Making Active Transportation more Accessible on the Dalhousie Studley Campus

A Traffic Demand Analysis of LeMarchant Street and University Avenue

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EXEUCTIVE SUMMARY

This research examines the current use of the University Avenue and LeMarchant Street intersection on the Dalhousie University Studley Campus. The current use by transportation type was determined through physical counts of pedestrians, cars, and cyclists at three different time intervals throughout Monday-Friday from 7-9 am, 11am-1pm, and 4-6 pm. Pedestrians were found to be the most common form of transportation in the intersection during all time slots and days using Single-Factor ANOVA by a highly significant amount (Table 3). The highest demand of traffic in the intersections was found to be during the middle time slot from 11am-1pm. Since this intersection is right in the center of the Studley campus and is a hotspot for pedestrian activity, it poses a safety risk to have the intersection available for use by all forms of transportation. We recommend that the Halifax Regional Municipality close LeMarchant Street from Coburg Road to South Street to vehicular traffic (excluding buses and bicycles) during the work week of Monday-Friday from 8am-5pm. With such high concentration of pedestrian activity, it increases the idle time of vehicles in the intersection, stops the flow of traffic, increases the potential for collisions, and discourages people from using active forms of transportation to an even greater extent due to the safety risks. We also recommend that there be better signage and marking in the intersection, primarily a marked pedestrian crosswalk with signals for pedestrians to cross and to alert drivers that there are pedestrians crossing.

BACKGROUND & RATIONALE

Universities are often some of the largest generators of traffic with high numbers of commuters to and from campuses (Kaplan, 2013). Furthermore, transportation is often one of the top three contributors to a university's ecological footprint along with air travel and energy (Bonham & Koth, 2009). The high traffic generation of universities is especially relevant in cities like Halifax with an extremely high student population as a result of the eight post-secondary institutions within the regional boundaries ("Studying in Halifax", 2015). Transport Canada explains sustainable transportation in "that the transportation system, and transportation activity in general, must be sustainable on three counts — economic, environmental and social. Practically, this means ensuring that decisions are no longer made with the environment as an afterthought" (Gilbert & Cormier, 2005). Transitioning to more sustainable forms of transportation is crucial to reduce Dalhousie University's ecological footprint. The special Intergovernmental Panel on Climate Change (IPCC) report on 1.5 degrees celsius of global average temperature warming states that the entire globe must reach zero carbon emissions by 2050, and reduce them 45% by 2030 to avoid the worst impacts of climate change and that rapid structural changes are necessary to ensure a safe climate (Allen et at., 2018). Universities have an important role in reducing emissions to meet the necessary levels to mitigate climate change.

Universities are often adopters of new infrastructure and progressive urban planning and can be leaders for the surrounding community in promoting environmentally sustainable behaviours (RB Duque, 2014).They can act as a laboratory for testing new ideas to encourage the use of active modes of transportation that could be adopted by the larger community (Dehghanmongabadi & Hoskara, 2018). However, university policies on transportation and carbon emissions usually ignore the commuters which are non-professional staff that often do not live close enough to campus for car-free transportation to be accessible (RB Duque, 2014). They also have to consider the sociological and cultural influences on people's decision of what forms of transportation they choose and where the different intervention points for changing transportation behaviour might be (RB Duque, 2014). For example, to foster cycling culture there has to be thorough consideration to the needs for showering and changing as well as bike storage, and services to make cycling more accessible should be offered for free in an attempt to change foster active transportation behaviour (Bonham & Koth, 2009).

Inclement or cold weather is often the most significant factor as to why students will not walk or use other forms of active transportations as well as misconceptions that car-free transportation takes longer (Kaplan, 2013). The main discouraging factor, however, is infrastructure that make those forms of transportation more challenging (Kaplan, 2013). For instance, there is often a lack of good bikeways and streets that may be too busy for cycling which creates safety concerns that discourage people from cycling (Kaplan, 2013). Cyclists' rights to safe travel environments are often ignored in urban design and planning (Bonham & Koth, 2009). Walking and cycling are the best modes of transportation to substitute for private car trips because they preserve independent choice of route and schedules (Dehghanmongabadi & Hoskara, 2018).

This research will be examines the transportation needs of Dalhousie students, staff, and faculty near the intersection of University Avenue and Lemarchant Street on the Dalhousie Studley campus in Halifax, Nova Scotia, Canada. Dalhousie has annual commuter surveys, and in 2017 half of all respondents to the survey owned a vehicle (McCarthy & Habib, 2018). About half of all respondents had access to bicycles (McCarthy & Habib, 2018). Most importantly, the primary commute method to campus of all staff, faculty, and students was walking (40.4%) and public transportation being the second most used (McCarthy & Habib, 2018). Examination of transportation demand is very commonly done through traffic counts which calculate the transportation use by type (Bonham & Koth, 2009) as well as self-reported commuter surveys like those done by Dalhousie University (McCarthy & Habib, 2018). This study examines how Dalhousie University and Halifax Regional Municipality can address the transportation needs or faculty, staff, and students by increasing accessibility to active transportation methods.

