EXPLORING BUS DRIVERS' PERCEPTIONS OF INTERSECTION-RELATED ACCIDENTS ON HIGHWAYS

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ABSTRACT

Intersections are crucial locations for drivers due to the escalating rate of accidents occurring at conflict points. In addition to road design, the safety perception of drivers at intersections is a major concern, particularly in developing countries like Bangladesh, where many drivers may lack of formal education and awareness of safety measures. Therefore, it is necessary to understand drivers' insights into accidents in such hazardous locations. This study aims to explore dangerous drivers' behavior and factors associated with highway intersection accidents, perceived by bus drivers and establish a relationship between the factors and drivers' behaviors. A questionnaire survey was conducted on 255 bus drivers on two pivotal highways in Bangladesh: the Dhaka-Bhanga Expressway (N8), and the Joydebpur-Elenga Highway (N4). The questionnaire consisted of three sections; the first section included the socio-demographic characteristics of the drivers. The second section encompasses the driver's experience and behavior while driving on the road and the third section comprises road-related factors. The research identifies three types of dangerous driving behavior (DDB) associated with intersection accidents: namely, reckless driving, faulty maneuvering, and lack of awareness or distracted driving. Conventional statistical tests were employed to elucidate the relationship between the DDB and accident-contributing factors. The chi-square tests demonstrated a significant relationship between the dependent variables (DDB) and drivers' age, driving experience, driving frequency, speed limit violations, and other factors. Further analysis revealed that younger graduates with less than five years of driving experience are involved in reckless driving. Conversely, older experienced drivers are more prone to engaging in faulty maneuvering, and distracted driving is associated with driving frequency and non-compliance with traffic regulations. Understanding the perspectives of Bangladeshi bus drivers regarding accidents at highway intersections can facilitate the development of improved intersection designs that align with drivers' expectations and contribute to the reduction of accidents.

Keywords: *Bus drivers' perception, intersection accident, dangerous driving behaviors, statistical tests*

1. INTRODUCTION

Intersections, an inseparable element of road transportation systems, are infamous for accidents due to their complexity, especially on highways. A large proportion of fatalities occur on rural sections of the main highways, particularly near intersections. The Federal Highway Administration of the United States (FHWA) (2023) reported that each year, 25% of traffic fatalities and 50% of all traffic injuries are related to intersections. The highway intersections in Bangladesh are also no different from this phenomenon. The country's highway infrastructure comprises busy and tangled junctions that lead to more collisions. These collisions range from fender-benders to life-ending fatal crashes. The Daily Star reported that in January 2021, 427 road accidents took place across the country, and 35.83% of them occurred on highways. As the country steps into modernization, it is important to improve the transportation system and ensure safety as well.

Accidents at highway intersections occur due to numerous factors. Both road attributes and human factors are associated with such kinds of accidents. Different road features, such as lane width, visibility obstruction, availability of road signs and markings, etc., contribute to highway accidents. Conversely, the human factors associated with accidents include the driver's socio-demographic characteristics, their driving experience, frequencies, past accident histories, etc. A study by Vogel and Bester (2005) showed that the human factor accounted for 75.4% when weighted with the number of times the accident type occurred.

Despite the effects of human factors, several dangerous driving behaviors, such as reckless driving, faulty maneuvering, and distracted driving, are also correlated with traffic accidents. Reckless driving is one of the major causes of highway accidents. It includes careless driving techniques, weaving in and out of traffic, speeding, etc. Bener and Crundall (2005) concluded in their study that reckless driving was the most important factor in accidents in the UAE (35%), while excessive speed was the second most common cause. Distraction is another major contributing factor to highway accidents. Distracted driving means talking with passengers, using cell phones, smoking, etc. while driving. According to the Traffic Safety Facts, a research note (2023); 29% of crashes in the United States occurred due to distracted driving. People of all ages are severely affected by distraction-led accidents. In the study by Thompson et al. (2012), 39% of elderly and 43% of middle-aged drivers exhibited a notable increase in driving safety errors during distraction. Similarly, faulty maneuvering while driving can increase the probability of traffic collisions on the highway. Such maneuvers include overtaking, abrupt lane changing, stopping here and there, etc. Chandraratna and Stamatiadis (2003) showed that older drivers are more likely to be involved in crashes related to maneuvers like turning, high-speed lane changes, etc.

