Active Transportation Infrastructure – Examining Safety Implications And Effect On Modal Split

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1.0 Introduction

Active transportation's place within transportation engineering has continued to grow. Pedestrian infrastructure has always been a consideration, but bicycle infrastructure was generally an afterthought. Where it was once not considered whatsoever in road design or for planning purposes, it is now normal to see its inclusion, often prominently, in transportation master plans as an effective method of transportation demand management, in the promotion of healthy lifestyles and the mitigation of greenhouse gas emissions from motor vehicles.

There are some important implications related to attempts to increase the cycling mode share for commuters and increasing cycling in general. It would seem obvious that different types of cycling infrastructure would have different effects on the number and frequency of collisions involving cyclists. That relationship was explored though an examination of applicable research.

The establishment of different types of cycling infrastructure also are likely to have an effect on the amount of commuters who would be willing to switch to that mode. Their willingness to switch, even if it is not full-time, is likely based upon their own perceived safety and comfort levels with the different types of infrastructure options. This was the second focus of examination.

Finally, there is a discussion of the methods in which jurisdictions within New Brunswick can incorporate active transportation infrastructure and the potential effect on vehicular traffic. New Brunswick is in a cold weather climate; Fredericton sees average daily temperatures below freezing for 4 months per year (Environment Canada, 2017). These conditions will also affect cycling commuting numbers and this will be considered in the discussion.

2.0 Safety Implications of AT Infrastructure

The common terminology for bicycle infrastructure includes three classifications. These are cycle tracks (paths that are physically separated from motor vehicles and pedestrians), bicycle lanes (paths painted on the road surface with no separation from road traffic) and shared roadways where there may be signage or pavement markings but no lane delineation (NACTO, 2014).

Bicycles are considered vehicles and are permitted to use roads in the same manner as any type of motor vehicle. This creates a potential problem as the difference in size is considerable. Bicycles may weigh in the range of 30lbs while even the tiny Smart Car weighs around 2000lbs with more typical vehicles being at least double that amount (Car and Driver, 2017). Placing cars and bicycles in the same space can cause uneasiness in both cyclists and drivers. The speed differential between the two modes also causes vulnerability for cyclists (Pucher & Buehler, 2006). The implications of safety on the amount of people who choose to use the bicycle appear to be obvious as "safer cycling would encourage more people to cycle because risk averse and vulnerable groups are deterred from cycling by fear of injury and thus do not enjoy the health benefits of the physical activity of cycling" (Jacobsen & Rutter, 2012).

There are estimates from North America and Europe that "suggest that cyclists are seven to 70 times more likely to be injured per kilometer traveled than car occupants" Reynolds, Harris, Teschke, Cripton, & Winters, 2009). This safety gap likely explains the trepidation many people feel about making cycling

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trips that is often borne out in surveys that ask what the factors are towards choosing to use the bicycle as a means of transportation (Reynolds et al, 2009).

Not all injuries on bicycles are a result of motor vehicle collisions even though they present a considerable danger. One study found that “although only 15 percent of the injured cyclists presenting at emergency rooms were hit by motor vehicles, 36 percent of those hospitalized were”, (Jacobsen & Rutter, 2012) while other studies have shown that “approximately 90 percent of cyclist deaths involve motorists” (Jacobsen & Rutter, 2012).

It would seem obvious that separating bicycles from motor vehicles would increase safety for cyclists. It is possible that by separating the flows that the number of cyclists would increase which could then lead to an increase in the number of collisions, if not frequency. Research has been carried out in order to determine if installing different types of cycling infrastructure has an effect on cycling safety.

Cycle tracks are a relatively new type of infrastructure in North America while they have been in place for a long time in some European cities and countries. This is reflected in the relative lack of research conducted within North America (Thomas & DeRobertis, 2013).

“Many of the early studies on the safety of cycle tracks had a significant limitation in that they did not control for the amount of bicycling, also called bicyclist exposure” (Thomas & DeRobertis, 2013). Consequently, these early studies showed that when cycle tracks were constructed the amount of collisions and injuries increased without consideration to whether the number of cyclists increased as well.

Some of the studies that have been conducted focused on either cycling infrastructure within intersections or infrastructure along road segments between intersections. These are two very different environments with the road segments being a place of much less potential conflict than an intersection. Other studies combine both types of infrastructure which produces an average across an entire system. This may be more useful in terms of policy and design discussions because one type of cycling infrastructure can’t exist without the other in a functional network of cycle tracks, lanes or shared roads.

