SMART MOVES: KEY PERFORMANCE INDICATOR PROPOSAL FOR THE MOVESMART STRATEGY

School of Urban and Regional Planning

Transportation and Fleet Management Services

Smart Moves: Key Performance Indicator Proposal for the MoveSmart Strategy

Prepared by: Stephanie Cantlay, Keith Holmes, Nico Koenig, Jennifer Yun Liu, Joyce Ngoya Tshiyoyo, and Aidan MacFarlane

Supervised by: Dr. Patricia Collins, Queen's University

In partnership with: Sari Liem and supported by Sadia Kahn and Michael DiBattista, City of Vaughan, Transportation and Fleet Management Services

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LAND ACKNOWLEDGEMENT

We respectfully acknowledge that the City of Vaughan is situated on the Treaty 13 lands of the Mississauga's of the Credit First Nation and the traditional territory of the Huron-Wendat and the Haudenosaunee Confederation. The City of Vaughan is home to many First Nations, Métis and Inuit people. Thus, there is an importance to maintain guest-host relationships by recognizing our duty as settlers to respect and take care of the lands we live on.

Queen's University is situated on traditional Anishinaabe and Haudenosaunee territory and we are grateful to be able to live, learn and play on these lands. To acknowledge this land also means to face how planning was and continues to be used as a colonial tool to isolate, oppress, and displace Indigenous Peoples.

In composing this report, we sought to understand the importance of our connection to land and its people. Our goal is to help sustain and care for this land for it to last for generations in the future. Being able to move about in our communities safely and sustainably are key aspects of how all of us function in our everyday lives. We hope that as you read this report, you are able to reflect on how our communities can offer safe and sustainable mobility options for all human inhabitants and that, in our efforts to promote mobility, we do not compromise the health and well-being of future generations. We all have a duty to take a holistic and equity lens approach by considering and caring for all aspects of the land that helps us breathe and live.

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TEAM MEMBERS

This report was written collaboratively by a group of six Urban and Regional Planning graduate students from Queen's University. This report was completed as part of SURP 823 Project Course under the direction of Dr. Patricia Collins.

Stephanie Cantlay

Keith Holmes

Nico Koenig

Jennifer Yun Liu

Joyce Ngoya Tshiyoyo

Aidan MacFarlane

EXECUTIVE SUMMARY

The purpose of Smart Moves is to provide the City of Vaughan ("**Vaughan**") with a set of key performance indicators ("**KPIs**") to assess the progress of the MoveSmart Mobility Management Strategy ("**MoveSmart Strategy**"). The KPIs listed in this report are based on research on Vaughan, other domestic and international jurisdictions, and academic literature. The twenty KPIs proposed for Vaughan are informed through a road safety and equity lens and best suited for Vaughan's context to measure the future success of the MoveSmart Strategy.

How Vaughan Moves is auto-oriented but municipal policies seek to improve sustainable transportation networks and intensify residential land-use. Collision statistics, spatial analysis and news media analysis identified the following Vaughan contextual findings to inform the set of KPIs

- KPIs cannot rely solely on police-reported collisions.
- Intersections are the site of most collisions, including ones involving pedestrians.
- Quantifying collision data by mode, vehicle size, and age can highlight systemic barriers related to road safety.
- Mapping socio-economic information with collision data can help transportation planners and engineers make equitable and evidence-based decisions and justify decisions to residents.
    - Areas of concern include Fossil Hill and Alba Avenue, Ashley Grove and Windflower Gate, Promenade Shopping Centre, and Mosque Gate and Ahmadiyya Avenue.
- News media has been used by Vaughan to promote municipal traffic policies, support police investigations, and notify residents regarding delays and road closures.
- Vaughan residents have mixed opinions regarding the effectiveness of traffic calming initiatives and cycling infrastructure investments and KPIs can be used to inform residents on MoveSmart Strategy progress.
- Speed, impaired driving, and collisions involving children are urgent concerns for Vaughan residents, which are largely portrayed as an effect of poor individual behaviour, with enforcement being portrayed as an effective deterrent to these behaviours.

Risky Moves cause traffic collisions and injuries. A comprehensive literature review identified factors that can effectively decrease the risks of collisions and be measured directly and indirectly through KPIs.

- Systemic determinants of traffic injuries and collisions are more prominent than determinants based on individual behaviours.
- Vulnerable road users are at greater risk for traffic collision and fatality.

- There can be multiple compounding factors that increase a vulnerable road user's exposure to vehicles which increases their overall risk of injury and fatality.
- Designing intersections and roadways for the maximum protection of vulnerable road users has been a successful strategy for improving overall road safety.

How Cities Move is by enhancing road safety and implementing mobility strategies like the MoveSmart Strategy. A comprehensive jurisdictional review of interviews and document analysis identified KPIs for each of the MoveSmart Pillars and the unique features that municipalities provide in their strategies.

- Suburban municipalities are likely to be car-dependant and there is a recognition of a paradigm shift or a new way of thinking. Both encouraging sustainable modes of transportation and creating a culture of road safety requires refocusing attention to non-vehicle road users.
- Many strategies contain long- and short-term goals and have their own "pillars" organised by themes, policies or focus areas and it is common to identify which department or staffing position is responsible for each activity or metric.
- Data-driven models can be proactive in addressing road condition deficiencies. When used in tandem with resident complaints, it can address equity concerns. A data-driven model can make more information available to be shared with the public on a periodical basis. At the same time, it is important to recognize resident lived experiences when addressing inequities and systemic barriers related to transportation.

Smart Moves are twenty measurable, meaningful, realistic, and understandable KPIs to measure the short-term and long-term progress of the MoveSmart Strategy (See Table i.i).

- All KPIs work together using a combination of outcome and output KPIs
- With measures to track progress and publicly share through transparency and accountability, it is possible that measures will trend in an undesirable direction.
- Data availability should not limit KPI adoption especially for demographic information of vulnerable road users and one way to address data availability concerns is through collaboration and partnerships

	Nine outcome KPIs measure the effect of Vaughan's transportation system
	Eleven output KPIs measure tangible projects and programs administered

Table i.i: Twenty Smart Moves for the MoveSmart Strategy by pillar and by outcome and output KPI.

Key Performance Indicator				
Rate of killed/seriously injured per 100,000 population	◎			
Rate of killed/seriously injured per 100,000 population at intersections	◎			
Number of engineering improvements installed in high-collision areas	☑			
Number of community presentations given	☑			
Number of in-service road safety reviews completed	☑			
Number of engineering improvements for standalone active transportation projects completed	☑			
Number of automated enforcement cameras installed	☑			
Number of community safety zones implemented	☑		☑	
Percentage change in high speeds		◎		
Number of streets with posted speed limit of 40 km/hour or below		☑		
Curbside parking utilisation rate		◎		
Average commute time by transportation mode		◎	◎	
Vehicle kilometres travelled per capita			◎	
User perception of walking, cycling or transit as a transportation option	◎		◎	
Percentage of students using active transportation to school			◎	
Percentage of residents with access within 500m (or 10 minutes non-auto travel time) from bicycle route and transit network			☑	
Mode shares for all trips			◎	
Kilometres of new, protected bicycle infrastructure constructed each year			☑	
Number of data collection and analysis reports completed within one year				☑
Number of active transportation volumes counts administered			☑	☑

Moving Forward is a set of recommendations to enhance the MoveSmart Strategy in the following ways:

1) Incorporate specific and actionable measures, responsible partners, and a theory of change, in ways that integrate social, environmental, and financial sustainability.
2) Describe how equity is understood in relation to road users, equity deserving populations, and the City of Vaughan's decision-making and capital expenditure process.
3) Limit the use of information-oriented public education campaigns.
4) Commit to Vision Zero language and terminology within the MoveSmart Strategy.
5) Support, integrate, and evaluate mixed land-use development policies which aim to decrease overall vehicle kilometres travelled of Vaughan residents.

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PROJECT OVERVIEW

The City of Vaughan ("**Vaughan**") adopted the MoveSmart Mobility Management Strategy ("**MoveSmart Strategy**") to inform and direct their vision to provide a transportation system that is safer, more efficient, and sustainable. In September 2022, a group of six Master of Urban and Regional Planning students from Queen's University ("**Project Team**"), with direction from Dr. Patricia Collins, were asked to produce a report which examines transportation Key Performance Indicators ("**KPIs**") from other municipalities, regions, and academic literature.

To complete the report, Vaughan recommended that the Project Team undertake two primary tasks:

1. Examine road safety KPIs in academic literature and across other municipalities to determine the socio-economic and spatial determinants of traffic-related fatalities and injuries, and how they are measured
2. Develop an effective KPI strategy to measure transportation initiatives, including a strategy to engage with vulnerable populations through the various stages of the MoveSmart Strategy.

KEY PERFORMANCE INDICATORS

KPIs are used throughout many disciplines, including economics, engineering, and mobility management. They can hold agencies accountable to their goals and objectives, reveal an agency's success and improvement areas, and justify future investment (Haas et al., 2009; Steinemann, 2012).

KPIs are a defined set of goals, that include a method of monitoring the progress towards achieving these goals (Steinemann, 2012). Higher-level values can also be embedded within KPIs, such as mobility, road safety, and equity. As a result, KPIs can allow agencies to measure their strategy's performance in regard to set-goals and broader societal values.

KPIs can be categorized as either outputs or outcomes. Output KPIs measure tangible outputs, or activities completed, resulting from policies or initiatives. Output KPIs, or action KPIs as they are sometimes referred to as, can often be the actions that cause a change in the outcome measures. By comparison, outcome KPIs relate to the ultimate intended effect or expected outcome of an action (Haas et al., 2009; Steinemann, 2012). While output and outcome KPIs provide evaluation methods of the objectives, many municipalities use a combination of both to provide a balanced approach to road safety and mobility strategy evaluation (City of Regina, 2017; Halifax Regional Municipality, 2017).

EQUITY LENS

The Project Team uses an *equity lens* throughout the Smart Moves report. Equity, in this way, refers to the fairness with which benefits and costs are distributed (Litman, 2022b). Referring to equity also acknowledges social inequity and historical injustices that exclude certain populations from realizing a safe, healthy, and meaningful life. Applying an equity lens seeks to uncover and rectify inequities within the organizational and social systems in which they exist.

Taking an equity lens to the MoveSmart strategy begins with the premise that a transportation system should benefit all people, and that in its current form, its costs and benefits are not distributed fairly. As will be described throughout this report, road users such as pedestrians and equity-deserving groups are disproportionately impacted by injuries and fatalities as compared with vehicle users. It is also worth stating that the Project Team has taken specific guidance from Vision Zero policies, also documented throughout this report, which seek to achieve the fundamental right of movement by addressing the systemic determinants of road safety.

As past [transportation] information was based on complaints and people's perceptions, we were seeing poor safety outcomes in certain areas of the city that may not see as many requests or complaints. So, there's an element of equity in that we see the collision data providing more of an objective look at where issues are and where a lot of our focus should be in terms of locations where we make improvements.

– City of Calgary Traffic Safety Engineer

We need to bring it back to data; we need to make sure we're telling the right story.

– Traffic and Road Safety Professional

I hope that we have a system that works for everyone, from an equity perspective but also in terms of a system that is convenient and easy to use for everyone as well.

– City of Vaughan Transportation Program Manager

NAVIGATING THIS REPORT

This report provides a comprehensive review of relevant research and literature which guides the final KPI recommendations for the MoveSmart Strategy. The report contains five sections and as well as supplemental supporting documents which informed, supported, or inspired the final KPI recommendations.

Objectives of each section of this report is as follows:

Section 1: How Vaughan Moves provides a background of Vaughan by describing its history of growth and the associated development patterns. Vaughan's current traffic collision conditions were reviewed, and its public perception of traffic collisions were studied through news media analysis. Understanding Vaughan's background ensures that the proposed KPIs suit the Vaughan-specific contexts.

Section 2: Risky Moves outlines the causes of traffic collisions and fatalities based on research and ensures that the proposed KPIs can be analyzed in ways that effectively decrease risk.

Section 3: How Cities Move constitutes highlights of interviews conducted and mobility strategy documents reviewed which informed the KPI proposals. Gaining a broad overview of what and how Canadian municipalities have been doing to address mobility initiatives, and in particular, road safety issues, paves way for the KPI proposals that are most appropriate for Vaughan to adopt.

Section *4: Smart Moves* KPI Proposal includes 20 KPIs which meet the criteria of measurable, meaningful, reliable, understandable, and suitable for Vaughan's context.

Section 5: Moving Forward completes this report with some overall program evaluation for the MoveSmart Strategy, and recommendation for Vaughan's consideration beyond the current iteration of the MoveSmart Strategy.

Smart Reads are text boxes to identify where further information can be found in the supporting information section.

Key Takeaways can be found at the end of each section, highlighting the overarching theme and main idea of the section.

Asking the Experts captures comments that support the section content from the interviews with staff members from the City of Vaughan, other Canadian municipalities, and professionals from transportation planning consultancies.

1. HOW VAUGHAN MOVES

Objective: provide a background of Vaughan by describing its history of growth and associated development patterns. Understanding Vaughan's background ensures that the proposed KPIs suit the Vaughan-specific contexts.

1.1 URBAN FABRIC

Vaughan is a lower-tier municipality located within York Region, north of the City of Toronto. Vaughan has experienced high levels of population growth since 1981 when the Greater Toronto Area ("**GTA**") began to expand. Much of this growth stems from Vaughan's convenient access to highways, railways, and airports within the GTA.

Over time, large tracts of relatively inexpensive land have been developed to accommodate this growth. The development occurred mostly through suburban residential development on 2x2 kilometre blocks bounded by regional arterial roads (City of Vaughan, 2012). As more subdivisions were built across Vaughan, a disconnected street grid developed, and an auto-oriented urban structure emerged (City of Vaughan, 2012). Vaughan's winding roads and few direct connections between subdivisions have made it difficult for York Regional Transit to provide efficient service (City of Vaughan, 2012). As such, arterial and collector roads have become increasingly congested for drivers, a factor which likely contributed to Vaughan's 2018 Citizen Satisfaction Survey which found that 59% of its residents named transportation as the most important issue facing their community (City of Vaughan, 2019).

1.2 VAUGHAN POLICY REVIEW

Vaughan's Official Plan ("**OP**") (2010) and Transportation Master Plan ("**TMP**") (2012) address issues related to transportation, mobility, and road safety. **The OP calls for improvements to its transit, cycling, and pedestrian networks** (OP Goal 5: Moving around without a car) and having 45% of its new residential growth to occur through intensification (OP Goal 8: Directing growth to appropriate locations). Vaughan's TMP (2012) builds on these goals by introducing 13 principles to encourage sustainable transportation by decreasing car dependency, improving road safety for all users, and promoting sustainable travel modes. **The TMP promotes the integration between the TMP and the OP, and between land use policies and transportation planning services**. It has been noted that at the time of this report, the OP and TMP are undergoing a review which will include substantial changes to policies to enhance road safety.

Key Takeaways:
Vaughan's municipal policies seek to improve sustainable transportation networks and intensify residential land-use.

1.3 THE MOVESMART MOBILITY MANAGEMENT STRATEGY

Vaughan City Council approved the MoveSmart Strategy to provide in March 2021 with the goal of providing a transportation system that is safer, more efficient, and sustainable. It responds to the increasing travel demand on Vaughan's mobility infrastructure with a holistic approach from internal and external stakeholders. As a five-year plan (2021 – 2026a), it has capital investment of $8 million and an additional investment of $2.4 million in annual operating costs to support the program and its initiatives (City of Vaughan, 2021b).

The strategy consists of four pillars:

Figure 1.3.1: An image showing the four pillars of the MoveSmart Mobility Management Strategy and their descriptions (City of Vaughan, 2022).

Together, these pillars seek to achieve the following strategic objectives:

- Provide a framework for collaboration with the community and other stakeholders
- Define a set of goals for transportation encompassing community values and identify a plan to address the City's mobility needs in an effective, responsible, and sustainable manner
- Identify opportunities for a more balanced approach to transportation and road safety, including the most vulnerable road users

Our plan is based on the safe systems approach to road safety, which is based on the principle that nobody should die or be seriously injured as a result of a collision. That's why we focused on fatal and major injury collisions as opposed to other types of injury collisions, which a lot of other jurisdictions include in their performance measures for their action plans. [The City of Ottawa's] main performance indicator is the percent reduction in the rate of fatal and major injury collisions.

– City of Ottawa Road Safety Project Manager

1.4 VAUGHAN INSIGHTS

A group interview with three transportation program managers from different departments from the City of Vaughan was conducted to identify current transportation planning practices and difficulties. Program managers indicated a wide variety of methods used depending on the department. Vaughan aims to make evidence-based planning decisions and collects data through a variety of techniques itself as well as through partnerships. Current approaches to collision prevention are based on resident complaints. All interviewees highlighted the importance of collecting and managing data that is understandable to inform transportation planning decisions. This aims to create a more proactive and equitable approach to transportation planning that targets populations with the highest need of attention. It was suggested that collecting accurate data on behaviour and infrastructure projects for all road users can encourage more proactive and equitable approaches to decision-making. One of the difficulties noted by interviewees was a discrepancy between resident and city staff knowledge of transportation planning. KPIs also need to examine community outreach to improve or reduce discrepancies between residents and city staff on the perceived causes and solutions to collisions. The MoveSmart Strategy is considered a strength in terms of advancing sustainable and equitable transportation in Vaughan. The findings from this interview further support the need for Vaughan to collect more detailed data, adopt a more equitable approach to implement planning initiatives, and create a more proactive educational outreach program to improve public engagement.

A complete interview summary with the City of Vaughan is found within Supporting Documentation Section A.

Key Takeaways

Vaughan uses a variety of data collection techniques and requires KPIs to make informed decisions rather than complaints-based decisions. Vaughan residents are very involved in collision prevention, but may not know what is considered a short-term or long-term best practice to reduce traffic collisions.

1.5 TRAFFIC COLLISION DATA ANALYSIS

Traffic collisions data for Vaughan is available to the public using York Region's traffic collision data. Traffic collision data provides a general snapshot of where traffic collision hotspots are and who is being affected. It should be noted that **York Region traffic collision data is only for regional roads, which are under the jurisdiction of York Region**. Vaughan's traffic collision data is collected by York Regional Police's ("**YRP**") Corridor Control and Safety division which maintains and manages York Region's traffic data system. The police database records all motor vehicle accident reports on York Region roads involving a fatality, an injury, or property damage of $2,000 or greater (York Region, 2021). While offering a comprehensive data set, **collisions unreported to YRP are not included in the police database**.

Across York Region, total collision rates have decreased by 46% between 2010 and 2019 when collisions per 10,000 people fell from 197 to 107 (York Region, 2021). Despite this decrease, there was a total of 4,538 collisions in York Region, where 1,085 of which resulted in injury and 15 in fatalities (York Region, 2021). The number of fatal collisions has remained constant, shown in Figure 1.5.1. York Region confirm that this downward trend is the results of stricter legislation, technological advancements, and road safety initiatives' success (York Region, 2021).

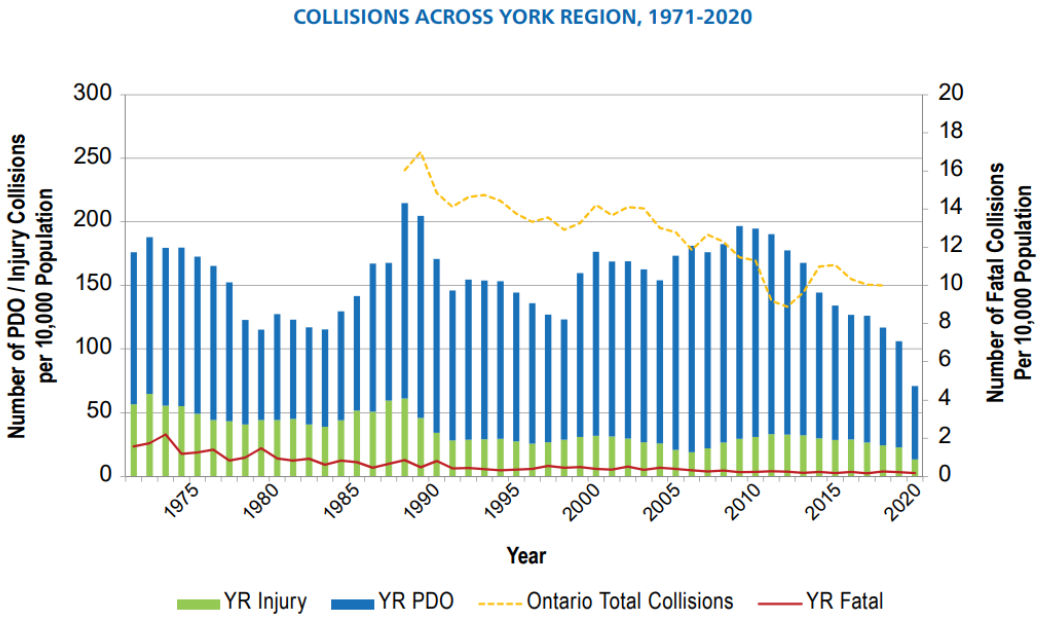


Figure 1.5.1: A graph showing the decline in collisions causing property damage only (YR PDO), York Region injuries (YR Injury), and York Region fatal collisions (YR Fatal) since 2009 (York Region, 2021).

The *2021 York Region Traveller Safety Report* ("**YRTSR**") offered collision data that was recorded in the first year of the COVID-19 pandemic in 2020. It should be noted that the public health measures associated with COVID-19 encouraged residents to stay home and, as a result, reduced the number of trips made, with York Region (2021) estimating that traffic volumes on

regional roads decreased by 20-50%. With this context in mind, the YRTSR reported decreased collision statistics in Figure 1.5.1.

While data from YRTSR is only collected on regional roads, which carry higher vehicle volumes with vehicles moving at higher speeds as compared to Vaughan's local roads, it describes data that may have important implications for Vaughan. Although regional roads fall within the jurisdiction of the York Region, statistics from YRTSR are likely to involve Vaughan residents, employees, visitors, and those who travel through Vaughan or to nearby municipalities. YRTSR highlights the following details in Figure 1.5.2.

87% of total trips were taken by automobile

Two thirds of collisions occur at intersections

87% of pedestrian collisions occurred at intersections

Adults over 75 years old have the highest fatality rate out of all age groups in York Region

More than 50% of York Region's truck collisions happen in Vaughan

15–19-year-olds are the most likely cohort to get injured in a collision

Figure 1.5.2: Noteworthy traffic collision details from the 2021 York Region Traveller Safety Report York Region (2021)

Key Takeaways:

- Region of York residents strongly favour automobile use which likely influences Vaughan's auto-centric travel patterns.
- Intersections represent areas of concern in the Region of York as they are both the sites where most collisions occur and are especially dangerous for pedestrians.
- Within the Region of York, older adults and those aged 15-19 are a specific demographic of concern due to their high rates of injuries and fatalities due to collision.