RESEARCH METHODS

We collected data using a quantitative approach. Researchers conducted counts of automobiles, pedestrians, and cyclists, as well as incidents of 'near accidents'. These counts were done during the intervals of 7am-9am, 11am-1pm, and 4pm-6pm. Six different counts were conducted in each time interval, three facing north and three facing south, for a total of sixteen separate counts of each transportation category during the working week of Monday-Friday. Due to the nature of our research question and the requests of the Office of Sustainability, we decided to forego any qualitative data, such as a survey, in order to collect as much hard data as possible. We believe a focus on quantitative data (i.e. counts of motorists, cyclists, and pedestrians), provides a better understanding of the traffic demand at the intersection of LeMarchant and University than a survey gauging the perspectives of the Dalhousie community of the issue could provide. A count is the appropriate method of data collection for our purposes because it allows us to determine who is using the intersection (motorists, cyclists, pedestrians) and how that usage changes over the course of the day. It also allows us to determine if there are any times of particularly high traffic at the intersection.

Researchers were positioned at a vantage point on the southeast corner of the second floor of the McCain building. From here, researchers looked north the first week (towards Coburg Rd.) and south the second week (towards South St.), and recorded the number of cyclists, motorists, and pedestrians they observed using counter applications or a manual counter provided by the Office of Sustainability. Near accidents were also recorded, which can be defined as instances in which a vehicle failed to come to a complete stop within a safe distance of a pedestrian or another vehicle. Factors which could potentially influence the quantity or makeup of traffic at the intersection were also noted, such as severe weather conditions. No personal or descriptive information was recorded, solely the type and quantity of transportation utilized by commuters at the intersection of LeMarchant and University.

Single factor ANOVA was used to determine the presence of significant variation within the datasets, and two-paired t-tests to further disambiguate between the sources of said variance when present.

The survey data has limitations. First of all, because there was only one team member counting traffic at a time, it was difficult to accurately count all forms of transportation users in the intersection, especially during peak times. Due to sheer volume of traffic during some parts of the day, particularly the 11am-1pm time slot, some pedestrians could have been missed or potentially double-counted. Furthermore, the data provides a small snapshot of the intersection over a 2-week period and it is not unreasonable to assume that the volume would fluctuate between seasons or that the period observed is not entirely indicative of the average conditions at the intersection. Weather conditions could have affected the pattern of data as well. For example, in snow or rain, some people's travel patterns will change, and the number of pedestrians could be affected.

RESULTS

Counts were conducted for the University/LeMarchant intersection over a span of thirty-six hours total which was comprised of three, two-hour slots for both north and south during each of three time slots. This produced a sample size of eighteen total counting sessions with six for each time slot and three for each direction within that. This counting period produced a data set where pedestrian totals per time slot were approximately three-times larger than the automobile and bike counts at minimum, extending up to seven-times at most (Figure 1). The 11am-1pm time slot displayed the most traffic for all factors by a wide margin, with the evening and morning following in that order though with a much smaller margin (Figure 1). Incidents of unsafe conduct were also recorded, with no occurrences found in the morning time slot across the sampling period and the evening being marginally more consistent than the afternoon, producing three more accidents on average every six-hours (Figure 2).

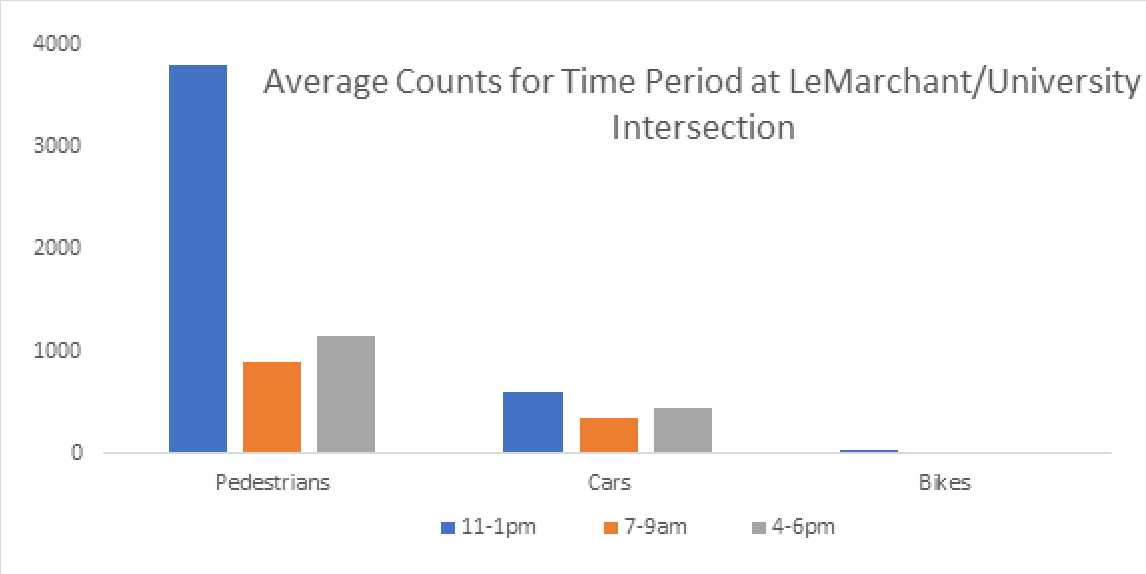

Figure 1: Averaged counts for time slot sample (n=6) for factors pedestrian, automobiles, and bikes at the LeMarchant/University intersection on Dalhousie's Studley campus. Sampling period was 2 hours, and bike values were 32/9/17 respectively.