To create a safer transportation system, it is necessary to understand the relationship between traffic accidents and dangerous driving behavior. However, no prior research has been conducted in the context of Bangladeshi bus drivers' perceptions, where buses are widely used as the most common public transport on highways. According to Islam and Dinar (2021), 38% of the total accidents were caused by buses. Therefore, the current study is designed to identify the dangerous driving behaviors associated with accidents at an intersection point according to the bus drivers' perceptions and to find out the relationship between the behaviors and accident attributes.

2. METHODOLOGY

2.1 Study Area Description

For this study, two of the most important highways in the country were selected. One of them is the Bangabandhu Sheikh Mujibur Rahman Expressway, also known as the Dhaka-Bhanga Expressway (N8). It starts at Jatrabari Interchange in Dhaka district and ends at Bhanga Interchange in Faridpur district. It is the first fully complete expressway in Bangladesh that will later be connected to the Asian Highway 1 (AH1) (The Asian Highway, 2021). The Dhaka-Bhanga expressway has a total length of 55 kilometers. The expressway comprises eight lanes, including four service lanes on either side. The other

one is the Joydebpur-Elenga highway (partially operational expressway) (N4), starts at Vogra from the Dhaka-Mymensingh road in Gazipur district and ends at Elenga in Tangail district. This expressway stretches 70 kilometers altogether and will have four lanes upon completion. However, the authorities are incorporating lanes for slow-moving vehicles as this expressway is going to be an international standard expressway.

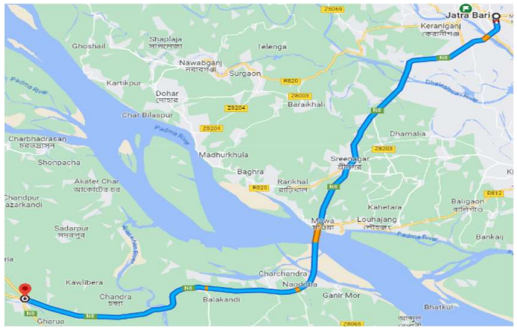

Figure 1: Dhaka–Bhanga Expressway (N8)

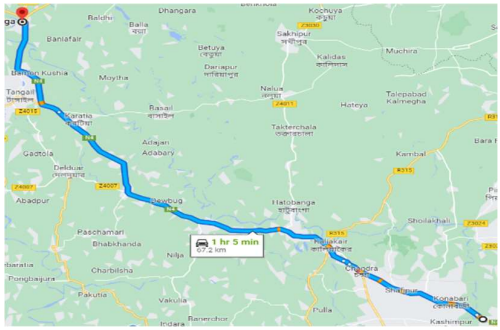

Figure 2: Joydebpur-Elenga Highway (N4)

Source: Google Maps

2.2 Data Collection

To gather data for this study, a questionnaire-based survey was conducted with random drivers at the study sites. A total of 255 bus drivers were interviewed. The approach incorporates a purpose-built questionnaire, and the questionnaire contains three parts. The first part was about the respondent's demographic information, consisting of drivers' age, education, and income. The second part involved questions about driver behaviors, which included drivers' experience, driving frequency, experience of conflicts, speed limit violations, etc. The third part involves questionnaires about road features such as lane effects, intersection point identification, and obstruction of visibility. All these questions had multiple choices from which the respondent chose their answers.

2.3 Statistical Analysis

This paper deals with descriptive analysis of the data collected and the chi-square test. The descriptive analysis represents the brief statistics that summarize the dataset. The chi-square statistical tool was employed to test for the hypothesis relating to driver's behaviors. Thus, the null and alternative hypotheses for the testing were:

H_o: The dangerous driving behaviors and accident contributing factors are independent of each other.

H_1: The null hypothesis is not true.

