Toronto Cyclist Collisions

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***Abstract*—The report explores the conditions of cycling in Toronto from 2006 to 2020 and analyzes the issues the city faces in trying to improve the safety of cyclists.**

Keywords—cyclist collisions, cycling safety, Toronto cycling, cycling infrastructure, cyclist KSI

I. Introduction

The dataset we will be exploring is the Cyclists dataset provided by Toronto Police Service. The dataset is a subset of their KSI (Kill or Seriously Injured) dataset, so all the data recorded for cyclist collisions are only those that resulted in a death, or the cyclist being seriously injured. The dataset consists of cyclist collisions from 2006 to 2020, containing information such as the location, time, weather condition, reason of collision, etc.

II. Comparing Total Collision Locations: Fatal/Non-Fatal Injuries

A. Total Collisions (Both Fatal and Non-Fatal):

The following plots identify the total number of collisions among cyclists within different locations in Toronto. The data collected only accounts for accidents which resulted in fatal or non-fatal injuries. The number of accidents were highest within the downtown area, especially along the waterfront. In dense populations like downtown Toronto, where there is a vast number of cyclists and vehicle drivers sharing the road, many cyclist collisions are apparent. Among the collisions, the majority of accidents occurred along intersections. According to a recent case study [1], common causes of cycling accidents occur as a result of driver inattention, distracted driving, excessive speed, and illegal and unsafe turns, among other factors

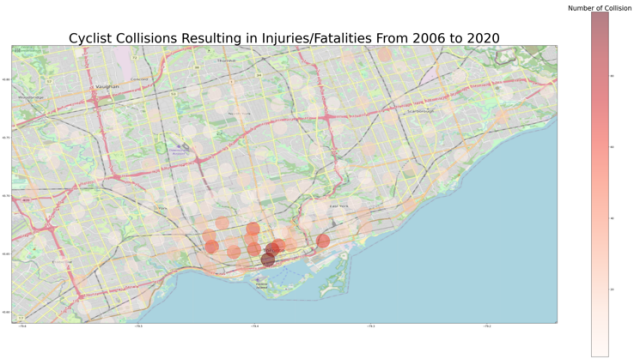

Figure 1 - Map of Cyclist Collisions Resulting in Injuries/Fatalities (2006-2020)

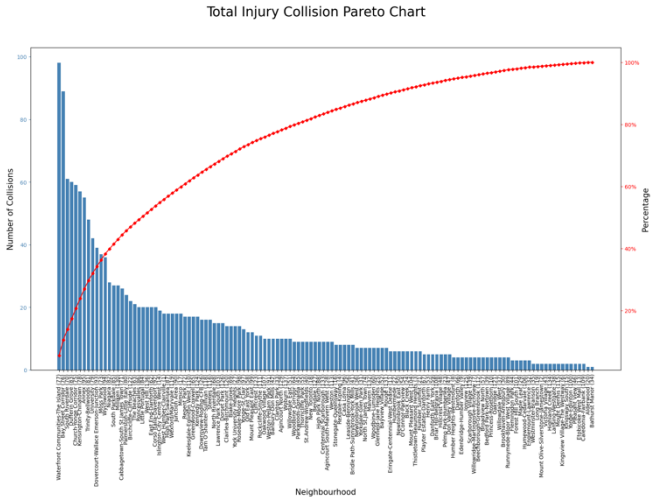

Figure 2 - Pareto Chart of Total Injury/Fatalities Among Toronto Neighbourhoods

Table 1 - Cumulative Percentage of Collision Among Toronto Neighbourhoods

	NEIGHBOURHOOD	count	cumulative_percent
0	Waterfront Communities-The Island (77)	98	5.508713
1	Bay Street Corridor (76)	89	10.511523
2	South Riverdale (70)	61	13.940416
3	Dufferin Grove (83)	60	17.313097
4	Church-Yonge Corridor (75)	59	20.629567
5	Kensington-Chinatown (78)	57	23.833614
6	Annex (95)	55	26.925239
7	Trinity-Bellwoods (81)	48	29.623384
8	University (79)	42	31.984261
9	Dovercourt-Wallace Emerson-Junction (93)	39	34.176504

