

SEVERITY ANALYSIS AND BLACKSPOT IDENTIFICATION OF ROAD TRAFFIC ACCIDENTS: A CASE STUDY OF THE GAZIPUR METROPOLITAN AREA

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ABSTRACT

In the modern era, roads and transport play a crucial role in national development, yet they also increase the risk of life-threatening accidents. Road crashes cause extensive fatalities and injuries, influenced by factors such as road geometry, pavement conditions, weather, and vehicle type. This study examines the severity of road traffic accidents in the Gazipur Metropolitan Area over a five-year period (June 2019–June 2024) using 356 accident records. Variables considered include age group, accident time, gender, vehicle type, number of vehicles involved, and the causes of crashes. Statistical and descriptive methods were employed to interpret the data, while the rate-quality control method was used to identify accident blackspots. Findings reveal an upward trend in accidents, raising safety concerns. Temporal patterns reveal accident peaks during morning rush hours and midday, which are linked to commuting, school trips, and commercial transportation. Pedestrians are identified as the most vulnerable group, with Sadar reporting the highest casualties (111), followed by Bason (61) and Tongi East (44). Gacha recorded 40 pedestrian casualties but no driver or passenger deaths, indicating risks concentrated in pedestrian-dense areas. Analysis by collision type reveals that pedestrian fatalities are the dominant category. “Hit Pedestrian” incidents caused 43% of pedestrian casualties, underscoring critical safety failures such as speeding and inadequate crossings. Head-on collisions accounted for 23% of pedestrian casualties, 32% of passenger casualties, and 56% of driver fatalities, reflecting high-speed, multi-victim crashes. Lateral collisions further exposed pedestrian vulnerability, while rear-end collisions disproportionately harmed passengers, suggesting weak seatbelt compliance. Spatial analysis reveals that National Highways and city roads are the most accident-prone due to heavy traffic and high speeds. Most accidents occurred on paved, two-way, divided roads, often due to overtaking or complacency in unsafe driving. Uncontrolled traffic zones and non-junction areas also posed significant risks. Daytime accidents were most frequent, coinciding with peak traffic volumes, while nighttime accidents, though fewer, remained concerning. Blackspot analysis identified high-severity accident locations along the N3 and N4 highways, including Tongi Station Road, Bonomala, Board Bazar, Vogra, Naojore, Konabari, and T&T Bazar. These findings underscore the urgent need for targeted safety interventions, particularly in areas with high pedestrian risk and stricter enforcement of traffic regulations.

Keywords: Road Traffic Accidents, Accident Severity Analysis, Pedestrian Vulnerability, Blackspot Identification, Gazipur Metropolitan Area

1. INTRODUCTION

One of the leading causes of death in the world is road accidents. Over 1.5 million individuals worldwide lose their lives in traffic accidents each year, according to the Global Safety Report (Badgular et al., 2017). Several variables influence the likelihood of an accident, including the state of the pavement, the vehicle's condition, the road's geometric features, and the prevailing weather conditions. Every aspect plays a part in the likelihood of accidents, and there may be numerous other situation-specific factors (Singh et al., 2023). Over the past five years, comprehensive data on traffic accidents that occurred in the Gazipur Metropolitan Area have been gathered to assess the influence of various factors on accident frequency.

Roads and transportation have become crucial for a country's development in the modern world. In one way or another, everyone is a road user. Although the current transportation system has reduced the distance, the risk to life has grown. Thousands of individuals experience severe injuries, and one lakh people die in every traffic accident (Comi et al., 2022).

To incorporate the data elements required for the crash database, understanding the factors contributing to these incidents is crucial. Such understanding ultimately helps in developing effective preventive measures and enhancing road safety. Four major factors significantly impact the occurrence and severity of road crashes. Firstly, the condition of vehicles plays a crucial role in the occurrence of accidents. Defective brakes, worn-out tires, and inadequate safety features significantly increase the probability of accidents. Additionally, the use of older or poorly maintained vehicles can pose a higher risk on the roads. Secondly, the state of road infrastructure and conditions significantly influences accident rates. Poor road design, inadequate maintenance, absence of proper signage, insufficient lighting, and limited pedestrian facilities contribute to a higher possibility of accidents. Moreover, the absence of effective traffic management systems can increase the risks on the roads. Thirdly, human behaviour plays a pivotal role in road accidents. Factors such as distracted driving, speeding, fatigue, trouble concentrating due to alcohol or drugs, and violating traffic rules contribute significantly to the incidence of accidents. Moreover, lack of experience, overconfidence, and aggressive driving behaviours are additional human elements that elevate accident risks. Lastly, Environmental factors, such as adverse weather conditions, low visibility due to fog, rain, or darkness, and unexpected hazards on the road, contribute to accidents. These elements often enhance the risks faced by drivers and impact their ability to react appropriately to changing circumstances (Borghetti et al., 2021; Nour et al., 2020).

According to the Roads & Highways Department (RHD), the severity classification followed in Bangladesh consists of four categories: Fatal Crash, Grievous Crash, Simple Injury Crash, and Motor Collision. A fatal crash is defined as an incident resulting from a traffic accident where one or more people die as a result of injuries sustained in a road crash. A grievance crash is an incident arising from a traffic crash where one or more individuals sustain serious injuries that require extensive medical care and are kept in the hospital overnight for treatment. A simple injury crash is an incident resulting from a traffic collision where individuals sustain minor injuries that typically do not require extensive medical treatment. A motor collision is a road crash resulting in vehicle damage but no casualties (Road Safety Report, 1996).