One study estimated that crashes on cycle tracks occurred at a rate of 2.3 per million bicycle kilometers while crashes when bicycles travelled on the road ranged from 3.75-54 per million bicycle kilometers in the United States and 46-67 per million bicycle kilometers in Canada. This is a wide range which was attributed to the potentially wide range of “study methods, case definitions, design features and context; however, all such rates of which we are aware are greater than the cycle track rates” (Lusk, Morency, Miranda-Moreno, Willett, & Dennerlein, 2013).

A before and after study conducted in New York City on three cycle track installations showed decreases of 30%, 56% and 62%. On the cycle track that decreased by 62%, there were double the amount of bicyclists riding on the weekends (Lusk et al, 2013).

In another study on New York’s cycle lanes it was found that crashes involving bicycles and pedestrians increased after installation. However, frequencies were not accounted for and the authors believed that the increases are due to “higher exposure levels as bicyclists took advantage of the new bicycle lanes” (Chen et al, 2011). This demonstrates the need to collect bicycle volume data so proper comparisons can be made. The study compared sections of road that were treated with bicycle lanes and similar sections that were not treated. Analysis was completed at the intersection and road segment level. It is noted that intersections were not treated with any pavement markings, which likely contributed to there not being a decrease in collisions. One other important finding was that injurious or fatal crashes decreased, so even if the total number of crashes increased, their effects were not as serious (Chen et al, 2011).

A study from Montreal examined injury and crash rates on cycle tracks versus in the street along the same corridor. The examined cycle tracks were two-way facilities constructed between the sidewalk and road. Cycle tracks were found to have a 28% lower injury rate than the untreated streets while seeing 2.5 times the number of cyclists. This evidence seems to show that cycle tracks provide a considerable amount of increased safety (Lusk et al, 2011). Two-way cycle tracks have been found to produce more intersection collisions than one-way cycle tracks and therefore results such as the previous study cannot be applied to different facility types (Thomas & DeRobertis, 2013).

One underlying principle appears to be the concept of safety in numbers. This is "supported by studies of injury and ridership patterns in California, Australia, and Europe, as well as between cities and within cities over time" (Reynolds et al, 2009). A study from Finland also found this to be the case. Cycle tracks attract more cyclists which creates an increased awareness of cyclist's presence which reduces their risk of collision and injury (Thomas & DeRobertis, 2013). It has been termed the 'safety in numbers' effect.

Another study found that "sidewalks and multiuse/shared paths present higher risks than cycle tracks and bike-only paths" (Thomas & DeRobertis, 2013). This is likely because of the speed differential between bicycles and pedestrians. In this case the pedestrians are the vulnerable group.

The concept of raised cycle crossings at intersections was shown to decrease crashes by 33%-51% and decrease vehicle turning speed by 40% for one-way cycle tracks. This type of installation may not always be possible but the main finding at intersections is that increasing visibility through physical treatments at intersections "reduces collisions and injuries" (Thomas & DeRobertis, 2013).

There is a lack of injury severity analysis that hides the true safety impact of different types of infrastructure. Without this, it is not possible to truly quantify risk as minor injuries have a relatively small impact while permanently disabling injuries or fatalities are irreversible and have a much large impact on the individual and society as a whole.

3.0 Bicycle Infrastructure and Mode Share

"For the bicycle to be useful for transportation, bicyclists need adequate route infrastructure – roads and paths on which to get places" (Furth, 2012). This was true when bicycles first became widespread over 100 years ago and it is true in today's context as well. The difference now is that motor vehicles can travel at speeds that are dangerous to non-motorized forms of transportation. As demonstrated in the previous section, infrastructure that separates cyclists and automobiles increases safety for cyclists by removing some of the potential conflict. The next step is to prove the assertion that this increase in safety brought about by installing separated infrastructure increases the bicycle mode share.