The expected cell frequencies were compared with the observed cell frequencies using the test chi-square, as estimated.

$$X^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \quad (1)$$

Where: X^2 = chi-square

O_{ij} = observed frequency of the cell in the i th row and j th column

E_{ij} = expected frequency of the cell in the i th row and j th column

3. DATA ANALYSIS AND INTERPRETATION

3.1 Descriptive Analysis

A descriptive statistical representation of the dataset was conducted. Table 1 shows the socio-demographic class of the respondents. The age group was decided according to Indexmundi (2021): <25, 26 – 50 and > 50. The middle-aged and older groups together constitute nearly three-fourths of the

respondents. The education level of the respondents was mostly graduation or below graduation level, and around two-thirds had incomes under BDT 10,000 to 30,000.

Table 1: Socio-demographic characteristics of respondents

Socio-demographic characteristics	Class	Percentage
Age	<25	27.1
	26-50	35.6
	>50	37.3
Education	Primary	27.1
	Graduate	50.5
	Post-Graduate	22.4
Income	10,000 - 30,0000	62.0
	30,000-50,000	38.0

Table 2 represents the dataset of drivers' experiences and behaviors. The majority of the respondents have been driving for a while, with 42.7% having experience of more than 10 years, 34.5% less than 5 years, and 22.7% between 5 and 10 years. Half of them are driving three times a week on the highway. About 43% of respondents accused vehicles coming from slip roads of being the leading factor in accidents. Additionally, the collected data stated that 60.8% of the respondents violated speed limits, over 50% have experienced accidents before, and always unfollow the traffic rules.

Table 2: Drivers' experience and behaviors

Drivers' Experience and Behavior	Class	Percentage
Driving experience	Less than 5	34.5
	From 5 to 10 years	25.1
	Above 10 years	40.4
Driving frequency	Daily	37.3
	Triweekly	50.2
	Weekly	12.5
Factors leading to accidents	Irregular parking	27.8
	Police standing	29.4
	Coming vehicle from slip road	42.7
Speed limit violations	Yes	60.8
	No	39.2
Prior involvement in accidents within the last 3 years	Yes	56.5
	No	43.5
Non-compliance with traffic rules	Always	53.3
	Sometimes	34.9
	Never	11.8

Table 3 illustrates the road features perceived by drivers at the study sites that are linked to accidents. The interviewees were asked about whether the correlation between road lanes and driving behavior has any impact on traffic accidents. 40% of respondents agreed that a wider lane is linked to accidents, 44.3% stated that a vehicle-separated lane is more associated, and a minority of participants provided responses regarding a narrower lane. Alternatively, detecting the intersection points specifically on the highway in Bangladesh is very difficult as the overhead sign is not used frequently like in other countries. As a consequence, drivers face difficulty in identifying the intersection points and they were asked about it during the survey. In general, 60% of bus drivers recognize the intersection based on the presence of police, while 30.2% identify it by following the leading vehicle. Out of the 255 interviewees, 30% expressed the belief that the presence of concrete dividers obstructs their visibility at intersection points. Furthermore, more than 50% of bus drivers held the opinion that there was

sufficient space at the intersection points, and the available road markings and signs in the study locations were deemed satisfactory.

Table 3: Road features

Road attributes	Class	Percentage
Lane effects	Wider lane	40.0
	Narrower lane	15.7
	Vehicle separated lane	44.3
Identify intersection point	Overhead sign	9.8
	Police presence	60.0
	Following a vehicle	30.2
Visibility obstruction	Concrete divider	30.2
	Environmental	19.2
	Police presence	23.5
	Irregular parking	27.1
Space occupancy at the intersection	Yes	54.0
	No	46.0
Adequacy of road signs and markings	Yes	37.5
	No	62.5

3.2 Dangerous Driving Behaviour Associated with Intersection Accidents

Drivers' perceptions were compiled from all interviewees, and an overall picture is presented in this section. The bus drivers were asked about the primary driver behaviors they deemed most relevant to traffic accidents at highway intersections. The options were reckless driving, faulty maneuvering driving, and lack of awareness or distracted driving, represented as DDB1, DDB2, and DDB3, respectively, where DDB signifies the dangerous driving behaviors perceived by the bus drivers. Figure 3 shows that, according to the respondents, reckless driving is identified as the primary cause of accidents, followed by faulty maneuvering driving and distracted driving. The findings are relevant as the study road has been newly designed following the introduction of expressways for the first time in Bangladesh and road layout is highly associated with reckless driving (Reckless Driving Still Rampant, 2020).