However, since the likelihood of being injured in an accident is often predicted and there are numerous efficient countermeasures, road traffic fatalities and injuries can be avoided to a substantial degree. An integrated strategy with close coordination of numerous sectors would be the most efficient way to lower deaths and injuries. The number of traffic accidents and fatalities is gradually declining in various regions of the world through multisectoral strategic plans (Singh, 2017).

2. METHODOLOGY

The primary aim of crash data collection is to identify the problems causing crashes and to assess the resulting loss, either quantitatively or qualitatively. Appropriate data collection leads to identifying appropriate measures to reduce the repetition of crash occurrences. (Ballamudi, 2019)

According to the World Health Organization (WHO, 2010) and the Federal Highway Administration (FHWA, 2012), the following data should be addressed in a data collection format, as presented in Table 1.

Table 1: Data requirements for accident analysis as per WHO & FHWA

WHO	FHWA
Roadway Related Data	Crash Related Data
Vehicle Related Data	Roadway Related Data
Person Related Data	Vehicle Related Data
	Person Related Data

2.1 Study Area

This study encompasses the Gazipur Metropolitan area, which comprises eight police stations: Sadar, Bason, Kashimpur, Konabari, Gacha, Pubail, Tongi East, and Tongi West. The authors visited these eight police stations under the Gazipur Metropolitan Police (GMP) to gather the recorded crash data. The collected crash data were recorded in either Accident Reporting Form (ARF) or First Information Report (FIR) format over a five-year period (June 2019–June 2024) using 356 accident records.

2.2 Crash Investigation, Reporting, and Recording Process in a Police Station

A traffic crash investigation is designed to gather all possible evidence and obtain witness testimony following a crash. Accident investigators generally follow several important steps when examining a car accident scene, including Visual observation, Interviewing Drivers and witnesses, Collecting Evidence, Assessing Human casualties, and Evaluating Vehicle damage.

Investigations are often complex and time-consuming, requiring skilled professionals who know what evidence to look for and how to secure it. In the case of the Gazipur Metropolitan Area, police officers are responsible for reporting crashes using the Accident Reporting Form (ARF), as they prepare the First Information Report (FIR) and must visit the accident site if anyone is injured there. The concerned Police Stations fill out the form for each accident.

Police officers document each personal injury accident as a First Information Report (FIR), which includes information about the vehicle and the circumstances of casualties. When a traffic accident occurs, the Investigating Officer (IO) records the incident, investigates the situation, and then completes the Accident Reporting Form (ARF). A separate register of traffic accidents must be kept by each police station. The police are required to record each accident in a register with a unique serial number (Bin Siraj, 2021).

2.3 Method of Analysis

To analyze the crash data gathered from the study area, a descriptive method has been employed to gain a comprehensive understanding of crash occurrence and the significant variables influencing crash severity. Additionally, using the rate-quality control method, blackspots on the road network of the study area, especially national highways, have been identified.

2.3.1 Descriptive Analysis

The study area's traffic crash data, collected from eight police stations, undergoes a detailed descriptive analysis to investigate the interrelationships among various variables and pinpoint potential causes and contributing factors. This analytical process is crucial for identifying crash variables that exhibit significantly higher frequencies compared to others, offering insights into the patterns and trends within the data.

Moreover, the frequency of crashes plays a pivotal role in understanding these relationships between different crash variables. For instance, a higher frequency of crashes at certain intersections or during specific times may indicate areas of higher risk or patterns of behaviour that contribute to accidents. This analysis not only helps in understanding the distribution and characteristics of crashes but also

aids in formulating targeted interventions and policies aimed at reducing the incidence of traffic accidents. By identifying and understanding the relationships among crash variables, stakeholders can make informed decisions to improve road safety and mitigate the impact of traffic crashes on the community.

2.3.2 Identification of Black Spot

According to the rate quality control method, three parameters need to be calculated for each one-kilometre road section. Accident Rate, Accident Frequency, and Severity Index (SI) are the three parameters. A critical value is compared to each of these values. A road segment is referred to as a "black spot" if its values exceed the critical values for each of the three metrics.

3. RESULTS AND DISCUSSION

3.1 Trend of Accident

An upward trend in accidents in the study area (Figure 1) poses a significant safety concern that warrants serious attention. Due to infrastructure deficiencies, Inadequate enforcement, and limited road safety interventions, these are the key reasons for the upward trend in accidents. In addition, the construction of the BRT-3, Dhaka Bypass Road, and other projects also contributes to the road safety issues.