There are many reasons people may choose to cycle and there are also reasons people may stay away from this mode. Traffic stress is a concept that describes the relative stress cyclists experience when riding with motor vehicle traffic. "The combined concerns of safety and comfort make separation from traffic stress a critical factor in attracting people to cycling. In many North American surveys, the chief reason given for not cycling more is the danger posed by motor traffic" (Furth, 2012). Judging from the bike mode share in many US cities, often under 1%, (Lusk et al, 2011) and their relative lack of dedicated cycling infrastructure, it is clear that there are only a small percentage of individuals who are comfortable enough to ride in traffic. "The mainstream population has been characterized as traffic-intolerant" (Furth, 2012).

Vulnerable users such as the young, seniors and persons with physical limitations are not likely to feel safe cycling with fast moving, heavy vehicles. In surveys more women than men have described these same issues as reasons for choosing not to ride a bicycle. When riding a bicycle without infrastructure is the only option available, cyclist numbers tend to be dominated by physically fit men aged 24-60

(NACTO, 2014). In order to increase mode share, it is imperative to attract the relatively more vulnerable segments of the population who wish to have a greater level of perceived safety.

There is a clear difference in the type of infrastructure and the levels of separation and safety that they provide. There are cycle tracks physically separated from traffic, bike lanes painted on the road, shared streets/lanes and standalone paths that have their own right-of-way.

In the United States, there is a lack of criteria for when active transportation infrastructure should be separated from motor vehicle traffic. The American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* does not describe any criteria for when certain types of bicycle focused infrastructure should be constructed (Furth, 2012). This is in contrast to countries such as the Netherlands that have criteria that, for example, a cycle track should be in place on any street with more than two lanes and on any urban street with a speed limit greater than 50km/h. For shared streets/lanes, streets should have speed limits of 30km/h or under, traffic volumes under 5,000 vehicles per day and, if possible, should have traffic calming measures present. Bike lanes are ideally installed if vehicle traffic exceeds 4,000 vehicles per day because of ‘over-taking squeeze’. This is when two cars traveling in opposite directions pass the same point at the same time more than once per minute (Furth, 2012).

A study from New Orleans, Louisiana focused on a bike lane installation on a major thoroughfare in the city. The study counted cyclists before and after installation as well as how many cyclists were male, female, or children and how many cyclists rode on the sidewalks. Almost no children were seen riding in the bike lane before or after installation. The study found an increase of 133% and 44% for female and male cyclists, respectively. In total, an increase of 57% was seen in bike lane use. This increase happened in the face of gasoline prices dropping by almost $1 per gallon before and after installation. Unexpectedly, there was roughly the same amount of cyclists riding on the sidewalk before and after installation. This finding is theorized to have occurred because of the high speed limit on the road (35 mph) that often see large trucks as well as the parking lane to the right of the bicycle lane making it difficult to access destinations from the street (Parker, Gustat, & Rice, 2011).

From 1977 to 2009 the mode share for bicycle trips nearly doubled. This was most prominently seen in Portland, Oregon and San Francisco which, in 2009, saw bicycle mode shares of 5.8 percent and 3.0 percent respectively (Cervero, Caldwell, & Cuellar, 2013). One place that it may be possible to increase bicycle mode share is encouraging park-and-ride users at public transit stations to switch to bike-and-ride. San Francisco attempted to increase bicycle use towards their Bay Area Rapid Transit (BART) stations. This was done by equipping stations with bicycle parking, secure lockers and repair facilities at the stations, as well as installing bike paths and bike lanes on routes toward stations. Another aspect was introducing measures to make driving less appealing. This was done by charging for on-site parking and by introducing traffic calming measures in the neighbourhoods surrounding stations. Between 1998 and 2008, when these measures were introduced, the mode share of bicycle trips to BART stations grew by 69 percent and to make up 4 percent of all trips to BART stations (Cervero et al, 2013).

Since 2001, Washington, DC has purposefully invested in bicycle infrastructure across the city and launched a bikesharing program. There has been a “steady increase in the bicycling mode share in the District” (Perez, Buck, Ma, Robey, & Lucas, 2017). The bicycle mode share increased from 1.25 percent in 2000 to almost 4 percent in 2015. From 2001 to 2015 the amount of bike lanes grew from 2 miles worth to 17 miles in 2005 and to 97 miles in 2015 with an additional 8 lane miles of separated cycle tracks. The bikeshare program that was started in 2008 now provides over two million rides annually across the District (Perez et al, 2017).