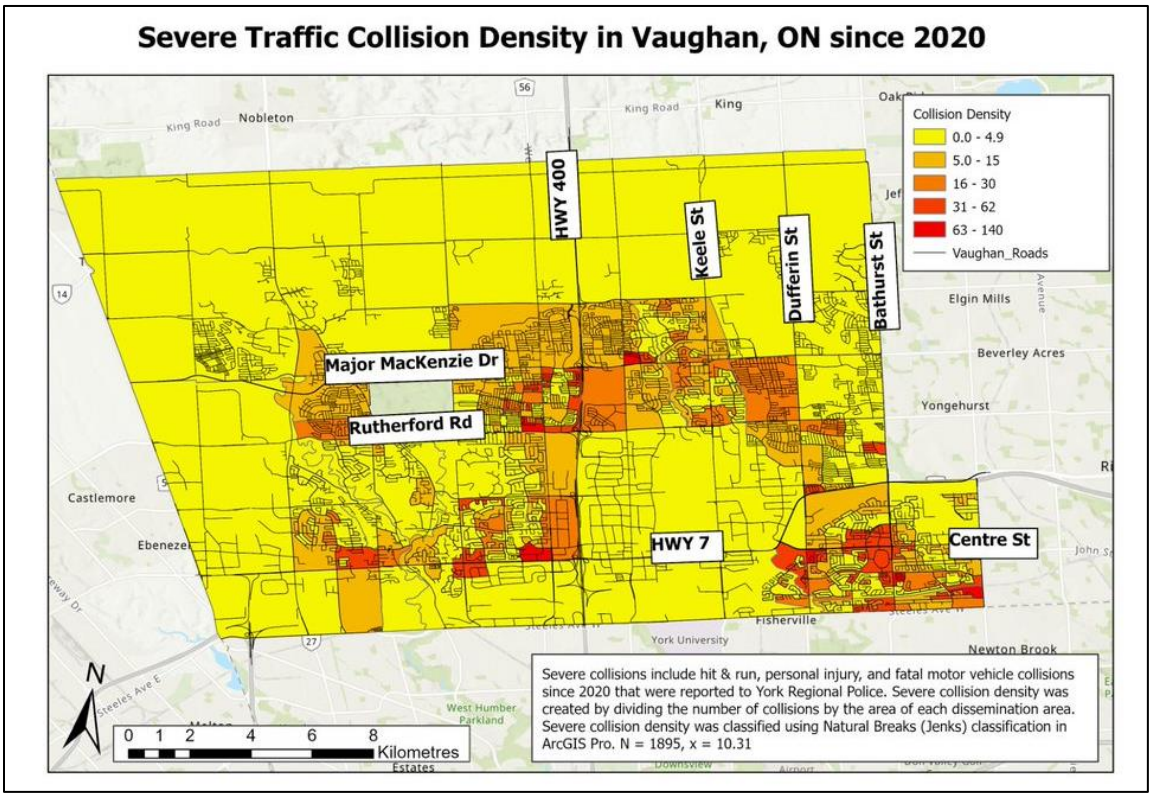
1.6 VAUGHAN CONTEXT MAPS

The most important data is where, when, and how the collisions are happening.
– City of Toronto Vision Zero Project Manager

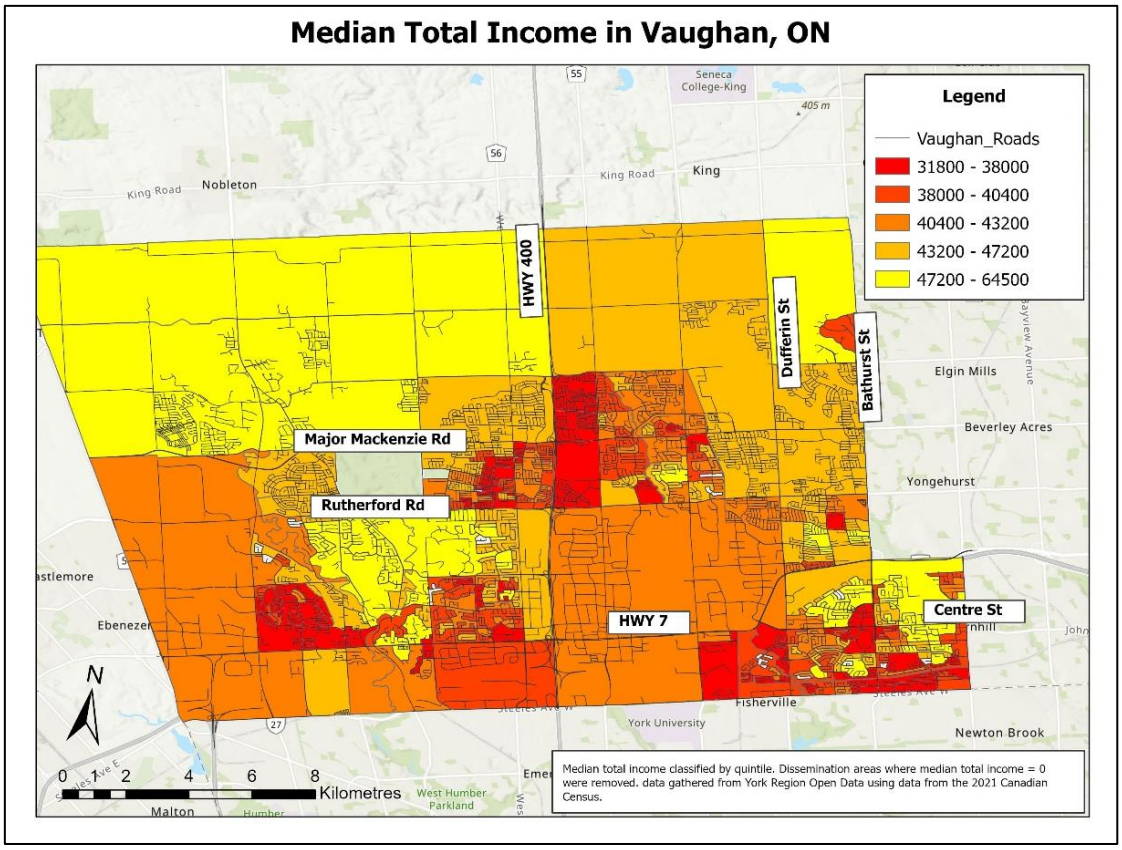
To investigate collisions that have happened specifically in Vaughan, rather than York Region, the Project Team downloaded York Regional Police's collision data since 2020 and analysed it in ArcGIS Pro. The data was filtered by collision type and separated into dissemination areas and presented in Map 1.6.1 showing the density of severe collisions across dissemination areas ("**DAs**") in Vaughan since 2020. Severe collisions are classified as motor vehicle collisions that involved a fatality, an injury, or a hit and run.

Research has shown that equity deserving groups are disproportionately affected by traffic collisions. For example, lower-income neighbourhoods are more likely to receive more non-local traffic than higher-income neighbourhoods, thereby increasing their exposure to traffic collisions (Atlantic Collaborative on Injury Prevention, 2011; Morency et al., 2012). Map 1.6.2 describes median total income distribution with DAs in red indicating lower income.

Supporting Documentation Section B offers Vaughan-specific maps which are overlayed with select socio-economic information including refugee status, single parents, and older adult population density levels.

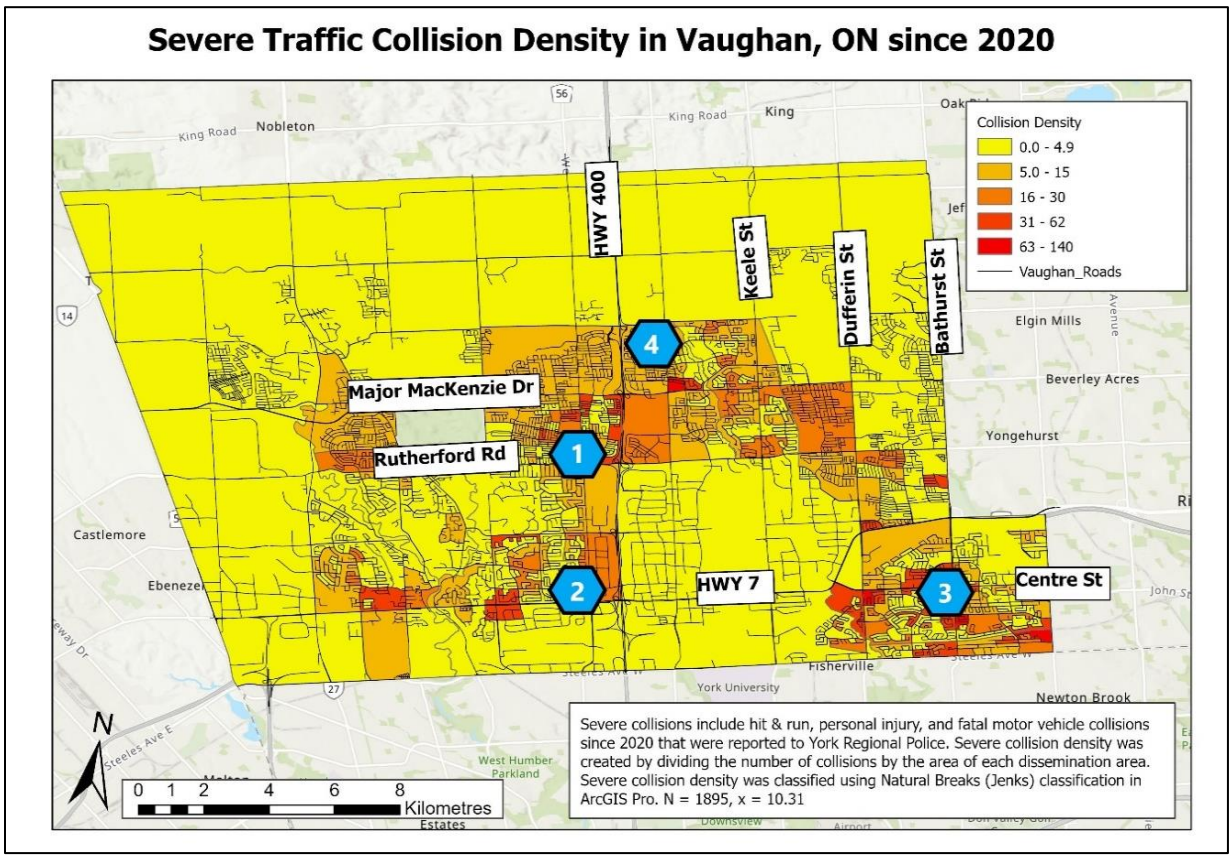


Map 1.6.1: A map showing dissemination areas with high densities of severe collisions in bright red.



Map 1.6.2: A choropleth map showing median income by quintile across Vaughan, ON in 2021.

To highlight the most affected populations, collision data was overlayed with select socio-economic information using 2021 Canadian Census data. By reviewing socio-economic information alongside collision density areas, four areas of concern emerge and are detailed in Map 1.6.3 and within following table. Note that percentages used are in regard to DA specific population.



Map 1.6.3: A map showing Vaughan's four dissemination areas with the highest levels of collisions, deprivation, and vulnerability.

Table 1.6.1: Areas of concern identified from collision analysis

Area of Concern	Equity Indicators
1 - Fossil Hill and Alba Avenue	• High level of collisions (136 collisions/km^2) • Low median income ($31,800) • Cluster of refugees nearby
2 - Ashley Grove and Windflower Gate	• High level of collisions (98 collisions/km^2) • High percentage of older adults who are low-income (38%)
3 - Promenade Shopping Centre	• Medium-high level of collisions (31 – 62 collisions/km^2) • Low median incomes ($31,000 - $40,000) • High percentage of residents older than 65 (53%) • Medium-high percentage of older adults as low-income (17-32%) • Medium-high percentage of lone parent households (18-24%)
4 - Mosque Gate and Ahmadiyya Avenue	• Low median income ($31,800) • High percentage of refugees (22%)

Key Takeaways:

- Mapping socio-economic information with collision data can help transportation planners and engineers make equitable decisions.
- Vaughan areas of concern include Fossil Hill and Alba Avenue, Ashley Grove and Windflower Gate, Promenade Shopping Centre, and Mosque Gate and Ahmadiyya Avenue.

1.7 NEWS MEDIA ANALYSIS

News media analysis helps provide context about perceptions of traffic collisions, fatalities, injuries, and overall road safety in Vaughan. The way traffic collisions are portrayed by the media may influence and potentially reinforce how traffic collisions are perceived in Vaughan. For example, how traffic collisions are portrayed, and who or what is considered at fault, is likely to influence resident and city council support of novel traffic and road safety policies.

Complete news media collision analysis, methodology, and study limitations are described within Supporting Documentation Section C.

The news media analysis used Canadian Newsstream to review 134 unique articles related to traffic collisions which occurred within Vaughan from 2017-2022. A variety of collision themes emerged from this analysis, which are described below along with inferences made by the Project Team.

VEHICLE COLLISIONS

The most frequent collision type reported in the news media analysis were those involving vehicles. Consistent with collision findings, intersection collisions were also frequently noted in the media analysis. The make or model was not always reported, but several articles connected collisions and luxury vehicle ownership (Vaughan Citizen, 2020a, 2022c). As detailed in Section 1.5, more than half of York Region's collisions involving commercial trucks occur in Vaughan, yet these vehicle collisions were not frequently mentioned. This suggests that **the media may not be accurately depicting the danger of tractor trailers and commercial vehicles.**

DANGEROUS DRIVING

The news media analysis identified several driver-specific determinants of collisions including dangerous driving, impaired driving, distracted driving, and inattentiveness. Speeding was the most frequently occurring element in the media analysis, and the most common factor influencing collisions in Vaughan (Vaughan Citizen, 2020c). In contrast, there was only one article found where the cause of collision in relation to the design of a street (Vaughan Citizen, 2021c).

Dangerous driving, specifically in regard to speeding and impaired driving, was frequently noted as a collision cause in the news media analysis. The legal consequences of dangerous driving, and recommendations to counter it, were also often noted. Several articles recommended that both drivers and pedestrians should pay attention to prevent collisions (Markham Economist & Sun, 2018). Recommendations included increasing fines and expanding automated speed enforcement from community zones to main roads (Vaughan Citizen, 2021c, 2022b). Many

articles which reference dangerous driving were focused on detailing the dangerous driver's convictions and their poor judgement. Collectively, **this suggests that there is a perception that individual choice is a significant cause to vehicle collisions, and that enforcement is an effective deterrent**.

VULNERABLE ROAD USERS

Among vulnerable road users, **pedestrians struck by vehicles were more likely to have a news article report compared to cyclists and motorcyclists**, which is consistent with the results of the YRTSR that pedestrians are the most vulnerable road user (York Region, 2021). As a result, York Regional Police provided suggestions for improving pedestrian safety, including wearing reflective clothing when walking at dusk (Vaughan Citizen, 2017a). These findings suggest that, while vehicles are involved in pedestrian collisions, news media tends to prioritize pedestrian's behaviour as a way of reducing overall collision risk.

CYCLING INFRASTRUCTURE

One news media opinion piece suggested that local roads in Vaughan do not have adequate cycling infrastructure, resulting in fewer cyclist fatalities due to less volume of cyclists (Vaughan Citizen, 2018b). Another piece suggested that even with the presence of cycling infrastructure, cyclists are not using bike lanes and instead opting to ride on sidewalks (Vaughan Citizen, 2020b). These opinions suggest that there may be a public perception that existing cycling infrastructure may not be high-quality, or designed for the cyclist to feel safe, or that cycling infrastructure is not worth capital investment by the municipality.

TRAFFIC CALMING MEASURES

Traffic calming measures aimed at reducing vehicular speed were frequently mentioned, with some Vaughan's transportation management strategy and lawn sign campaigns also noted. This indicates that the **news media can help promote novel municipal-led traffic calming strategies**. Yet, while the public were infrequently interviewed in news articles, residents offered mixed views on their value. For example, a local traffic calming advocate was critical of existing initiatives and suggested council "[likes] Band-Aid solutions… they want to placate residents, so they put signs up" (Vaughan Citizen, 2021c). This finding suggests that **Vaughan could clarify and promote the effectiveness of traffic calming initiatives**.

CHILDREN

Children and youth were frequently reported as injured or fatalities as a passenger or pedestrian. Overall, **the media reported more children involved in collisions compared to any other age demographic**. For example, in 2015, an impaired driver struck another vehicle killing three

children and their grandfather (The Brampton Guardian, 2017). Although the fatal collision occurred prior to the media analysis time period selection criterion, this story has maintained its presence in the local news media cycle, and the collision was often referenced in articles involving other impaired driving collisions, or collisions involving children. These findings suggest that **the perception of Vaughan's roads being unsafe for children may persist as a narrative in the news media, despite actual road improvements.**

POLICE REPORTING

The analysis noted that news media was used to solicit information, evidence, and witnesses to assist the police in their traffic collision investigations. Several articles acknowledged and thanked resident assistance for reporting suspected impaired driving resulting in charges through the "Safe Roads … Your Call" program (Vaughan Citizen, 2018a).

TRAFFIC DELAY INFORMATION

News articles were frequently used to provide information to residents about traffic delays, unscheduled road closures, and detours. There may be an opportunity to **review how reporting traffic delays emphasize increasing road capacity for vehicles as compared to diversifying mode share**.

EQUITY

Analysis regarding the heightened vulnerability of specific road users was not common throughout the news analysis. Child-involved collisions were frequently reported compared to any other demographic group followed by teenagers and older adults. Beyond age, other equity-deserving groups were rarely reported. Little demographic information was available in the news articles which may be reflective of the availability of demographic information available for police-reported collisions. These findings suggest that **collecting demographic information could enhance collision statistics which could also be used by news media.**

Key Takeaways:

- News media has been in used by Vaughan to promote municipal traffic policies, support police investigations, and notify residents regarding delays and road closures
- The media accurately reports that the most frequent type of collision involves vehicles within intersections, however news media may underreport collisions made by tractor trailers and commercial vehicles
- Vaughan residents have mixed opinions regarding the effectiveness of traffic calming initiatives and cycling infrastructure investments.
- Speed, impaired driving, and collisions involving children are urgent concerns for Vaughan residents, which are largely portrayed as an effect of poor individual behaviours, with enforcement being promoted as an effective deterrent to these behaviours.

2. RISKY MOVES

Objectives: To outline the causes of traffic collisions and fatalities based on research to ensure that the proposed KPIs can be analysed in ways that effectively decrease the risks of collision.

There's really no way of knowing where collisions are going to happen. It's about us trying to understand what factors lead to the potential of those collisions happening.

– City of Toronto Vision Zero Project Manager

This report uses an equity lens to recommend KPIs that favor increased overall road safety and the safety of vulnerable road users. The determinants of traffic collisions and fatalities, when analyzed over time, can be used to guide effective countermeasures that have the most impact for decreasing the risk of collision and improving overall road safety, and the outcomes of these countermeasures can be reflected in KPIs. To outline these determinants, a literature review was performed based on research performed within a North American context.

An overview of the results is listed below, with the most prominent and compounding factors described thereafter:

The in-depth literature review regarding the determinants of traffic collisions and fatalities is found in Supporting Documentation Section D.

Figure 2.1: Determinants of traffic fatalities categorized into themes that were found through an academic literature review.

Throughout the literature review, there were several prominent risks factors which are described in Table 2.1.

Table 2.1: Risk factors for traffic collision injury and/or fatality found through an academic literature review.

Risk Factor	**Description**
Pedestrians	Pedestrians are the most at risk of serious injury and fatality in the event of vehicular collision (Yannis et al., 2020).
Speed	As the speed of a vehicle increases, the fatality risk of a pedestrian increases when a collision occurs. Pedestrians are five to eight times more likely to die from collisions when the vehicle was traveling 50km/h as compared to 30km/h (ITF, 2012; Khorasani-Zavareh et al., 2015).
Vehicle Kilometres Travelled	All else being equal, traffic fatalities increase with vehicle kilometers travelled, displaying that an effective way of reducing traffic fatalities is to reduce vehicle usage (Ewing et al., 2016; Litman, 2017, 2022; Yeo et al., 2015).
Equity	Lower income, racialized communities, and other disadvantaged populations are disproportionately affected by traffic collisions, including those resulting in serious injury or death (Atlantic Collaborative on Injury Prevention, 2011; Brubacher et al., 2016; Chakravarthy et al., 2012).
Cycling Infrastructure	The implementation of cycle tracks is associated with greater cyclist safety and a reduction in collisions after adjusting for cyclist volume, while also reducing collisions in the areas surrounding the cycle tracks (Ling et al., 2020).

The risk associated of traffic injury and fatality are not static and they change depending on the relation to other risk factors. In Table 2.2, we will describe some of the relationships between, and in comparison, to other risk factors.

Table 2.2: The intersection between risk factors, and how they may lead to a greater risk of injury or death by collision.

Relationship	Description
Pedestrian activity	Pedestrian and cyclist collisions occur more frequently in areas with higher population density, largely due to increased exposure. However, it is not a linear relationship as there is a safety in numbers effect that occurs (Chakravarthy et al., 2012; Marshall & Ferenchak, 2017; Myers et al., 2013; Zhu et al., 2022).
Rural and urban	Pedestrian and cyclist traffic fatalities are more likely in rural environments; however, collision frequency is higher in urban areas (Marshall & Ferenchak, 2017, 2019; Myers et al., 2013).
Newcomers	Increased risk for traffic injury and fatality due transferring between safety cultures, transportation-planned environments, and increased traffic exposure due to higher rates of active transportation (Davison et al., 2013; Vanlaar et al., 2016).
Sprawl	Dispersed, sprawl land use development is associated with lower per capita rates of minor collisions, but significantly higher rate of fatal collisions due to the combination of more total motor vehicle travel and higher traffic speeds in dispersed, automobile-oriented areas (Ewing et al., 2016; Myers et al., 2013).
Intersections	Pedestrian injuries at an intersection increase with the addition of an extra lane of traffic, likely due to longer crossing times, increased vehicle speed, and increased traffic exposure (Stipancic et al., 2020).
Children	Children from visible minority groups or lower income families are at a greater risk of being involved in traffic collisions due to being more likely to live in a densely populated neighbourhood, increased exposure to high levels of traffic, exposure to high-speed traffic, and poor road design and maintenance (Chakravarthy et al., 2012; Davison et al., 2013; Embree et al., 2016; Harmon et al., 2020; Rothman et al., 2014).
Older Adults	Older adult pedestrians aged 65+ are at greater risk for traffic injury and fatality due to lack of all-ages pedestrian infrastructure, physical and cognitive mobility constraints, street crossing evaluation capability, lower levels of pedestrian confidence and fear of injury (Fang et al., 2018; Harmon et al., 2020; Kim, 2019; Vanlaar et al., 2016).

Key Takeaways:

- Systemic determinants of traffic injuries and collisions are more prevalent than determinants based on individual behaviours.
- Vulnerable road users are at greater risk for traffic collision and fatality.
- There can be multiple compounding factors that increase a vulnerable road users' exposure to vehicles which increases their overall risk of injury and fatality.
- Designing intersections and roadways for the maximum protection of vulnerable road users is an effective strategy for improving overall road safety.

3. HOW CITIES MOVE

Objectives:

- Provide insight to what municipalities in Canada and internationally have been doing in addressing road safety and mobility concerns.
- Analyze how municipalities have introduced and implemented their KPIs, and where that applies to Vaughan's MoveSmart Pillars.
- Examine the unique features that municipalities provide in their strategies.

Jurisdictional review methodology and extended municipal performance measures and actions from Edmonton, Toronto, and Lethbridge are detailed in Supporting Documentation Section E.