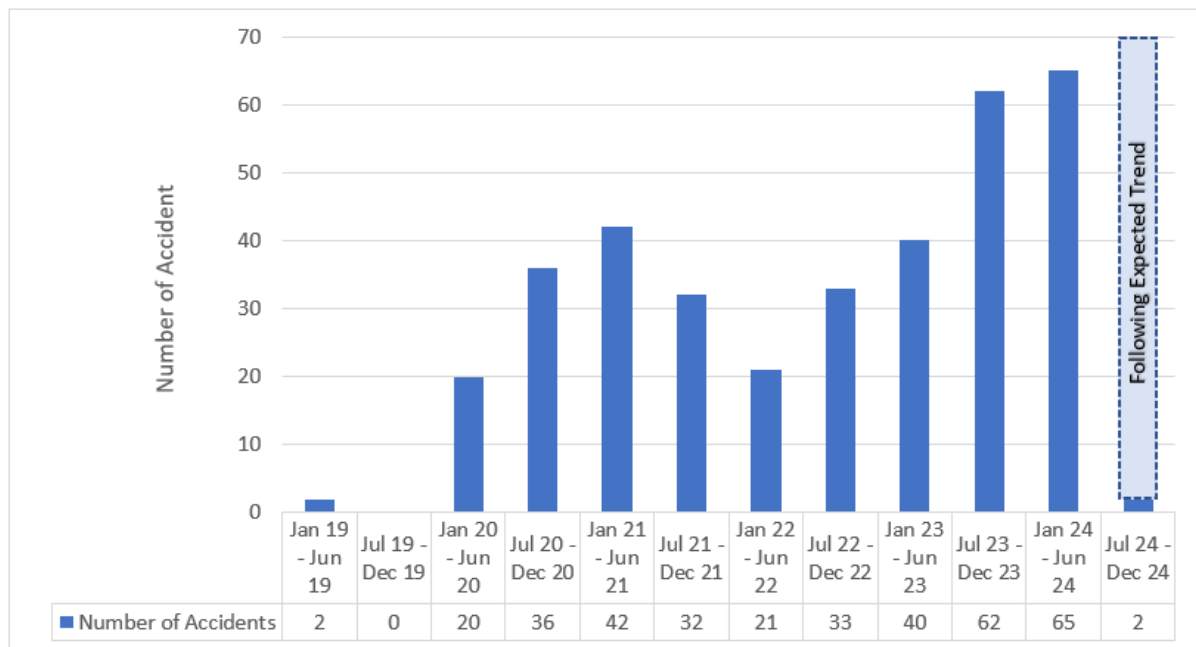


Figure 1: Semi-annual distribution of accidents

Hourly accident data from June 2019 to June 2024 reveals clear temporal patterns (Figure 2) that are crucial for developing targeted traffic safety interventions. Accidents peak during the morning rush hour and again around midday—periods associated with intense commuting activity, school trips, and commercial transport.

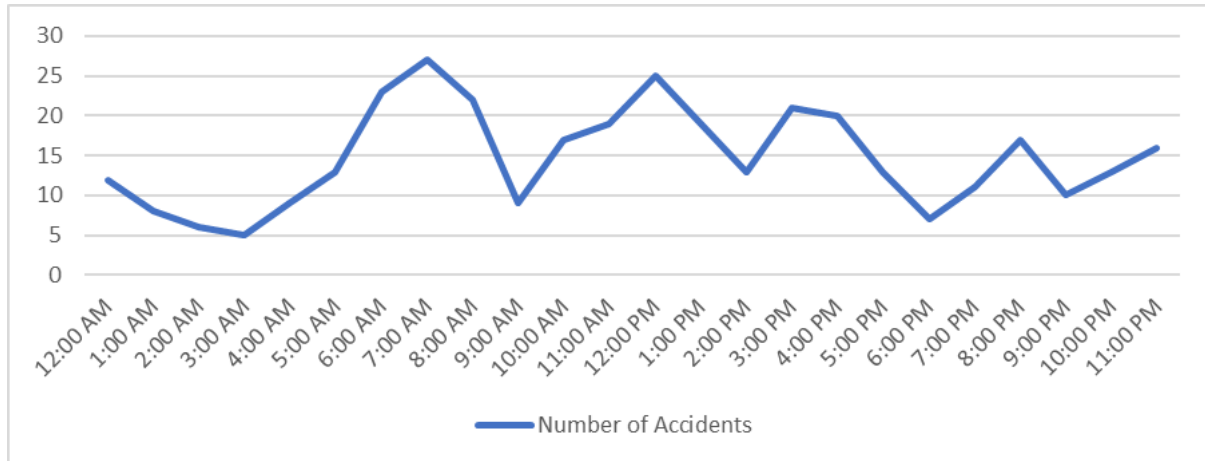


Figure 2: Hourly distribution of accidents

From the seasonal crash variation observed in the study area, the Monsoon season, spanning from June to October, had the highest number of crashes, accounting for 39.58% of the total. The winter season, spanning from November to February, accounted for 32.29%. The Pre-monsoon season, which spans March to May, accounted for 28.13% of the crashes. Overall, crashes were most frequent during the Monsoon and Winter seasons, with a notable decrease during the Pre-Monsoon period. But no greater fluctuations are found over all the seasons, as illustrated in Figure 3.

