Analyzing key factors influencing road traffic accidents

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Abstract

Purpose – Road safety is crucial in preventing high-severity crashes that contribute significantly to road traffic accidents (RTAs). However, limited research explores bus drivers' perceptions of RTA risk factors across different vehicle types. This study aims to examine key contributing factors from the perspective of various bus drivers.

Design/methodology/approach – A questionnaire survey was conducted among 243 experienced bus drivers (Big Bus, Mini Bus, Micro Bus, Tourist Bus) traveling through the Prithvi Highway. A purposive sampling technique was used for selecting the sample size, and ANOVA analysis in R was used to assess factors influencing RTAs based on the perceptions of different categories of bus drivers.

Findings – This study revealed that tourist and microbus drivers were found to be more prone to risky behaviors such as drunk driving, unhealthy competition and excessive use of loud music or headphones, compared to other bus types. Additionally, mini-bus and micro-bus drivers expressed greater concern about environmental factors, including roadside obstacles and limited visibility, which they felt played a crucial role in accidents. This highlights the primary role of driver behavior and environmental factors in contributing to RTAs. To improve road safety, targeted interventions addressing human factors, particularly stricter enforcement of laws related to drunk driving, as well as regulations to control unhealthy competition, and improvements in road visibility and signage to enhance safety and reduce RTAs. Addressing the unique challenges of each driver category improves public transport efficiency and safety, reducing RTAs and promoting safer driving practices.

Originality/value – This research provides original insights into the distinct risky behaviors of tourist and microbus drivers and the environmental concerns of mini-bus drivers. It highlights the need for targeted interventions to improve road safety, reduce accidents and promote safer driving practices in public transport.

Keywords Bus drivers, Road safety, Human factors, Road traffic accidents

Paper type Research paper

1. Introduction

Every day, thousands die or suffer severe injuries on roads worldwide. Road transport boosts economies and enhances access to jobs, education and healthcare, improving overall well-being. However, its growth also brings risks of rising road traffic accidents (RTAs) and declining physical activity, impacting public health. Balancing mobility benefits with safety measures is crucial to minimizing these negative effects (DP and Chetty, 2020). Current road

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safety efforts fall far short of addressing this devastating crisis, demanding urgent and substantial action (Singh *et al.*, 2016).

Road accidents are influenced by various factors, including road engineering factors, speed limits, road surface conditions, weather, lighting, time, severity and vehicle type. Most accidents result from human errors like unlicensed driving, texting, drunk driving and ignoring road rules (Kumar *et al.*, 2023). Vehicle condition is another major factor, as many are not mechanically safe for the roads. Driver fatigue is a dangerous condition, often caused by exhaustion and the hypnotic effect of night driving. It can lead to falling asleep at the wheel or making fatal errors. Preventing fatigue-related crashes requires rest, awareness and safer driving practices (Foya, 2019).

Road accidents stem from human errors, environmental conditions, vehicle defects, etc. They pose a serious human security threat, impacting households and national economies, especially in developing countries like Nepal. To reduce the prevalence of RTAs, implementing appropriate safety measures targeting human factors is crucial (Mahmood *et al.*, 2020). Urgent measures are needed to mitigate their widespread social and economic consequences (Nour *et al.*, 2020). A deeper understanding of effective interventions is essential for individuals, organizations and governments seeking to replicate or implement successful road safety strategies (Gifty *et al.*, 2021). Given the urgency of the issue, this study explores key factors contributing to RTAs from bus drivers' perspectives, providing insights to improve safety measures.

2. Literature review

Road accidents are a major global issue, ranked eighth in causes of death, leading to economic losses and fatalities, with over half of the victims being vulnerable groups like pedestrians, cyclists and two-wheeler riders (Pandya *et al.*, 2025). A traffic accident occurs when a vehicle collides with another vehicle, a pedestrian, an animal or a stationary object. These crashes often result in injuries, fatalities, vehicle damage and financial loss. Beyond human casualties, they cause property damage and resource depletion, placing a significant burden on individuals and societies (Mohammed *et al.*, 2019). Road accidents occur at a moderate to high rate, strongly linked to age, driving experience, literacy, sleep hours and substance use. Key risk factors include mobile phone use, seat belt compliance and speeding (Ishtiaq *et al.*, 2024). They are unintentional events involving vehicles and/or road users, leading to casualties or property loss. A 1% increase in road accidents results in a 0.42% decline in real GDP, while a 1% rise in casualties leads to a 0.18% GDP decrease. Although a long-term relationship exists between road accidents and GDP, no statistically significant impact is observed in the short run, highlighting the delayed economic effects of traffic-related issues (Tandrayen-Ragoobur, 2024).

Table 1 presents the compliance level of 12 United Nations (UN) Road Safety targets in Nepal. In 2021, Nepal had a population of 30.3 million and reported 2,883 road traffic fatalities. WHO estimated road traffic deaths at 28.2 per 100,000 persons, with a total of 8,479 fatalities (95% CI: 7,622–9,336). The country had 3,987,267 registered vehicles (13,275.4 per 100,000 people), with motorized two/three-wheelers comprising 79.2%. Nepal, classified as a lower-middle-income country, had a total paved road length of 20,248 km. These statistics highlight Nepal's road safety challenges and the high burden of traffic-related incidents.