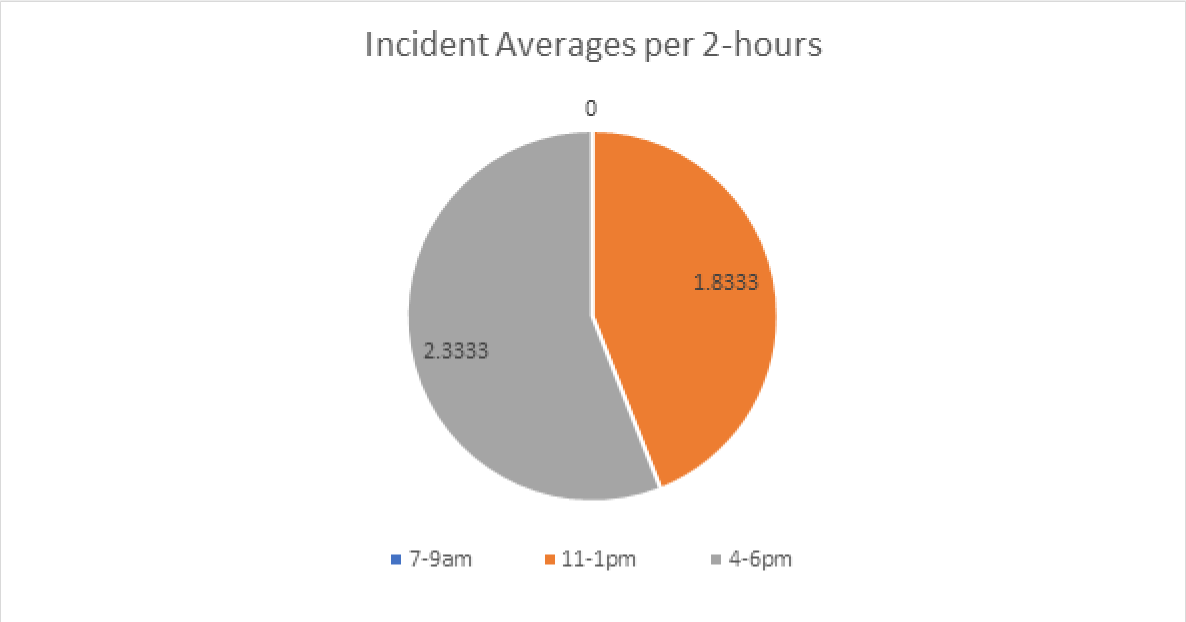

Figure 2: Average occurrence of incidents per 2-hour sampling period between automobiles/humans at the LeMarchant/University intersection on Dalhousie's Studley campus.

The count data was compared by category and by direction using a two-sample T-test assuming unequal variances to verify that the differences between counts taken facing north and counts taken facing south were not significantly different. Pedestrians, automobiles, and bikes may overlap from the north perspective into the south perspective during their daily route, however this cannot be assumed. The difference between category counts when compared by perspective was found to be insignificant, where significance is considered as

P(T<=t) two-tail < 0.05 (Table 1), meaning counts can be considered as a population independent of the collection perspective.

Table 1: P(T<=t) two-tail values for the comparison of North versus South counts for factors Pedestrians, Car, Bikes as counted during different time-frames where sample size was equal to six, where insignificant is defined as P < 0.05.

	7-9am	11-1pm	4-6pm
Pedestrians	0.1604	0.1780	0.0565
Automobiles	0.4759	0.3091	0.9525
Bikes	0.3421	0.8804	0.8857

Counts of pedestrians, cars, and bikes were amalgamated into individual populations to test for variance among morning, afternoon, and evening time frames using Single-Factor Analysis of Variance (ANOVA) against the null hypothesis (H_O): there is no change in traffic counts at the LeMarchant/University intersection as the time period changes. Factors were considered significant when the F-value was larger than the F-crit, where any significance indicates further testing needs to be done to determine the source. Significant differences were found when comparing the timeframes for all of pedestrians, automobiles, and bikes, meaning that the H_O should be rejected (Table 2).

Table 2: Single Factor ANOVA results for the comparison of timeframes (7-9am, 11-1pm, 4-6pm) for pedestrian, automobile, and bike factors. H_O was rejected when the F-value > F-crit value indicating any difference in the population is significant.