The project team composed this section to introduce some of the municipalities that inspired our 20 chosen KPIs (found in Section 4 of the report). We chose to highlight seven municipalities that featured important road safety mobility strategies that were supported with KPIs, interviews, and document analysis. **The purpose of this chapter is to introduce examples of what other cities are doing to address traffic-related issues and incorporate Vision Zero aspects into their strategies.**

Each city has different evaluation methods, therefore, not all evaluation results are the same. It should be noted that not all cities have recorded data to prove the effectiveness of their programs or initiatives, but the majority are able to create priority lists and describe how they evaluate their progress by using data, research, and KPIs. Additionally, cities explore their outcomes by creating key actions that help frame road safety or mobility programs, listing present and future initiatives that addresses the 3Es (Engineering, Enforcement, and Education), collaborating with other municipal departments, and engaging with the public to understand their experiences as road users. The outcome section of each municipality looks at the actions taken to implement the road safety plan or mobility strategy that are related to a MoveSmart Strategy pillar. Interviews were conducted with staff members from the City of Ottawa, the City of Calgary, City of Toronto, the City of Lethbridge, and the Region of Durham, which helped inform the Project Team of project outcomes. Overall, the purpose of this section was to highlight growing, urban and suburban municipalities who align with Vision Zero within road safety goals and conducted a jurisdictional review to identify road safety KPIs to determine the socio- economic and spatial determinants of traffic-related fatalities and injuries, and how they are measured.

City of Ottawa	**Road Safety**
Program Background	The City of Ottawa ("**Ottawa**") introduced the "Think Safely, Act Safely" program to promote road safety for all road users, and guide development to incorporate better road safety designs (City of Ottawa, 2020). Ottawa previously implemented two strategic road safety action plans and has expanded a third version, the *2020-2024 Road Safety Action Plan* ("**RSAP**"), to eliminate collisions that result in serious injury or fatality by 2035. Currently, the overarching goal is to see a 20% reduction in fatal and severe injury collision by 2024
Implementation	In 2020, the City invested approximately $27.5 million, which included a one-time $4 million addition to implement measures identified in the RSAP (City of Ottawa, 2021). These measures were created to address collision types leading to death or serious injury for all road users, including drivers, passengers, pedestrians, cyclists, and motorcyclists. In 2021, the City allocated approximately $33.8 million to other existing road safety programs (City of Ottawa, 2021).
KPIs	Ottawa has one key performance indicator: *The percent reduction in the rate of fatal and major injury collisions*.
Outcomes	The outcome is to encourage a road safety culture that will help reduce the future frequency of FMI collisions city-wide. Ottawa also developed a list of priority areas for road safety, known as Emphasis Areas: Vulnerable Road Users. Rural Areas, Intersections, High-Risk Driver Behaviours**.** Ottawa targets these areas through additional actions and programs in order to reduce overall FMI and reduce collisions.
Lessons Learned	One key finding from the interview was discovering that "20% of major collisions happen in rural areas." Ottawa noted that between 2013 and 2017, the rural area accounted for approximately one third of the fatal collisions (City of Ottawa, 2019). As a result, there is a greater emphasis to make rural roads safer by developing functional designs at rural intersections, as well as adding cameras, stop signs, and LED beacons. Additionally, Ottawa is implementing maintenance priorities and enforcement measures that are practical for rural areas (City of Ottawa, 2020).

City of Edmonton	**Road Safety - Public Engagement Model**
Program Background	In 2015, the City of Edmonton ("**Edmonton**") adopted Vision Zero with the goal of creating a city that is safe, comfortable, and easy for all people to navigate. In developing their *Safety Mobility Strategy (2021-2025),* Edmonton introduced a philosophy and approach called *Safe Systems Approach which* focuses on human life and health as a crucial part of navigating the environment (City of Edmonton, 2021d).
Implementation	Edmonton invested approximately a total of $42.1 million dollars in the 2021 Traffic Safety Funding, including: $12 million for the City of Edmonton Vision Zero Program, $22.3 million for Edmonton Police Service, and $8 million for the Community Facility Partner Capital Grant Program.
KPIs	• *Number of Safe Crossings projects completed* • *Number of School Safety projects completed* • *Number of engineering improvements on the High Injury Network* • *Number of Traffic Safety Community Activation projects* • *Number of hours of enforcement in High Crash Neighbourhoods*
Outcomes	Edmonton has seen positive outcomes in traffic safety. For example, the *2021 Crash Trends and Causes* report demonstrated reductions of 50% in traffic-related fatalities, 32% in serious injuries, and 27% in pedestrian fatalities and serious injuries, since 2015 (City of Edmonton, 2021c). Edmonton also composed *Community Outcomes*, which are actions and measures related to traffic safety culture change such as the performance, behavior, and perceptions of its residents.
Lessons Learned	Edmonton created a *Crash and Equity Analysis*, to utilize data and lived experiences in addressing how residents are affected by road safety and illustrate where collisions are happening as well as the different types of collisions. They also introduced an equity analysis component to address the inequities within the transportation system and how it impacts various communities (City of Edmonton, 2021a). Of particular note, Indigenous Peoples and People of Colour may have different levels of opportunity and comfort when engaging with government agencies. There is hesitation and limited opportunities for racialized residents to participate in engagement due to lack of cultural and community-based approaches, which Edmonton accounts for in its strategies.

City of Calgary	**Road Safety**
Program Background	The City of Calgary's ("**Calgary**") *Safer Mobility Plan* adopts a Vision Zero approach to road safety by prioritizing the five Es of transportation safety (engagement, engineering, education, enforcement, evaluation) (City of Calgary, 2019). The *Safer Mobility Plan* is locally and contextually situated, evidence-based through a Safer Systems approach, achieved through partnerships, and recognizes how investments in road safety lead to cost savings. The Plan is in its second iteration and builds off the momentum from the 2013 – 2017 plan.
Implementation	Calgary is shifting from complaints-based to data-driven solutions using collision data. According to municipal staff member, it "provides more of an objective look at where issues are." Collision data can be used to identify high-collision areas and make improvements to reduce collisions. In addition to data collection, analysing video-based conflicts and measuring near misses are more proactive approaches that can be relatively low cost. Calgary places cameras to collect data at intersections in both high-collision locations as well as locations that do not receive complaints. The data is collected by the municipality, while analysis and reporting are outsourced. Aside from conflict analysis, Calgary relies on police-reported collisions and hospitalization data.
KPIs	• *Collisions resulting in fatality and severe injuries, specifically for vulnerable road users* • *Comfort level of vulnerable road users at certain locations with a specific focus on neighbourhoods*
Outcomes	In the last year, there have been 10 fewer collisions and an overall 7.4% reduction in major injury and fatal collisions allowing leading to over $100 million dollars saved in social costs (City of Calgary, 2022). The Calgary interviewee noted how knowledge acquired during educational campaigns can be measured using social surveys and speed observations. Calgary was able to prove the effectiveness of the educational campaign by surveying the general public about their

	understanding as well as measuring actual behaviour from speed data before and after harmonization. In terms of road safety outcomes, Calgary's total collisions decreased by 13% and its pedestrian collisions decreased by 23% in 2020. However, in the same year its bicycle and motorcycle collisions increased by 21% and 12% respectively
Lessons Learned	The interviewee revealed that Calgary purposely measures fewer KPIs and that "when it comes to providing information to the general population, less is more". Calgary also noted that the exact numbers of collisions, fatalities and injuries are easier to understand as compared to rates.

City of Toronto	**Mobility Management**
Program Background	The City of Toronto (“**Toronto**”) uses its *Congestion Management Plan 2016-2020* (“CMP”) to better manage congestion and improve safety through innovation and technology to maximize the efficiency, reliability, and sustainability of the road network (City of Toronto, 2015).
Implementation	The CMP combines efforts from multiple city departments and agencies to implement the objectives of the strategy and has a budget of about $57 million (Moore, 2013). In terms of data collection, Toronto tracks vehicle speed and volumes by laying down road tube traffic counters and using GPS and Bluetooth data. Toronto can also collect data on turning movements, controlled crossings, and vehicle near-misses from cameras being used at select road intersections. This data then gets analysed by Toronto’s transportation planning departments to inform future road modifications and plans.
KPIs	• *Community Safety Zone installed* • *Senior safety zones installed* • *School safety zones installed* • *Traffic signals and pedestrian crossovers installed* • *Pedestrian head start signals installed* • *Red light cameras installed* • *Accessible pedestrian signals installed* • *LED Blank-out signs installed*
Outcomes	Toronto’s outcomes and programs directed by the CMP including corridor’ studies and arterial camera programs and are found in Supporting Documentation Section E.
Lessons Learned	The interview conducted with a Vision Zero Project Manager from the City of Toronto noted how collaboration between municipal departments and organizations was key to its success. By collaborating with data specialists at the City, Toronto is working on a midblock predictive technology where they may be able to determine the most at-risk intersections prior to citizen complaints or a police report due to a collision. Another example of collaboration reported from the interview was the importance of involving other departments,

such as the police, in road safety initiatives since they are the ones responsible for enforcing any new regulations. These lessons can extend to mobility management since they reveal the importance of sharing information between organizations and departments to implement effective strategies.

The interviewee made it clear that that it can be difficult to attribute change in KPIs to initiatives undertaken by the City because of the number of variables involved and the time it takes for initiatives to affect behavior. The Project Manger notes, “there’s really no way of knowing where collisions are going to happen. It's about us trying to understand what factors lead to the potential of those collisions happening.”

City of Lethbridge	**Mobility Management**
Program Background	The City of Lethbridge (“**Lethbridge**”) is a growing suburban municipality in Alberta and in 2020, implemented its *Transportation Safety Plan* (“***Plan***”) with a vision of eliminating deaths and injuries by 2040 (City of Lethbridge, 2020b). Between 2012 and 2016, there were 2,175 traffic collisions resulting in injury and 11 fatal collisions (City of Lethbridge, 2020a).
Implementation	The *Plan* notes staff resources and funding allocations are required to create a culture of transportation safety (City of Lethbridge, 2020a). Lethbridge recommends using diverse revenue streams to fund its projects, such as revenue from manual and automated traffic violations. The use of automated enforcement violations as a revenue source is common in Alberta as noted by a key informant road safety expert. If implementing automated speed enforcement, educating the public on the location of each camera and justification beyond revenue is important for public support.
KPIs	• *Reduction in pedestrian-related injuries* • *Increase in vehicle yield compliance* • *Reduction in night-time pedestrian and bicycle collisions* • *Injury collisions at intersections* • *Right-angle collisions at intersections* • *Injury collisions at signalized intersections* • *Right-angle collisions at signalized intersections* • *Reduction in severe collisions at intersections* • *Reduction in pedestrian collisions*
Outcomes	Lethbridge is among the first Canadian municipalities to implement Variable Speed Limits and introduced this technology to prevent collisions caused by adverse weather conditions. Although not publicly reported, these technologies significantly reduced the number of collisions during winter driving snowstorms (City of Lethbridge, 2020a). Variable Speed Limits help contribute to the goal of reducing severe collisions by 50% within 10 years.
Lessons Learned	The Plan estimates the social cost of collisions occurring annually total $130 million. To achieve a safer and more efficient roads for all road users, Lethbridge has implemented various traffic signal systems at locations based on high-risk collision potential (City of Lethbridge, 2020a).

Region of Durham	**Sustainable Mobility**
Program Background	The Region of Durham ("**Durham**") adopted a multi-pronged approach within the transportation planning group to tackle safe mobility initiatives. The Active Sustainable School Program ("**ASST**") under the overall Smart Mobility Durham ("**SMD**") initiative in particular, is an action-oriented program that collaborates with relevant community stakeholders, with aim to improve school zone safety, and encourage more students to walk, cycle and take the bus (*Smart Mobility Durham Program*, 2022).
Implementation	The effectiveness of the ASST program lies in its proactive approach and continuous engagement efforts with community stakeholders. A 6-step approach is used to create school travel plans which includes *"Convene, Observe, Plan, Implement, Evaluate and Keep it going"*, throughout the duration of the program's initiation, formation, implementation, and evaluation cycle. By using materials and delivery methods that are relatable and understandable for the target audience, messages are well communicated and received. Durham funds active transportation projects independently of other road reconstruction projects to fast-track active transportation improvements. At the same time, Durham is well aware that last mile facilities such as bike racks and lockers needed to complete the purpose of promoting active transportation. It is essential to ensure that the requirement is embedded in the built form during new builds, as retrofitting is expensive.
KPIs	• *Number of collisions resulting in fatality and serious injury* • *Kilometres of roads that has implemented Active Transportation initiatives* • *Mode share target by 2031 for active transportation and transit*
Outcomes	While few outcomes are currently available, Durham aims to achieve a ten percent reduction in fatal collisions and serious injuries by 2023 (Region of Durham, 2018).

Lessons Learned	Larger scale road safety programs such as the *2021 Regional Cycling Plan* and the data-driven transportation planning tool require Durham to collaborate with a wider range of stakeholders such as the lower tier municipality, the University of Toronto, Transportation Tomorrow Survey, and the Ministry of Transportation in order to more accurately model the travel needs and patterns for the future.

Halifax Regional Municipality	**Sustainable Mobility**
Program Background	The Halifax Regional Municipality ("**Halifax**") is a growing port city with 77% of trips being made by private vehicle in 2016 (Halifax Regional Municipality, 2017). In 2018, Halifax adopted the *Integrated Mobility Plan* ("**IMP**") which contains a series of policies, guidelines, actions, and measures to promote sustainable modes of travel and supporting land use policies with the overarching goal of achieving a minimum transit and active transportation mode share of 30% (Halifax Regional Municipality, 2017).
Implementation	The IMP provides the framework to guide transportation planning until 2031 and its list of actions were budgeted at $190 million (Halifax Regional Municipality, 2017). Halifax used an inter-departmental, inter-disciplinary, and internal team to develop the IMP and split actions into three categories consisting of short-, medium-, and long-term timeframes. Halifax further categorized these actions by level of effort, resources, and integration type. It is unknown how Halifax chose which ones to prioritize based on these categories, but the IMP provides the reader with a good understanding of what Halifax's goals and measures are, compared to other municipal plans.
KPIs (Sustainable Mobility Only)	• *Transportation Mode Share* • *Kilometres of Regional Centre 'AAA' bicycle network completed* • *Percentage of residents within 500 metres of bicycle route* • *Percentage of streets with sidewalk* • *Average commute duration for cyclists (minutes)* • *Average commute duration for pedestrians* • *Average commute duration for drivers (minutes)*
Outcomes	Halifax shared the IMP's *Implementation Update* published in 2021 with the following highlights: • Halifax built 8 kilometers of 'AAA' bikeways, increasing the inventory of 'AAA' cycling facilities to 19.7 kilometers, which is 34% of the planned network • Over the last three years, Halifax added approximately 19.6 kms of sidewalk and 18.5 kms of multiuse pathways

	• Halifax has implemented 25 Leading Pedestrian Intervals, 24 Rectangular Rapid Flashing Beacons, and 93 Accessible Pedestrian Signals
Lessons Learned	IMP describes how data used to measure KPIs will be obtained, how frequently KPIs will be measured, and identifying who is responsible for collecting and publishing the data (Halifax Regional Municipality, 2017). Despite significant progress made, the IMP's mode share goals have not been achieved as of yet. This finding highlights the delay that is inherently involved in sustainable transportation projects that require long periods of time before change is reflected in the data.

Rotterdam, The Netherlands	**Traffic Data Management**
Program Background	Rotterdam in the Netherlands has spearheaded efforts in developing and implementing an Intelligent Transportation System ("**ITS**") for road safety to proactively identify and address the unsafe road features at high-risk locations (International Transport Forum, 2020). Using a self-learning algorithm, the model was trained with approximately 1,500 variables with data from 2014 to 2018. The first iteration of the model correlated the historical crash data with physical data such as traffic, road features, buildings, and environmental data such as weather, and time.
Implementation	The ITS works by ranking areas of the road network between 1 and 5, offering road network improvements, and indicating the risk factors of the network. The system can accommodate for changes in car traffic levels, or the presence of on-street parking. The system can also run "what-if" scenarios to test the outcomes of proposed road improvements.
Outcomes	The ITS helped Rotterdam select streets and intersections to prioritise in infrastructure programs by focusing on locations with high-risk scores. The results from the model were combined with subjective data from people's experiences, including places that generate many citizen complaints concerning exposure to risk. If a connection between the outcome of the model and locations with many crashes or complaints of citizens, Rotterdam gave priority to this specific location to receive an intervention (International Transport Forum, 2020). The city performed an accuracy test of the model which found that 81% of the road sections and 96% of intersections labelled with a high-risk score matched with one or more traffic casualties that were unknown to the model (International Transport Forum, 2020).
Lessons Learned	The reliability of the ITS and its machine-learning features provide an insight into the future of traffic data collection and analysis. Because of its accuracy and demonstrated success, Rotterdam continues to develop the model further and the Rotterdam Police are hoping to use it for creating a more detailed crash database.

KEY TAKE-AWAYS

- The lessons learned from the strategies used by cities described in the section can provide insights for the future iterations of Vaughan's MoveSmart Strategy.
- There is a recognition of a paradigm shift or a new way of thinking among suburban municipalities. Encouraging sustainable modes of transportation and creating a culture of road safety require refocusing attention to non-vehicle road users.
- Many strategies contain long- and short-term goals and have their own "pillars" organised by themes, policies or focus areas and it is common to identify which department or staffing position is responsible for each activity or metric.
- Data-driven models can be proactive in addressing road condition deficiencies. When used in tandem with resident complaints, it can address equity concerns. A data-driven model can make more information available to be shared with the public on a periodical basis. At the same time, it is important to recognize resident lived experiences when addressing inequities and systemic barriers related to transportation.

4. SMART MOVES

Objectives:

To provide Vaughan with a set of KPIs that can be implemented for the MoveSmart strategy. Informed by the reflections from the previous sections, the KPIs in this section are tailored for Vaughan's current transportation landscape and context.

To align with the project goal of identifying KPIs as well as embedding equity in the approach, the Project Team focused on growing, urban and suburban municipalities who have pledged to Vision Zero within road safety goals and conducted a jurisdictional review to identify road safety KPIs to determine the socio- economic and spatial determinants of traffic-related fatalities and injuries, and how they are measured.

Vision Zero is a strategy to eliminate all traffic fatalities and severe injuries, while increasing safe, healthy, equitable mobility for all. It prioritizes preventative, data-driven, and evidence-based measures over reactive or complaints-based measures.

4.1 KPI DISTILLATION PROCESS

A total of 378 KPIs were gathered through the jurisdictional review process. A number of selection criteria were established to reduce this number to the proposed twenty by incorporating reflections from the previous chapters and by considering vulnerable road users.

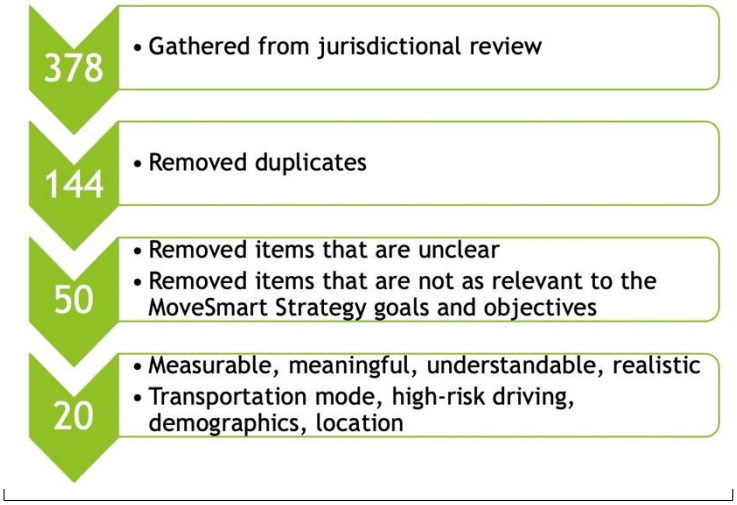


Figure 4.1.1: The Project Team's KPI distillation process.

A detailed KPI distillation process and list of 50 KPIs can be found in Supporting Documentation Section F. As the MoveSmart strategy evolves, alterative or additional KPIs may be required.

4.2 CATEGORIZING KPIS

Qualitative KPIs may not specify what outcome or output is expected to happen. Relatedly, general terminology such as reporting directional changes does not quantify metrics either. These KPIs may limit the ability to assess the municipality's efforts objectively and transparently. There are different ways to categorize KPIs depending on the focus it aims to serve. KPIs can be categorized into collision or non-collision KPIs or categorized by process as output or outcome KPIs.

Collision KPIs are common and measure traffic collisions, injuries or fatalities and interviewees directly noted including this KPI because of the Vision Zero approach. Related to this category include high-risk driving KPIs such as speeding, and traffic violations captured through enforcement. Non-collision KPIs measure related elements of the transportation system such as transportation behaviour, engagement and education, land-use planning and development policies, and infrastructure and engineering projects or programs.

Output KPIs measure tangible outputs, or activities completed, resulting from policies or initiatives, where as outcome KPIs relate to the ultimate effect of the transportation system on a community (Haas et al., 2009; Steinemann, 2012). For example, reporting the number of traffic collision fatalities and injuries and ultimate reduction as an outcome KPI, but this can take time. Reporting activities that attempt to contribute to reduced collisions is an output KPI. Interviewees noted using a combination of output and outcomes KPIs as output can be used to measure short term progress.

The set of KPIs, found in table 4.2.1, are the most suitable to monitor and evaluate the MoveSmart Strategy given Vaughan's current transportation landscape and context, while being measurable, meaningful, understandable, and realistic.

Table 4.2.1: Twenty Smart Moves for the MoveSmart Strategy by pillar and by outcome and output KPI. KPIs marked as a target represent Outcome KPIs, and KPIs marked as a checkmark represent Output KPIs.

Key Performance Indicator				
Rate of killed/seriously injured per 100,000 population	◎			
Rate of killed/seriously injured per 100,000 population at intersections	◎			
Number of engineering improvements installed in high-collision areas	☑			
Number of community presentations given	☑			
Number of in-service road safety reviews completed	☑			
Number of engineering improvements for standalone active transportation projects completed	☑			
Number of automated enforcement cameras installed	☑			
Number of community safety zones implemented	☑		☑	
Percentage change in high speeds		◎		
Number of streets with posted speed limit of 40 km/hour or below		☑		
Curbside parking utilisation rate		◎		
Average commute time by transportation mode		◎	◎	
Vehicle kilometres travelled per capita			◎	
User perception of walking, cycling or transit as a transportation option	◎		◎	
Percentage of students using active transportation to school			◎	
Percentage of residents with access within 500m (or 10 minutes non-auto travel time) from bicycle route and transit network			☑	
Mode shares for all trips			◎	
Kilometres of new, protected bicycle infrastructure constructed each year			☑	
Number of data collection and analysis reports completed within one year				☑
Number of active transportation volumes counts administered			☑	☑

4.3 LIST OF PROPOSED KEY PERFROMANCE INDICATORS

Rate of killed and / or seriously injured per 100,000 population
Outcome KPI

Inspired by:
Surrey Ottawa Surrey Manitoba Fort Saskatchewan St. Albert Toronto

Related Section in this report: 1.5 | 1.6 | 1.7 | 2.0

Rationale:

The rate of killed and / or seriously injured per 100,000 population is one of the most widely used road safety KPIs for municipalities to assess their progress in achieving the goal of Vision Zero. Measuring the rate of killed and / or seriously injured by traffic collision is typically reported as a whole number to adjust for demographic trends and to be consistent with other municipalities and international standards.
While it is calculated as an all-encompassing rate, the KPI can be divided into sub-categories such as:

- Mode of transportation (supported by background findings)
- Demographics such as age group, sex/gender, race/ethnicity (equity lens)
- By ward (to focus on equity deserving groups neighbourhoods identified in section 1.6)
- Month and time of day

Target:

Vision Zero cities hope to achieve zero injuries and fatalities. Reduction targets from the cities cited above range between 15% to a more ambition goal of 50% achieved between 4 and 10 years.