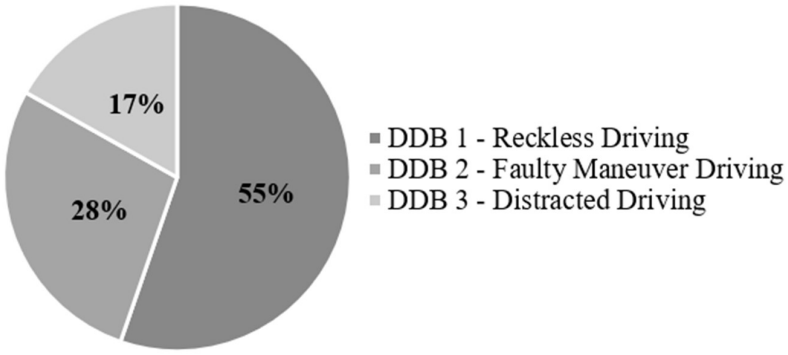

Figure 3: DDB perceived by bus drivers

3.3 Chi-square Test

The significance value obtained by performing the chi-square test provides insights into the influence of independent variables on dependent variables. Cells in Table 4 marked with (√) indicate a significant association with the dependent variable with a p-value < 0.05. The chi-square test of independence is used to test the null hypothesis of the sample.

Table 4: Association of the factors with DDB

Features	Variables	DDB
Socio-demographic	Age	√
	Education	√
	Income	X
Drivers' experience and behaviors	Driving frequency	√
	Driving experience	√
	Involvement in accidents within the last 3 years	√
	Factors leading to accidents	√
	Speed limit violation	√
	Non-compliance with traffic rules	√
Road features	Lane effect	√
	Space occupancy at the intersection	X
	Identifying intersections point	√
	Visibility obstruction	√
	Adequacy of road signs and markings	X

3.4 Relationship between DDB and Accident Contributing Factors

The relationship between the DDB and other factors such as the respondent's age, educational background, driving behavior, road attributes, etc. is explored in this section. Noticeably, these relationships are specifically examined for variables that have been identified as significantly linked to the dependent variable.

3.4.1 Relationship between Age and DDB

Driver's age is one of the factors that influences road safety. Figure 4 shows that both younger and middle-aged people are more involved in reckless driving than older ones. It is evident that younger, impulsive individuals having less experience often fail to think about the possibly serious consequences. The result is consistent with the findings of McNally and Bradley (2014). Conversely, older drivers are more prone to distracted driving and faulty maneuvering, obviously due to their extensive driving experience and frequent encounters with such road conditions.

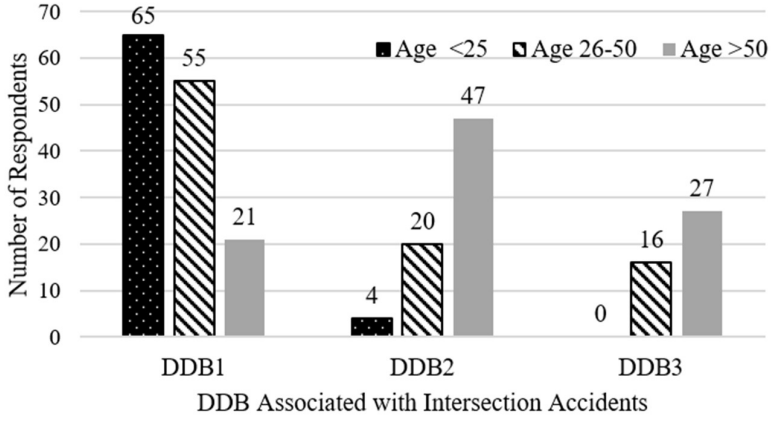

Figure 4: Age and DDB

3.4.2 Relationship between Educational Background and DDB

In the current study, it has been found that approximately 51% of the interviewed bus drivers are graduates, and they are more frequently implicated in intersection accidents on such roads compared to individuals with lower and higher educational levels. These specific groups have been observed engaging in reckless driving, faulty maneuvering, and distracted driving. As depicted in Figure 5,

respondents perceive that 47% of graduated drivers are involved in reckless driving, 33% display faulty maneuvering, and 20% of drivers are distracted while driving.