	F-value	F-crit	H_O
Pedestrians	264.71	3.6823	Reject
Automobiles	82.347	3.6823	Reject
Bikes	20.474	3.6823	Reject

Single-Factor ANOVA indicated that significant variance was found within the population for each factor, but it did not show where the source of variance is within the counts. The source can be determined by using a two-sample T-test assuming unequal variances to test between pairs of the individual timeframes from each population, where a value for P(T<=t) two-tail < 0.05 is considered significant. The differences found between the counts in across timeframes was found to be significant in every instance aside from the 7-9am/4-6pm comparison for pedestrians and bikes, or that 2/9 tests returned results of no significant difference (Table 3).

Table 3 P(T<=t) two-tail values for the comparison of timeframes for factors Pedestrians, Automobiles, Bikes as counted during different time frames where sample size was equal to six. Bolded values indicate insignificant differences between timeframes, where insignificant is defined as P < 0.05.

	Pedestrians	Automobiles	Bikes
7-9am/11-1pm	1.0393E-08	1.1049E-08	9.9106E-05
11-1pm/4-6pm	2.0402E-06	6.9234E-05	0.0024
7-9am/4-6pm	**0.2992**	0.0067	**0.0822**

The occurrence of incidents between automobiles along with pedestrians and automobiles were also tracked during the data collection process as a factor to associate with overall traffic density. The analysis of this data followed the same process as above excluding the test of directionality of the values due to the much lower frequency of occurrence associated with these values (no value greater than four for any time period). The data across timeframes was tested for significant differences using Single-Factor ANOVA, and when significant variance was found (F-value: 10.0667 > F-Crit: 3.8853) the individual periods were tested using a two-sample t-test assuming unequal variance. The comparison of the 7am-9am and 4pm-6pm incident counts displayed a significant difference between values where P(T<=t) two-tail = 0.0086, and P(T<=t) two-tail < 0.05 is considered significant.

DISCUSSION

The comparison of north/south directionality produced insignificant results across all factors and timeframes (Table 1) which is likely a reasonable result, as portion of the people would be leaving one viewpoint to enter the other while moving around campus. Exclusive access to both bus routes and amenities while present from both perspectives are not so different in both function and distribution it would create an expectation for varied values. The northern end contains a higher density of housing which would create rationale for increased traffic to and from this direction depending on the time of day, but an absence of variance here is a likely indicator for a large amount of movement overlap between north and south counting perspectives.

The results from the ANOVA were to be expected as the on-campus traffic increased significantly during the 11am-1pm time period, with pedestrians and bikes close to tripling during that time frame, and automobiles rising by around 15%. These counts are in line with expectations as 11am-1pm covers multiple class changes in the early afternoon where the greater portion of the student body would be present, as opposed to earlier and later time slots when classes are not as active. Automobile use being highest in the afternoon was the least expected result as it could be assumed that the majority of the student body would already be on campus and would be aware of the increased pedestrian traffic, though this doesn't account for automobile presence which may not be related to the University.

The 11am-1pm time slot was the period which contained values that stood out at a base level compared to the others so it was expected that contrasting the remaining counts would produce results which were not significant, though this was only the case for the pedestrian and bike counts (Table 3). The significant difference found between morning and evening automobile counts is likely due to the 8:30am start time of classes causing the larger half of the morning period to be less likely to contain traffic compared to the evening period. The higher counts taken in the evening could also be attributed to the start of evening classes at 5:35pm coupled with those leaving for the day, which presents two causes for traffic as opposed to the one in the morning.

There were no incidents of danger to pedestrians and automobiles which occurred during the morning slot, which may be a product of a small sample size (n=6, 12 hours) but could also be due to a lower density of students arriving when vehicle traffic would be present on campus. This resulted in a significant difference when comparing the morning period to both the afternoon and the evening period, which averaged 1.8333 and 2.3334 incidents respectively per counting slot. The difference between the afternoon and evening period was found to be insignificant ($P = 0.5349$, $P > 0.05$), with the increase in the evening likely due to drivers being more tired at the end of the day compared to the afternoon, though whether this would have a greater effect than the increased pedestrians over a longer sampling period cannot be determined.

The overwhelming majority of transportation users in the was active commuter traffic compared to vehicular traffic observed at the intersection. In light of concerns for pedestrian safety, environmental impact, and active transport accessibility, we are recommending the Halifax Regional Municipality convert LeMarchant street to be use by buses, pedestrians and cyclists only between the hours of 8am and 5pm Monday to Friday. Removing motorists from the street during peak pedestrian hours would reduce the risk of accidents, reduce idling, and facilitate the use of active transportation on campus.

The benefits of pedestrian streets have been studied for years, and they've been instituted all over the world (Gehl, 1989). Many universities across Canada have already converted or taken steps to convert main thoroughfares on campus to vehicle-free streets, Ryerson University, the University of Manitoba, and McGill University to name a few (Johnson, 2014; Scott *et al.,* n.d.).