Rate of killed and / or seriously injured per 100,000 population at intersections
Outcome KPI

Inspired by:
St. Albert Ottawa Surrey Lethbridge Durham

Related Section in this report: 1.5 | 1.6 | 1.7 | 2.0

Rationale:

Intersections are high collision locations in York Region as highlighted in the Traffic Collision Data Analysis section. Reporting this KPI as a calculated percentage of total collisions involving serious injury or fatality can provide a focused evaluation of the success of the MoveSmart Strategy's measures at intersections.

While it is calculated as an all-encompassing rate, the KPI can be divided into sub-categories such as:

- Mode of transportation
- Demographics, such as age groups, sex/gender, race/ethnicity

St. Albert, for example, uses collision data recorded at intersections to identify the most dangerous intersections that require interventions, and for testing the success of the interventions once time has passed.

Target:

Intersection collision reduction targets vary by city. For example, Surrey aims to reduce collisions by 15% in 5 years, while Lethbridge aims to reduce them by 50% over the next 10 years.

Number of engineering improvements installed in high collision areas
Output KPI

Inspired by:
Edmonton San Francisco Saint John New York City

Related Section in this report: 1.5 | 1.6 | 2.0

Rationale:

Engineering projects aim to reduce vehicle speed, increase visibility between road users, and reduce conflicts at high collision areas, such as intersections. Examples include pork-chop islands, speed bumps, and curb extensions. This KPI measures both the short-term, low-cost, or temporary measures such as pavement markings and signage, as well as longer-term and permanent investments such as the image of the right in right out turn prohibition.

This KPI measures the number of engineering projects that have been implemented to track the progress Vaughan has made. These projects are ideally implemented based on data and equity considerations and placed in areas that are unsafe to non-vehicle road users.

Target:

In City of Edmonton's case, since Vision Zero was adopted in 2015, more than 300 crossings have been improved using funds from the Traffic Safety Automated Enforcement Reserve. The total number of projects varies from year to year, but 48 locations have been identified for 2022.

Total number of community presentations given
Output KPI

Inspired by:
Calgary New York City Strathcona County Fort Saskatchewan

Related Section in this report: 1.4 | 1.6 | 1.7 | 5.0

Rationale:

This KPI intends to measure the effort in creating opportunities for public dialogs and education. Presentations and engagements contribute towards creating a culture of safety through public dialogue. Equity consideration places more focus on vulnerable pedestrians such as children, youth, seniors, as well as in high-collision neighbourhoods.

Community presentations and messaging should be tailored to specific groups and create the opportunities to gain additional insights for ways of enhancing an existing road system.

The KPI should be measured by total amount of presentations given, and it should also be measured by ward. This will allow Vaughan to cross-reference the results of this KPI with the measure of killed and seriously injured in traffic collisions.

The target for this KPI can be at least one community presentation at each of the schools and community centres in each high collision neighbourhood within a given period of time.

Number of in-service road safety reviews completed
Output KPI

Inspired by:
St. Albert Montreal Strathcona County

Related Section in this report: 1.5 | 1.6 | 1.7 | 2.0

Rationale:

In-service road safety reviews are administered by several municipalities on a regular basis, and often in response to fatal collisions. The format and contents can vary by municipality, but generally assesses how the road's current state contributed towards the collision. Reviews that are regularly administered survey risks that roads present to all road users that could potentially lead to a collision in the future.

It is recommended that Vaughan starts conducting road safety audits of its high collision areas and tracks the number of audits completed by ward. The number of audits completed can inform the public of the progress being made on improving road safety across the city, while documenting which roads pose the highest risk.

Target:

The Montreal Fatal Post-Collision Analysis Team analysed 22 fatal collisions in 2020.

Number of engineering improvements for standalone active transportation projects completed
Output KPI

Inspired by:
Toronto Saint John Lethbridge Brantford Montreal Edmonton St. Albert
Arizona Durham Regina New York City Strathcona County

Related Section in this report: 1.5 | 1.6 | 1.7 | 2.0

Rationale:

This KPI focuses specifically on engineering projects completed to improve the active transportation network. Examples include bike lanes, bike boxes, curb extensions, pedestrian crossovers, and curb-radius reductions. This KPI measures the progress made on shifting attention towards non-automobile users and the promotion of active transportation.

Many jurisdictions have indicated their progress in achieving a more welcoming sustainable transportation environment by addressing the needs of road users other than cars. This KPI would help steer the focus of the Vaughan council and its decision makers effectively.

Target:

New York City completed turn calming treatments at 44 of the 50 most dangerous intersections to improve cyclist safety in 2020 (New York City, 2021).

Number of automated enforcement cameras installed
Output KPI

Inspired by:
Guelph Toronto Brantford Durham
Fort Saskatchewan Strathcona County

Related Section in this report: 1.4 | 1.5 | 1.6 | 1.7 | 2.0

Rationale:

In response to residents' concerns around speeding in Vaughan, this KPI is necessary to measure the progress made on installing automated enforcement cameras and the impact they can have on driving behaviour before and after the installations. As monetary fines are typically associated with this type of violation, automated enforcement cameras are cost effective over the long run as they can generate positive return on investment.

This KPI should be measured by total cameras installed, and cameras installed by ward. This is to understand if these road safety measures are being installed equitably. Using this KPI alongside collisions by ward will help determine where enforcement cameras should be installed.

Target:

The number of automated enforcement cameras installed varies by city, depending on budget availability and balance of works in the pipeline. For reference, Guelph is scheduled to have six locations operational with red light cameras, while Toronto has a target of implementing 95 automated enforcement cameras by the end of 2022.

Number of community safety zones implemented
Output KPI

Inspired by:
Montreal Edmonton Guelph Saint John Toronto

Related Section in this report: 1.5 | 1.7 | 2.0

Rationale:

Safety zones are traffic calming measures located in priority locations aimed to reduce vehicle speed. This measure tracks the number of areas used to create a safer road environment for the vulnerable populations.

As an escalated monetary fine is associated with speeding violations within the safety zones, this KPI can serve as both an effective engagement tool with the communities, and an enforcement mechanism to deter undesirable aggressive driving behaviour.

The number of community safety zones implemented should be measured by total zones implemented, and zones implanted by ward. Over time, this KPI can show the effectiveness of safety zone implementation when used alongside other road safety KPIs that are measured by ward.

Target:

Toronto aspires to install 100 community safety zones in 2022.

Percentage change in high speeds (85th percentile speed)
Outcome KPI

Inspired by:
Lethbridge St. Albert Spruce Grove

Related Section in this report: 1.4 | 1.5 | 1.6 | 1.7 | 2.0

Rationale:

The 85th percentile speed is the speed at which 85% of the drivers travel on a road segment, therefore it tracks the majority of traffic speeds and excludes the speeds of dangerous drivers.

Speeding is a common concern for Vaughan given its land use pattern and the driving culture. This KPI tracks the prevalence of speeding and the effectiveness of speed reduction measures before and after initiatives have been implemented.

The extended version of this KPI can examine specific sub-areas of Vaughan to provide more detailed analysis of driver behaviour to aid program evaluation efforts in specific neighbourhoods.

Number of streets with posted speed limit of 40 km/hour or below
Output KPI

Inspired by:
Saint John

Related Section in this report: 1.4 | 1.5 | 1.6 | 1.7 | 2.0

Rationale:

Road safety literature and reports highlight that a reduction in vehicle travel speeds reduce severity of injuries and fatalities. In response to the residents' concern around speeding in Vaughan, this KPI can serve as a status update at periodical intervals to signal the policy shift towards safer streets, as well as improved system protection for the vulnerable road users.

It is also suggested for this KPI to be separated by ward in order to ensure that 40 km/h speed limits are being implemented equitably across Vaughan's neighbourhoods.

Target:

Saint John reduced the speed limit of 14 streets to 40 km/h in 2022 (Perry, 2022).

In 2010, the City of Edmonton reduced the posted speed limit in six residential communities from 50 to 40 km/h and found that mean free-flow speed reduced by 4.88km/h after 6 months (Islam, El-Basyouny & Ibrahim, 2014)

Curbside parking utilization rate
Outcome KPI

Inspired by:
Halifax

Related Section in this report: 1.3 | 3.2

Rationale:

Measuring on-street parking utilisation rates is the first step to making a fair assessment of the true economic value of land which is currently used as on-street parking. If measured at an ongoing basis, this KPI can establish a parking demand trend for Vaughan, to corroborate with its transportation and transit demand. Underutilized parking space can be converted into greenspace, patios, bike lanes, bus lanes, etc. in order to support Vaughan's other priorities.

On-street parking should be priced to reflect Vaughan's desire towards reducing congestion, safer roads, and offering more sustainable mobility options, so that the existing infrastructure can be best utilised as-is or transformed into active transportation related infrastructure.

Target:

Richard Willson suggests in *Parking in the City* (2018) that parking spaces should have a vacancy rate of 10-15% in order to maximize use and revenue, while preventing too many cars from searching for parking spaces.

Average commute time by transportation mode
Outcome KPI

Inspired by:
Halifax

Related Section in this report: 1.1 | 1.2

Rationale:

A predictable travel time is of key interest to most road users, not only to address congestion concerns, but also to provide insight into volume, capacity, and condition for level of road services. To improve the quality of infrastructure for all road users, it is important for Vaughan to understand the current experience of all road users, to measure the progress of the MoveSmart Strategy implementation meaningfully.

Traffic congestion is a primary concern for many Vaughan residents. As the City of Vaughan encourages sustainable travel modes and improves its active transportation network, it must document the changes in commute time for all road users to measure progress.

As Vaughan looks to improve active transportation infrastructure and enhance traffic signal operations, Vaughan should expect average commute duration to go down over time, however it may take time to observe significant change.

Target:

Halifax collects this data from Statistics Canada and found that it takes cyclists 21 minutes to get to work and 16 minutes for pedestrians to get to work.

Vehicle kilometres travelled per capita
Outcome KPI

Inspired by:
Halifax Lethbridge Regina Peterborough
Owen Sound

Related Section in this report: 1.2 | 1.3 | 1.4 | 1.7 | 2.0 | 5.0

Rationale:

Vehicle kilometres travelled (VKT) is a common measure to gauge auto-dependency used in many cities. We recommend Vaughan to track VKT per capita in order to account for Vaughan's growing population and measure auto-dependency on an individual basis.

As Vaughan encourages more trips being made by sustainable modes, Vaughan must track the number of vehicle kilometres travelled per capita. In order to mark the progress made towards sustainable travel modes, this KPI should result in a decrease in kilometres travelled by vehicles. In doing so, it can justify and support the transportation initiatives implemented by Vaughan that encourage sustainable travel.

As discovered through the literature review, vehicle kilometres travelled is typically correlated to a greater number of traffic collisions. Reducing vehicle kilometres travelled will in turn, make roads safer. VKT per capita is an effective KPI to measure alongside rate of killed and seriously injured by traffic collisions.

Halifax uses VKT as a performance indicator of its Integrated Mobility Plan and states that it will collect VKT data from Statistics Canada to evaluate its progress every 5 years.

Every additional kilometre driven incurs some risk. Even if it's a low-risk kilometre, if you do enough of them, you're going to have a crash.

– Academic Transportation Researcher

User perception of walking, cycling or transit as a transportation option
Outcome KPI

Inspired by:
Calgary Edmonton Halifax Spruce Grove
Strathcona County New York City

Related Section in this report: 1.2 |1.4 |1.7 | 2.0

Rationale:

Public perceptions of sustainable travel modes are insightful indicators for Vaughan to know about the residents' willingness to choose an alternative mode of transportation to a private vehicle. It is possible that the perception can be lagging due to socio-economical and psychological reasons outside the influence of the MoveSmart Strategy. However, a positive change should be a fair reflection of the overall improvement towards more equitable road sharing.

The data needed for this KPI can be acquired through surveys to assess road safety management, for the KPI to be reported as a proportion of the survey sample population. The survey should also inquire about the demographics and ward of the individual to gauge perception change throughout the city.

Target:

Calgary has set a target of 60% of Calgarians reporting very satisfied with walking programs and facilities in Calgary by 2025.

Percentage of K-12 students using active transportation to school
Outcome KPI

Inspired by:
Calgary Edmonton

Related Section in this report: 1.6 |1.7 | 2.0

Rationale:

The future of Vaughan's road culture starts at how children get to their schools.

There are general safety concerns for students who live within walking distance of school due to the high proportion of parents driving students to school, which in turn creates a feedback loop of increased travel to schools by means of private automobile. Concurrently, a general increase in specialised and private schools also leads to children living farther from school.

This KPI intends to steer policy focus towards creating a safe environment that encourages families and children to walk to school. As policy and programs are implemented, it is important to measure the success of such initiatives to further refine the policy and programs. It is recommended to partner with the York Region School Board to measure this KPI and measure it for total and by ward.

Target:

Calgary introduced a target of 20% of students (K-12) walking to school by 2025.

Percentage of residents with access within 500 metres non-auto travel time from bicycle route / transit network

Output KPI

Inspired by:
Edmonton Halifax

Related Section in this report: 1.4 |1.6 |1.7 | 2.0

Rationale:

The MoveSmart Strategy is prepared through an equity lens. Accessibility to nearby bike routes or transit options for residents create the foundation for mobility options that are sustainable for residents of all ages, all abilities and in all seasons. In order to encourage more travel by bike and transit, Vaughan must expand the bike and transit network to where people live, or center development around sustainable transportation nodes.

This KPI should be measured by total residents with access, and residents with access per ward. Measuring per ward will inform of whether there are communities that are being left behind while others benefit from new infrastructure.

Target:

Halifax states that 56% of its residents live within 500 metres of bicycle route (Halifax Regional Municipality, 2021)

Accessibility-based planning, which assumes that our goal is to help people get where they want, recognizes the important roles that walking, bicycling and public transit play in an efficient and equitable transportation system.

- **Academic Transportation Researcher**

Mode share for all trips
Outcome KPI

Inspired by:
Halifax Regina Durham

Related Section in this report: 1.2 |1.4 |1.7 | 2.0

Rationale:

Tracking resident travel modes can detect shifts from private vehicles to more sustainable modes of transportation.

Residents in Vaughan are currently heavily reliant on private vehicles to make all trips. This is a KPI which garners public interest and therefore a useful feedback tool to engage with the residents to bring more awareness to alternative modes of transportation.

While it should be measured as an all-encompassing percentage breakdown, the KPI should be further divided and measured by:

- Demographics, such as age groups, sex/gender, race/ethnicity
- Time of day, including on-peak and off-peak hours

Target:

Region of Durham is aiming to achieve 10% of trips made with means of Active Transportation, and 20% by public transit by 2031.

Kilometres of new, protected bicycle infrastructure constructed each year
Output KPI

Inspired by:
Halifax Brantford Lethbridge Edmonton Saint John Montreal Regina
New York City International Road Assessment

Related Section in this report: 1.2 |1.3 |1.4 |1.7 | 2.0

Rationale:

This KPI collected over time can contribute towards creating the cultural shift in an environment where biking can be an enjoyable and practical option for the residents of Vaughan. Measuring the construction of protected bike lanes and associated infrastructure will communicate the progress of overall annual bicycle network expansion.

Through MoveSmart's Sustainable Mobility Program, Vaughan is looking to improve the connectivity and quality of the bicycle network. This KPI will track the progress of their initiatives. This KPI should be measured by total kilometres built, and kilometres built by ward. Measuring by ward will display to what degree the distribution of the infrastructure is equitable to the needs to the residents.

Target:

Halifax has built 8 km of 'AAA' bikeways in 3 years (Halifax Regional Municipality, 2021), Edmonton has built 15 km of protected bike lanes since 2009 (City of Edmonton, 2020), and New York City built 46.5 kilometres of protected bicycle lanes in 2020 (New York City, 2021).

Number of data collection and analysis reports completed within one year

Output KPI

Inspired by:
Guelph Strathcona County

Related Section in this report: 1.3 | 1.4

Rationale:

Data collection and analysis are essential components of the annual report preparation.

Providing a report on a consistent basis creates the necessary data transparency around collision trends to communicate with the residents in Vaughan.

This can serve as an effective public engagement tool, as well as an indication of effort to ensure that the MoveSmart Strategy is progressing in the right direction according to the policy intent.

Target:

Strathcona County publishes one annual Traffic Safety Report and one annual Traffic Collision Statistic Report to communicate the county's yearly road safety context to its citizens.

Number of active transportation volume counts administered

Output KPI

Inspired by:
Lethbridge Brantford Saint John New York City

Related Section in this report: 1.4

Rationale:

The literature and jurisdictional review revealed that active transportation volume data is often lacking in traffic safety strategies, due to community opposition, and/or a lack of investment.

Active transportation volume data is extremely important in measuring the success of Vaughan's active transportation projects. This KPI measures the total number of counts administered to measure active transportation traffic volumes. This KPI should be measured by total and by ward to display equity efforts.

By reporting the number of observational, manual, or automatic counting projects, this KPI can contribute directly towards the effort by Vaughan to rebalance the emphasis on protecting vulnerable road users.

During an interview with multiple Vaughan employees, they had mentioned how performing frequent active transportation volume counts along certain corridors, such as the VMC, will allow them to better plan for shared spaces between vehicles and active transportation users.

4.4 CONSIDERATIONS FOR THE PROPOSED KPIS

To complement the proposed KPIs, it is equally important for Vaughan to consider the following:

- **KPIs mean accountability:** It is commendable for Vaughan to take up the KPI monitoring and evaluation framework as part of the MoveSmart Strategy, as the evaluation exercise will hold the City more accountable with its effort and progress. It is therefore important to start with simple KPIs, invest in engagement and education with key stakeholders ranging from the council members, planners and engineers, local school boards, and communities and resident groups. Focus on building information consistency and transparency is important to establish a credible monitoring and evaluation framework around the MoveSmart Strategy for its long-term success.
- **No singular KPI can paint the entire picture:** It is impossible to measure and evaluate any MoveSmart Strategy initiative with the use of one KPIs. All implemented initiatives should ideally to be working in convergence towards the strategy objectives.
- **Data availability should not limit KPI adoption:** Data availability is essential to evaluating the progress of initiatives. Our review identified multiple ways to collect data for KPIs such as traffic volume, speeds, enforcement, collisions, and public engagement. The calculation of any KPI depends heavily on data availability and integration, as well as hardware infrastructure capacity dedicated human resources. At the same time, the suitability of the KPIs should not be restricted by current data and resource availability, given that the MoveSmart Strategy is set to improve the overall road safety condition in Vaughan in the long term.

Metrics are driven by data availability, which shouldn't be the case, but unfortunately it is.

– City of Vaughan Transportation Program Manager

- **Use both outcome and output KPIs:** Combine the usage of both outcome and output KPIs to address the temporal nature of the road safety monitoring and evaluation framework.
- **Collaboration is key:** municipalities do not always collect the data themselves. This could be because they are not responsible for data collection or because they do not have the resources. This can be addressed by collaborating with organizations and entering into data-sharing agreements. Examples include police-reported collision statistics or hospitalization and ambulatory data from traffic-related injury admissions. Increased partnership with school boards, police, social services, and hospitals within York Region will contribute towards a successful delivery of the MoveSmart Strategy, not only for the data and information sharing, but also for the long-term public transit planning and implementation.

Key Takeaways:

- Twenty KPIs in total are proposed in this section. Eleven of them are classified as Output KPIs to measure the effort and programs implemented towards delivery of road safety improvement, and nine of them are classified as Outcome KPIs to evaluate the status of road safety condition overall for Vaughan.
- To ensure the success of the MoveSmart Strategy, in addition to the adoption of the proposed KPIs, considerations need to be given to the data infrastructure, partnership with York Region, and investment in effective engagement and continuous education with different key stakeholders.

5. MOVING FORWARD

Objectives:
To provide Vaughan with a set of recommendations that are based on the previous section's research and proposed KPIs.

Recommendations are described in detail with comparative municipal examples within Supporting Document Section G.

Based on the research conducted, there exists additional considerations which may support Vaughan with its mobility plans moving forward. To support the next iteration of the MoveSmart Strategy, this report offers the following recommendations:

1) **Incorporate specific and actionable measures, responsible partners, and a theory of change, in ways that integrate social, environmental, and financial sustainability**. While the MoveSmart Strategy is generally focused on communicating policies that support high-level program areas, there are opportunities to clarify program goals with specific and measurable actions and responsible partners. Sustainability, as a societal, environmental, and financial cost and benefit, could also be defined within the strategy.

2) **Describe how equity is understood in relation to road users, equity deserving populations, and the City of Vaughan's decision-making and capital expenditure process**. A significant portion of the literature and jurisdictional review emphasised the need to meet the needs of the most vulnerable road users, which the MoveSmart Strategy objectives also articulate. However, it remains unclear how the most vulnerable road users are considered conceptually, within its theory of change, and within program goals. Our interviewees consistently noted the need for a proactive approach, as opposed to a complaint-based approach, to fully document, understand, and respond to the needs of its vulnerable road users and equity deserving populations.

3) **Limit the use of information-oriented public education campaigns.** Public education and outreach campaigns are often used by municipalities and police services to address road safety concerns and reach their goals of increasing public awareness, similar to MoveSmart's program goal. The literature review in Section 2 confirmed that information-oriented public education campaigns are less effective in decreasing traffic injuries and collision as compared to other systemic-level improvements.

4) **Commit to Vision Zero language and terminology within the MoveSmart strategy.** As MoveSmart Strategy Executive Summary notes how it will work towards a Vision Zero goal, Vaughan should fully support Vision Zero principles and the national network in order increase wide-scale adoption, public awareness, and robust policy development.

5) **Support, integrate, and evaluate mixed land-use development policies which aim to decrease overall vehicle kilometres travelled of Vaughan residents**. As identified in the Vaughan context and literature review, municipal policies that promote auto-dependent and single-use land development tend to increase overall vehicle kilometres travelled thereby increasing a vulnerable population's overall exposure to collisions.

Key Takeaways:

Moving forward, the next iteration of the MoveSmart Strategy should:

- Incorporate specific and actionable measures, responsible partners, and a theory of change, in ways that integrate social, environmental, and financial sustainability.
- Describe how equity is understood in relation to road users, equity deserving populations, and the City of Vaughan's decision-making and capital expenditure process.
- Limit the use of information-oriented public education campaigns.
- Commit to Vision Zero language and terminology within the MoveSmart strategy.
- Support, integrate, and evaluate mixed land-use development policies which aim to decrease overall vehicle kilometres travelled of Vaughan residents.

6. SUMMARY

This report has revealed that the City of Vaughan is not alone in attempting to reduce traffic collisions. Across the country, municipalities are creating a variety of strategies that refocus their attention from moving traffic as efficiently as possible, to encouraging sustainable modes of transportation and creating a culture of road safety. As municipalities undergo this shift, they must be prepared to monitor, evaluate, and improve upon these strategies.

