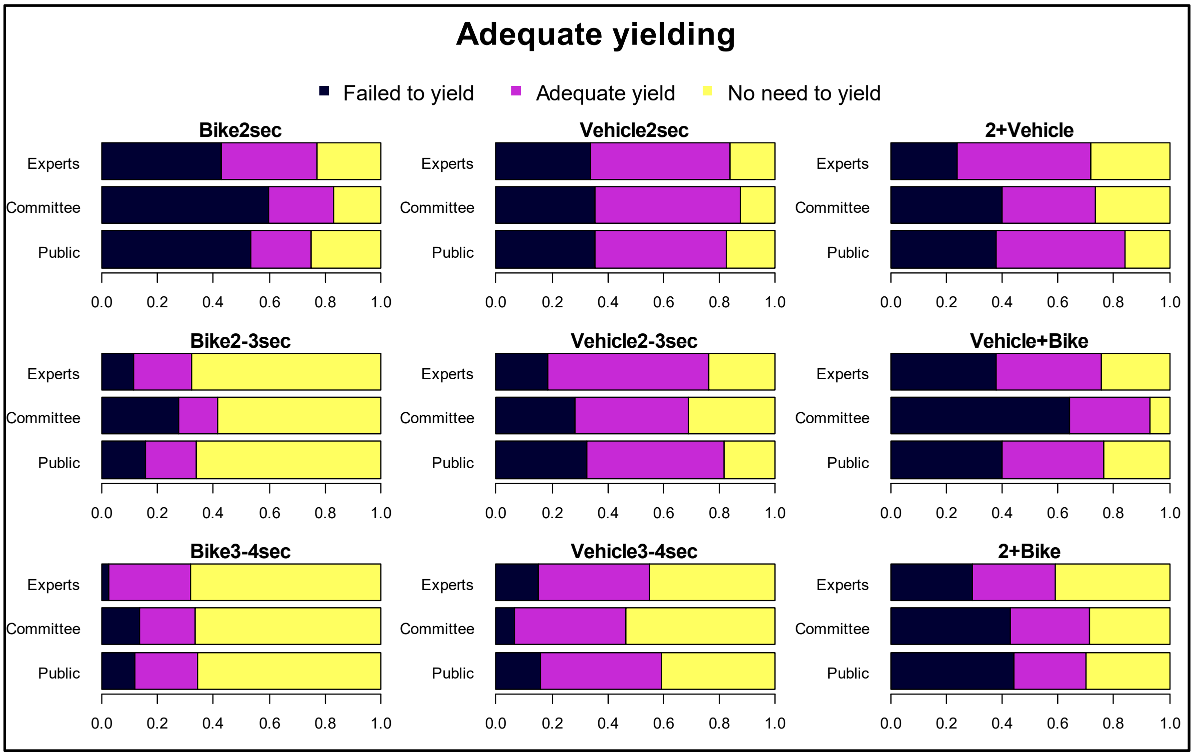

Figure 31. Ratings distributions by respondent pool and strata for adequate yielding

Response distributions among pools were compared for all 45 strata-outcome combinations (i.e., the preceding five figures) using Chi-squared tests with a 95% confidence threshold. Only nine of the 45 tests were significant at $p<0.05$, summarized in Table 9.

Table 9. Significant differences in video ratings among pools

Stratum	Outcome	Differences	
2+ Vehicle	Should have yielded	Public vs Committee	Committee members more strongly disagreed that motorists should have yielded than the Public (marginal difference)
Bike 2 sec	Comfortable	Expert vs both other pools	Experts more frequently agreed that the pedestrians were comfortable in these interactions than either of the other two pools
Bike 2 sec	Low risk	Expert vs both other pools	Experts consistently agreed that the interactions were low-risk more frequently and strongly than the other two pools
Bike 2-3 sec	Low risk	Expert vs Public	
Vehicle 2 sec	Low risk	Expert vs Public	
Vehicle 2-3 sec	Low risk	Expert vs Public	
2+ Vehicle	Low risk	Expert vs Public	
Vehicle+Bike	Low risk	Expert vs both other pools	
2+ Bike	Low risk	Expert vs Public	

Appendix G: Bi-directional traffic adjustment

The same validation sub-sample described above to validate the City coding was used to estimate the interaction frequency with bi-directional traffic. The validation sub-sample included 266 pedestrian crossings. The joint distribution of interactions by type in each direction is given in Table 10. Bi-directional interaction rates are remarkably symmetrical, with nearly equivalent marginal distributions of the interaction frequency with vehicles and bicycles in each direction. The joint distribution of the sample interactions at the TAHZ locations with vehicle traffic (i.e., not Arthritis Centre Entrance) was similarly examined. Based on Chi-squared tests at a threshold of $p<0.05$, 1) we fail to reject independence of the marginal distributions of interaction frequency with vehicles and bicycles in each direction in the validation sub-sample, 2) we fail to reject independence of the marginal distributions of interaction frequency with vehicles and bicycles in each direction between the sample and the validation sub-sample, and 3) we fail to reject independence of the joint distribution of interaction frequency with vehicles and bicycles in each direction in the sample, but 4) we successfully reject independence of the joint distribution in the validation sub-sample.

Table 10. Joint distribution of bi-direction interactions in validation sub-sample

		Other direction				
		No interactions	1+ Vehicle	1+ Bike	Vehicle + Bike	Total
Coded direction	No interactions	42.9%	9.8%	3.8%	1.1%	57.5%
	1+ Vehicle	10.5%	15.4%	3.4%	1.5%	30.8%
	1+ Bike	4.5%	3.0%	1.1%	0.0%	8.6%
	Vehicle + Bike	1.1%	0.8%	0.4%	0.8%	3.0%
	Total	59.0%	28.9%	8.6%	3.4%	100%

Overall, independence by direction is a reasonable and convenient assumption to account for bi-directional traffic. We can further reasonably assume equal marginal distributions for traffic in each direction, given the similarities in interaction types. Thus, for interaction analysis, we assume equal marginal distributions of interaction types with traffic in each direction and independent joint distributions. To relax the independence assumption in future analysis, iterative proportional fitting could be used to match the (assumed equal) marginal distributions from an assumed joint distribution table (derived from validation data).

Appendix H: Location-specific on-site interview results

Location-specific safety concerns described during the on-site interviews are summarized in the following figures.

Figure 32. Lack of notice for eastbound pedestrians and cyclists of leading protected left phase for the east approach

Figure 33. Difficult for paramedics driving ambulances turning right into the Emergency entrance to see cyclists headed eastbound in protected bike lane

Figure 34. Design complexity pedestrians in front of the Mary Pack Arthritis Centre and the Spinal Cord Centre; varying paving materials can be a challenge, especially for people with disabilities and guide dogs

Figure 35. Access to VCH Cycling Centre is awkward for westbound cyclists; Cycling Centre door also opens directly into the pedestrian space (access has since been modified by VCH Cycling Centre)

Figure 36. Design complexity for pedestrians in front of the Eye Care Centre; end of cycling facility through parking lot driveway into the road right-of-way is also a significant conflict point