

Decoding Traffic Collision Trends: The Influence of Impact Type, Road Conditions, and Time of Day on Accident Outcomes*

Investigating How Collision Types and Road Conditions Affect Accident Patterns Over Time in Urban Areas

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This paper explores urban traffic accidents by considering the elements of impact types, road conditions, and time of day on accident frequency and severity. Severe accidents are more likely to occur in adverse conditions such as wet and icy roads in people's mind, but the collision happens on dry road is the most commonly things. These findings highlight key areas for strengthening traffic policy, road safety and accident prevention measures in Toronto.

Table of contents

1	Introduction	2
2	Data	3
2.1	Raw Data	3
2.2	Cleaned Data	3
3	Result	5
3.1	Analysis of the Number of Motor Accident Over Year	5
3.2	Analysis of the Number of Accidents by Hour of Day and Road Condition . . .	6
3.3	Analysis of the Number of Accidents by Injury Status and Impact Type	7
4	Discussion	8
5	Limitation	9

*Code and data are available at: <https://github.com/Fqy10987/Motor-Collision.git>

1 Introduction

According to the research, in Toronto, most of the injury caused by traffic accidents, incidents of violence, Fall accidents (especially among the elderly), and Workplace accidents. Among these accidents, the traffic accident has the highest rate of fatality(VSTR 2021; “Influence of Seatbelt Use on the Severity of Injury in Traffic Accidents” 2021), in particular, the motor rider has the highest rate of fatality.(Lawyers 2022; Insurance 2022)

Traffic accidents are always the biggest threat to public safety. Especially, the motor rider, it has the fastest speed with less personal protection. These accidents always happen caused of many different elements. According to the research, rear-end collisions are the most common accidents, especially during busy hours when traffic congestion is at its highest. These kinds of incidents commonly happen on dry roads, because under the condition, riders have more confidence to ride at a high speed(Lawyers 2022). However, under adverse road conditions, the probability of accident will increase(Salvi & Maher 2022). Understanding the relationship between the elements is significant in formulating effective safety precautions.

Although the safety engineering and traffic management policy will strengthen gradually over time, the probability of motor collision accidents is still high enough(Insurance 2022). At busy times, the traffic density has a large increase, and the rider or driver is tired, which causes more collisions. Furthermore, bad weather causes even more uncertainty(Scott J. Corwin 2018). This case shows that it only depending on safety engineering and management policy could not completely solve the problem of traffic safety.

To better provide a comprehensive analysis of the key factors influencing traffic collisions, the following will analyze the main elements that influence the number of accidents. It will focus on road conditions, time of day, injury, and impact type. This can help policymakers or traffic managers to make effective and targeted security policies or traffic management. Moreover, it can alert the rider need to put more attention to these conditions and avoid injury(Gelfand 2022).

2 Data

2.1 Raw Data

The analysis presented in this study utilizes data sourced from the City of Toronto’s traffic incident records, which are accessed via the Open Data Toronto platform. This research examines the impact of various road conditions on injury severity during incidents reported from January Jan 2006(Gelfand 2022). The analytical procedures were conducted using ‘R’ (R Core Team 2023) alongside various packages, including tidyverse (Wickham et al. 2019), lubridate (Grolemund and Wickham 2011), ggplot2 (Wickham 2016), here (Müller 2020), readr (Wickham, Hester, and Bryan 2024) and knitr (Xie 2024).

The dataset features records of incidents classified by impact type, injury severity, accident numbers, date, time, and road surface conditions. With a total of 18,957 recorded entries, the data is continuously updated to reflect recent events from Police Service, according to big data analysis, standardized reporting systems and data entry and validation(Gelfand 2022). It allows for a detailed analysis of how different conditions, such as wet surfaces, correlate with the severity of injuries sustained during accidents. Additionally, the dataset preserves the confidentiality of involved parties by anonymizing specific identifiers.

2.2 Cleaned Data

In “02-data_cleaning” it shows that for the column it need, like, number of accident does not contain any contain data, and impact type and road condition, although they contain ‘None’ in the data, but if I clean it up, it will lose most of data of the accident number, it will make the analysis unaccurate. Therefore, for “02-data_cleaning” just help it to filter the column which need to use in analysis, which are date, time, accident number, impact type and road condition. To choose these column to analysis, because it can shows most of the data for other elements, like road condtion can also represent weather(almost same as visibility, light), injury can detail fatal or non-fatal(FATAL_NO) and date, impact type, time and accident number is the key element to analysis. Therefore, cleaned data is somewhere same as raw_data, then whether using “Motor_date.cvs” or “analysis_data.cvs” does not create significant differences in result. Table 1, Table 2