This report found that strategies can be evaluated by using KPIs and data collected from traffic volume, speeds, collisions, and public engagement to evaluate the progress that their initiatives are making. Basing mobility strategies off of data rather than resident-complaints has been demonstrated to address equity concerns, tell a story, improve community relations, and maintain public trust. The collision data analysis and media analysis sections found in this report identified how public perception can differ from the reality of Vaughan's transportation context. The literature review section identified how transportation systems can contribute towards an inequitable distribution of traffic injuries. These findings must be taken into consideration when devising a mobility strategy in order to improve the transportation system for all of its users. The transparency of mobility strategies is also important, which is why a combination of output and outcomes KPIs are proposed to evaluate the progress made by the MoveSmart Strategy.

The Project Team identified a total of 20 KPIs for the MoveSmart strategy that are measurable, meaningful, understandable, realistic, applicable to Vaughan, and are used by multiple cities. These KPIs were proposed in consideration of the report's background research on Vaughan, its review of academic research, information gained from interviews, and jurisdictional review of municipalities committed to Vision Zero. In doing so, the Project Team completed a comprehensive review of transportation related KPIs that is one of the first of its kind in Canada.

The report's recommendations provide the opportunity for the City of Vaughan to compare the MoveSmart Strategy to other similar strategies and assess what elements of the strategy are aligned, ahead or in need of improvement. Looking into the future, the Project Team hopes that the City of Vaughan will implement this information and these recommendations in the next iteration of the MoveSmart Strategy. In doing so, Vaughan will meet its goals of improving its road safety, improving its mobility efficiency, supporting active transportation, and ensuring the accuracy and proficiency of its traffic data.

SMART MOVES:
KEY PERFORMANCE INDICATOR PROPOSAL FOR THE MOVESMART STRATEGY

SUPPORTING DOCUMENTATION

SMART READS: SUPPORTING DOCUMENTATION

SECTION A: VAUGHAN INSIGHTS

To identify Vaughan's current transportation planning practices and the difficulties it faces, a group interview was conducted with three transportation program managers from multiple departments at the City of Vaughan. Methods are further described in Supporting Documentation Section E. The interview asked the three program managers about Vaughan's current data collection strategy, what data and KPIs they would like to collect, the current difficulties in implementing road infrastructure, and their vision of transportation in Vaughan. The interview's findings are presented below.

DATA COLLECTION

In response to a question posed on how the city currently collects it transportation data, the program managers indicated the wide variety of methods used depending on the department. Some data collection methods included:

- Hosting a pop-up tent at community events to speak with residents and recording the number of visitors
- Recording the number of people who interacted with social media posts made by the City
- Entering partnerships with businesses to get traffic data from video counters and crowdsourcing models.

DATA AND KPI ASPIRATIONS

The staff members all highlighted the importance of collecting and managing data that is understandable to inform transportation planning decisions. This aims to create a more proactive and equitable approach to transportation planning that targets populations with the highest need of attention. In terms of expanding collision data, the staff members appreciated how Vaughan will be working with the Region of York to collect enforcement and hospitalization data to better understand how crashes occur, who is involved, and how severe they are. The program managers also indicated a desire for more accurate data on traffic and vehicle speeds. One program manager from the Infrastructure Planning and Corporate Asset Management department described was how data recording hourly pedestrian volume in urbanizing areas, such as the Vaughan Metropolitan Centre, would enable staff to better plan shared spaces between cars and pedestrians. All staff members interviewed also noted the potential benefit of a KPI that would record the distance of bicycle infrastructure built to track the progress on expanding active transportation networks.

DIFFICULTIES IN IMPLEMENTATION

One of the difficulties noted by interviewees was a discrepancy between resident and city staff knowledge of transportation planning. One example used by an interviewee was how some residents ask their councillor to have speed bumps and stop signs installed in their neighbourhood to slow down traffic, even if city staff do not support the installation. The interviewee explained that speed bumps and stop signs can be seen as "band-aid" solutions, since they often do not solve the root of the existing traffic problems. This example highlights how interviewees often identify different priorities than residents and elected city officials. It also emphasizes the importance of resident outreach and communication between transportation planning staff and Vaughan residents to better communicate the interests of the different stakeholders to move the city forward.

VISION FOR THE FUTURE

The interviewees all had a positive outlook on the future of transportation for Vaughan. One expressed confidence in the MoveSmart Strategy and believed that it will help solve some of Vaughan's current transportation issues. Another interviewee believed that Vaughan needs more mixed-use intensification along major roads that are served by transit for the city to grow more sustainably. Finally, another interviewee underlined the existential need for Vaughan to adopt more sustainable transportation modes to lower carbon emissions in efforts against climate change.

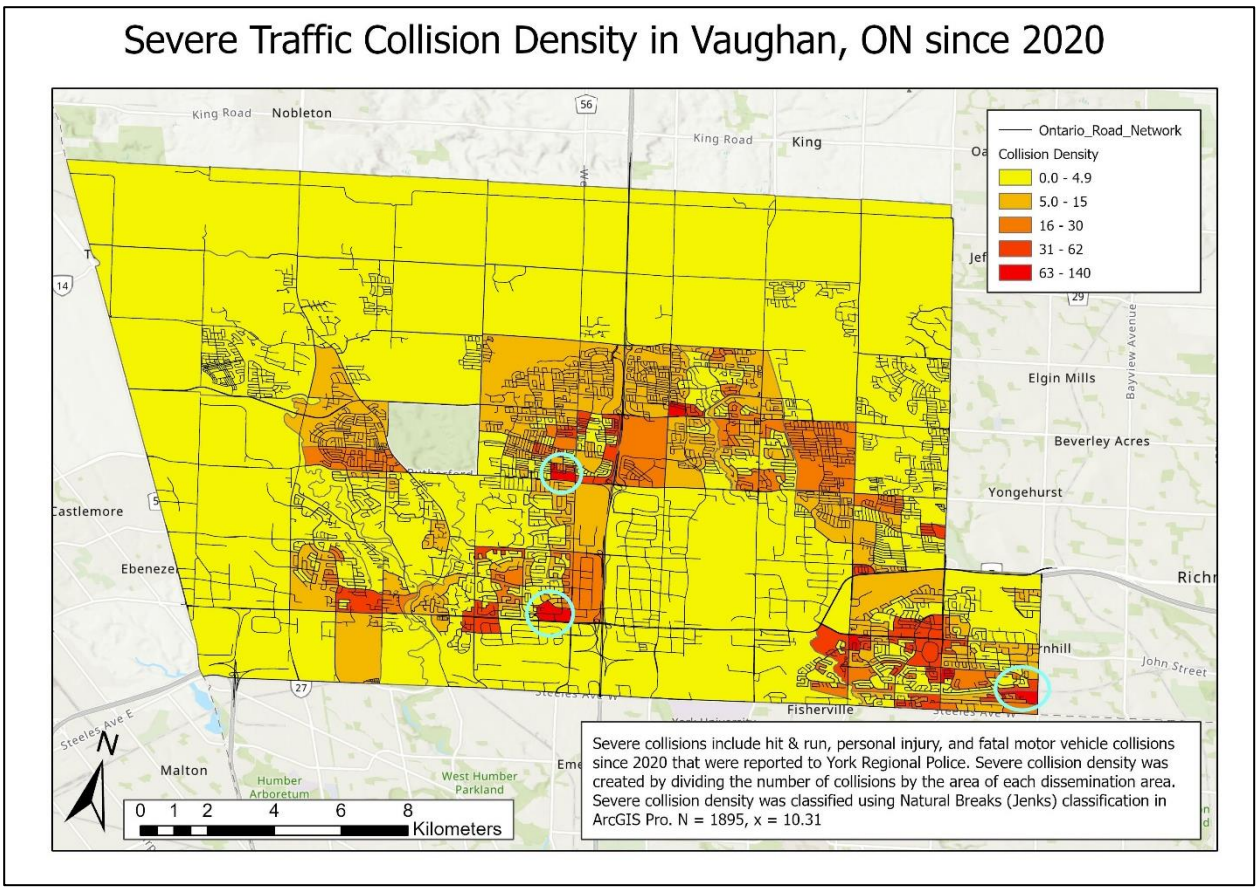
The findings from this interview further support the need for Vaughan to collect more detailed data, adopt a more equitable approach to implement planning initiatives, and create a more proactive educational outreach program to improve public engagement.

SECTION B: VAUGHAN CONTEXT MAPS

Traffic collision data recorded by York Region Police was primarily used as a data source and analysed in ArcGIS Pro. The data was filtered by collision type, separated into dissemination areas. Collision data was overlayed with select socio-economic information using 2021 Canadian Census data. This process produced the following maps:

- Severe Traffic Collision Density in Vaughan (Map B-1)
- Median Total Income Across Vaughan (Map B-2)
- Percent of Vaughan Residents over 65 Years Old (Map B-3)
- Percent of Older Adults who are Low-Income (Map B-4)
- Percent of Vaughan Households headed by Lone Parents (Map B-5)
- Percent of the Population who are Refugees (Map B-6)

These maps were chosen to highlight traffic collision hotspots, and areas in Vaughan where vulnerable populations reside. Research has shown that equity deserving groups are disproportionately affected by traffic collisions, and lower-income neighbourhoods are more likely to receive more non-local traffic than higher-income neighbourhoods, thereby increasing their exposure to traffic collisions (Atlantic Collaborative on Injury Prevention, 2011; Morency et al., 2012). While income is a common way of measuring social deprivation, per capita, Vaughan has a higher median income than the Greater Toronto Area (Statistics Canada, 2022a). The maps presented below were chosen to identify traffic collision hotspots and areas of socio-economic vulnerability. Mapping of demographic variables were selected in consultation with the City's Diversity and Inclusion Officer, and reflective of Vaughan's equity deserving communities. This information can help transportation planners and engineers make equitable decisions based on data gathered from York Region Police and the 2021 Canadian Census.



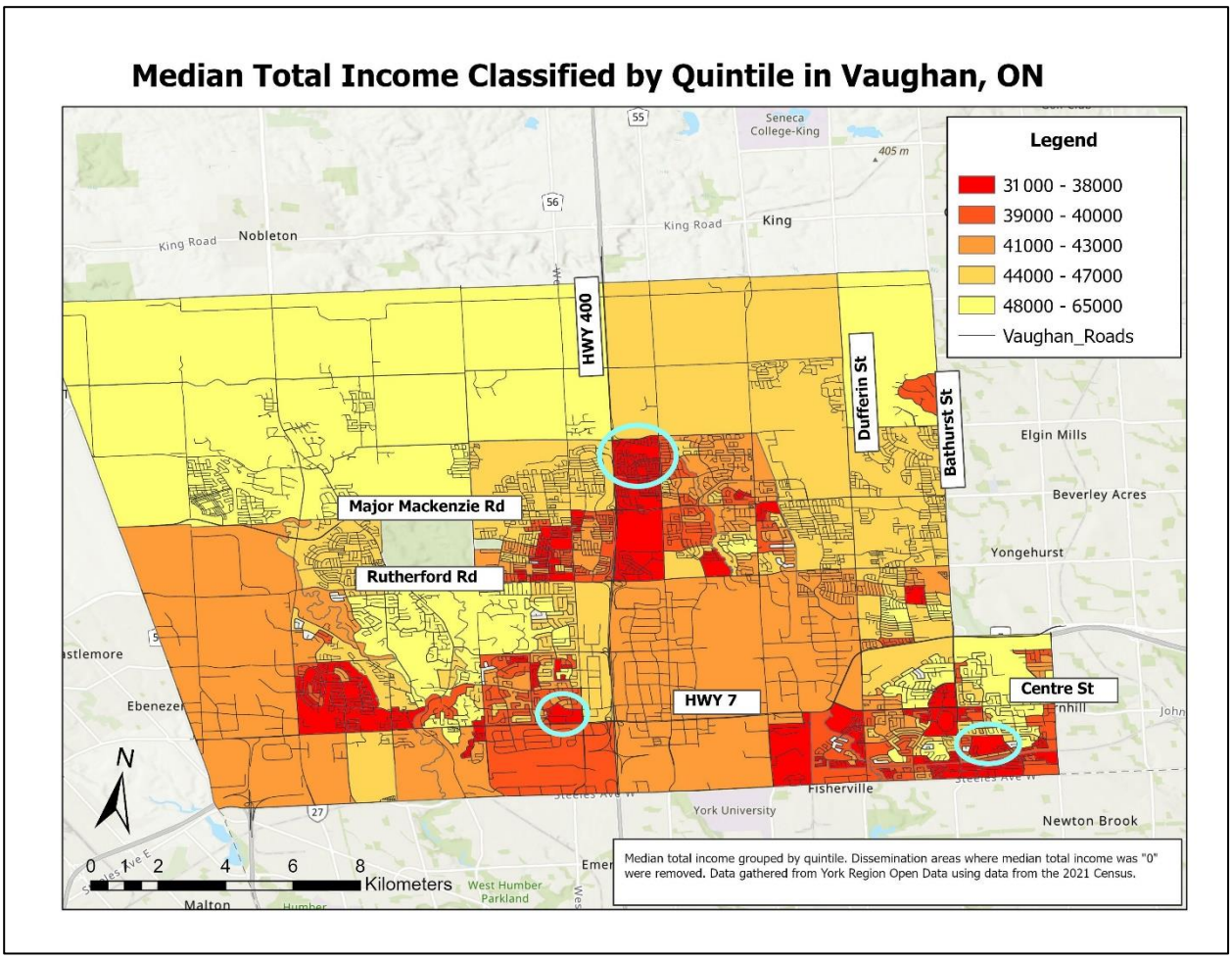
Map B-1: A map showing dissemination areas with high densities of severe collisions in bright red.

Map B-1 shows the density of severe collisions across dissemination areas (DAs) in Vaughan since 2020. Severe collisions are classified as motor vehicle collisions that include a fatality, an injury, or a hit and run. The map displays a general trend of severe collisions occurring along busy arterial roads such as Highway 7, Rutherford Road, Major Mackenzie Drive, Bathurst Street and Centre Street.

The three DAs with the highest collision density are:

1. The Fossil Hill Road and Alba Ave neighbourhood with 136 collisions per square kilometre (27 collisions total)
2. Ashley Grove Road and Windflower Gate neighbourhood with 98 collisions per square kilometre (35 collisions total)
3. Crestwood Ave and Yonge Street neighbourhood with 85 collisions per square kilometre (17 collisions total)

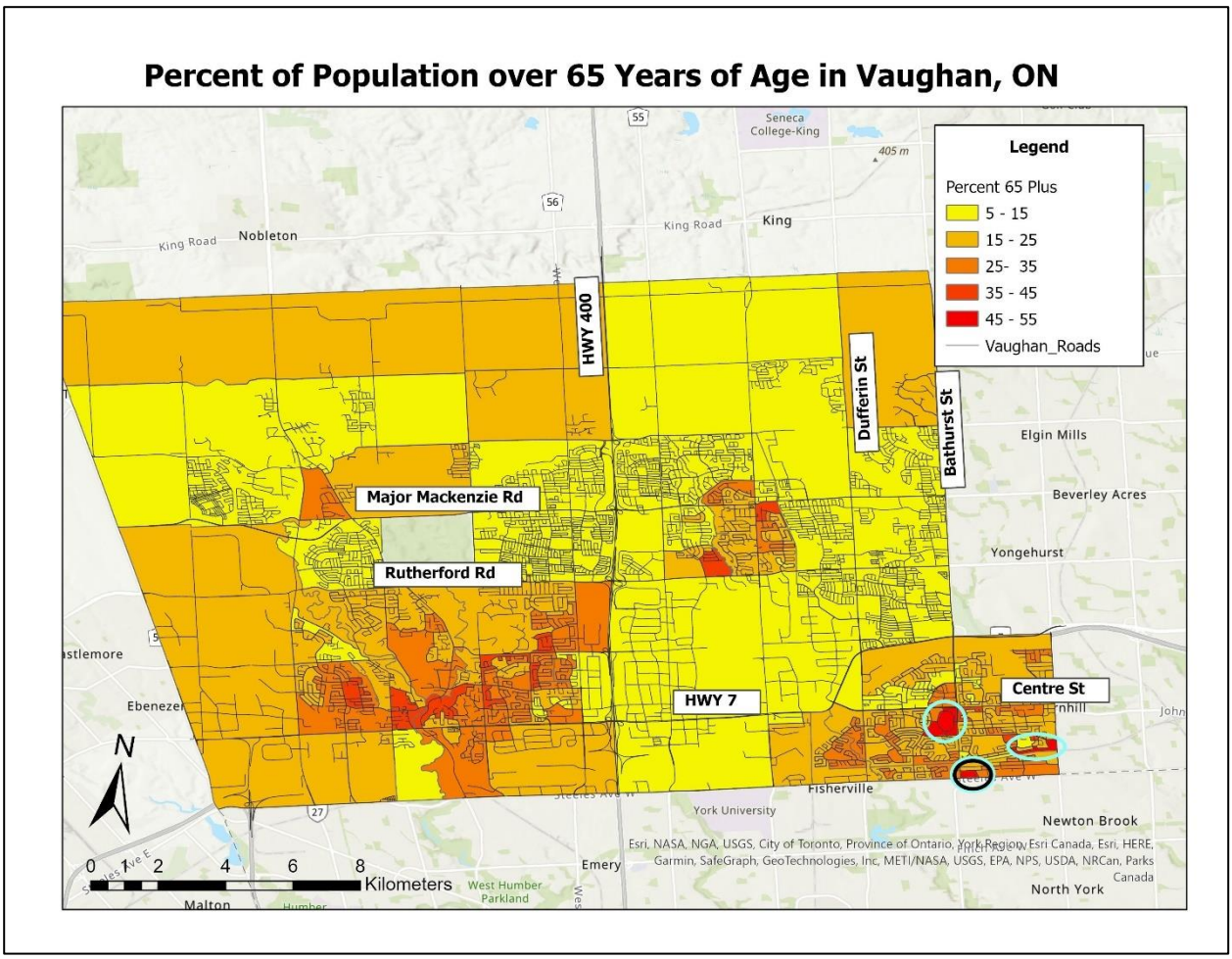
The collision density information gathered from Map B-1 can be combined with vulnerable population data to identify specific areas of traffic-related deprivation.



Map B-2: A choropleth map showing median income by quintile across Vaughan, ON in 2021.

Map B-2 shows the total median income of DAs in Vaughan. The three DAs with the lowest median income are circled in light blue. The map shows that DAs along HWY 400, HWY 7, Centre Street, and Bathurst Street often have lower median incomes. The three DAs with the lowest median income are the ones surrounding:

1. Alba Avenue and Fossil Hill Road with a median income of $31,800 per resident
2. Mosque Gate and Ahmadiyya Avenue with a median income of $31,800 per resident
3. Yorkhill District Park with a median income of $32,000 per resident

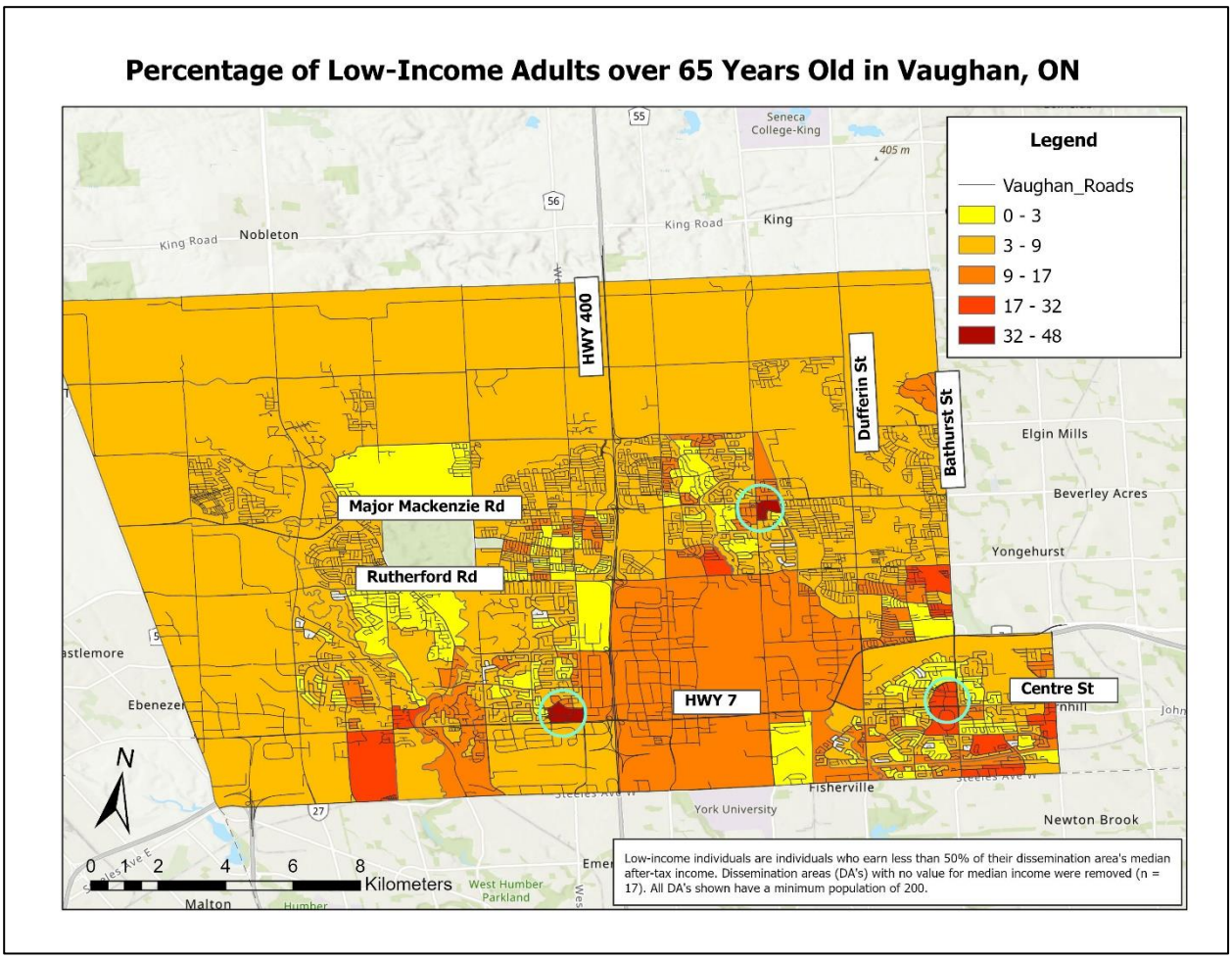


Map B-3: A map of Vaughan, ON showing the percentage of the dissemination area population is 65 years old or older.