The connectivity of a cycling network is very important towards increasing usage. One study from Montreal determined that, depending on a “cyclist’s ability, they are willing to detour up to 9% longer distances and time to reach their destination if they can use a cycling facility" (Perez et al, 2017). The study of Washington, DC's cycling initiatives focused on a statistical analysis of user demographics and a spatial network analysis evaluating its mobility and accessibility. Mobility is considered the ease or directness of travel possible on the network and accessibility is how far an individual must travel to gain access to the network.

The study found, as stated before, that the mode share for bicycles increased significantly, doubling from 2009 to 2014 in conjunction with the size of the network nearly doubling in the same time frame. It was found that parallel to increasing the network size, the accessibility also increased which was associated with a mode share increase. Mobility was associated in a similar manner to accessibility and network size (Perez et al, 2017).

Finally, the study completed on Calgary's Centre City Cycle Track Network Pilot Project showed that their 6.5km of installed cycle tracks and shared space in the downtown resulted in an inbound peak period bicycle mode split increase from 1.9% to 3% (Glowacz, 2016).

4.0 New Brunswick and Canadian Context

In New Brunswick the bicycle mode share is very low. For the entire province the mode share is 0.5%, while for the three largest census metropolitan areas/ census agglomerations, Moncton, Saint John and Fredericton, the mode shares are 0.6%, 0.2% and 1.4%, respectively (Statistics Canada, 2013). There are numerous factors for these low numbers. A lack of investment in infrastructure coupled with sometimes challenging topographical locations and a lack of density in the city cores can be seen as factors. While the summer weather is comfortable for cycling, colder temperatures persist for approximately half the year and combined with frequent snowfall, cycling is not always appealing no matter how enthusiastic individuals may be.

The same types of issues are prevalent to varying degrees across the country while the national bicycle commuting mode share is 1.4%. In British Columbia, the climate is less cold during the winter and this may be the most important factor in the relatively high levels of bicycle mode share seen in that province. In Vancouver, Victoria and Kelowna the bicycle mode shares are 1.9%, 6.4% and 2.9%, respectively. These are among the highest values seen across the country.

Other above average mode shares among the 25 largest CMAs exist in Ottawa and Kingston with mode shares of 2.2%; Winnipeg and Saskatoon are 2.1%; Montreal is 1.8%; London is 1.6% and Guelph is 1.5%. These places tend to have physical geographies that are conducive towards cycling and have made efforts to create dedicated cycling infrastructure.

In New Brunswick, Fredericton's relative success can be attributed to its network of trails that were repurposed, abandoned rail lines and the corresponding rail bridge that crosses the Saint John River and connects the city. These have been important assets that have helped increase bicycle mode share.

The issue of weather conditions is not just a New Brunswick problem, but one that extends across Canada and its cold winter climates. Cold weather also affects cities in the northern United States as well as the northern Scandinavian countries in Europe. Many studies from all of these regions have found correlations between colder weather, precipitation and fewer sunlight hours with reductions in bicycle commuting (Gebhart & Noland, 2014).

Bikesharing programs allow for much more detailed data collection of ridership numbers that allow for easier comparisons to weather conditions and these comparisons can be made at the hourly level instead of by the day. This can provide for a much more accurate examination of travel trends. Within Canada there are bikesharing programs in Montreal, Hamilton, Ottawa, Toronto, Vancouver, Victoria and Edmonton.

The Capital Bikeshare in Washington, DC provided data for analysis. Even though it is not located in what many in Canada would consider a cold weather climate, the city does receive snow and experiences some freezing days in the winter. When temperatures were below 9.4 degrees centigrade, there was a correlation with shorter average trip durations. In general, as temperatures decreased, the amount of trips taken decreased. The same effect could be seen for snow and rain events as well as for when darkness set in. This decreases usage in winter months as it is more like to be a low temperature, experience snow events and with the sun rising later and setting earlier, extends hours of darkness. Extremely humid days also had a negative effect on trips but hot days (above 32.2 degrees centigrade) did not have much of an impact (Gebhart & Noland, 2014). This is not as much an issue in New Brunswick but there are days in the summer when it can get extremely hot and humid. Across Canada, this is a potential issue as there are many cities that experience high temperatures and high humidity in the summer months.