Table 1: Sample of cleaned lead data

Date	Injury Severity	Count of Incidents
2006-01-01	Major	2
2006-01-01	Minor	7
2006-01-01	None	4
2006-01-02	Major	1
2006-01-02	None	1
2006-01-04	Major	1
2006-01-04	None	1
2006-01-06	Major	1
2006-01-06	None	1
2006-01-07	Fatal	1

Table 2: Raw Data check table

Elements	Condition(T/F)
Accident > 0	TRUE
Impact Type is Character	TRUE
Injury is Character	TRUE
Min Year 2006	TRUE
Max Year 2023	TRUE

3 Result

3.1 Analysis of the Number of Motor Accident Over Year

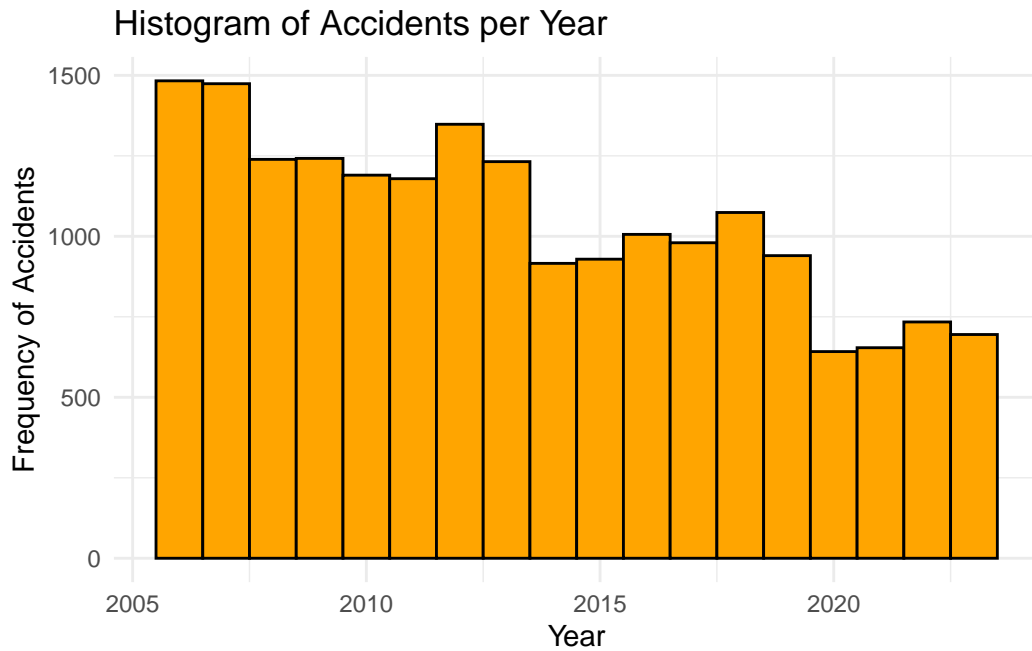


Figure 1: Histogram of Accidents per Year

In this histogram Figure 1, it shows the frequency of number of accident from year 2006 to 2023. Which x-axis represent year, and y-axis represented the frequency of the accident of motor. Through the graph, we can clear see that the trend of number of accident is decreasing over year. In 2006 to 2010, it have the largest number of accident. We can clearly know that the traffic management policy and Road safety measures advance over year.