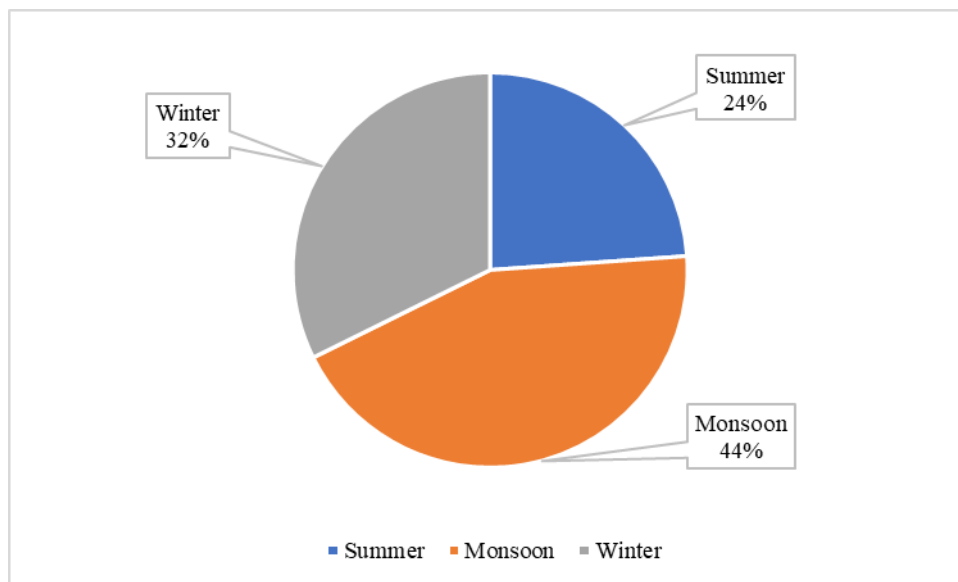


Figure 3: Seasonal frequency of crashes

3.2 Crash Severity

Out of 356 traffic accidents occurring in the study area, 307 crashes were fatal accidents, 43 were Grievous injury accidents, and 6 were simple injury accidents. According to Figure 4, fatal accidents are the most prevalent type of accident in the study area. The overwhelming majority of crashes, around 86%, resulted in fatalities, whereas 14% crashes caused injury.

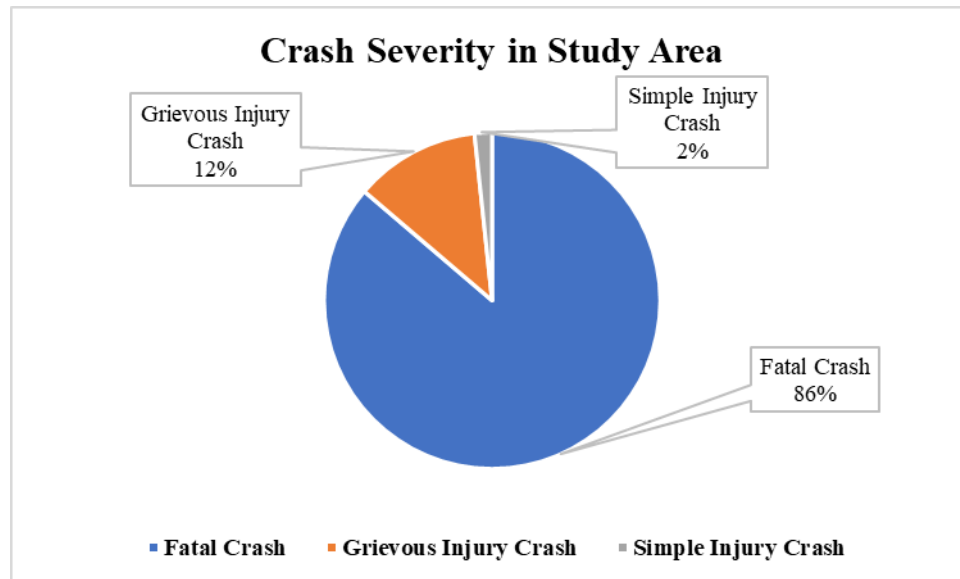


Figure 4: Crash severity in the study area

3.3 Accidents and Casualties

The accident data from 2019 to 2024 reveal an overall increase in casualties over the five-year period. In the earlier years, notably 2019 and the first half of 2020, driver casualties were minimal, while passenger and pedestrian casualties were modest (Figure 5). However, from mid-2020 onward, all categories saw a rise: driver casualties began to appear and peaked at 11 in the latter half of 2023, while passenger casualties reached 19 in the same period. Pedestrian casualties, in particular, demonstrated a steady upward trend, peaking at 60 in the first half of 2024. The sudden drop in figures for the second half of 2024—recording zero driver and passenger casualties and only 2 pedestrian casualties—is likely due to the partial collection of secondary data (up to August 2024).