A study conducted in Vermont found that “nearly all factors had a significant independent relationship with bicycle commuting” (Flynn, Dana, Sears, & Aultman-Hall, 2012). The weather related factors were temperature, snow depth, daylight hours, precipitation and wind. Commuters were nearly twice as likely to commute by bicycle if there was no precipitation in the morning while “a one degree Fahrenheit increase raised the likelihood of biking by about 3%” (Flynn et al, 2012). With a one inch change of snow present on the ground, there was a 10% decrease in the likelihood of biking.

A comparison between Canadian cites and American cities noted that cycling rates are nearly three times higher in Canada (Pucher & Buehler, 2006). This demonstrates that colder climates do not necessarily result in lower bicycle mode share as, at the time this study was published, Canada had a national bicycle journey to work mode share of 2.0% while California and Florida had mode shares of 0.8% and 0.6% respectively. It was found that the higher density of the Canadian cities analyzed, greater safety outcomes (about half as many deaths per 100 million km cycled in Canada) and shorter trip distances along with other, smaller factors contributed to this disparity (Pucher & Buehler, 2006). Weather was also a factor however there are wide variations in weather across both countries so it is difficult to analyze its effect in aggregate.

The analysis looked at the 5 biggest CMAs in Canada which is useful for those cities however it is not especially informative in the context of New Brunswick or for other, smaller cities across the country. New Brunswick’s cities are much smaller and do not have the same high density development patterns. The top 5 largest CMAs in Canada all have densities near or above 200 people per square kilometer, while New Brunswick’s 3 largest cities, at the time of the study, had densities of 52.5, 36.4 and 19.0 people per square kilometer for Moncton, Saint John and Fredericton (Statistics Canada, 2010). The New Brunswick context looks a lot more similar to the United States than the largest Canadian cities and this holds true for many other smaller CMAs across the country.

5.0 Discussion and Conclusions

The low mode share of bicycles in New Brunswick and in many Canadian cities may or may not be something that residents wish to increase. There are obvious health benefits to commuting with the bicycle and beneficial environmental impacts from moving away from automobile centric commuting. If that is a decision that is taken, regardless of location, the steps to increasing bicycle mode share seem clear.

Making infrastructure accessible to all users, regardless of skill, is imperative. They must feel comfortable and safe so the integration of separated cycle tracks will help a great deal in that regard. If that is not always possible, the implementation of painted bike lanes along with shared streets as bike routes is recommended. For shared streets, it is important the motor vehicle traffic moves slowly through traffic calming measures. Speeds greater than 30km/h will deter cyclists from using these types of facilities.

It should be ensured that networks are fully connected. This may not be possible to complete instantaneously, but plans should be in place to fill out the network and ensure its continuity.

Designing intersection treatments to be safer is very important to increasing cycling mode share. It is the major point of potential conflict of any network and the best way to mitigate these conflicts is to increase visibility between all modes. Visibility can be increased through various measures which can include the installation of clear delineators or markings through intersections. This is often accomplished through the use of colour on the asphalt surface. Ensuring a visibility triangle exists between all legs of an intersection creates increased visibility for all modes. This provides proper sight distances so potential collisions can be avoided because of being able to see potential dangers before they may escalate.

Within New Brunswick, if some vehicle lanes are reconfigured or removed in favour of bicycle infrastructure, there is not likely to be a large effect on vehicle delay. Due to population size and density, traffic congestion is relatively low and peak periods do not last as long as bigger cities.

There are obviously some geographical and climatological constraints on cycling and walking in New Brunswick. The Hill on the south side of Fredericton is a major impediment to active transportation and the hilly topography of Saint John does not encourage cycling. The long winter months also keep cycling supressed. Dedicated infrastructure would help, even in the winter, but there must be rules that ensure it is properly cleared after snow events. Bike lanes are often not properly cleared which deters cyclists from riding as this forces them into the street where they may not feel comfortable or safe, especially in potentially icy conditions. The weather related issues are common across the Canadian climate and should be properly addressed at the local level to reach the desired outcomes for increasing mode share and ensuring that bicycling is as safe as possible as a year-round activity.

Slow progress can be made but ensuring there is adequate funding is important. Planning for separated facilities wherever possible and ensure that networks are well connected and easily accessible is the best possible way to increase mode share. Education is also a very important consideration that needs to be included in any plan. Education for cyclists, but also the general population, is critical so that individuals know what to expect as a motor vehicle drivers or pedestrians when they encounter cyclist infrastructure.

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