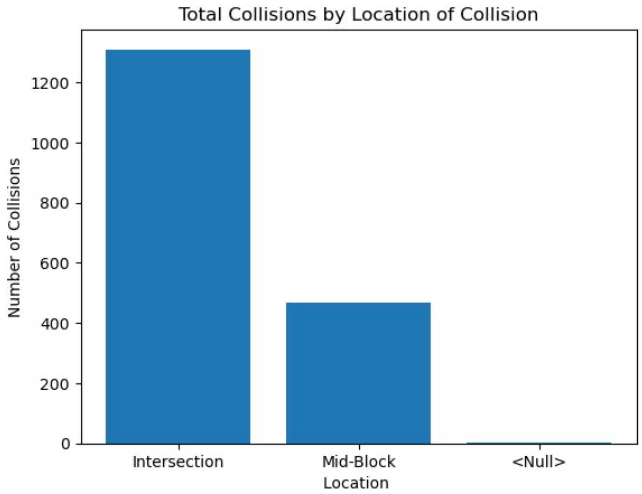

Figure 3 - Location of Collision Resulting in Injury/Fatality

B. Total Collisions (Fatal Injuries):

The following plots map out the cyclist accidents which resulted in fatal injuries. From the map plot given above, you would assume that downtown Toronto, where the majority of accidents relating to injury occurred, would have the highest fatality rate among cyclists. However, as seen below, this is not the case. According to a recent study done in 2019 [2], this is due to a few reasons. First, collisions among drivers (Both cyclists and vehicles) are more fatal along lanes that are wide and straight, which can cause drivers to feel more comfortable speeding and driving inattentively. Second, the roads outside downtown Toronto are more prone to potholes and bad pavement conditions, which poses as a hazard for cyclists. Finally, while downtown Toronto has implemented many bike lanes and other infrastructure to promote bike safety, this is not the case outside of the downtown area, where many cyclists need to share the road with other vehicles.

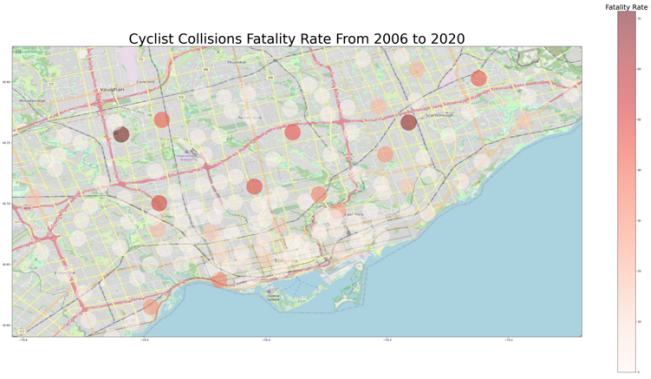

Figure 4 - Map of Cyclist Collisions Resulting in Fatalities (2006-2020)