A total of 21 near collisions were recorded across 9 time slots, that represents over one near accident every hour. Diverting traffic from the intersection would reduce any potential for vehicular-pedestrian accidents, increasing both public safety and accessibility. The researchers all noted that the majority of motorists were required to come to a stop and wait for a number of pedestrians to cross the street before continuing through the intersection. The harmful effects of vehicle traffic, particularly idling, on both human and environmental health have been thoroughly reported, our proposal would go a long way towards reducing these impacts (Jou & Chen, 2011; Rakowska, 2014). Banning vehicles from LeMarchant avenue during the peak weekday hours would allow for greater cyclist accessibility. The street represents a major artery of Dalhousie campus and connects Coburg Rd. with South St. The city has already planned to increase the connectivity of bike-lanes around Halifax, we believe this proposal would support that goal.

However, closing the street to motorists would eliminate roughy 30 paid-parking meters along LeMarchant and in front of the Killam Library. This is a small number of parking spots that so we believe that the impact of losing them would be outweighed by the benefits of a pedestrian-only street. The loss of those parking meters may even increase the sale of campus parking passes due to the removal of central parking spaces. Also, we believe it would be necessary to continue to allow Metro Transit, and potentially other commercial vehicles, to access LeMarchant between South St. and University Ave. This would allow transit routes to continue without redesign and for vendors in the Student Union Building to continue to receive shipments. In addition, there is an issue concerning the parking garage underneath the Marion McCain building. The exit to the parkade is located on LeMarchant St. and in order to move forward with our proposal the parking garage would need to be redesigned so that vehicles entering and existing can do so on Seymour St.

CONCLUSION

Based on the data and analysis collected it is evident that from 8 am to 5pm on weekdays is the busiest time on Studley Campus and that the traffic flow is primarily dominated by pedestrians. During this period, forbidding vehicles from entering the Studley campus through the LeMarchant/University intersection, and from traversing the campus by LeMarchant, it would make the intersection much safer for pedestrian.

Our recommendation is to close LeMarchant Street to North-South vehicular traffic between Coburg Road and South Street from 8am-5pm on weekdays. This change would reduce the traffic pressure in the centre of campus and improve the accessibility of active transportation within the school. Most importantly, this will also improve the safety of pedestrian traffic on campus and reduce the likelihood of potential collisions. Implementing a car ban on this major intersection would also encourage active transportation and reduce carbon emissions from motor vehicles from commuters to Dalhousie campus. Vehicles will not waste time waiting and idling while pedestrians cross at the intersection. This proposal would be a major step in reducing the carbon footprint of Dalhousie University.

In order to reduce the counting inaccuracies, future research could collect more data for a longer period of time and throughout different seasons. The volume of formal raw data should be several times larger than the current data to have the most accurate representation of the traffic demand in this intersection. A potential sampling frame could be recording the entire day's traffic flow for one week in each month of the year at this intersection, however that would require a large number of sampling hours.

Further data collection could facilitate the assessment of a pilot project implementing the vehicular ban on LeMarchant St. to vehicular traffic. It could determine whether a car-free street is the solution to providing the most accessible and safe intersection for active transportation users, or if other solutions might need to be considered as well. In addition, further planning will include designing a route to ensure that vehicles enter the school without LeMarchant Street. In order to design a reasonable route without increasing the traffic pressure at other intersections, this may require the collection of traffic flow data at other intersections nearby.

REFERENCES

Allen et al. (2018). Special report: global warming of 1.5°C, summary for policy makers. *Intergovernmental Panel on Climate Change*. Retrieved from https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/

Bonham, J. & Koth, B. (2010). Universities and cycling culture. *Transportation Research*, 15, 94-102.

Cormier, A. & Gilbert, R. (2005). Defining sustainable transportation; prepared for Transport Canada. *The Centre for Sustainable Transportation*. Retrieved from

https://www.wellingtonpark.org.au/assets/wellingtonpark_CSTdefiningsustainabletransportation2005.pdf

Dehghanmongabadi, A. & Hoskara, S. (2018). Challenges of promoting sustainable mobility on university campuses: the case of Eastern Mediterranean University. *Sustainability*, *10*, 4842-4861.

Duque, RB., Gray, D., Harrison, M., & Davey, E. (2014). Invisible commuters: assessing a university's eco-friendly transportation policies and commuting behaviours. *Journal of Transport Geography 38*, 122-136.

Gehl, J. (1989). A Changing Street Life in a Changing Society. *Places*, *6*(1), 9-17.

Johnson, T. (2014, August 6). Transforming the campus with car-free pedestrian zones. Retrieved from https://www.universityaffairs.ca/features/feature-article/unpaving-paradise/

Jou, R., Wu, Y., & Chen, K. (2011). Analysis of the environmental benefits of a motorcycle idling stop policy at urban intersections. *Transportation*, *38*(6), 1017-1033. doi:10.1007/s11116-010-9318-5

Kaplan, DH. (2013). Transportation sustainability on a university campus. *International Journal of Sustainability in Higher Education, 16(2),* 173-186.