Map B-3 shows the per the centage of DA population over 65 years old, with where there is a higher percentage of older adults. The three DAs with the highest percentage of older adults are the ones surrounding:

1. Steeles Avenue and Bathurst Street, with 54% of its population being older than 65 years old
2. The Promenade Shopping Centre, with 53% of its 1,060 population being older than 65 years old
3. Green Bush Crescent and York Hill Boulevard, with 49% of its population being older than 65

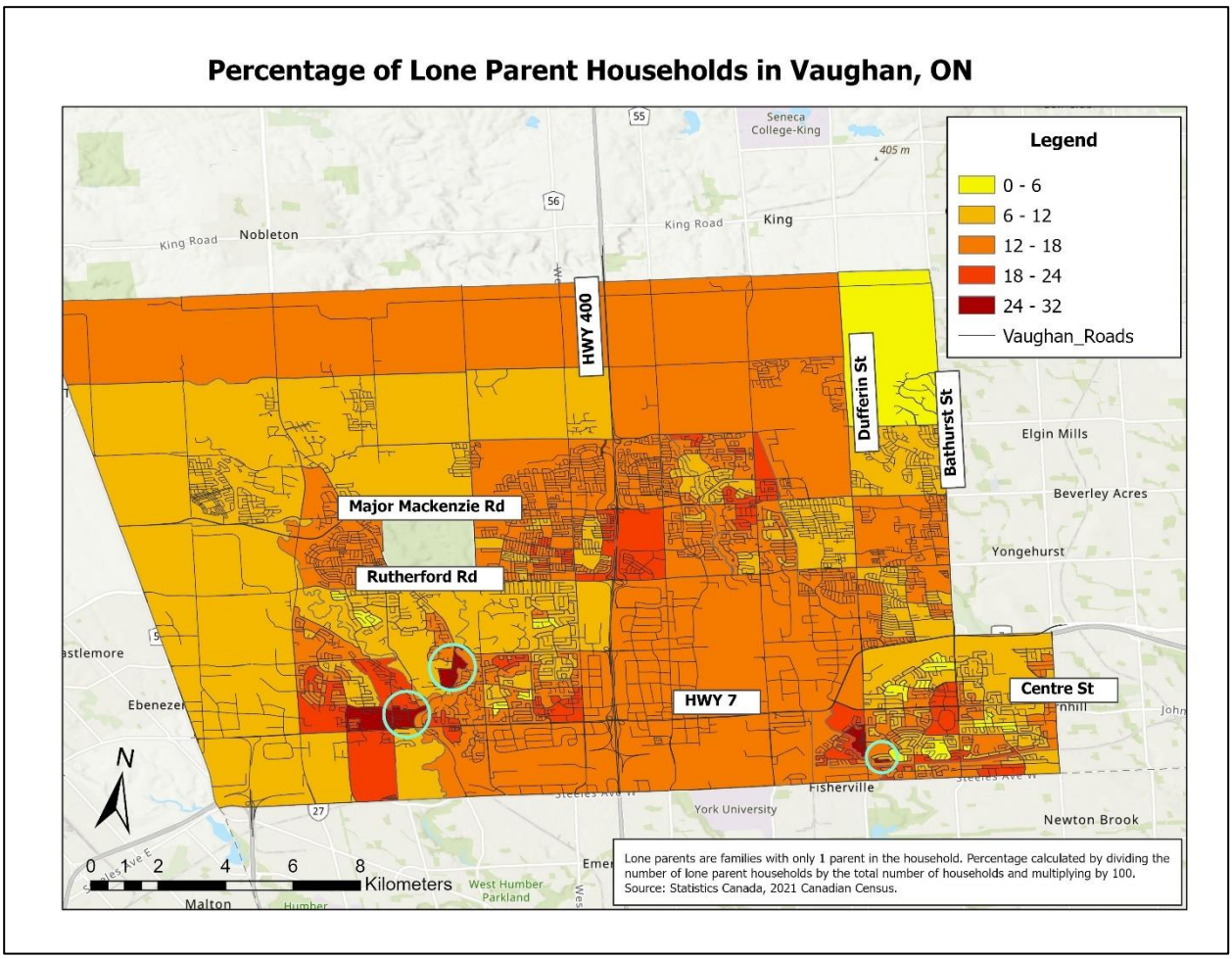
These DAs have an older adult population of over 45% and, therefore should be prioritized through outreach, engagement, and project implementation. Compared to Map ,1 showing the collision density across Vaughan, mane DAs with the highest collision density are also DAs with the highest percentage of older adults. This correlation highlights the importance of targeting these DAs in the MoveSmart Strategy to better protect older adults from severe collisions.



Map B-4: A map of Vaughan, ON showing the percentage of the dissemination area population older than 65 years old and make less than 50% of DA median income after-tax.

Map B-4 shows the percentage of low-income adults over 65 years old who may be more economically vulnerable. “Low-income” is defined in the 2021 Statistics Canada Census as individuals who make less than 50% of their DA’s median income. The three DAs with the highest percentages of economically vulnerable residents are the ones surrounding:

1. Ashley Grove Road and Windflower Gate, with 48% of older adults being economically vulnerable
2. Marlott Road and Oakdale Road, with 44% of older adults being economically vulnerable
3. North Park Road and Disera Road, with 32% of older adults being economically vulnerable

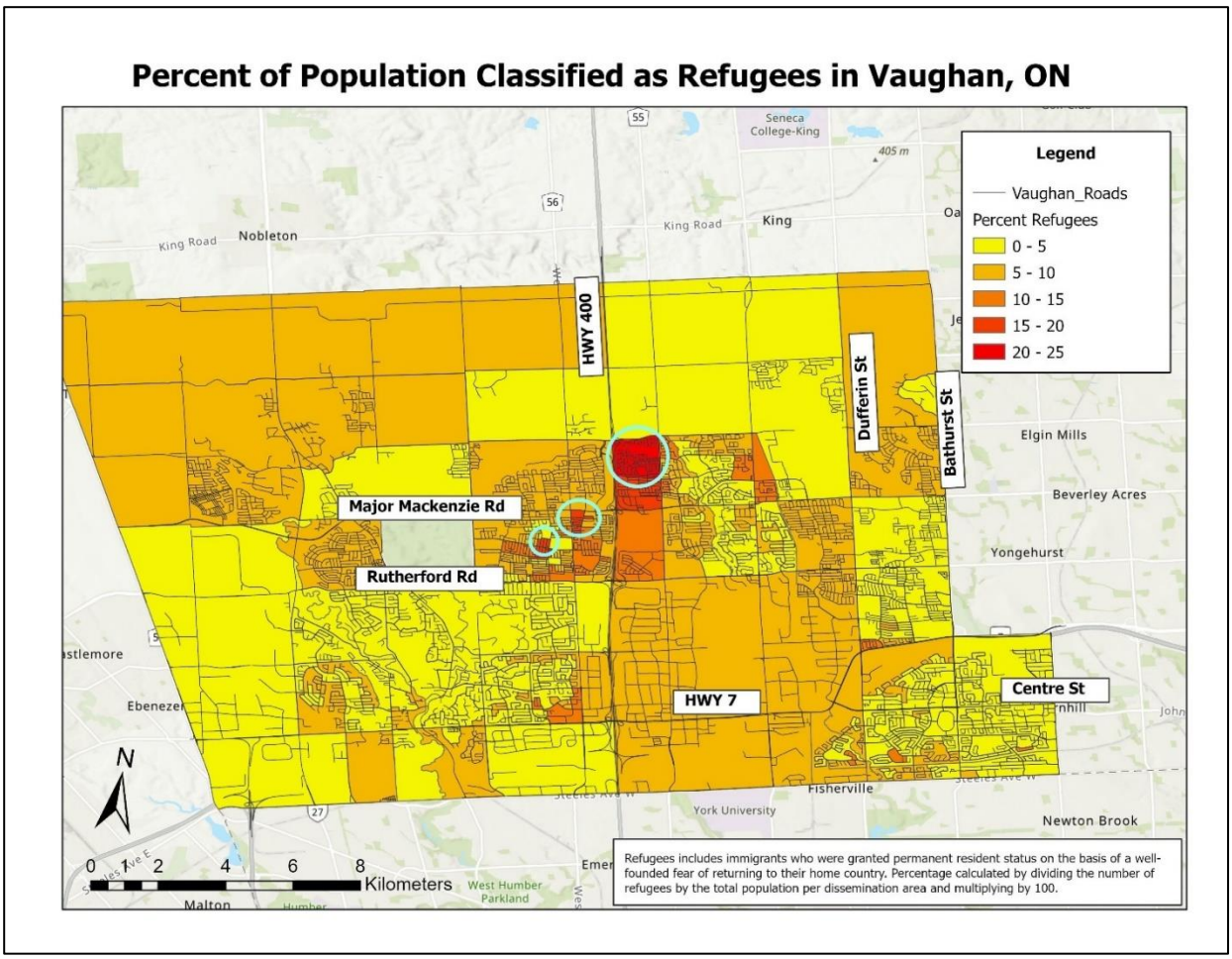


Map B-5: A map of Vaughan, ON showing the percentage of households led by a single parent by dissemination area.

Map B-5 shows the percentage of lone parent households in Vaughan. The three DAs with the highest percentage of lone parents in Vaughan are the areas surrounding:

1. Cheltenham Avenue and Kipling Avenue, with 30% of households being led by a single parent
2. Islington Avenue and Pine Grove Road, with 29% of households being led by a single parent
3. Gayla Avenue and Donist Avenue, with 28% of households being led by a single parent

The Chelthenham Avenue and Kipling Avenue DA also has a median income of $38,000, making it one of the poorest in Vaughan. Therefore, DAs with high percentages of lone parents and lower median incomes must be prioritized to respond to their road safety needs.



Map B-6: A map of Vaughan, ON showing the percent of the dissemination area population that are refugees.

Finally, Map B-6 shows the number of refugees as a percentage of the DA population. Refugees are defined as immigrants who were granted permanent resident status on the basis of a well-founded fear of returning to their home country (Statistics Canada, 2022b). Newcomers, including refugees have higher risks of traffic collisions due to different transportation environments and safety cultures compared to their home countries. They experience greater traffic exposure in Canada due to higher rates of active transportation. Furthermore, refugees have fewer resources available to them because of their precarious situations and are more economically vulnerable than other immigrants to Canada. Over the last five years, there has been a rapid increase in refugees in Vaughan as Canada has admitted 218,430 refugees nationally (Statistics Canada, 2022), and 17,835 refugees have been welcomed to Vaughan. The neighbourhoods with the highest percentage of refugees are:

1. Mosque Gate and Ahmadiyya Avenue, with 22% (1,630) of the population being refugees
2. Starling Boulevard and Dolce Crescent, with 18% (155) of the population being refugees
3. Fossil Hill and Davos Road with 17% (95) of the population being refugees

In summary, the four areas that experience higher levels of collisions and deprivation are shown below in Table B-1.

Table B-1: A table showing Vaughan's four dissemination areas with the highest levels of collisions, deprivation, and vulnerability.

Neighborhood Surrounding	**Reasoning**
Fossil Hill and Alba Avenue	High level of collisions (136 collisions/km^2) Low median income ($31,800) Cluster of refugees nearby
Ashley Grove and Windflower Gate	High level of collisions (98 collisions/km^2) High percentage of older adults who are low-income (38%).
Promenade Shopping Centre	Medium-high level of collisions (31 – 62 collisions/km^2) Low median incomes ($31,000 - $40,000) High percentage of residents older than 65 (53%) Medium-high percentage of older adults as low-income (17-32%) Medium-high percentage of lone parent households (18-24%)
Mosque Gate and Ahmadiyya Avenue	Low median income ($31,800) High percentage of refugees (22%)

SECTION C: NEWS MEDIA ANALYSIS

News media analysis helps provide context about perceptions of traffic collisions, fatalities, injuries, and overall road safety in Vaughan. The way collisions are portrayed influences and potentially reinforces the collision context in Vaughan through resident advocacy, blaming, shaming, and city council decisions. This analysis identifies the types of collisions occurring in Vaughan and who is perceived at risk to identify what KPIs should measure.

METHODOLOGY

Article selection criteria included the following keyword search terms using Canadian Newstream: “traffic or fatalities or violence or fatal or collisions or road or injuries or morbidity or speed or dangerous driving or safety or transport or crash or struck or hit or collide”. Articles were limited to only collisions within Vaughan from 2017 – 2022. The initial search resulted in 165 articles and after removing duplicates left 134 articles to analyse. Twenty-eight articles did not reference a specific collision and provided commentary on road safety, common collision locations in Vaughan and prevention measures.

News media articles were thematically analysed deductively and inductively to identify common themes, patterns and elements across articles as well as identifying conflicting statements or unique collision and opinion articles. Following the analysis, 5 elements and 23 categories (See Table C-1) were then simply quantified to quickly identify the most frequently and infrequently occurring elements. The number of articles analysed does not equal the number of collisions in Vaughan during the selected period as multiple articles could report on the same collision and some articles did not reference a specific collision and instead provided commentary on road safety in Vaughan. These elements and categories are used to identify Vaughan issues and potential to measure change or effectiveness through KPIs.

FINDINGS

The **most frequent collision type reported in the news media analysis were those involving vehicles** as depicted in Figure C-1. However, a limited number of articles described a vehicle as a “weapon”. The make or model was not always reported, but several articles connected collisions and luxury vehicle ownership (Vaughan Citizen, 2020a, 2022c). While the 2021 Traveller Safety Report found that the half of collisions involve commercial trucks, tractor trailer were not as frequently mentioned (York Region, 2021). This suggests the media may not accurately depict the frequency or potential commercial vehicle collisions in their reports. Among vehicle collisions, single vehicle collisions were more frequently reported than multi-vehicle collisions, which often involved a vulnerable road user, followed by collisions with inanimate objects. It is also worth mentioning that collisions resulting in no injuries were rarely covered. However, when mentioned, it was used describe the psychological injury as a result of being involved in a

collision, having a loved one involved, or as an emergency responder, was described. In this way, **the concept of invisible injury may be helpful for framing societal cost of vehicle collisions**.

Figure C-1: A word bubble depicting the collision elements with the more frequently reported are larger in blue and less frequently reported are smaller in green.

Intersections are a frequent location of collisions for pedestrians and cyclists as a result of drivers making turns and failing to yield (Toronto Star, 2019). Among the ten most dangerous intersections in York Region, half were located in Vaughan and the most dangerous intersection was located at Highway 7 and Weston Road reporting 120 traffic collisions between 2016 and 2018 (The Georgina Advocate, 2020). In 2018, the Maple and Thornhill neighbourhoods made the top ten list of least safe places to drive according to Allstate Insurance's annual safe driving study, but the article did not mention which locations were least safe places for other modes of travel such as walking and cycling nor distinguish between regional or local roads (Vaughan Citizen, 2018d). This finding suggests **metrics should measure conflicts or collisions at intersections as well as improvements to high-collision areas**.

Among vulnerable road users, **pedestrians struck by vehicles were more likely to have a news article report compared to cyclists and motorcyclists**, which is consistent with the results of the 2021 Traveller Safety Report that pedestrians are the most vulnerable road user (York Region, 2021). However, some articles had put pedestrians at fault for the collisions (Vaughan Citizen, 2019). As a result, York Regional Police provided prevention measures aimed at pedestrians including wearing bright, light-coloured, or reflective clothing when walking at dusk, dawn or in the dark, walking on sidewalks and crossing at crosswalks, removing distractions such as headphones or ear buds, and making eye contact with drivers before crossing the road (Vaughan Citizen, 2017a).

Table C-1: Media analysis collision elements by frequency and percentage.

Collision Element	Category	Count & %
Transportation Mode	Vehicle	106 (79%)
	Luxury Vehicle	15 (11%)
	SUV or Pickup Truck	15 (11%)
	Tractor Trailer	9 (7%)
	Motorcycle	9 (7%)
	Pedestrian or Cyclist	30 (22%)
	E-Bike or E-Scooter	2 (1%)
Age	Child	31 (23%)
	Teenager	25 (19%)
	Older Adults	17 (13%)
Collision Type	Single Vehicle Collision	63 (32%)
	Multi Vehicle Collision	43 (32%)
	Injury	64 (48%)
	Fatality	51 (38%)
Collision Location	Highway	32 (24%)
	Intersection	23 (17%)
	Off-Street Location	14 (10%)
Collision Cause	Dangerous Driving	18 (13%)
	Speeding	20 (15%)
	Impaired Driving	19 (14%)
	Distracted Driving & Inattentiveness	4 (3%)
	Police Investigating & Seeking Information	37 (28%)
	Road Closure	38 (28%)
*Frequencies do not equal 100% as there is article overlap among elements and percentage is reported out of article total		

Allstate Insurance's representative noted that distracted driving can be prevented through adjusting driver mirrors, and York Regional Police recommended using properly working headlights, defensive driving, courteous driving, and wearing seatbelts (Vaughan Citizen, 2017a, 2017b). However, **no articles referenced cellphone use, navigation systems, or other distracting features found within a vehicle**.

Figure C-2: A cyclist riding utilizing an "informal" bike lane in Vaughan (Source: Project Team, 2022)

Overall traffic collisions in York Region are declining on regional roads, yet the relationship is reversed when the traffic collisions involve cyclists and pedestrians (Toronto Star, 2019). One author suggested local roads do not have the necessary cycling infrastructure (See Figure C-2), which may result in fewer cyclist fatalities due to less volume rather than safety (Vaughan Citizen, 2018b). Another opinion piece suggested that even with the presence of cycling infrastructure, cyclists are not using bike lanes and instead opting to ride on sidewalks (Vaughan Citizen, 2020b). This suggests that existing cycling infrastructure may not be high-quality or designed for the cyclist to feel safe, or that **there may a perception that cycling infrastructure is not worth capital investment**.

Given the presence of speeding and collisions involving pedestrians, it is unsurprising that traffic calming measures aimed at reducing vehicular speed were mentioned. These included line painting to make the road appear smaller to drivers, floppy bollards , speed limit reduction, and speed boards or radar signs (Vaughan Citizen, 2021b, 2021c, 2022a, 2022b). Other City of Vaughan initiatives were also mentioned, including a transportation management strategy and lawn sign campaign to encourage people to reduce travel speeds while driving (Vaughan Citizen, 2021a, 2021a). **The public were infrequently interviewed in news articles**. One article quoted a Vaughan resident who was in favour of automated speed enforcement to reduce speeding (Vaughan Citizen, 2022a). A local traffic calming advocate was critical of existing initiatives and suggested council "[likes] Band-Aid solutions... they want to placate residents, so they put signs up" (Vaughan Citizen, 2021c). **A mobility strategy that uses signs to educate the public or reduce speeding is likely to benefit from showing the effectiveness of such measures and earning public trust**.

Children and youth were frequently reported as injured or fatalities as a passenger or pedestrian. Vaughan has been the location of several high-profile fatal traffic collisions in recent years, and these collisions have had a lasting impact in the news media cycle. In 2015, an impaired driver struck another vehicle killing three children and their grandfather (The Brampton Guardian, 2017). These fatalities have maintained their presence in the local news media cycle, and often

referenced in articles involving other impaired driving collisions, or collisions involving children. A more recent collision involved a speeding teenage driver striking two children and their neighbour in a driveway resulting in two fatalities and one injury (The Toronto Star, 2022; Vaughan Citizen, 2022d). These tragic stories dominate the news media and suggest that **impaired driving, speeding, and collisions involving children are specific concerns residents want addressed and eliminated.**

Speeding was the most frequently occurring factor influencing collisions in Vaughan. Between March and October of 2020, York Regional Police issued over 900 charges for speeding in excess of 50km/h over the posted limit (Vaughan Citizen, 2020c). **Although the design of streets can influence the likelihood of speeding, it was rarely mentioned as a cause of the collision**. In 2021, York Regional Police created Regional Enforcement Priorities teams to increase road safety by focusing on dangerous driving and impaired driving (Vaughan Citizen, 2021c). In 2018, close to 1000 incidents of impaired driving were investigated by York Regional Police resulting in seven fatalities (Vaughan Citizen, 2018a, 2018c). One strategy that York Regional Police have used in an attempt to deter impaired driving is by "naming and shaming" individuals with impaired driving-related offences (The Liberal, 2018, 2022; Vaughan Citizen, 2018c). News media articles were frequently used to communicate the legal consequences of dangerous driving. Recommendations to reduce the frequency of speeding included increasing fines and expanding automated speed enforcement from community zones to main roads (Vaughan Citizen, 2021c, 2022b). Many articles focused on collisions resulting in charges and convictions, which **simplified traffic collisions as the result of an individual's poor judgement rather than the physical elements of the streetscape**.

Figure C-3: Observed tire tracks on a sidewalk at Napier Street and Stegman's Mill (Source: Project Team, 2022).

News articles were frequently used to provide information to residents about traffic delays and detours as well as solicit information, evidence, and witnesses to assist the police in their traffic collision investigations. **Unscheduled road closures were frequently reported suggesting vehicle traffic delays could be used to diversify mode share and reporting commute times to measure travel efficiency.**

Several articles acknowledged and thanked resident assistance for reporting suspected impaired driving resulting in charges through the "Safe Roads ... Your Call" program (Vaughan Citizen, 2018a). Client-facing collision prevention maps including suggesting improvements for

sustainable mobility transportation modes and automated enforcement cameras can be leveraged to encourage existing resident involvement in road safety. Data-driven strategies are more transparent than complaint-based as they may not be representative of actual collisions and traffic safety.

LIMITATIONS

By scoping only Vaughan collisions to understand the local context, regional and comparable jurisdictions are excluded from the analysis leaving out potentially relevant news articles. Different articles were written about the same collision either by separate news outlets and reporters or by the same reporter and news outlet over the course of the collision investigation. As such, a collision can be reported over the course of a week from many news outlets and articles with the earlier articles reporting injuries and later articles reporting fatalities. Additionally, elements relating to high-profile collisions may be overly represented in the analysis. Although this limitation is not unique to document analysis, analysing media articles means the researcher is constrained to articles the media decides to report or is of importance.

The themes and elements identified are not exhaustive and future analysis could focus on just one theme or element for a deeper understanding of traffic collisions, determinants of traffic collisions and road safety in Vaughan. Other project expansions include combining news media and spatial analysis together to geocode collision articles or examining collision articles for their sentiment. Although the length of news articles provides less information or content as compared to scholarly or grey literature articles, this enabled the analysis of over 100 articles.

Key Takeaways

- Road user type should be differentiated in collision metrics including pedestrians and cyclists and further subcategorizing vehicles such as luxury or heavy trucks
- There is a desire to track reductions in speeding and impaired driving particularly at intersections and collisions involving children
- Pedestrians are targeted in educational campaigns to encourage road safety, but these campaigns should also targe driver behaviour to prevent collisions
- The media could be used as a tool to build and maintain public trust and illuminate the effectiveness of the MoveSmart Strategy

SECTION D: RISKY MOVES

To better understand how to minimize traffic collisions and fatalities in our cities, we first must understand the determinants of traffic collisions and how collisions occur. The determinants of traffic collisions will be categorized by either a "human" or a "system" factor. Human determinants are factors personal to the individual, such as driving behaviour, or choice of travel modality. System determinants are factors in our physical and social environment that may influence the rate and severity of traffic collisions, whether created by humans or by-products of our culture. These include factors such as road design, human demographics, as well as temporal and climate factors. In the following sections, "human" and "system" determinants are broken down into sub-categories with determinants being presented in bullet point form.