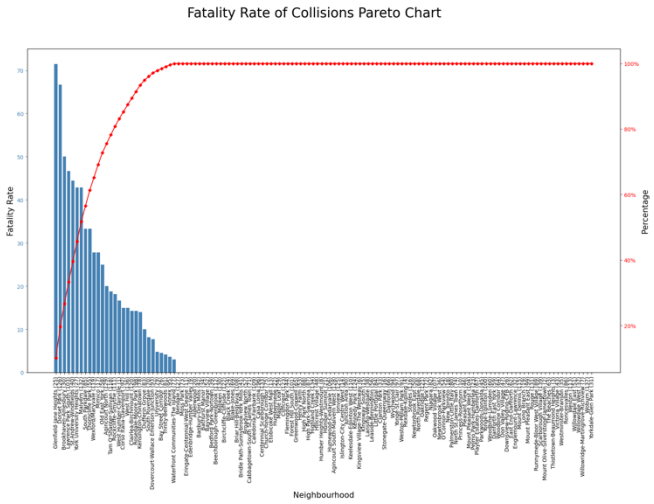

Figure 5 - Pareto Chart of Fatalities Among Toronto Neighbourhoods

Table 2 - Cumulative Percentage of Fatal Collisions Among Toronto Neighbourhoods

	NEIGHBOURHOOD	Fatal	Non-Fatal Injury	Fatality Rate	cumulative_percent
0	Glenfield-Jane Heights (25)	5	2	71.428571	10.140955
1	Dorset Park (126)	10	5	66.666667	19.605847
2	Brookhaven-Amesbury (30)	2	2	50.000000	26.704515
3	Lawrence Park South (103)	7	8	46.666667	33.329939
4	St.Andrew-Windfields (40)	4	5	44.444444	39.639867
5	York University Heights (27)	6	8	42.857143	45.724440
6	Malvern (132)	3	4	42.857143	51.809013
7	South Parkdale (85)	9	18	33.333333	56.541459
8	Thorncliffe Park (55)	3	6	33.333333	61.273905
9	Wexford/Maryvale (119)	5	13	27.777778	65.217610

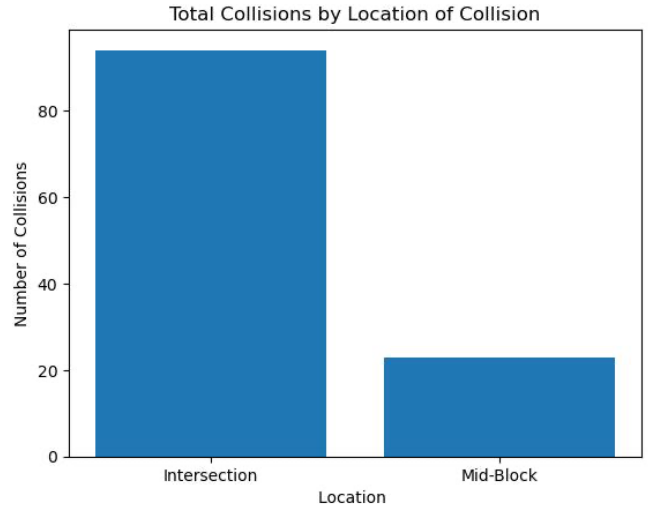

Figure 6 - Location of Collision Resulting in Fatality

III. Year to Year Collision Trends

The infographic below shows the trend with bicyle accidents on a yearly basis. From the infographic, it is evident that there has been a steady rate of yearly collisions, with the number of injuries/fatalities among cyclists which were highest between 2011-2013. Although in 2020, there has been comparatively less cyclist collisions relating to injury/fatality, this may have been a result of the covid

pandemic where the lockdown forced many citicizens to spend their times indoors.

In a Cycling Study done in 2019 by the City of Toronto (Article 2), it highlighted that the number of cyclists has risen steadily over the past 20 years. While the total number of injury related collisions may not have seen a significant decrease year over year (with the exemption of 2020), the fact that the number is not increasing is a good indication that bicycle related infrustructure implemented by the city of Toronto has had some positive effect on cycling safety.