Table 2 provides a summary of reported and estimated road traffic deaths per 100,000 population in South Asian countries for 2021. It includes data for Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka. The population of these countries ranges from 0.52 million (Maldives) to 1,407.56 million (India). Reported road traffic deaths vary significantly, with

Table 1. The compliance level of 12 UN road safety targets in Nepal

Compliance	Level
Population (million)	30.3
Reported road traffic fatalities (year)	2,883 (2021)
WHO estimated road traffic deaths per 100,000 persons (year)	28.2 (2021)
Total registered vehicles (rate per 100,000 population) (year)	3,987,267 (13,275.4) (2021)
Country income level category	Lower-middle income
WHO estimated road traffic fatalities (95% CI) (year)	8,479 (CI 7622–9336) (2021)
Total paved road length in km (year)	20,248 (2021)
% share of motorized two/three-wheelers in total registered vehicles	79.2

Source(s): WHO (2024)

Table 2. Summary of reported and estimated road traffic deaths per 100,000 population in countries of the South Asia region

Member state	Bangladesh	Bhutan	India	Maldives	Nepal	Sri Lanka
Estimated population in 2021 (million)	169.36	0.78	1,407.56	0.52	30.03	21.77
Reported road traffic deaths in the year 2010	2,872	79	130,037	6	1,689	2,483
Reported road traffic deaths in the year 2021 [% change since 2010]	5,084 [+77.0]	71 [−10.1]	153,972 [+18.4]	5 [−16.7]	2,883 [+70.7]	2,513 [+1.2]
Reported road traffic deaths per 100,000 population in the year 2010	1.9	11.2	10.5	1.7	6.2	12.0
Reported road traffic deaths per 100,000 population in the year 2021 [% change since 2010]	3.0 [+55.4]	9.8 [−12.5]	11.6 [+10.5]	0.9 [−47.0]	9.7 [+56.5]	11.7 [−2.5]
Estimated road traffic deaths for the year 2010	25,697	125	212,091	13	6,797	2,805
Estimated road traffic deaths for the year 2021 [% change since 2010]	31,578 [+22.9]	95 [−24.0]	216,618 [+2.1]	7 [−46.2]	8,479 [+24.7]	2,513 [−10.4]
Estimated road traffic deaths per 100,000 population for the year 2010	17.3	17.7	17.1	3.6	25.0	13.6
Estimated road traffic deaths per 100,000 population for the year 2021 [% change since 2010]	18.6 [+7.5]	12.2 [−31.1]	15.4 [−9.9]	1.3 [−63.9]	28.2 [+12.8]	11.5 [−15.4]
Estimated road traffic death rate/ reported road traffic death rate for the year 2021	6.2	1.2	1.3	1.4	2.9	1.0

Source(s): WHO (2024)

India having the highest (153,972) and Bhutan the lowest (71). Nepal reported 2,883 fatalities, an increase of 70.7% from previous years. The reported road traffic death rates per 100,000 population range from 0.9 (Maldives) to 12.0 (Sri Lanka), with Nepal at 9.7. Estimated road traffic deaths provide a more comprehensive picture, with India reaching 216,618 and Nepal 8,479 fatalities. Estimated death rates per 100,000 are highest in Nepal (28.2) and lowest in the Maldives (1.3). Percentage changes in reported and estimated fatalities show varying trends across countries, with Bhutan and Sri Lanka experiencing decreases, while Nepal and

Bangladesh show significant increases. The estimated fatality risk per 100,000 vehicles highlights Nepal (2.9) as one of the highest. These statistics emphasize the urgent need for enhanced road safety measures in South Asia, particularly in Nepal.

Human factors, particularly driver behavior, are the leading cause of traffic accidents, followed by vehicle issues (Omidi *et al.*, 2020). Inadequate road design worsens safety issues, with poorly planned intersections, lack of proper signage, and insufficient lighting being major contributors to road crashes, posing significant risks to drivers, pedestrians, and overall traffic flow (WHO, 2024). In Lebanon, vehicle-related factors like steering wheel defects and mechanical faults are major contributors to road accidents. Human factors, particularly failure to follow driving codes, have a slight impact on traffic accidents, highlighting the need for vehicle maintenance and driver awareness (Karim and Albrka Ali, 2020). In Turkey, the main factors contributing to RTAs include road defects, vehicle defects, passenger errors, driver errors and pedestrian errors (Vitalis *et al.*, 2022). Among these, driver defects had the most significant impact, while road defects had the least effect on the occurrence of RTAs (Üniversitesi *et al.*, 2012). In Tanzania, factors such as dangerous driving, driver negligence, car defects, cyclists, motorcycles, overspeeding, bad roads, overtaking and alcoholism significantly increase the likelihood of road accidents. These elements contribute to a higher risk of accidents on the road (Abbafati *et al.*, 2020). Narrow roads, sharp curves, steep gradients, damaged pavement surfaces and poorly lit roads significantly contribute to road accidents. These hazardous conditions increase the risk of accidents, highlighting the need for better road design and maintenance to enhance safety (Vitalis *et al.*, 2022).