3.2 Analysis of the Number of Accidents by Hour of Day and Road Condition

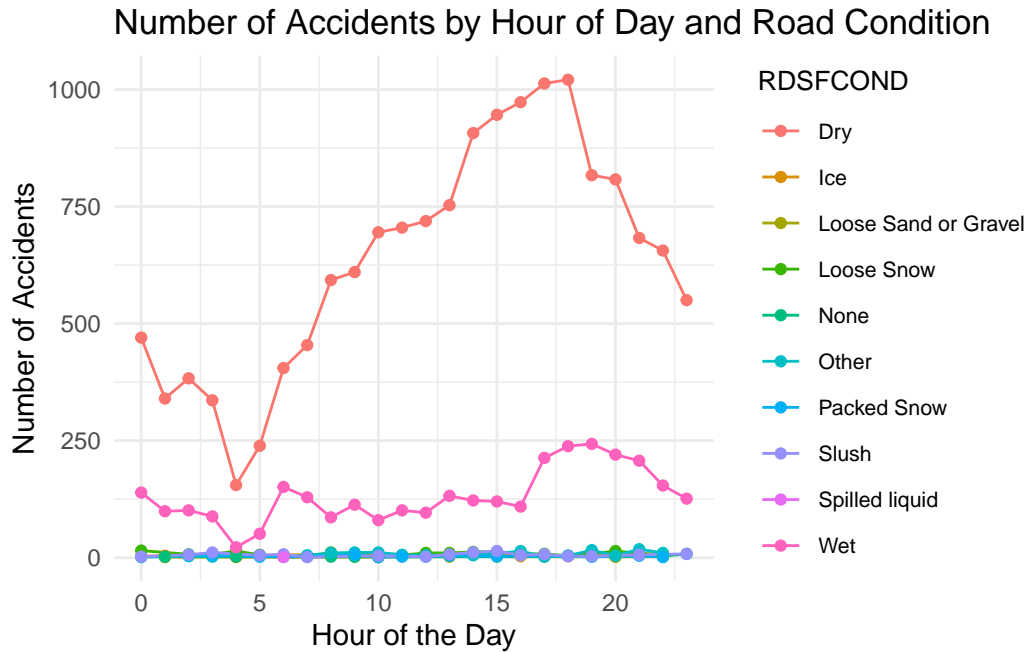


Figure 2: Number of Accidents by Hour of Day and Road Condition

In this line graph Figure 2, it shows under different road condition, the number of accident happens in every hours a day. The data is grouped by the hour and road condition (RDSF-COND), and the graph uses color to differentiate between road conditions such as dry, wet, or icy. The X-axis represents the time of day, while the Y-axis represents the number of accidents. From the graph we can know that from 15:00 to 19:00 the number of accident is the highest in a day, which reach a peak from 20:00 to 4:00 whatever any road condition the number of accident is large compare to other time besides 15:00 to 19:00. Especially, when road is dry and spilled liquid.

3.3 Analysis of the Number of Accidents by Injury Status and Impact Type

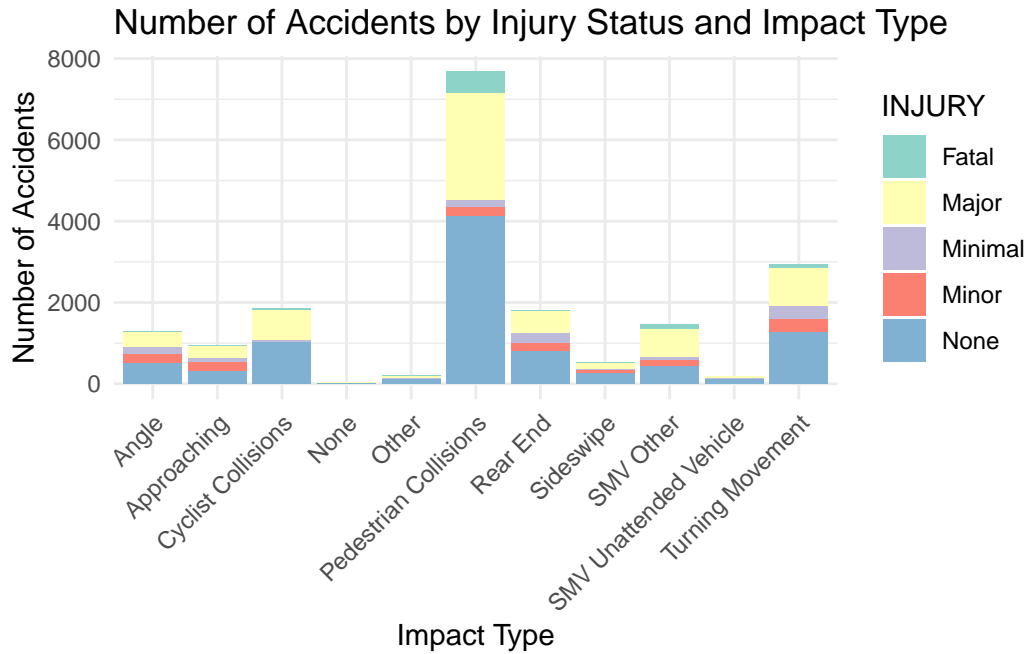


Figure 3: Number of Accidents by Injury Status and Impact Type

This plot Figure 3 shows the distribution of accidents based on both the type of collision and the injury severity. Pedestrian collision have the highest number of accidents overall, but they tend to result in fewer serious injuries, mostly causing no injuries or minor ones. This makes pedestrian collision the most frequent but generally less severe. In contrast, turning movement is the second highest number of accident due to total accident count besides pedestrian collision.