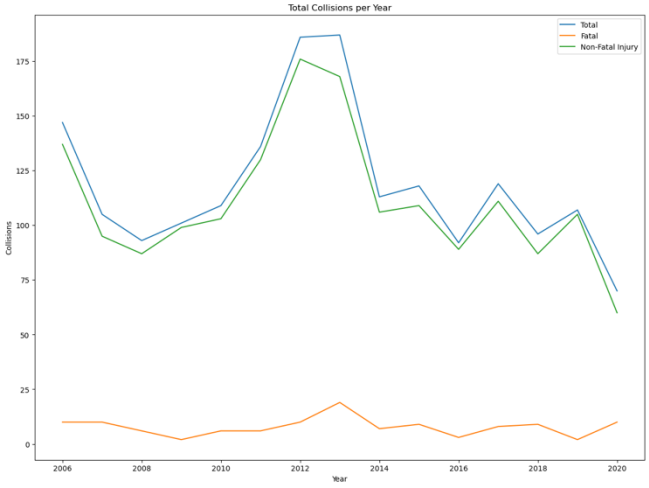

Figure 7 - Total Injury/Fatal Collisions by Year

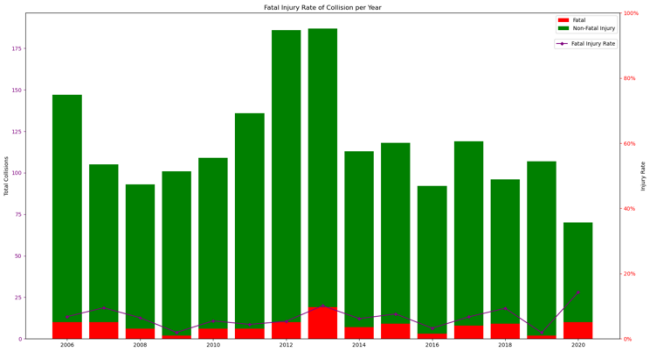

Figure 8 - Collisions by Year

IV. Common Causes and Outcomes for Cyclist Collisions

The third infographic shows the common causes and patterns within the outcomes for cyclist collisions. Roughly 40% of total cycling accidents resulting in injury/fatality includes aggressive driving as a reason for the collision. Aggressive driving entails behaviours such as erratic driving, operating a vehicle in a careless matter, brake checking, illegal passing, etc. These collisions are most frequent in the evening and, from the statistic below, found that 37% of cylist collisions relating to injury occur around rush hour. These findings are comparable to results determined by Statistics Canda in a report done to research circumstances surrounding cycling fatalities between 2006 – 2017 (Article 4). In the report, it was found that canadian cyclists suffer more fatalities during evening rush hour and many people claimed that environmental conditions affecting visibility, such as darkness, rain, or blinding lights, have played a role in these accidents.