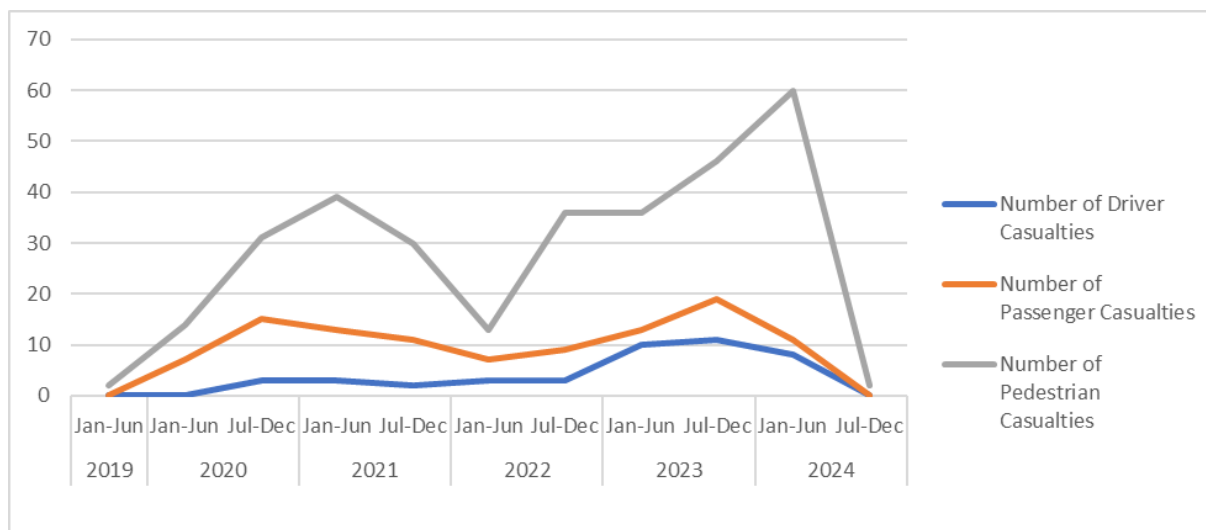


Figure 5: Trend of total casualties

The accident data (June 2019–June 2024) highlights the severe vulnerability of pedestrians, with pedestrian casualties accounting for the majority of fatalities in all Thanas (Figure 6), particularly in Sadar (63), Bason (61), and Tongi East (44), reflecting systemic infrastructure gaps such as inadequate crosswalks or lighting. Sadar emerges as the highest-risk zone, with total casualties (111) nearly double other areas, driven by high driver (17) and passenger (31) tolls, likely linked to dense traffic or poor enforcement. Strikingly, Gacha reported 40 pedestrian casualties but zero

driver/passenger deaths, suggesting risks localized to pedestrian-heavy zones like markets or unregulated walkways. While Pubail and Tongi West had lower pedestrian casualties (7 and 15), disparities highlight uneven safety measures across regions. The data signals an urgent need for pedestrian-centric interventions—such as crosswalks, speed calming, and nighttime lighting—in high-risk Areas, alongside stricter traffic compliance in zones like Sadar and Bason, to address multi-user fatalities.

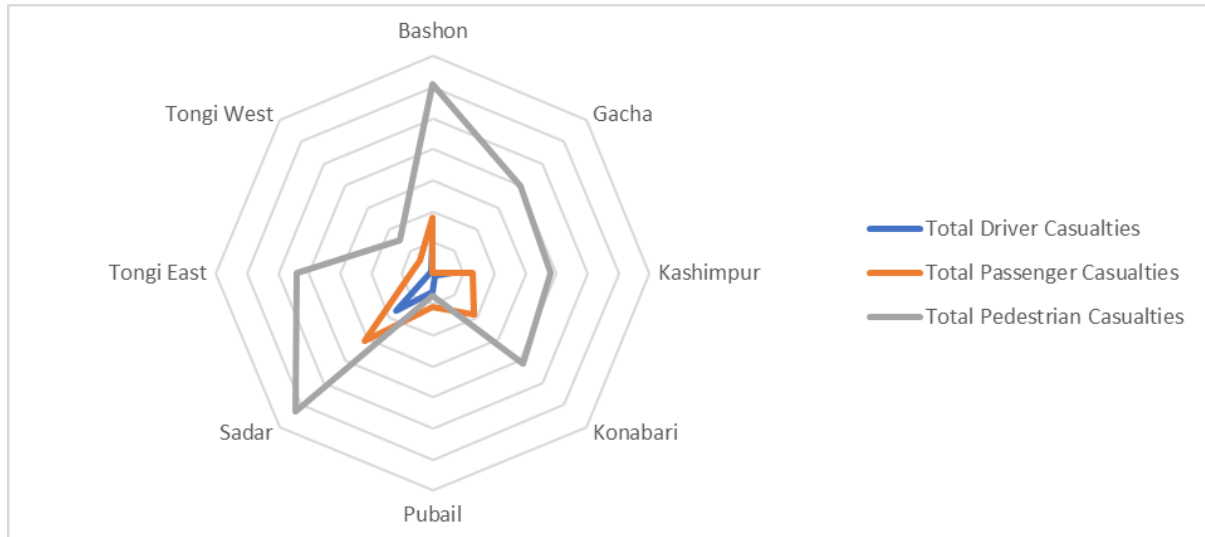


Figure 6: Thana-wise casualties scenario

3.4 Types of Collision

According to Figure 7, a total of 356 road crashes were analyzed in the study area from June 2019 to August 2024. The most common collision type was hitting pedestrians, accounting for 33% of all incidents, followed by head-on collisions, which accounted for 24%. Lateral or side swipes and rear-end crashes made up 12% of the total, while overturned vehicles, right-angle crashes, hitting parked vehicles, and other types of crashes each represented smaller proportions. These results suggest that pedestrian safety is a significant concern in the area.