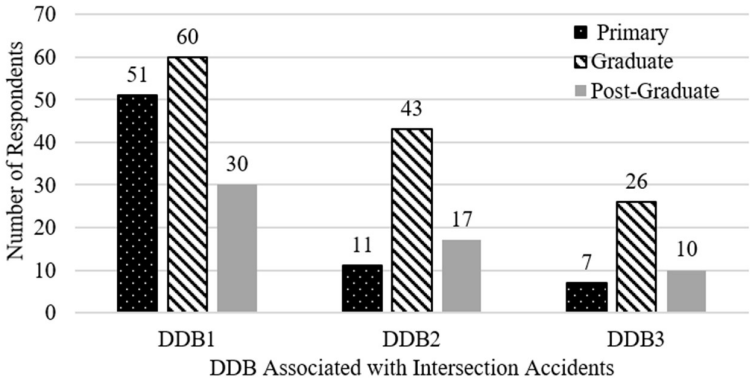

Figure 5: Educational background and DDB

3.4.3 Relationship between Driving Experience and DDB

The causal justifications for accidents and risk perceptions differ widely across expert and novice drivers. Expertise can be defined as extensive knowledge and experience in driving, whereas beginners can be defined as a lack of experience in driving. The current study demonstrated that novice drivers with driving experience of fewer than 5 years primarily exhibit reckless driving behavior (72%), as opposed to faulty maneuvers or distracted driving. Conversely, experienced drivers are involved in other forms of risk-taking behaviors (65%) rather than careless driving. These findings align with the research by Kouabenan (2002), which elucidated that inexperienced drivers tend to undervalue traffic risks and overemphasize their driving skills. Alternatively, experienced drivers adopt a more comprehensive perspective that considers various aspects of road traffic, leading them to undertake risky actions such as frequent lane changes or using phones while driving.

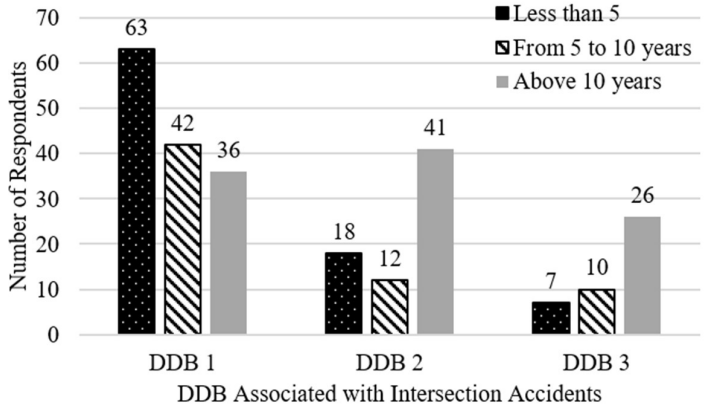

Figure 6: Driving experience and DDB

3.4.4 Relationship between Driving Frequency and DDB

The respondents' driving frequency was categorized into three scenarios: daily, triweekly (driving three times a week), and weekly. In Figure 7, it is evident that among bus drivers who drive three times a week on the highway, 67% exhibit reckless driving. Moreover, 37% of respondents who navigate similar roads daily have been identified as engaging in all recognized risk-taking behaviors. This suggests that individuals driving on a daily or triweekly basis are more susceptible to participating in these activities, increasing their likelihood of being involved in accidents.