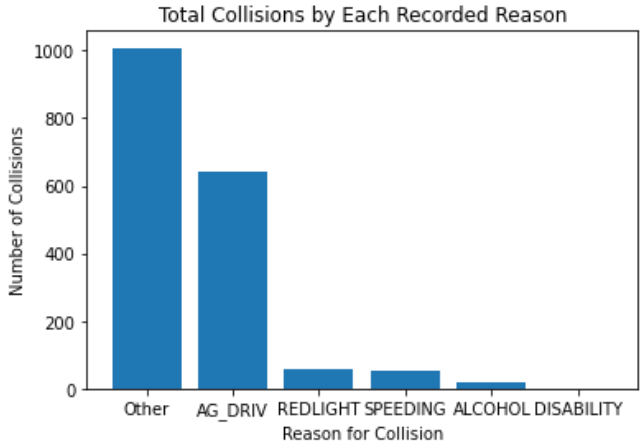

Figure 9 - Common Reasons for Cyclist Collisions

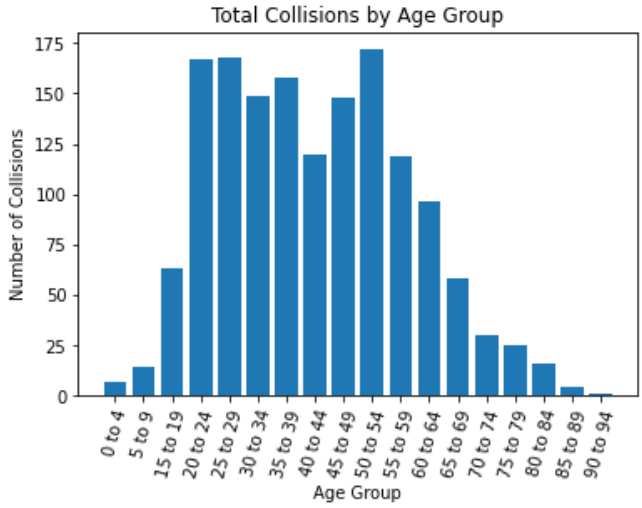

Figure 10 - Age Group of Cyclists in Accidents

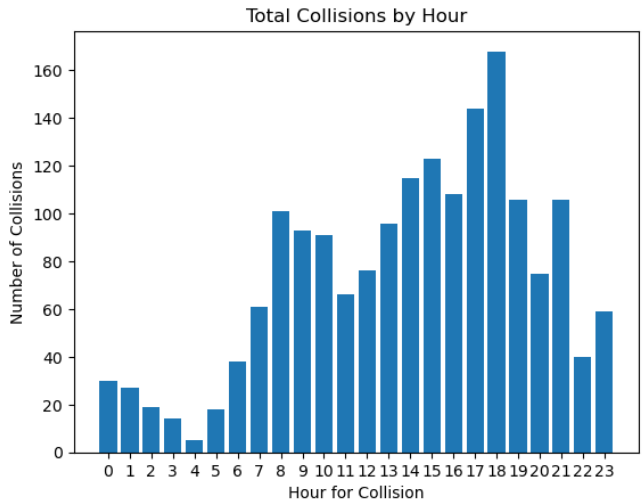

Figure 11 - Accidents by Time of Day

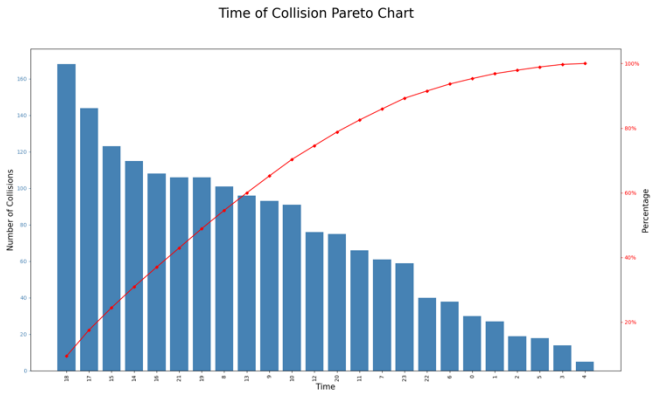

Figure 12 - Pareto Chart of Time of Day of Collision

V. Observation of Data Trends

Based on the various graphs and tables we've generated, here are three statistics we found that stood out. (1) 37% of cyclist collisions resulting in injury occoured around rush hour between the year 2006-2020. (2) About 37% of collisions that lead to injuries were a result of aggressive driving. (3) Between the year 2006 to 2020, 21% of cyclist collisions resulting to injury were located within 5 out of 128 neighourhoods.

VI. Solutions From Research Journal

A. Cyclist Target and Setup for Evaluation of Cyclist-Autonomous Emergency Braking

This journal paper analyzes the development and testing of the Cyclists-AEB (Autonomous Emergency Braking) System, which is a system dedicated to avoiding and mitigating passenger car-to-cyclist collisions [3].

- Euro New Car Assessment Programme analyzed and tested a AEB system for cyclists using cameras and LiDAR to detect when there a presence of a cyclist to stop the vehicle
- They tested this system with the vehicle traveling at various speeds and the cyclist dummy coming from different directions of potential impact
- The system is still going through more tests as of 2020 but has potential to be extremely impactful for future vehicle systems

This solution focuses on the issue of cyclist and vehicle collision and tries to mitigate the severity of possible injuries with this autonomous braking system.

B. The Dutch Road to a High Level of Cycling Safety

The Netherlands is the world leader in cycling safety and the journal analyzes how they've been able to achieve an 80% reduction in number of cyclist deaths (mostly cyclist-vehicle collision) per billion bicycle km over thirty years [4].

The research pinpointed that the Netherlands were able to achieve this over their many years of continued commitment to embrace cycling as part of their culture. The exact components that they used and created were major contributors to their success.

- Travel behaviour and exposure to risk (road infrastructure)
- Risk factors for user behaviour, infrastructure, and vehicle design
    - Road users (Cycling speed, cyclist experience, legal liability, education and training, safety measures, bike paths, etc.)

Given all aspects that contribute to why the Netherlands were able to improve their cyclist safety, the key factors identified by the study were (1) low cycling speeds, (2) one-way bike paths, (3) and intersection treatments such as speed reducing measures.

Additionally, the Netherland's intersection design is much better in terms of safety for pedestrians and cyclists. The design of the intersection makes it so that drivers turning on to the main road from intersections must check multiple times before being able to turn safely on to the main road. The roads of the intersection that aren't the main road are slightly lower, which makes drivers need to check and allow for pedestrians and cyclists to safely cross before moving on to the middle island on the road where they then wait for an oppourtunity to turn on the main road.