4 Discussion

In Section 3, it analysis three graph, which is about the relationship between year and motor accident number, time of day and motor accident number with road condition, and injury and impact type with motor accident number. It shows the number of accident is decreasing over yearFigure 1, from 10:00 to 20:00 which is the busy time in traffic of a day have the highest number of accident, especially when road is dry or with spilled waterFigure 2, and None, major and fatal are the main injury in motor collision, especially cause pedestrian collisions. Turning movement, angle, cyclist collision, rear end and SMV other are other main reasonsFigure 3.

All three of these results have a same origins, the safety measurements and traffic manage policy are not completely well-formed, although in the first graphFigure 1 implies that from 2006 to 2007, 2013 to 2014 and 2019 to 2020, the policy has a large strengthened. Another main reason is people do not care too much about the element which cause collision of motor vehicle and like to ride in a high speed on a good weather.(National Transportation Safety Board 2018; Insurance Institute for Highway Safety 2022) From the analysis in the second graphFigure 2, it implies that people like to ride a motor in a good weather, so the most of accident happen on a dry road and at busy times of day, which the rider want to catch up a emergency event or feel relax. Insurance (2022), for the road with spilled water(raining or other weather), motor's wheel has less friction with road, which also cause a large number of accident.Scott J. Corwin (2018) For other condition of road, motor almost do not have accident. Other then those reasons, rider need to concerned more about the danger that may be coming soon. This is the main purpose that the third graphFigure 3 want to express.

In summary, the frequency and severity of motorcycle accidents are related to multiple factors, including road conditions, time, and driving behavior. By thoroughly analyzing these factors, we can better understand the complexity of traffic safety and take necessary measures to improve the current situation. For policy manager and policy, this graph is important to help them to pay more attention at the busy time and when road is under a bad condition(National Transportation Safety Board 2018; Insurance Institute for Highway Safety 2022). Moreover, to strengthen the policy about the speed of motor in city. Urban planners can use this data to optimize traffic signal placements, add pedestrian crossing facilities, or improve road designs to reduce accident rates and enhance driving safety(Lawyers 2022). These data analysis also can be use on education and training, which face to motor vehicle rider to let them know the value of life and different status of dangerous under different condition.(Scott J. Corwin 2018; Motorcycle Accident Resource 2016) Especially, emphasizing safe driving behavior in specific situations.(Insurance Institute for Highway Safety 2022)

Whether a Paper is importance or valuable, it shows how it can influence in the society. If more people read, it will decrease the accident number. More people can start to reflect the behaviour they have done before, or even the transport agency can organized community activity to let more people to know the important of that.(National Transportation Safety Board 2018; Scott J. Corwin 2018)

In conclusion, this analysis emphasizes the importance of understanding motorcycle safety to effectively reduce accidents and promote responsible riding behavior. By addressing specific factors that contribute to motorcycle incidents—such as road conditions, time of day, and rider behavior—communities can take concrete steps toward creating safer environments for all road users. Focusing on public education, improving infrastructure, and implementing informed policy decisions are crucial for fostering a culture of safety and awareness among drivers and riders alike.(Insurance Institute for Highway Safety 2022; Motorcycle Accident Resource 2016)

5 Limitation

This analysis of traffic collision data have several important limitations. Firstly, the dataset includes all traffic incidents where individuals were either killed or seriously injured (KSI) since 2006(National Transportation Safety Board 2018; Insurance Institute for Highway Safety 2022). However, the specific locations of these events have been changed to protect the privacy of those involved.(Motorcycle Accident Resource 2016) As a result, the numbers reported by division and neighborhood may not accurately reflect the true occurrences within those areas.(Lawyers 2022; Scott J. Corwin 2018)

Moreover, the Toronto Police Service does not guarantee the accuracy and completeness of the data. This means that the dataset should not be compared to other sources of crime data, as variations in data collection and reporting methods can lead to discrepancies. Thus, while this analysis offers valuable insights into traffic safety trends, it's crucial to keep these limitations in mind when interpreting the findings and drawing conclusions. (Insurance Institute for Highway Safety 2022; Lawyers 2022)

Future research should focus on improving data accuracy by implementing more comprehensive reporting methods, ensuring that the specifics of location and incident types are clearly maintained. One promising avenue is to leverage advanced technologies like geospatial analysis and machine learning algorithms(Insurance Institute for Highway Safety 2022). These tools can enhance data collection processes and provide deeper insights into traffic patterns, helping to inform better safety strategies.

Additionally, collaboration with key stakeholders—including local communities, law enforcement, and public health officials—will be vital in gathering more detailed information about the circumstances surrounding traffic incidents. This collaborative approach can lead to a more nuanced understanding of the various factors that contribute to accidents, ultimately enabling the development of targeted interventions aimed at improving traffic safety.(National Transportation Safety Board 2018; Insurance Institute for Highway Safety 2022)

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