HUMAN DETERMINANTS

INDIVIDUAL BEHAVIOUR

Risk factors: Inattentive driving, frequent mobile phone usage, headphone usage, fatigue, age related cognitive decline, choice of modality

- Inattentive driving increases risk for collisions (Dezman et al., 2016; Kulharni, 2020).
- Frequent mobile phone usage affects driving performance by contributing to slower reaction times, being a distraction from adhering to traffic signals, and reducing the ability to drive within the correct lane (Kulharni, 2020).
- Mobile phone usage among pedestrians and cyclists causes distraction and sensory deprivation, which negatively affects the perception of the auditory environment (Dezman et al., 2016).
- 20% of collisions in high-income countries involve the consumption of alcohol, while 33-69% of collisions in low-income countries involve the consumption of alcohol (Lakhan et al., 2020).
- People who drive with fatigue experience the same effect on their driving as one would do with alcohol consumption (Lakhan et al., 2020).
    - Young drivers, males, shift workers, those with sleep apnea, and those who drive between 2am and 5am are most likely to be affected with fatigue (Lakhan et al., 2020).
- Age-related visual cognitive decline such as diminished visual processing speeds and lower selective visual attention places older adults at greater risk of traffic collisions (Dommes & Cavallo, 2011).
- Speed can be classified as a human and a systematic determinant of collisions (Lakhan et al., 2020).

- Pedestrians are the most at risk of serious injury and fatality in the event of vehicular collision (Yannis et al., 2020).

SYSTEM DETERMINANTS

SPEED, VEHICLE KILOMETERS TRAVELLED, AND VEHICLE SIZE

Risk factors: Speed over 45 km/hr and 50km/h, Vehicle Size

- As the speed of a vehicle increases, the fatality risk of a pedestrian increases when a collision occurs. In well-publicized research, it was found that pedestrians were five to eight times more likely to die from collisions when the vehicle was traveling 50km/h as compared to 30km/h (ITF, 2012; Khorasani-Zavareh et al., 2015).
- Vehicle speeds over 45km/hr increase the likelihood for cyclist fatalities (Cushing et al., 2016).
- All else being equal, traffic fatalities increase with vehicle kilometers travelled, displaying that an effective way of reducing traffic fatalities is to reduce vehicle usage (Ewing et al., 2016; Litman, 2017, 2022a; Yeo et al., 2015).
- During 2020, the COVID-19 pandemic reduced U.S. vehicle travel by 13%, but traffic deaths increased by 7% due to the less congested roads influencing higher-risk activities such as speeding and impaired driving (Litman, 2022a; Stiles et al., 2021).
- Due to their increased momentum, an SUV is two to three times more deadly to pedestrians as compared to being struck by a regular car (National Highway Traffic Safety Administration, 2015).

DEMOGRAPHICS

Risk factors: Having lower income, lower education level, lower socioeconomic status, racialized communities, other disadvantaged populations

- Lower income, racialized communities, and other disadvantaged populations are disproportionately affected by traffic collisions, including those resulting in serious injury or death (Atlantic Collaborative on Injury Prevention, 2011; Brubacher et al., 2016; Chakravarthy et al., 2012).
- It is suggested that lower-income neighbourhoods are more likely to receive more non-local traffic than higher-income neighbourhoods, this is an issue as (Morency et al., 2012; Yiannakoulias & Scott, 2013):
    - It exposes low-income neighbourhoods to greater amounts of traffic
    - Non-locals tend to drive at faster speeds
    - Non-locals are unfamiliar with the neighbourhood's safety culture and customs

- Indigenous peoples living on reserve and in non-metropolitan areas in British Columbia experience greater risk of transportation injury, largely due to socioeconomic disparities (Brussoni et al., 2018).
- Those with a lower level of education are at greater risk of injury from a traffic collision, as they are more likely to be pedestrians and live in dense neighbourhoods (Haghighi et al., 2020; Saeednejad et al., 2020).
    - Conversely, countries with higher education rates have lower rates of traffic fatalities (Haghighi et al., 2020)
- Newcomers have an increased risk for traffic injury and fatality due to multiple factors, such as (Davison et al., 2013; Vanlaar et al., 2016):
    - Transferring between safety cultures and transportation-planned environments
    - Increased traffic exposure due to higher rates of active transportation

AGE-SPECIFIC

Risk factors: School distance, driving behaviour in school zones, non-local traffic, child exposure to traffic, older adult pedestrians

- School-aged children using active transportation to school are more likely to be involved in a traffic collision. Distance of the walk and built environment features are two important factors in the involved risk (Chakravarthy et al., 2012; Davison et al., 2013; DiMaggio et al., 2016; Rothman et al., 2014; Yiannakoulias & Scott, 2013).
- High population density, greater traffic exposure, and high-traffic speeds contribute to a child's increased risk for traffic injury and fatality (Chakravarthy et al., 2012; Davison et al., 2013; Harmon et al., 2020).
- Children from visible minority groups or lower income families are at a greater risk of being involved in traffic collisions due to being more likely to live in a densely populated neighbourhood, increased exposure to high levels of traffic, exposure to high speed traffic, and poor road design and maintenance (Chakravarthy et al., 2012; Davison et al., 2013; Embree et al., 2016; Harmon et al., 2020; Rothman et al., 2014).
- As a vulnerable road user, older adult pedestrians aged 65+ are at greater risk for traffic injury and fatality due to (Fang et al., 2018; Harmon et al., 2020; Kim, 2019; Vanlaar et al., 2016):
    - Lack of all-ages pedestrian infrastructure
    - Physical and cognitive mobility constraints
    - Street crossing evaluation capability
    - Lower levels of pedestrian confidence and fear of injury

LAND-USE & AUTO-CENTRICITY

Risk factors: High pedestrian activity, land-uses, school density, urban form, auto-dependant cities

- Areas with high levels of pedestrian activity, such as commercial zones in urban areas, and large institutional areas such as universities, experience a higher frequency of pedestrian collisions compared to areas with lower levels of pedestrian activity (Pulugurtha et al., 2013; Ukkusuri et al., 2012; Zhu et al., 2022).
- Traffic collisions are the least likely in single-family residential areas (Pulugurtha et al., 2013).
- Cyclist collisions are less likely to occur in areas with mixed land use, due to the higher probability of appropriate bicycle infrastructure (Chen & Shen, 2019).
- Auto-dependant American cities have greater traffic casualty rates than in cities where a greater portion of trips are by means of walking, bicycling and public transit (Frederick et al., 2018).
- An urban area's per capita crash rates decline with more job-housing balance, increased population density, greater transportation network connectivity, more public transit facilities, and grade-separated highways (Najaf et al., 2018).
- Dispersed, sprawl land use development is associated with lower per capita rates of minor collisions, but significantly higher rate of fatal collisions due to the combination of more total motor vehicle travel and higher traffic speeds in dispersed, automobile-oriented areas (Ewing et al., 2016; Myers et al., 2013).

ROAD DESIGN

Risk factors: Speed differentials, number of traffic lanes, width of traffic lanes, gradient changes, street lighting, street trees/flora, block length, presence of bicycle lanes, transit stop density, collision points at intersections.

- The presence of speed differentials within the traffic flow increases the likelihood of collisions (Ghods et al., 2012).
- Pedestrian injuries at an intersection increases with the addition of an extra lane of traffic, likely due to longer crossing times, increased vehicle speed, and increased traffic exposure (Stipancic et al., 2020).
- Four and five way intersections have an increased frequency of collisions compared to a two or three way intersection (Ukkusuri et al., 2012; Zhang et al., 2015).
- A road network with greater amounts of intersections and shorter blocks tend to have lower collision rates with pedestrians and cyclists, largely due to lower vehicle speeds (Stoker et al., 2015; Zhang et al., 2015).

- Traffic injuries and fatalities have been observed to occur at a higher frequency on arterial roads with greater amounts of traffic lanes, higher vehicle speeds, and low pedestrian activity (Mohan et al., 2017; Stipancic et al., 2020; Ukkusuri et al., 2012).
- Areas with greater ratio of arterial to non-arterial roads experience higher collision fatality rates (Mohan et al., 2017).
- Collisions are more likely to occur on roadways with less gradient change due to the increased pedestrian and commercial activity that occurs on flatter roadways (Dai & Jaworski, 2016).
- Pedestrian collisions were more likely to occur in areas with a greater amount of transit stops, perhaps due to the increased pedestrian activity in those areas (Dai & Jaworski, 2016).
- A greater amount of right-turn-only lanes increases pedestrian collision rates (Stipancic et al., 2020).
- The presence of street trees is associated with a reduction in pedestrian injuries, as they create a well-defined protective edge of the road and functions to modify the visual perception of drivers (Naderi, 2003; Zhu et al., 2022).
- The presence and implementation of bicycle lanes can reduce bicycle-vehicle collisions providing the infrastructure actively removes conflict between the two modes of transportation (Jarry & Apparicio, 2021).
- The implementation of cycle tracks is associated with greater cyclist safety and a reduction in collisions after adjusting for cyclist volume, while also reducing collisions in the areas surrounding the cycle tracks (Ling et al., 2020).

POPULATION DENSITY

- Pedestrian and cyclist collisions occur more frequently in areas with higher population density, largely due to increased exposure. However, it is not a linear relationship as there is a safety in numbers effect that occurs (Chakravarthy et al., 2012; Marshall & Ferenchak, 2017; Myers et al., 2013; Zhu et al., 2022).
- Pedestrian and cyclist traffic fatalities are more likely in rural environments; however, collision frequency is higher in urban areas (Marshall & Ferenchak, 2017, 2019; Myers et al., 2013).

IMPLICATIONS & CONCLUSIONS

As traffic and transportation agencies continue to work on minimizing traffic collisions, understanding the determinants and diagnostics of collisions becomes increasingly important. Focusing on all determinants is a challenging task but understanding where to direct resources will yield the best results for collision prevention. When using a human-system determinant approach, it can be shown that there are a larger number of systematic determinants compared

to human determinants. However, it should be noted that a greater number of determinants does not necessarily mean that there are a greater number of collisions attributed to them.

A key determinant that was pervasive throughout the review was motorist speed. While speed itself was shown to be a significant determinant of the collision severity, speed was also shown to be influenced by road geometry, intersection geometry, density, and identity tied to the specific area (non-locals versus locals). It is suggested that to reduce the frequency of speeding, that it may be useful to address the systematic determinants that could influence speeding as a method of human behaviour change. Lastly, an equity lens must be applied to understand the populations who are experiencing an increased risk of collision and fatality. Youth and seniors are more vulnerable road users due to multiple systematic factors (Chakravarthy et al., 2012; Davison et al., 2013; DiMaggio et al., 2016; Fang et al., 2018; Harmon et al., 2020; Kim, 2019; Rothman et al., 2014; Vanlaar et al., 2016; Yiannakoulias & Scott, 2013). Neighbourhoods with lower socioeconomic status are more likely receive non-local traffic, which is more prone to driving at greater speeds despite the potential unfamiliarity of the area (Morency et al., 2012; Yiannakoulias & Scott, 2013). This may be due to neighbourhood street design, or the location of the neighbourhood to major roadways. Implemented KPIs and policies utilizing a road safety lens should address the determinants of traffic collisions to achieve the most important measures and data.

Key Takeaways

- Determinants of traffic fatalities can be a result of human or systematic factors.
- Vulnerable road users such as pedestrians, active transportation users, children, older adults, and those with low socioeconomic status are at greater risk for traffic collision and fatality.
- A deep understanding of the determinants of traffic fatalities can help guide action to greater road safety policies and initiatives.

SECTION E: HOW CITIES MOVE

INTERVIEW METHODOLOGY

One of the key tasks required to enhance the research project was to conduct interviews with industry, government, professionals, and academic contacts who would offer perspective on key performance indicators and other related Road Safety measures. The research team started composing a draft list of potential key informants and potential questions best suited on their work, including peer reviewed drafted email letters.

Interview request emails were sent out to potential key informants. The interview process required sending participating key informants a letter of information (LOI) defining the intention of the project and interview, and ethical considerations. Pending key informants received follow-up emails within a week if they did not reply to the original email. Participating key informants received confirmation emails which outlined the interview date and time using the Microsoft Team invite and the LOI document.

Fourteen key informants were able to participate in the interview process. The City of Vaughan confirmed the interviews of six participating key informants. The research team prepared various questions catered to the position, experience, and expertise of each key informant. Most questions were geared towards receiving knowledge of the use of key performance indicators in the road safety and mobility strategy. Ethics approval for the interviews were approved from the Queen's General Research Ethics Board. Each interview was held through Microsoft Teams using audio and video conferencing. The interviews were typically 30 minutes in length with others extending to an hour. There were mainly two team members in each interview stating questions and note taking. The research team did note taking, video recording, transcription, and follow-up emails depending on the scope of the interview.

LIMITATIONS

1. The insights of the key informants were limited by a moderate sample size.
2. The research team was able to draft numerous KPIs from different municipalities but could only select a few to interview
3. Not every municipal interview or industry interview had a focus on KPIs which limited the information on existing KPIs
4. A small number of individuals agreed to be interviewed which was lower than the potential key informants that received an email request
5. Interviews were hosted within a short timeframe

DOCUMENT ANALYSIS METHODOLOGY

A major piece of the jurisdictional review included a document analysis to identify KPIs used by municipalities to assess the effectiveness and success of mobility strategies and initiatives. The selection criteria included descriptive or demographic information such as suburban municipalities and population growth to resemble the Vaughan context. Implementing a Vision Zero strategy was another criterion to identify best practices in mobility strategies. The inclusion criteria were fluid and flexible rather than restrictive or systematic to identify a broad range of KPIs. In other words, a municipality was not eliminated if it had experienced a population decrease or was more densely populated than Vaughan and a strategy lacking an explicit Vision Zero approach was not excluded from further analysis. In both cases, the implementation, KPIs and lessons learned from other jurisdictions will inform to the implementation and evaluation of the MoveSmart Strategy.

A total of 64 jurisdictions were identified resulting in 60 Canadian examples and 4 international examples (3 American and 1 in the Netherlands). Most jurisdictions were municipalities except for a few Canadian provincial and regional examples. Within Canada, explicit focus was on municipalities in Ontario, British Columbia, and Alberta because they are the most-populated English-speaking provinces.

A variety of documents were reviewed to identify KPIs including traffic safety plans, transportation master plans, mobility strategies, active transportation strategies, active transportation master plans and traffic calming guidelines. The oldest strategy or plan was implemented in 2006 and the most recent implemented in 2022 with most plans implemented within the last 5-years.

To narrow the document search, exclusion criteria were established for jurisdictions that did not publicly provide information on how they explicitly evaluate or monitor the effectiveness or success of their strategy as this would not yield KPIs. This resulted in further analysing only 28 jurisdictions, including 24 Canadian examples and 4 international examples. The significant reduction is also evidence of municipalities implementing a strategy without publicly creating a plan for evaluation or monitoring. This suggests the MoveSmart Strategy is ahead of most Canadian municipalities. Vision Zero is strongly related to data-driven, evidence-based initiatives and strategies. As such, there is a strong presence of Vision Zero strategies and associated KPIs because of the requirement to evaluate and monitor reducing traffic fatalities.

MUNICIPAL OUTCOMES

Presented below are Edmonton's measures and evaluations of its Community Outcome initiatives. These findings inform Vaughan of how Edmonton measures and evaluates its initiatives to improve Vaughan's initiative evaluation for the future iterations of the MoveSmart Strategy.

Table E-1: Edmonton's community outcomes

Community Outcome	How they are measured or evaluated
Speed and Speed Limit Compliance	Speed data can be used to evaluate the safety risk at a given location. The change in driver behaviour can also be evaluated by tracking speed compliance before and after a project is completed.
Automated Enforcement Violations	City-wide behaviour change can be measured by evaluating the total number of speed and red light running violations captured by automated enforcement, as well as the number of repeat offenses within specific periods of time. Progress can be identified through continuous decreases in these measures.
Mode Shift	Edmontonians' perceptions and feelings of safety are connected to their choice of transportation mode, and currently many Edmontonians feel less safe when traveling by modes other than driving a personal vehicle. As we improve safety for all modes, progress in this area will be measured by the increase in daily trips made by active transportation.
Perception of Safety	Hearing directly from Edmontonians about how their feelings of safety were impacted by changes in their community provides important lived experience data and demonstrates connections to livability.

Toronto's featured outcomes from its Congestion Management Plan highlight the success that the city has seen since its implementation. Many of these initiatives have been extended or built upon in response to their successful outcomes.

Table E-2: Toronto's outcomes.

Initiative	Outcome
Arterial Traffic Monitoring Camera Program	In the Spring of 2015, the City installed 43 new traffic cameras (primarily along the Pan Am Games Route Network) that were instrumental in managing traffic during the Games. The city installed 80 between 2015 and 2016 and then proposed to expand this program by an additional 40 cameras in each of 2018 and 2020 (City of Toronto, 2015).
'Priority Corridor' Signal Timing Optimization Studies	The City completed 15 optimization studies using CMP funding and observed a 5% to 10% reduction in travel times from this initiative (City of Toronto, 2015).
'**Auxiliary' Corridor Signal Timing Plans**	In three of the City's highest priority corridors, special timing plans were developed to better manage the special traffic patterns observed during nights, weekends, and expressway closures. The estimated benefit of this project is a 3% to 5% reduction in the travel time in these corridors during expressway closures (City of Toronto, 2015). Toronto planned to retime 357 traffic signals on 17 corridors by the end of 2016. More than 330 signals had already been targeted in 2015 which resulted in an 8 per cent reduction in vehicle delays and a 10 per cent drop in stops (Shum, 2016).
Upgraded Traffic Field Equipment	Between 2014 and 2016, the City modernized 250 traffic signal controllers and upgraded 60 RESCU controllers (used to control cameras, signs, etc., on expressways). This improved the operation of traffic signals, traffic cameras, variable message signs providing travel times, and traffic flow detection (City of Toronto, 2015)
Streamlined procurement process	To reduce the overall duration of the procurement process, a roster of pre-qualified consultants were selected in six categories of work, which was estimated to reduce procurement lead times by approximately 40% (City of Toronto, 2015).

Initiative	Outcome
Deployed traffic reports via Twitter	Using Twitter helped notify drivers of traffic reports and help them avoid congestion and collisions.
Installed new expressway variable message signs	The City installed 13 variable message signs along the Don Valley Parkway and Gardiner Expressway in 2014. These signs helped to convey safety and congestion messages to travellers along their travel path (City of Toronto, 2015)
Upgraded transportation operations centre	The City updated its 20-year-old Transportation Operations Centre to help the City to better manage and improve response time to incidents on roadways.

Lethbridge has five strategies each with their own set of KPIs to track the progress on actions towards achieving each objective (City of Lethbridge, 2020a).

Table E-3: Lethbridge's KPIs

Strategy	Qualitative and Quantitative KPIs
Data Collection and Management	• Support for updated definitions • Completion of feasibility study • Proportion of police collision reports with information on behaviour • Number of observational surveys conducted
Safety Management System	• Policy for network screening Documentation of practices • Policy for Road Safety Audits (RSAs) • Number of training sessions completed • Number of RSAs completed • In-Service Road Safety Reviews (ISRSRs) • Number of corridor reviews completed • Number and value of recommendations implemented
City Planning and Development	• Completion of list of policies • Completion of supporting processes • Completion of training of processes • Updated TIA Guidelines and distribution to development industry • Updated development cost charge structure • Adoption of Complete Streets Guidelines • Revised design standards

Communications / Public Awareness	• Annual reports on the progress and success of the communication strategy • Number of contest submissions received • Number of stickers issued • Number of reports of positive behaviours • Number of drivers thanked for positive behaviours
Transportation Safety Culture	• Number of people participating in survey Transportation safety culture index • Change in transportation safety culture index over time

SECTION F: SMART MOVES

The jurisdictional review revealed an abundance of KPIs with 378 publicly reported from during the jurisdictional review of twenty-four Canadian municipalities and four international cities with methodology detailed in Supporting Documentation Section E.

After removing duplicates and grouping of similar KPIs based on available explanation, the total number of KPIs was reduced to 144. By adhering to the goals and objectives of the pillars within the MoveSmart Strategy, the number was further condensed to 50.

Careful considerations were given to the fifty KPIs to derive the final twenty to ensure they are most suitable for Vaughan's overall context, current mobility approaches and issues which the MoveSmart Strategy is attempting to address. As the MoveSmart strategy evolves, additional or alternative KPIs may be required. The project team has provided 50 KPIs grouped by collision, transportation behaviour, high-risk driving and enforcement, engagement and education, land-use, infrastructure and engineering projects, maintenance, municipal policy and development, review and audit, and data management. Similar KPIs are grouped together while still maintaining the nuances and local context of the municipality.

Table F-1: Fifty key performance indicators identified during jurisdictional review.