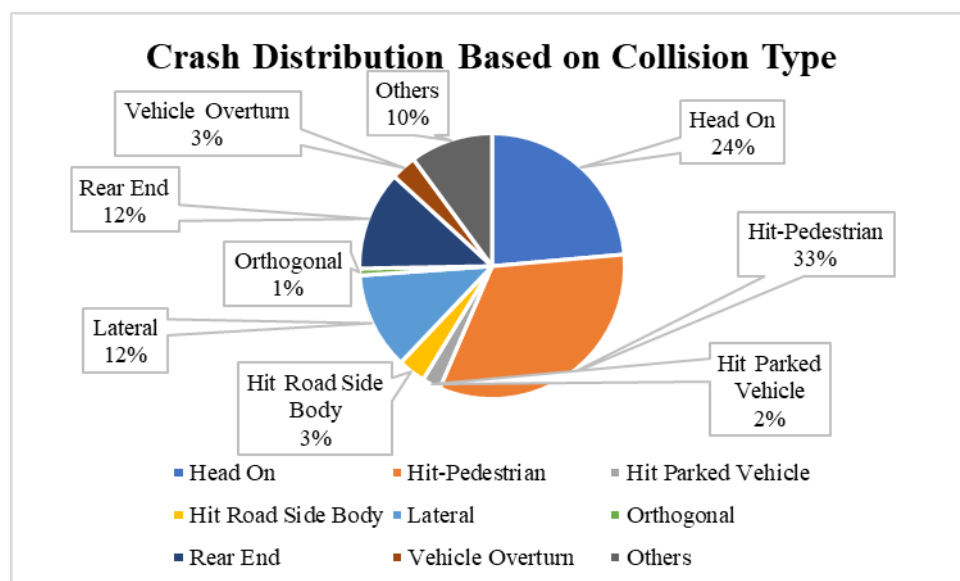


Figure 7: Crash distribution based on collision type

The accident data underscores pedestrian fatalities as the dominant casualty category, with "Hit Pedestrian" collisions alone causing 43% pedestrian casualties—far exceeding driver and passenger casualties in this category, implying severe pedestrian safety failures (Figure 8). Head-on collisions also proved catastrophic, resulting in 65 pedestrian (23% of total pedestrian casualties), 30 passenger (32% of total passenger casualties), and 23 driver casualties (56% of total driver casualties), reflecting high-speed impacts with multi-victim severity. Lateral collisions further highlighted pedestrian risks (18% of total pedestrian casualties), likely due to poor intersection safety or reckless turning. Notably, rear-end collisions disproportionately affected passengers (32% of total passenger casualties), suggesting inadequate seatbelt use or rear-seat vulnerability. The near-absence of driver casualties in "Hit Pedestrian" incidents (0) versus high pedestrian tolls implies systemic issues like speeding, unmarked crosswalks, or distracted driving.

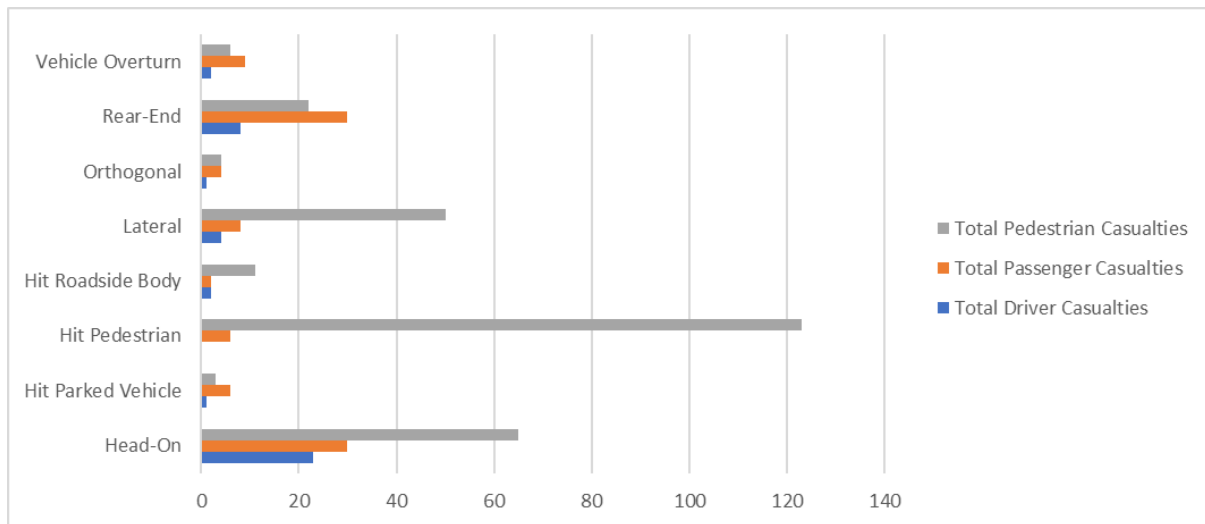


Figure 8: Casualties based on collision type

3.5 Crash in Junctions

The crash data collected over five years show that most traffic crashes occur in non-junction areas. Figure 9 illustrates that about 41% crashes occur where there are no junctions. T-Junctions were the next most common, accounting for 10% of crashes. The influence of other junction types was quite insignificant, with the least frequency of 7% observed in the Cross-Junction. Overall, the study area saw the highest crash frequency at non-junction locations, indicating potential issues with uncontrolled intersections or straight road segments.