McCarthy, S. & Habib, MA (2018). Dalhousie University commuter survey 2017 (fall).*DalTRAC; Dalhousie Transportation Collaboratory prepared for the Office of Sustainability*. Retrieved from https://cdn.dal.ca/content/dam/dalhousie/pdf/dept/sustainability/Transportation/CommuterSurveyReport_2017Fall_UpdatedJan10.pdf

Rakowska, A., Wong, K. C., Townsend, T., Chan, K. L., Westerdahl, D., Ng, S., … Ning, Z. (2014). Impact of traffic volume and composition on the air quality and pedestrian exposure in urban street canyon. *Atmospheric Environment*, *98*, 260-270. doi:10.1016/j.atmosenv.2014.08.073

Scott, A., Nwadike, N., Seibel, L., Dosch, G., & Uchendu, N. (n.d.). *Creating a car free campus*. Retrieved from https://umanitoba.ca/campus/sustainability/media/Creating_a_Car_Free_Campus.pdf

"Studying in Halifax" (2015). *Halifax Partnership*. Retrieved from http://www.halifaxpartnership.com/en/home/Live/studying-in-halifax.aspx

"Transportation Standing Committee" (2019). *Halifax Regional Municipality*. Retrieved from https://www.halifax.ca/city-hall/standing-committees/transportation-standing-committee

APPENDIX

Table 1: Raw counts for the sampling of traffic and pedestrian use of the LeMarchant/University intersection on Dalhousie's Studley campus as part of group research for ENVS3502: Problem Solving II The Campus as a Living Laboratory.

Date	Timeslot	Pedestrian	Car	Bike	Vehicle/Pedestrian Incidents	Observer	Direction Facing
Monday, March 11th	7-9 am	603	354	2	0	Lily	North
Tuesday, March 12th	7-9 am	719	348	9	0	Lily	North
Thursday, March 14th	7-9 am	733	337	10	0	Lily	North
Monday, March 18th	7-9 am	1392	389	13	0	Lily	South
Wednesday, March 20th	7-9 am	1238	371	17	0	Lily	South
Tuesday, March 12	11am-1pm	3856	628	38	4	Jacob	North
Wednesday, March 13	11am-1pm	3624	578	23	2	Jacob	North
Tuesday, March 19	11am-1pm	3769	564	27	2	Jacob	South

Wednesday, March 20	11am-1pm	4236	580	32	1	Jacob	South
Thursday, March 21	7-9am	741	328	5	0	Jacob	South
Wednesday, March 13	4pm-6pm	1036	499	27	3	Anna	North
Thursday, March 14	11am-1pm	3466	625	36	2	Anna	North
Wednesday, March 20	4pm-6pm	1188	479	24	2	Anna	South
Thursday, March 21	11am-1pm	3842	612	41	0	Anna	South
Monday, March 11th	4pm-6pm	1113	421	11	3	Conner	North
Friday, March 15th	4pm-6pm	1089	386	13	4	Conner	North
Friday, March 22nd	4pm-6pm	1148	391	10	2	Conner	South
Monday, March 25th	4pm-6pm	1156	428	14	3	Conner	South

Table 2: Averaged count values independent of directionality for the traffic and pedestrian use of the LeMarchant/University intersection on Dalhousie's Studley campus as part of group research for ENVS3502: Problem Solving II The Campus as a Living Laboratory.

Averages for Timeslots			
	Pedestrians	Cars	Bikes
11-1pm	3799	598	32
7-9am	904	355	9
4-6pm	1143	434	17

Table 3: Results for Two-sample T-test assuming unequal variances testing North vs South values for the traffic and pedestrian use of the LeMarchant/University intersection on Dalhousie's Studley campus as part of group research for ENVS3502: Problem Solving II The Campus as a Living Laboratory. Morning (7-9am), Afternoon (11-1pm), Evening (4-6pm).

T-test Morning Pedestrians		
	Variable 1	*Variable 2*
Mean	685	1123.667
Variance	5092	115754.3
Observations	3	3
Hypothesized Mean Difference	0	
df	2	
t Stat	-2.185639461	
P(T<=t) one-tail	0.080212842	
t Critical one-tail	2.91998558	
P(T<=t) two-tail	0.160425684	
t Critical two-tail	4.30265273	

T-test Afternoon Pedestrians		
	Variable 1	*Variable 2*
Mean	3648.666667	3949
Variance	38481.33333	63109
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	-1.632066953	
P(T<=t) one-tail	0.089000813	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.178001627	
t Critical two-tail	2.776445105	

T-test Evening Pedestrians		
	Variable 1	*Variable 2*
Mean	1120	1165
Variance	337	523
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	-2.657809904	
P(T<=t) one-tail	0.028259641	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.056519282	
t Critical two-tail	2.776445105	

T-test Morning Automobiles		
	Variable 1	*Variable 2*
Mean	346.3333333	362.6667
Variance	74.33333333	982.3333
Observations	3	3
Hypothesized Mean Difference	0	
df	2	
t Stat	-0.870294921	
P(T<=t) one-tail	0.237949179	
t Critical one-tail	2.91998558	
P(T<=t) two-tail	0.475898359	
t Critical two-tail	4.30265273	