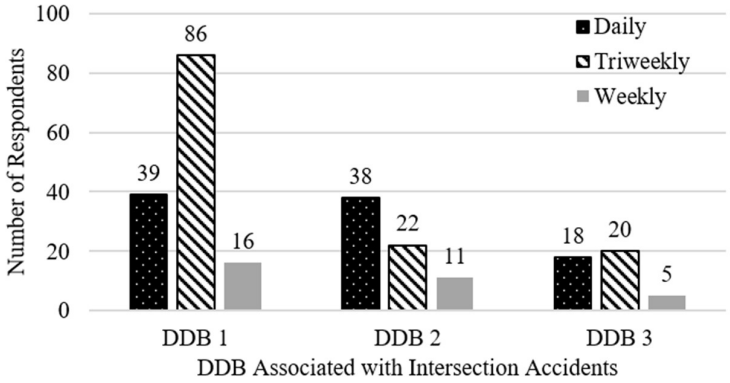

Figure 7: Driving frequency and DDB

3.4.5 Relationship between Prior Accidents Involvement and DDB

The respondents were asked about their involvement in accidents over the past three years to find out the relationship between the DDB and their historical accident records. It has been noticed that out of the 255 interviewees, 144 constituting more than half of the respondents, have experienced conflict on highways. Within this group of 144 bus drivers, 64% believed that aggressive driving is largely associated with their prior accident involvement, despite acknowledging that accidents can be attributed to drivers' overtaking habits, lane-changing behaviors, talking with passengers, and using cell phones. This implies that accidents are more commonly encountered by reckless drivers compared to those engaging in faulty maneuvers or distracted driving. The finding is consistent with the findings by Sharif et al. (2020).

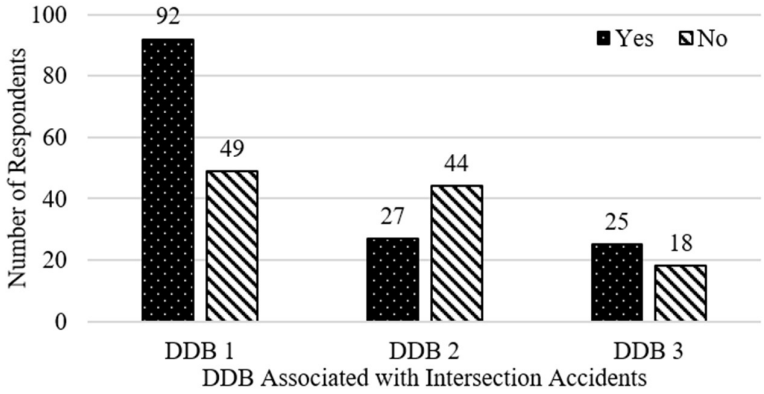

Figure 8: Prior accidents involvement and DDB

3.4.6 Relationship between Factors Leading to Accidents and DDB

Three distinct factors have been identified from the bus drivers' responses as contributing attributes to accidents in the study areas: irregular parking at intersection points, the presence of standing police officers, and vehicles emerging from slip roads. As depicted in Figure 9, irregular parking does not emerge as a significant factor in causing traffic accidents for drivers exhibiting recklessness or distraction. However, the abrupt maneuvering of front vehicles, such as sudden parking near intersections, is accountable for accidents involving following cars—a prevalent occurrence on Bangladesh highways. Conversely, careless drivers face confusion when encountering a police officer stationed at an intersection, leading to difficulties in driving and an increased likelihood of accidents. Similarly, distracted drivers meet challenges as they neglect police instructions, resulting in accidents. Additionally, vehicles coming from slip roads correlate firmly with DDB 1, as they exhibit rude driving behavior and disregard traffic directions and guidelines, contributing significantly to traffic accidents.