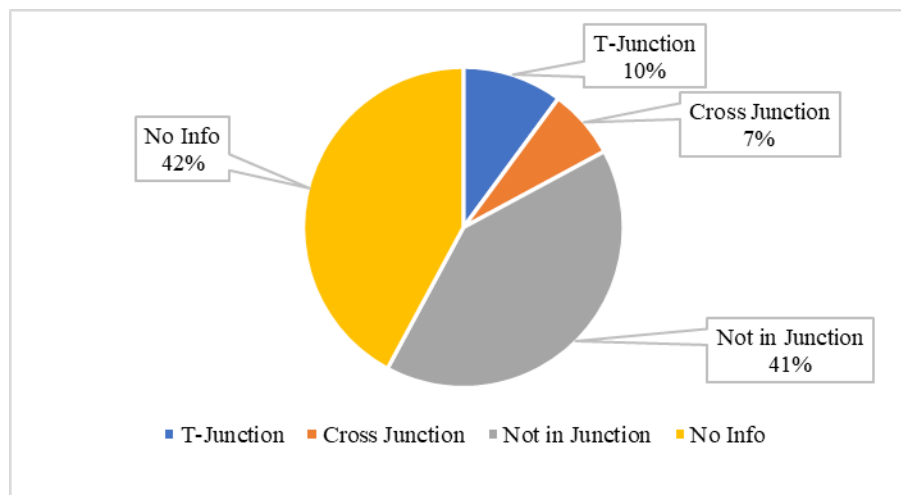


Figure 9: Crash distribution in junctions

3.6 Blackspot Identification

3.6.1 Accidents on Different Categories of Road

The accident data (2019–2024) highlights National Highways and City Roads as high-risk zones (Table 2), likely due to higher traffic density and speeds. Most accidents occurred on paved roads, particularly on two-way routes and roads with dividers, suggesting risks associated with overtaking or complacency on divided roads. Uncontrolled traffic areas and non-junction locations are also accident-prone, emphasizing risks in unstructured zones. Daytime lighting conditions were associated with the highest number of accidents, correlating with peak traffic activity, while nighttime accidents were fewer but still notable.

Table 2: Number of accidents as per road category

Road Characteristics	Sub-category	Number of Accidents	Percentage
Road Category	National Highway	146	50.87%
	City Road	97	33.80%
	Feeder Road	30	10.45%
	Regional Highway	14	4.88%
Surface Type of Pavement	Paved	296	98.67%
	Brick Road	2	0.67%
	Earthen Road	2	0.67%
Road Divider Availability	Road Divider Available	190	64.85%
	No Road Divider	103	35.15%
Traffic Movement in Accident Spot	Two-way	198	63.87%
	One-way	112	36.13%
Traffic Control System	Uncontrolled	94	34.43%
	Controlled by Road Divider	92	33.70%
	Police controlled	59	21.61%
	Pedestrian Crossing	28	10.26%
Junction Type	Not in Junction	145	70.39%
	T-Junction	36	17.48%
	Cross Junction	25	12.14%
Lighting Condition	Day	193	59.57%
	Dawn	35	10.80%
	Night (Streets with Lights)	74	22.84%
	Night (Dark Street)	13	4.01%
	Evening	9	2.78%

3.6.2 Identifying Black Spots

Locations with the highest Severity Index (SI) values are classified as black spots. A segment with high SI values is used to define black spot locations (Figure 10). Major blackspot locations are located along the N3 and N4. These locations are- Tongi Station Road, Bonomala, Board Bazar, Vogra, Naojore, Konabari, T&T Bazar etc.