Key Performance Indicator		**Municipality**
Collision key performance indicators		
1.	Rate of killed and seriously injured per 100,000 population	Surrey, British Columbia, City of Ottawa, Manitoba, Fort Saskatchewan, St. Albert
2.	Frequency and/or percentage of fatal and injury collisions	Lethbridge, Calgary, Edmonton, Saint John
3.	Intersection collisions Intersection collision rates; Percentage of fatal/major injury collisions at/or related to intersections; Rate of intersection killed and seriously injured per 100,000 population; Collisions at intersections; Signalised intersections; Severe collisions at intersections	St. Albert, Ottawa, Surrey, Lethbridge, Durham
4.	Collision type Head-on collisions; Left-turn movements; Right angle collisions	Lethbridge, Durham
5.	High risk driving collisions Percentage of fatal/major injury collisions involving one or more drivers engaging in one or more high-risk driving behaviours; Number of collisions with alcohol or drugs involved; Aggressive driving citations; Distracted driving	Ottawa, Saint John, Lethbridge

Key Performance Indicator		Municipality
6.	Percentage of fatal/major injury collisions in rural area	Ottawa, Strathcona County
7.	Frequency or percentage of injury and fatal collision by transportation mode Pedestrians; Cyclists; Cars; Motorcycles; Trucks	Surrey, St. Albert, Edmonton, Calgary, Lethbridge, Durham, San Francisco, Montreal, Ottawa, Toronto
8.	Number of fatal and severe injuries by: Age; Sex; Race; Ethnicity	San Francisco
9.	Proportion of fatal and severe injuries in a specific location Community of concern; High collision location	San Francisco, Edmonton
10.	Social cost of collisions; Downward trending over the next ten years in the societal cost of collisions in Manitoba on a per capita basis	Saint John, Manitoba
Transportation behaviour key performance indicators		
11.	Mode shares percentage Transit; Bicycle; Pedestrian; Bicycle; All trips; Different times of day; Key districts; short trips; Home-based work trips	Regina, Halifax
12.	Vehicle Kilometres Average daily vehicle kilometres travelled; Bicycle-kilometres travelled; Vehicle kilometres travelled per capita; Reduction in percent of vehicle-kilometres travelled on arterial and collector roads; Vehicle kilometres of travel/year during 2026 PM peak hour based on SimTraffic outputs; Reduction in in-vehicle travel time on the road network	Halifax, Lethbridge, Regina, Peterborough, Owen Sound, Owen Sound
13.	Commute Duration Average commute duration for pedestrians; Average commute duration for cyclists; Average commute duration for drivers by region; Emergency response time; Average truck travel times	Halifax, Saint John, Regina
14.	Peak Periods Average AM peak period and average PM peak period auto travel trip time; Duration of peak periods; Three major corridor links at or approaching capacity during 2026 PM peak hour based on 2026 model forecasts	Regina, Halifax, Peterborough, Owen Sound
15.	Walking Trips Number of walking trips; Daily trips made by active transportation; Percentage of walking trips; Percentage of K-12 students walking to school	Calgary, Edmonton

Key Performance Indicator		Municipality
16.	Perceptions of Transportation User perception of walking, bicycling, and taking transit as a transportation option; Comfort levels with cycling for people by gender, age, ability; Public reactions to bike lanes	Calgary, Edmonton, Spruce Grove, Strathcona County, Halifax, New York City
17.	On-street parking utilisation rates	Halifax
18.	Usage of the bicycle infrastructure and programs by gender, age, ability	Edmonton
High-risk driving and enforcement key performance indicators		
19.	Yield rates and distances; Yield compliance	St. Albert, Calgary
20.	Speed Reduction Reduction in vehicle speeds; Reduce the 85% percentile speed	Lethbridge, Spruce Grove, St. Albert
21.	Speeding Number of vehicles exceeding speed; Peak periods for excess speeding; Peak periods when excess speeding; Percentile of vehicle speeds; Percentage of cars speeding	Spruce Grove, New York City
22.	Speed Speed limit compliance rates; Speed of moving vehicles; Average speed travelled	Spruce Grove, Saint John, St. Albert
23.	Automated Enforcement Number of Red Light Cameras; Number of Intersection Safety Devices (ISD); Number of red-light cameras installed; Number of locations identified for red light cameras; Number of ISD locations	Guelph, Fort Saskatchewan, Strathcona County, Toronto, Brantford, Fort Saskatchewan, Montreal
24.	Number of joint forces operations	Spruce Grove, Strathcona County
25.	Number of school zone patrols	Spruce Grove
26.	Violations Total number of speed and red-light running violations captured by automated enforcement; Speed on green and red-light infraction rates at signalised intersections; Speed and red-light running violations captured by automated enforcement repeat offenses within specific periods of time	Edmonton, Strathcona County
Engagement and education key performance indicators		
27.	Complaints Number of 311 services requests received; Number of 311 services requests closed; Number of residential and school-related complaints	Calgary, Edmonton, Strathcona County

Key Performance Indicator		Municipality
28.	Customer contact performance (Score)	Chilliwack
29.	Educational Campaigns Number of community events attended; Number of presentations given; Number of schools visited; Number of seniors centres visited; Number of priority locations visited	Strathcona County, New York City
30.	Advertisements Citizen exposure to education and promotion activities; Google analytics; Number of advertisements; Awareness of Vision Zero; Number of signs distributed	Strathcona County, Halifax, New York City, San Francisco, Brantford
Land-use key performance indicators		
31.	Network Connectivity (Score) Access and availability to the network by distance and/or time with consideration to equity	Edmonton
32.	Percent of residents within 500m of a bicycle route	Halifax
33.	Walking audit tool (Score)	Calgary, Strathcona County
Infrastructure and engineering project key performance indicators		
34.	Sidewalk length or frequency Square feet of pathways/sidewalks; Sidewalk provision; Percentage of collector and arterial roadways with sidewalks; Kilometres of missing sidewalks installed; Percentage of streets with sidewalks by sub-region; Number of kilometres of new sidewalks; Percentage of roads where pedestrians are present and traffic flows at 40km/h (25mph) or faster and have formal footpaths or sidewalks	Arizona Department of Transportation, Regina, Halifax, Saint John, Montreal, International Road Assessment
35.	Bicycle Infrastructure Length or Frequency Kilometres of regional centre 'AAA' bicycle network completed; Kilometres of bike lanes; Kilometre of facilities that protect micro-mobility devices; Amount of bicycle infrastructure constructed; Number of kilometres of new cycling infrastructure; Number of protected bike lane distance created; Protected bicycle lane miles installed; Dedicated bicycle lane miles installed; Kilometres of on street bicycle facilities; Kilometres of off street bicycle facilities; Number of bike boxes; Number of kilometres of new cycling infrastructure; Number of protected bike lane distance created; Percentage of roads where bicyclists are present and traffic flows	Halifax, Brantford, Lethbridge, Edmonton, Saint John, Montreal, New York City, Regina, Brantford, International Road Assessment

Key Performance Indicator		Municipality
	at 40km/h (25mph) or more have dedicated bicycle facilities;	
36.	Pedestrian Crossings Number of pedestrian crossovers installed; Distance between controlled pedestrian crossings; Number of new safe pedestrian crossings; Number of crossovers; Number of safe crossings projects completed; Number of traffic signals; Percentage of roads where pedestrians cross and traffic flows at 40km/h (25mph) or more have pedestrian crossing facilities	Toronto, Saint John, International Road Assessment, Lethbridge, Brantford, Arizona, Montreal, Edmonton
37.	Safety Zones Number of community safety zones implemented; Number of senior safety zones implemented; Number of school safety zones implemented; Number of school safety projects completed	Toronto, Saint John, Montreal, Edmonton
38.	Percentage of school star rating data points that are 3-star or better for children	International Road Assessment
39.	Number of LED Blank-out signs installed	Montreal, City of Toronto
40.	Projects Number of management programs implemented; Number of activities completed; Total safety projects completed; Number of standalone (as opposed to coupled with road improvement project) active transportation projects funded from the municipal budget; Number of implemented complete street projects; Number of programs/projects ordered as a result of an in-service road safety review; Number of engineering improvements on the High Injury Network; Number of implemented geometric modifications; Number of implemented geometric modifications	St. Albert, New York City, Durham, Regina, Strathcona County, Edmonton, San Francisco, Saint John, New York City
41.	Quick-Build projects completed on the High Injury Network	San Francisco
42.	Number of streets with reduced speed limits	Saint John
Maintenance key performance indicators		
43.	Percent of network (sidewalks and pathways) repaired/plowed annually	Regina
44.	Number of LED Streetlights	Montreal
Municipal policy and development key performance indicators		
45.	Number of TDM initiatives adopted by city and large employers	Regina

Key Performance Indicator		Municipality
46.	Measure of Effectiveness Score Supports mobility and performance goal for the road network; Supports active modes of transportation; Supports business activity	Peterborough
Review and audit key performance indicators		
47.	Corridor Reviews Number of corridor reviews completed; Number and value of recommendations implemented	Lethbridge
48.	Audits Number of in-service road safety reviews; Number of road safety audits; How many road safety audits are completed each year	Calgary, St. Albert
Data management key performance indicators		
49.	Proportion of police collision reports with information on behaviour	Lethbridge
50.	Data collection and analysis completed by the end of Q1 for the previous year	Strathcona County

SECTION G: MOVING FORWARD

The ultimate vision of the MoveSmart Strategy is to provide a transportation system for Vaughan that is safe, efficient, and sustainable. This vision is likely to take some time beyond the duration of the current iteration of the MoveSmart Strategy, time bound till 2026, to deliver. Keeping its three strategic objectives in mind, this report will close with some final recommendations in anticipation of the next iteration of the MoveSmart Strategy.

Recommendation #1: Incorporate specific and actionable measures, responsible partners, and a theory of change, in ways that integrate social, environmental, and financial sustainability

Our review recognises that the one-page summary of the MoveSmart Strategy, with program areas represented by different colours with graphics accompanying program-specific goals, is an effective way of providing an overview of the framework to internal and external partners, as well as to Vaughan residents. Each of the four program areas of the MoveSmart Strategy contain timebound program goals. The framework and goals represent a significant step towards creating an effective municipal strategy. Our jurisdictional review has noted a variety of approaches for defining and communicating municipal transportation and road safety goals which may enhance the MoveSmart Strategy.

Table G-1: Action measures table for achieving the goal of slowing vehicle speeds (San Fransicso, 2021).

ACTION	LEAD AGENCY	TIME FRAME
SLOWING VEHICLE SPEEDS		
Apply the Quick-Build toolkit on the entire HIN by 2024* (see map on pages 30-31 for more details).	SFMTA / SF Public Works	2024
Develop a comprehensive speed management plan with the goal of slowing vehicle speeds on the HIN using tools such as speed limit reductions (as authorized by AB 43), traffic signal re-timing, installing traffic calming devices, and re-purposing travel lanes (road diets). The Plan will include complementary tools like education and outreach and high visibility enforcement to slow speeds (see pages 34-35 for more details).	SFMTA	2022
Complete 100 traffic calming devices annually, including locations focused on areas that have been prioritized for seniors, people with disabilities, and schools.	SFMTA	Annual
Expand active transportation network for biking and walking, including low-car and car-free streets, Slow Streets, and protected bike lanes, with community support (see map on pages 38-39 for more details).	SFMTA /SF Recreation and Parks	2024

The MoveSmart Strategy program goals are generally focused on creating, consolidating, or updating plans or policies that support high-level program areas. It could be enhanced by providing program objectives with specific and measurable actions. For example, specify the

number, proportion, or percentage of markings and signs intended to be replaced per given year associated with the program goal "Pavement Markings and Signs" under the Mobility Management Program where "replace and optimise marking and signs" are noted (City of Vaughan, 2021a). A clearer goal could be to.

For both action-oriented goals and policy development goals, there is also an opportunity to **indicate which internal or external partners are responsible.** Table G-1 is an example from San Francisco's Vision Zero Strategy that articulates goals which fit under a higher-level objective with associated lead agencies and time frames.

There may also be ways to communicate how program areas and program goals support its vision in a holistic manner. For example, the MoveSmart Strategy Executive Summary notes that traffic congestion is of concern to Vaughan residents, and so "the mobility management program is designed to manage congestion"(City of Vaughan, 2021a). This speaks to the MoveSmart Strategy's vision for an efficient transportation system; however, efficiency may contradict its vision for safety and sustainability. Improving efficiency, especially of vehicles, may decrease the interest of sustainable transportation modalities and increase collision risk of pedestrians.

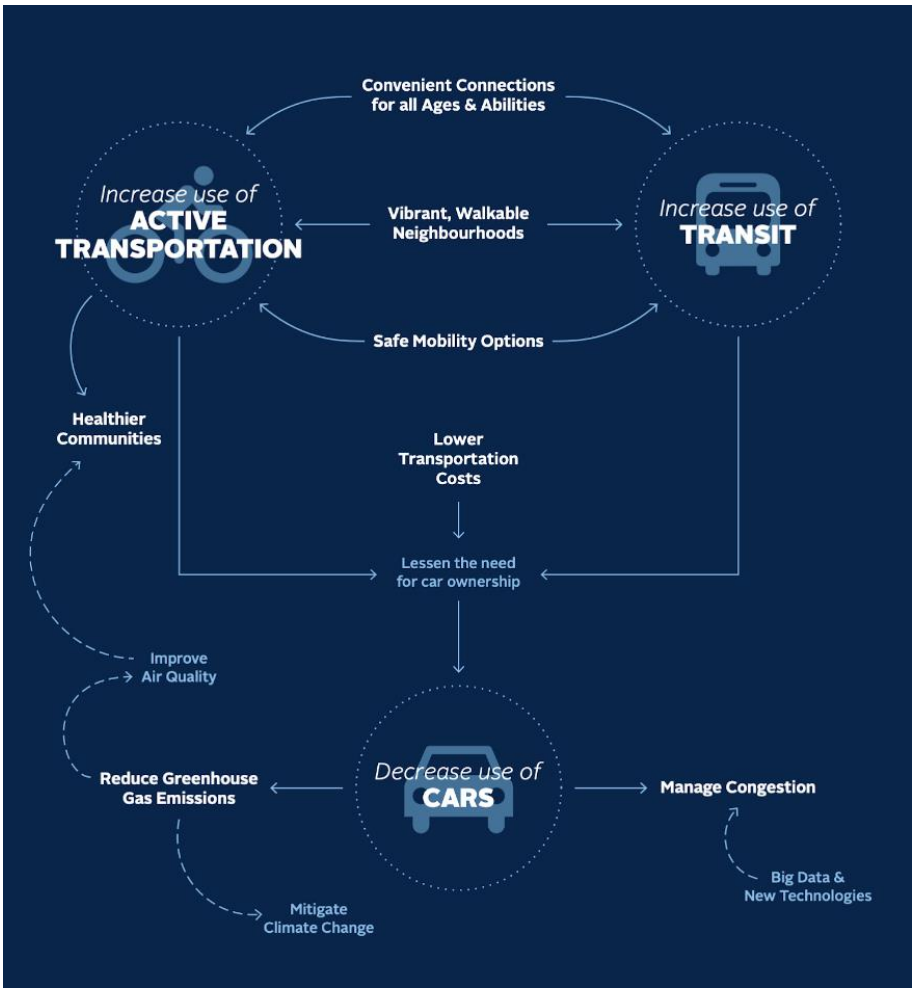


Figure G-1: The Integrated Mobility Plan describes the relationship between its goals and plans (Halifax Regional Municipality, 2017).

As a way of clarifying potentially contradictory goals, MoveSmart Strategy could state its theory of change. Figure G-1 offers an example from the Halifax Regional Municipality's *Integrated Mobility Plan* which frames why its plan is needed and serves as way of communicating how its goals interact.

The term *sustainable* can have a variety of implications within Vaughan's MoveSmart Strategy vision. It could be interpreted that mobility needs should be achieved in ways that support sustainable development, for example by lowering carbon emissions, replenishing natural resources, or more broadly, ensuring health, peace, and prosperity for its citizens. Alternatively, it may be interpreted that mobility should be achieved in a way that is financially sustainable. In either case, there are ways to **communicate and integrate sustainability into program areas and goals**. For example, by stating that the MoveSmart Strategy supports emission and air quality targets, physical activity levels, and social equity considerations, it both strengthens MoveSmart Strategy as interdepartmental policy, and increases public awareness as a communication strategy.

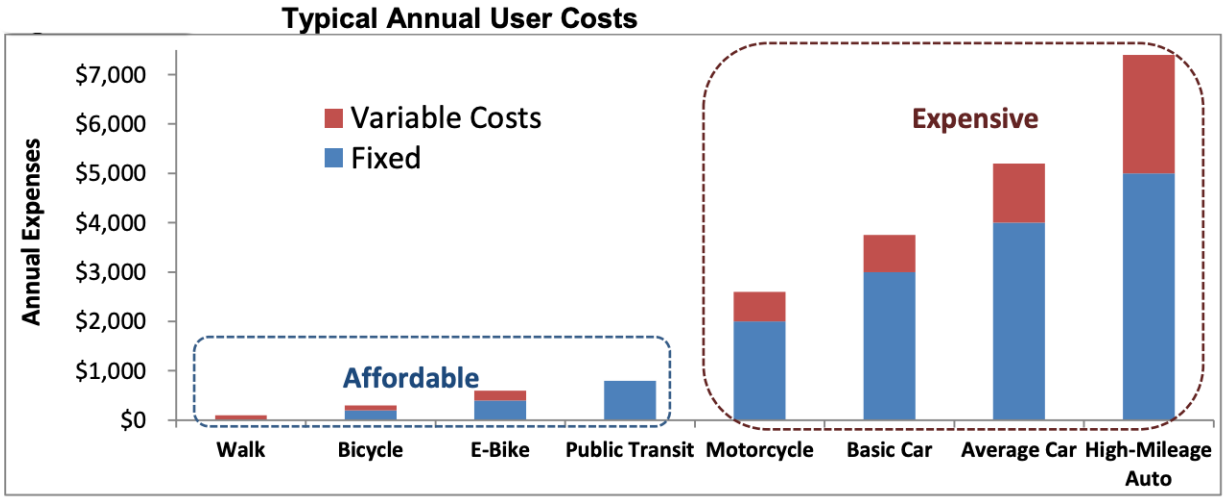


Figure G-2: Walking, bicycling, e-bikes, and public transit are more affordable than automobile travel (Litman, 2022a).

It may also be beneficial to **frame its strategy in relation to financial sustainability.** For example, significant individual user savings are likely to occur with shifts towards sustainable modes of transportation, as noted in Figure G-2 and Table G-2. A different emphasis on financial sustainability is used by the City of Lethbridge's *Transportation Safety Pla*n, which focuses on the direct and indirect costs of collisions over a five-year period, concluding that their plan expects "significant societal cost savings through the overall reduction of incidents" (City of Lethbridge, 2020a).

Table G-2: Collisions in Lethbridge have imposed a cost to society of nearly $650M over 5 years, or nearly $130M per year (City of Lethbridge, 2020a).

Total Cost of Collisions in Lethbridge (2012 – 2016)

Collision Type	Direct Cost	Indirect Cost	Total Cost
Fatality	$ 2,421,661	$ 73,779,508	$ 76,201,169
Injury	$ 18,161,250	$ 432,194,250	$ 450,355,500
Property Damage Only	$ 119,821,330	-	$ 119,821,330
TOTAL	**$ 140,404,241**	**$ 505,973,758**	**$ 646,377,999**

Recommendation #2: Describe how equity is understood in relation to road users, equity deserving populations, and the city of Vaughan's decision-making and capital expenditure process.

A significant portion of the literature and jurisdictional review emphasised the need to meet the needs of the most vulnerable road users, which the MoveSmart Strategy objectives also articulate. However, it remains unclear how the most vulnerable road users are considered conceptually, within its theory of change, and within program goals. By comparison, the City of Surrey, shown in Figure G-3, embeds equity into their decision-making process as part of their *Safe Mobility Plan,* while the City of Edmonton lists *equitable safety* as one of their four themes within their *Safe Mobility Strategy* (City of Edmonton, 2021b; City of Surrey, 2019). Our interviewees consistently noted the need for a proactive approach, as opposed to a complaint-based approach, to fully document, understand, and respond to the needs of its vulnerable road users and equity deserving populations. In summary, MoveSmart Strategy should **demonstrate how equity is integrated within its plan.**

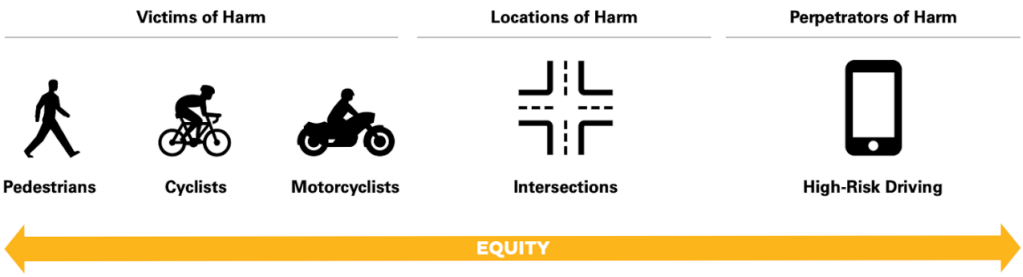


Figure G-3: City of Surrey ensures that equity is embedded within each of its focus areas (City of Surrey, 2019).

Vulnerable road users are accounted for within the Sustainable Mobility program area, however the remaining three program areas seem to favour actions that manage vehicle traffic, as opposed to enhancing non-vehicle uses directly. An alternative approach to balance the distribution of priorities can be seen within the City of Vancouver's *Transportation 2040 Plan*, which states that decisions "generally reflect a hierarchy of transportation modes, with walking as the top priority", as shown in Figure G-4. (City of Vancouver, 2012). Regarding financial

implications, MoveSmart Strategy requires a capital investment of nearly $8 million, but how this investment is allocated based on travel mode or user vulnerability is unclear. Overall, the MoveSmart Strategy could **describe its balanced approach in terms of decision-making processes and within financial allocations.**

Recommendation #3: Limit the use of information-oriented public education campaigns

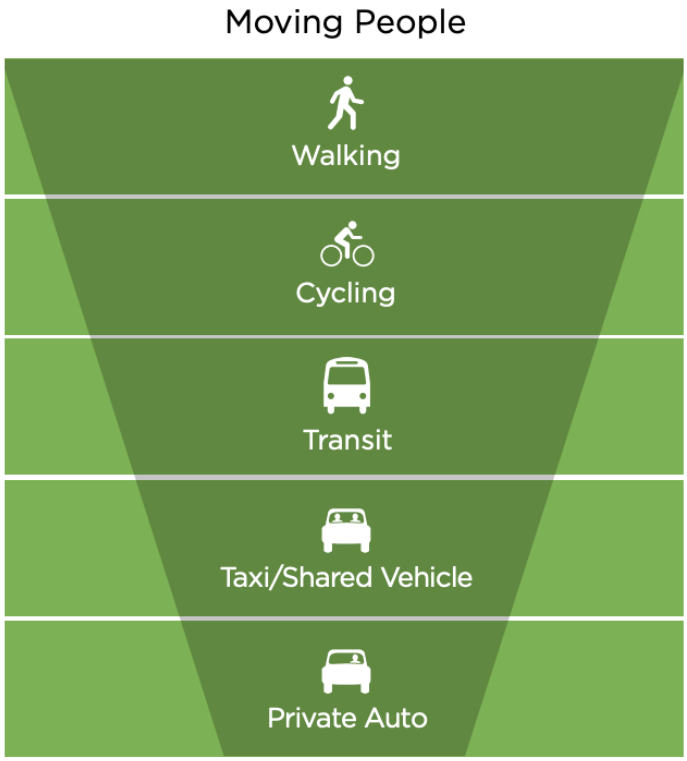


Figure G-4: Those who walk are given the highest priority when making transportation-related decisions according to the Vancouver (City of Vancouver, 2012).

One of the MoveSmart Strategy's program areas is to increase road safety and raise public awareness. Public education and outreach campaigns are often used by municipalities and police services to address road safety concerns. From road safety workshops in schools to social media campaigns, there exist a vast array of communication and education-based strategies to support behaviour change. In practice, however, there tends to be an emphasis on road safety campaigns that are promoted through public information such as "slow-down" lawn signs, billboards, brochures, and stickers. Contrary to the popularity of this approach, in an extensive review of the effectiveness of behaviour highway safety countermeasures, the Transportation Research Board concluded that information-only safety messages are unlikely to have a significant effect on behaviour (Transportation Research Board, 2008). More recently, the National Highway Traffic Safety Administration, in *Countermeasures That Work* note that educational campaigns are the least effective tools to increase road safety in comparison to other strategies (National Highway Traffic Safety Administration, 2020). While public education campaigns can still be useful, notably by target messaging towards a specific group and improving access to the suggested action for this group, MoveSmart **should limit information-oriented public education campaigns as they are less effective.**

Recommendation #4: Commit to Vision Zero language and terminology within the MoveSmart Strategy and elsewhere within the city of Vaughan

The MoveSmart Strategy Executive Summary notes how it will work towards a Vision Zero goal. However, Vision Zero and the Safe Systems Approach, are not present within the body of the MoveSmart Strategy itself. To enable long-term change at the cultural and political level, multi-sectoral partnerships, and collaboration with partners outside of Vaughan will be essential. While the City of Edmonton first adopted a Vision Zero approach to road safety in 2015, our review notes that 17 other municipalities in Canada have adopted Vision Zero, and 10 others are in development. As such, the City of Vaughan should work with Vision Zero municipalities and **fully support Vision Zero to increase wide-scale adoption, public awareness, and robust policy development.**

Recommendation #5: Support, integrate, and evaluate mixed land-use development policies which aim to decrease overall vehicle kilometres travelled of Vaughan residents.

As identified in our literature review, municipal policies that promote auto-dependent and single-use land development tend to increase overall vehicle kilometres travelled thereby increasing a vulnerable population's overall exposure to collisions (Chen & Shen, 2019; Frederick et al., 2018; Myers et al., 2013). Our review notes that some municipalities use relevant KPIs that speak to this correlation, such as county compactness index in the United States (Ewing et al., 2016), while the City of Calgary uses WalkScore. While literature strongly supports this direction, our jurisdictional review notes that use of related land-use KPIs by Canadian municipal transportation departments is still in development. Therefore, our report does not recommend WalkScore as a KPI, but the MoveSmart Strategy should prioritise program goals that **support and evaluate mixed and sustainable land-use development policies.**

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