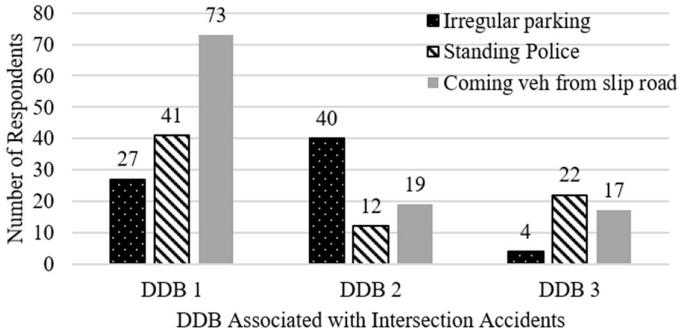

Figure 9: Factors leading to accidents and DDB

3.4.7 Relationship between Non-compliance with Traffic Rules and DDB

According to the interviewee's perception, reckless drivers always disregard traffic rules and regulations. Approximately 59% of reckless drivers consistently fail to adhere to traffic rules, followed by 33% of drivers engaged in faulty maneuvering and 67% of distracted drivers. On the other hand, Figure 10 indicates that 35% of reckless drivers sometimes follow traffic rules, and 47% of faulty maneuvering is associated with negligence of rules. However, the study reveals a notably low number of drivers who stick to traffic rules appropriately among those exhibiting the mentioned behavior.

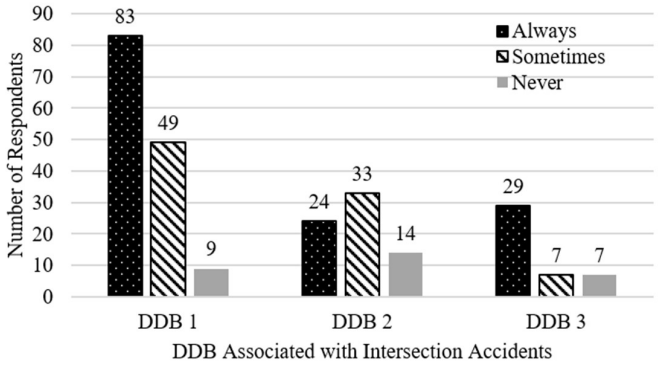

Figure 10: Non-compliance with traffic rules and DDB

3.4.8 Relationship between Speed Limit Violation and DDB

Figure 11 clearly states that the majority of reckless drivers violate the existing speed limit, with faulty maneuvering and distracted driving as notable contributors. The finding is consistent with An et al. (2023), who revealed that 57% of speeding was attributable to reckless drivers. In the present research, 32% of reckless drivers, 18% of faulty maneuvering, and 10% of distracted drivers concurred that these identified dangerous driving behaviors are strongly correlated with speed limit violations.

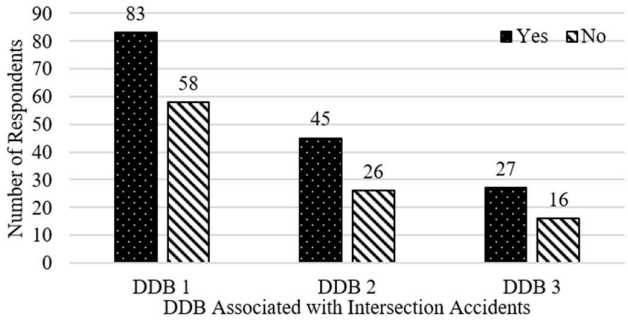

Figure 11: Speed limit violation and DDB

3.4.9 Relationship between Visibility Obstruction and DDB

The research identifies four distinct road features at the study sites that contribute to visibility issues for drivers. According to the bus drivers' perception, concrete dividers stand out as the major factor influencing reckless driving among these features. It can be exemplified by the fact that the absence of oncoming traffic or opposite traffic on roads with concrete dividers encourages drivers to drive fearlessly. Conversely, among distracted drivers, approximately 70% are affected by the presence of police at intersections and irregular parking. One plausible explanation is that distracted drivers, who engage in activities like cell phone use or eating, divert their attention from driving, leading them to disregard police directions and increase the risk of collisions. Additionally, Figure 12 illustrates that bus drivers' faulty maneuvering is equally influenced by all four of these visibility-obstructing factors identified in the study.