T-test Afternoon Automobiles		
	Variable 1	*Variable 2*
Mean	610.3333333	585.3333
Variance	786.3333333	597.3333
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	1.164085546	
P(T<=t) one-tail	0.154544264	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.309088528	
t Critical two-tail	2.776445105	

T-test Evening Automobiles		
	Variable 1	*Variable 2*
Mean	435.3333333	432.6667
Variance	3346.333333	1952.333
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	0.063452109	
P(T<=t) one-tail	0.476225397	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.952450793	
t Critical two-tail	2.776445105	

T-test Morning Bikes		
	Variable 1	*Variable 2*
Mean	7	11.66667
Variance	19	37.33333
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	-1.076923077	
P(T<=t) one-tail	0.171066063	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.342132126	
t Critical two-tail	2.776445105	

T-test Afternoon Bikes		
	Variable 1	*Variable 2*
Mean	32.33333333	33.33333
Variance	66.33333333	50.33333
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	-0.160356745	
P(T<=t) one-tail	0.440186206	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.880372412	
t Critical two-tail	2.776445105	

T-test Evening Bike		
	Variable 1	*Variable 2*
Mean	17	16
Variance	76	52
Observations	3	3
Hypothesized Mean Difference	0	
df	4	
t Stat	0.153093109	
P(T<=t) one-tail	0.442868692	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.885737384	
t Critical two-tail	2.776445105	

Table 4: Single-Factor Analysis of Variance between factors to test for variance across the sampled time slots. Count data was taken to assess the traffic and pedestrian use of the LeMarchant/University intersection on Dalhousie's Studley campus as part of group research for ENVS3502: Problem Solving II The Campus as a Living Laboratory.

Pedestrians		
7-9am	11-1pm	4-6pm
603	3856	1036
719	3624	1113
733	3466	1089
1392	3769	1188
1238	4236	1148
741	3842	1156

ASF Pedestrians
SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
7-9am	6	5426	904.3333	106067.1
11-1pm	6	22793	3798.833	67696.17
4-6pm	6	6730	1121.667	2950.667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	31185170.78	2	15592585	264.709	2E-12	3.68232
Within Groups	883569.5	15	58904.63			
Total	32068740.28	17				

F > Fcrit indicating that the mean of all factors are not equal and we reject the Ho

Cars		
7-9am	11-1pm	4-6pm
354	628	499
348	578	421
337	625	386
389	564	479
371	580	391
328	612	428

ASF Cars
SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
7-9am	6	2127	354.5	502.7
11-1pm	6	3587	597.8333	740.9667
4-6pm	6	2604	434	2121.6

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	184745.4	2	92372.72	82.34657	8.16E-09	3.68232
Within Groups	16826.33	15	1121.756			
Total	201571.8	17				

F > Fcrit indicating that the mean of all factors are not equal and we reject the Ho

Bikes		
7-9am	11-1pm	4-6pm
2	38	27
9	23	11
10	36	13
13	27	24
17	32	10
5	41	14

Anova: Single Factor
SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
7-9am	6	56	9.333333	29.06667
11-1pm	6	197	32.83333	46.96667
4-6pm	6	99	16.5	51.5

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1740.778	2	870.3889	20.47439	5.16E-05	3.68232
Within Groups	637.6667	15	42.51111			
Total	2378.444	17				

F > Fcrit indicating that the mean of all factors are not equal and we reject the Ho

Table 5: Results for Two-sample T-test assuming unequal variances testing for difference between timeslots for the traffic and pedestrian use of the LeMarchant/University intersection on Dalhousie's Studley campus as part of group research for ENVS3502: Problem Solving II The Campus as a Living Laboratory.

T-Test 7-9am and 4-6pm		
	7-9am	*4-6pm*
Mean	964.6	1138.8
Variance	105343	1486.7
Observations	5	5
Hypothesized Mean Difference	0	
df	4	
t Stat	-1.19175	
P(T<=t) one-tail	0.14962	
t Critical one-tail	2.13185	
P(T<=t) two-tail	**0.29923**	
t Critical two-tail	2.77645	

Bolded value > 0.05, not significantly different

T-Test Cars 7-9 and 4-6		
	7-9am	*4-6pm*
Mean	354.5	434
Variance	502.7	2121.6
Observations	6	6
Hypothesized Mean Differenc	0	
df	7	
t Stat	-3.80133	
P(T<=t) one-tail	0.00335	
t Critical one-tail	1.89458	
P(T<=t) two-tail	**0.0067**	
t Critical two-tail	2.36462	

Bolded value < 0.05, significantly different

T-test Bikes, 7-9 and 4-6		
	7-9am	*4-6pm*
Mean	9.33333	16.5
Variance	29.0667	51.5
Observations	6	6
Hypothesized Mean Difference	0	
df	9	
t Stat	-1.95576	
P(T<=t) one-tail	0.0411	
t Critical one-tail	1.83311	
P(T<=t) two-tail	**0.0822**	
t Critical two-tail	2.26216	