C. How to Make More Cycling Good for Road Safety

This research journal analyzed current road safety problems for cyclists, why cyclists run relatively high risks, and why cyclists may be considered 'vulnerable road users'. They analyzed many other research studies to find which methods were most affective to improving cycling safety [5].

- Reduced vehicle speeds when traveling next to bikes/bike lanes to reduce collisions and injury rates.
- Reduce injury rate by having better helmets and vehicle designs (cars with exterior air bags or side-underrun protection can result in the injury being less severe).
- Separated bike paths, reducing speed of vehicles at intersections.
- Improving cyclist and motorist behaviour through education and enforcement (in cities that have high number of child cyclists, cycling safety is taught in school).

VII. General Solutions and Guidelines

Aside from the solutions explored in the research journals above, there are other counter measures that can be taken to improve the overall safety of cyclists.

A. Bicycle Safety from National Highway Traffic Safety Administration

The National Highway Traffic and Safety Administration has access to collisions that occour in the Unites States and have indicated ways to improve safety for cyclists in the US [1].

- Ride a bike that works and fits you. Collisions may happen because of hard to control the bike or the brakes fail to work. To avoid these types of problem, the size of bikes and brakes should be checked in advance before the ride.
- Wear protective gears and get front and rear reflector installed on bikes. Collisions or falling of the bikes may happen even people follow the rules. So, protective gears are important to prevent these things from happening. The reflectors or headlights

illuminates the roads and makes bicyclist visible for vehicles or pedestrians to visualize them.

- Increase the number of bike-specific lanes or dismount on pedestrian walkways. Bike lanes are limited in Ontario, so bicyclist must either choose to bike on car lanes or pedestrian walkways which increase the number of collisions with vehicles or pedestrians. Increasing the amount of bike lanes will decrease the numbers of these types of collisions. Also, it is necessary for bicyclist to dismount when on pedestrian walkways. Because it is hard sometimes for people to visible and avoid the coming bicycles.
- Be careful during bad weathers. Under bad weathers like snow, raining, or even a day with big wind may increase the odds of experiencing collisions

B. *City of Toronto Cycling Study 2019*

This study focused showed what factors were important to safety towards utilitarian cyclists within Toronto [6].

- Create more separated bike lanes from car traffic
- Repairing potholes and bad pavement
- Better enforcement of laws
- More cycle routes on-street
- Better education for cyclists
- Better education for motorists
- Reduce automobile speeds

C. *Toronto Community Bikeways Coalition*

These safety suggestions are from a cycling group in Toronto, giving insight from their experiences of cycling in Toronto [2].

- Ensure that bikeways are maintained well and useable during any weather conduction
- Regularly maintain and upgrade bikeways to the best safety design standards
- Ensure bikeways are kept free from intrusions by cars and trucks
- Ensure there are safe route options around road constructions sites

VIII. How to Improve Toronto's Cycling Safety

Toronto only had 35km of bike lanes in 2001 and originally had a plan to build 10,000km of bike paths called the Shifting Gears, which had a 10-year timeline from 2001 to 2011 but was continually delayed due to city council decisions. By mid 2014, 571km of the planned 10,000km had been complete (Sharma, 2016). As of 2022, around 750km of the planned paths have been completed. Toronto seems to realize there is a problem with cyclist collisions and have always had a solution in mind, however their implementation compared to other countries with good cycling safety ratings is quite poor (City of Toronto, 2022). However, given their slow approach to implementing their solutions, they should also explore options that can see results in a quick rate such as education cyclists and motorists and maintaining and upgrading current bike paths to reduce injuries.

Their long-term solutions should be to continue building more bike paths but also consider implement different solutions for intersections, such as how the Netherlands constructs their intersections as most collisions in Toronto occour at street intersections. If AEB systems were to be implemented into cars as a standard in the future, this would also highly benefit Toronto cyclists, however, the implementation of such a technology is not in their hands but rather on vehicle manufacturers.

References

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