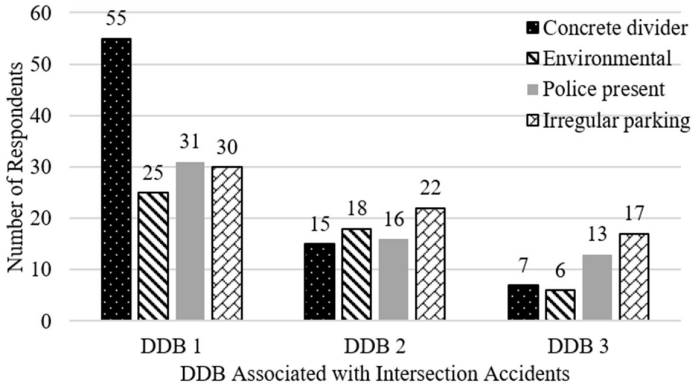

Figure 12: Visibility obstruction and DDB

3.4.10 Relationship between Identifying Intersection Point and DDB

Identifying intersection points on highways is crucial because vehicles encountered on access roads contribute to severe traffic accidents. While standard highways typically feature overhead signboards indicating the distance to access roads and other facilities, such signage is uncommon in our country, especially on newly constructed expressway-style highways. To understand how drivers, navigate such roads, respondents were asked about their methods for identifying intersection points. Three options were given, namely: an overhead sign, standing police, and following vehicles. The majority (60%) indicated that they rely on the presence of police, while approximately 30% follow the vehicles in front of them, and a small percentage use overhead sign. Figure 13 illustrates that around 50% of reckless drivers are more prone to accidents than faulty maneuvering and distracted drivers, particularly in the presence of police. The possible explanation is that their high-speed driving causes them to overlook the presence of police and collide with access vehicles. Moreover, both DDB 1 (63%) and DDB 2 (20%) are linked to following vehicles, as drivers following the lead car remain unaware of vehicles entering from slip roads and ultimately causing collisions.

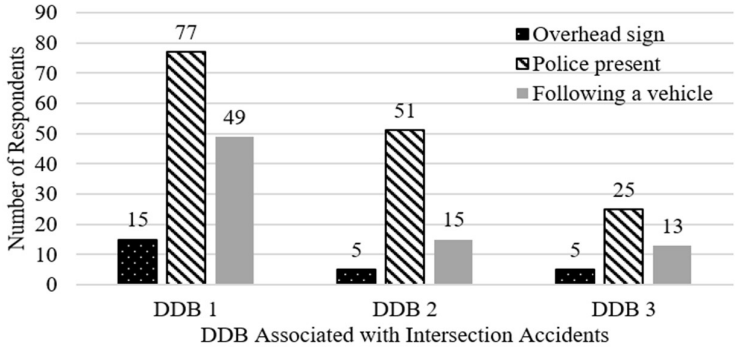

Figure 13: Identifying intersection point and DDB

4. CONCLUSIONS

The intersection plays a crucial role in the transportation network, particularly on highways, where accidents occur frequently. Therefore, enhancing intersection design by reducing accidents and ensuring safety is imperative. The current research is designed to find out the drivers' behavior related to traffic accidents at highway intersections and also establish a relationship between these behaviors and associated factors extensively based on Bangladeshi bus drivers' perceptions. Numerous road attributes and human factors are taken into account during the analysis to establish the relationship. The study categorizes three driving behaviors as dangerous driving behaviors (DDB). According to bus drivers' perceptions, it is observed that intersection accidents are mostly linked to reckless driving behavior (55%), followed by faulty maneuvering (28%), and distracted driving (17%). Conventional statistical tests were performed to build the relationship between these behaviors and factors. The results from chi-square tests indicate a significant association between a driver's socio-demographic characteristics, including age and education, driving behaviors such as frequency and experience, a driver's prior involvement in accidents, and road features like lane effects and visibility issues, with the dependent variable dangerous driving behavior (DDB). Reckless driving is more prevalent among young, middle-aged, graduate, and novice drivers, whereas older and more experienced drivers tend to engage in faulty maneuvering and distracted driving. Additionally, the faulty maneuvering behavior of bus drivers is linked to irregular parking at the intersection point. Over 60% of the respondents perceive speed limit violations as the primary contributing factor to accidents, correlated with all dangerous driving behaviors (DDBs). Approximately 70% of distracted drivers agreed that their visibility was hindered by standing police and irregular parking at the intersection point, thereby elevating the risk of collisions.

The findings of the current research are helpful for urban planners to better understand drivers' behavior at highway intersections. These insights can guide them in implementing essential measures to reduce traffic accidents and establish a safer environment for the country.

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