Bolded value >0.05, not significantly different

T-test Pedestrians: 7-9 and 11-1		
	7-9am	*11-1pm*
Mean	904.333	3798.83
Variance	106067	67696.2
Observations	6	6
Hypothesized Mean Difference	0	
df	10	
t Stat	-17.0087	
P(T<=t) one-tail	5.2E-09	
t Critical one-tail	1.81246	
P(T<=t) two-tail	**1E-08**	
t Critical two-tail	2.22814	

Bolded value < 0.05, significantly different

T-Test Cars: 11-1 and 4-6		
	11-1pm	*4-6pm*
Mean	597.833	434
Variance	740.967	2121.6
Observations	6	6
Hypothesized Mean Differenc	0	
df	8	
t Stat	7.50067	
P(T<=t) one-tail	3.5E-05	
t Critical one-tail	1.85955	
P(T<=t) two-tail	**6.9E-05**	
t Critical two-tail	2.306	

Bolded value < 0.05, significantly different

T-Test Bikes: 7-9 and 11-1		
	7-9am	*11-1pm*
Mean	9.33333	32.8333
Variance	29.0667	46.9667
Observations	6	6
Hypothesized Mean Difference	0	
df	9	
t Stat	-6.60148	
P(T<=t) one-tail	5E-05	
t Critical one-tail	1.83311	
P(T<=t) two-tail	**9.9E-05**	
t Critical two-tail	2.26216	

Bolded value < 0.05, significantly different

T-test Pedestrians, 11-1 and 4-6		
	11-1pm	*4-6pm*
Mean	3798.83	1121.67
Variance	67696.2	2950.67
Observations	6	6
Hypothesized Mean Difference	0	
df	5	
t Stat	24.672	
P(T<=t) one-tail	1E-06	
t Critical one-tail	2.01505	
P(T<=t) two-tail	**2E-06**	
t Critical two-tail	2.57058	

Bolded value < 0.05, significantly different

T-test Cars, 7-9 and 11-1		
	7-9am	*11-1pm*
Mean	354.5	597.833
Variance	502.7	740.967
Observations	6	6
Hypothesized Mean Differenc	0	
df	10	
t Stat	-16.9015	
P(T<=t) one-tail	5.5E-09	
t Critical one-tail	1.81246	
P(T<=t) two-tail	**1.1E-08**	
t Critical two-tail	2.22814	

Bolded value < 0.05, significantly different

t-Test: Two-Sample Assuming Unequal Variances		
	11-1pm	*4-6pm*
Mean	32.8333	16.5
Variance	46.9667	51.5
Observations	6	6
Hypothesized Mean Difference	0	
df	10	
t Stat	4.03186	
P(T<=t) one-tail	0.0012	
t Critical one-tail	1.81246	
P(T<=t) two-tail	**0.00239**	
t Critical two-tail	2.22814	

Bolded value < 0.05, significantly different

Table 6: Single-Factor Analysis of Variance between factors to test for variance across the sampled time slots. Count data was taken to assess occurrence of safety incidents at the LeMarchant/University intersection on Dalhousie's Studley campus, where incident is defined as a vehicle failing to come to a full and complete stop at a distance that poses no risk to another vehicle or pedestrian.

7-9am	11-1pm	4-6pm
0	4	2
0	2	2
0	2	3
0	1	3
0	0	4
0	2	0

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
7-9am	5	0	0	0
11-1pm	5	9	1.8	2.2
4-6pm	5	14	2.8	0.7

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20.13333	2	10.06667	10.41379	0.002386	3.885294
Within Groups	11.6	12	0.966667			
Total	31.73333	14				

Table 7: Results for Two-sample T-test assuming unequal variances testing for variance among occurrence of safety incidents across timeslots at LeMarchant/University intersection on Dalhousie's Studley campus as part of group research for ENVS3502: Problem Solving II The Campus as a Living Laboratory. Morning (7-9am), Afternoon (11-1pm), Evening (4-6pm).

T-test Morning/Afternoon		
	Variable 1	*Variable 2*
Mean	0	1.833333
Variance	0	1.766667
Observations	6	6
Hypothesized Mean Difference	0	
df	5	
t Stat	-3.37862	
P(T<=t) one-tail	0.009852	
t Critical one-tail	2.015048	
P(T<=t) two-tail	0.019704	
t Critical two-tail	2.570582	

T-test Morning/Evening		
	Variable 1	*Variable 2*
Mean	0	2.333333
Variance	0	1.866667
Observations	6	6
Hypothesized Mean Difference	0	
df	5	
t Stat	-4.1833	
P(T<=t) one-tail	0.004314	
t Critical one-tail	2.015048	
P(T<=t) two-tail	0.008627	
t Critical two-tail	2.570582	

T-test Afternoon/Evening		
	Variable 1	*Variable 2*
Mean	1.833333	2.333333
Variance	1.766667	1.866667
Observations	6	6
Hypothesized Mean Difference	0	
df	10	
t Stat	-0.64253	
P(T<=t) one-tail	0.267491	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.534982	
t Critical two-tail	2.228139	