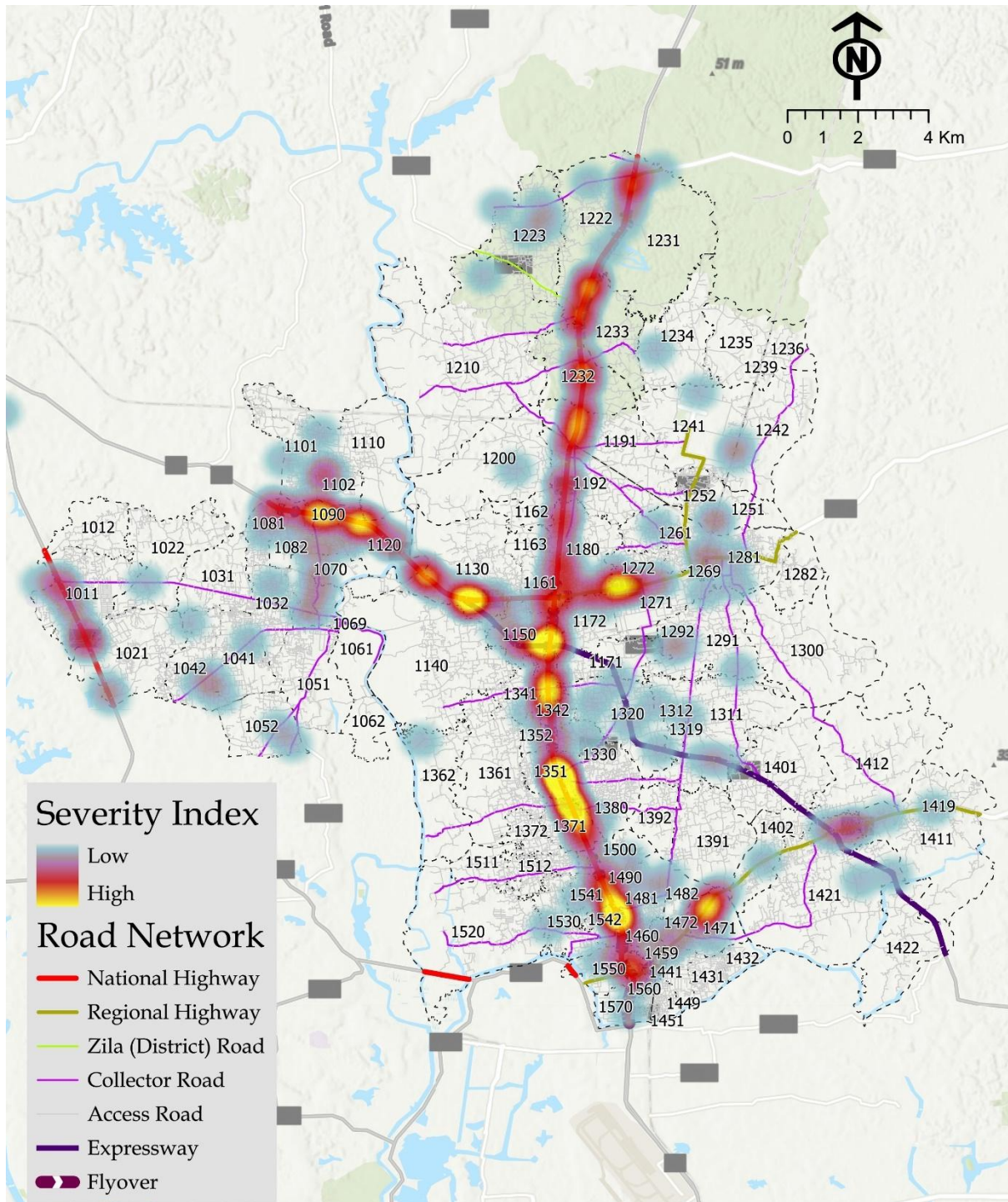


Figure 10: Accident blackspot identification in the study area

3.7 Factors Contributing to the Accident

Accidents often result from a combination of various factors. In GMP ARF, approximately 14 different factors are to be collected for each accident. However, data collected from GMP have many missing values for the contributing factors and are quite imbalanced in nature. The 14 factors under the ARF are listed below (Table 3).

Table 3: Factors contributing to the accident

Parameter	Subcategory	Parameter	Subcategory
Accident Severity	Collision	Traffic Control System	Uncontrolled
	Minor injury		Controlled by Road Divider
	Severe Injury		Pedestrian Crossing
	Fatal		Police Controlled
Collision Type	Head-on	Traffic Direction	Controlled by Traffic Lights
	Rear-End		Controlled by Police and Traffic Lights
	Orthogonal		Controlled by Stop/Go Signage
	Lateral		Others
	Vehicle Overturn	Traffic Direction	One-Way
	Hit an On-road Object		Two-Way
	Hit Roadside Body	Weather	Fair
	Hit Parked Vehicle		Rain
	Hit Pedestrian		Stormy
	Hit Animal		Foggy
Junction Type	Others	Area Type	City
	Not in Junction		Rural
	Cross Junction	Day	Saturday
	T-Junction		Sunday
	Staggered Junction		Monday
	Roundabout		Tuesday
	Railway Crossing		Wednesday
Others	Thursday		
Lighting Condition	Day	Weekday/Weekend	Friday
	Evening		Weekday
	Dawn	Weekend	
	Night (Streets with Lights)	Time of Day	Morning
	Night (Dark Street)		Noon
	Afternoon		
Road Category	National Highway	Peak/Off-peak	Evening
	Regional Highway		Night
	Feeder Road		Late Night
	Rural Road		Peak
	City Road	Off-peak	
Surface Type	Paved	Road Divider	Yes
	Brick Road		No
	Earthen Road		

4. CONCLUSIONS

This study examined road traffic accidents in the Gazipur Metropolitan Area from 2019 to 2024 to identify key causes, severity patterns, and blackspot locations. Results indicate a rising trend in

crashes, mainly due to poor enforcement, unsafe road design, and rapid urbanization. Pedestrians were the most affected group, particularly along national highways and major city roads with limited crossing facilities. “Hit pedestrian” and head-on collisions dominated, highlighting the urgency of stricter speed control and improved pedestrian safety measures. Blackspot analysis identified several high-risk sites, including Tongi Station Road, Board Bazar, and Konabari, requiring targeted interventions. An integrated approach—combining infrastructure upgrades, stronger law enforcement, and public awareness—is essential to reduce accident severity and frequency. These measures can significantly improve traffic safety and promote sustainable urban mobility in Gazipur.

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DECLARATION OF USE OF AI

The authors declare that no artificial intelligence (AI) tools or technologies were used in the writing, analysis, data interpretation, or preparation of this conference paper. All research activities, including data collection, analysis, and manuscript development, were conducted solely by the authors.

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