Weak enforcement of traffic regulations has led to reckless driving and rule violations, significantly increasing accidents and fatalities, especially among vulnerable road users such as pedestrians, cyclists and motorcyclists (Islam and Bhuiyan, 2024). Effective interventions are needed to enhance driver safety and reduce accidents (Saei *et al.*, 2017). Key steps include increasing law enforcement, conducting awareness campaigns, equipping agencies with resources to enforce compliance and implementing anti-corruption strategies within law enforcement to ensure effective road safety measures and reduce accidents (Modipa, 2022).

Driver faults like reckless driving, overtaking and speeding cause 80% of RTAs in Nepal, making them the primary cause. Urgent action is needed to address this worsening situation through stricter regulations, awareness programs and improved enforcement to enhance road safety and reduce accidents (Giri *et al.*, 2024). Road engineering factors like shoulder and lane width, number of lanes and horizontal curve radius significantly impact RTAs. Improving safety requires increasing curve radius, lane width and shoulder width to reduce accident risks and enhance road conditions (Giri, Shahi, Selvam, *et al.*, 2023). Addressing risks faced by road users through effective measures is crucial to reducing fatalities and improving overall road safety (Giri, Selvam, Shahi, *et al.*, 2023). Human behavior causes over 70% of road accidents (McCarty and Kim, 2024), but collecting individual driver data is challenging. As a result, studies often have limited scope and generalizability. Improving road safety by gaining deeper insights into driver behavior offers a practical and effective strategy for reducing traffic collisions and promoting safer driving practices (Moslem *et al.*, 2024). This study addresses the issue by analyzing demographic-related variables from the perspective of drivers of different bus types contributing to RTAs, offering broader insights to inform effective road safety policies and targeted interventions.

3. Methodology

The Prithvi Highway, a crucial transportation corridor in Nepal, connects Kathmandu to Pokhara, facilitating both tourism and trade. Spanning approximately 200 km, the highway traverses uneven terrain and offers scenic landscapes. A particularly significant segment, the

36-km Mugling–Narayanghat road, links Kathmandu and Pokhara to the southern plains, serving as a vital trade route. To examine the factors influencing RTAs on these routes, a questionnaire survey was conducted among experienced bus drivers (Big Bus, Mini Bus, Micro Bus and Tourist Bus) who frequently travel these highways. In Nepal, buses are classified by size and use: Big buses carry over 35 passengers, Mini buses accommodate 15–35 passengers and Micro buses carry 9–14 passengers. Tourist buses, usually larger and more comfortable, are licensed specifically for tourist transport, often featuring air-conditioning and fixed routes. Only drivers with over a year of experience departing from Pokhara to Kathmandu and Chitwan were selected as respondents.

The population consists of buses: 410 big buses (including tourist buses), 309 minibuses and 211 microbuses. The sample includes 243 buses, with 95 big buses, 44 tourist buses, 82 minibuses and 22 microbuses. A convenience sampling technique was adopted for sampling. To reduce the bias of convenience sampling, the researcher categorized bus drivers by type and age into distinct clusters. This matched grouping helped isolate the relationship between visual impairment and key study variables. By acknowledging the method's limitations, the researcher strategically designed the study to minimize bias and enhance the validity of the findings. According to Emerson, creating matched groups is a fundamental method to avoid sampling bias, as it ensures comparability and enhances the reliability of study results (Emerson, 2021). This approach enhances the reliability and validity of the findings (Giri, 2023).

A 35-item questionnaire was developed to examine factors influencing RTAs, drawing from the World Bank Group (2019), Elvik *et al.* (2009) and Giri *et al.* (2024). The questionnaire uses a five-point Likert scale, enabling participants to express their level of agreement or disagreement with each statement. The data collection instruments were carefully validated through expert reviews and consultations to ensure their relevance and appropriateness for the Nepal context. Pilot testing was conducted with a 10% sample to assess the clarity and fit of the research instrument. The pilot test confirmed that the instrument was well-understood and suitable for the Nepalese context, ensuring the reliability and validity of the data collected in the main study.

ANOVA was used to compare mean differences in RTAs contributing factors across multiple demographic groups. It is more suitable than multiple *t*-tests, as it controls for Type I error and efficiently tests group-level differences. ANOVA was performed using R statistical software to analyze the data and assess differences between groups. The software's robust statistical functions enabled a detailed comparison, providing insights into the significance of various factors influencing RTAs based on the study's sample data and the objective.

4. Result and discussion

Figure 1 presents the percentage distribution of different bus types. Among the types of bus driving, 39% of respondents drive big buses, making them the largest group. Mini-bus drivers account for 34%, while tourist bus drivers represent 18%. The smallest proportion, 9%, are micro-bus drivers. Understanding their perception is essential for improving road safety measures. Addressing the specific challenges faced by each category of drivers can contribute to enhancing overall public transport efficiency and safety on the roads.

Table 3 presents an analysis of the contributing factors of RTAs based on the perceptions of different types of bus drivers in Nepal. The study categorizes responses from four groups of drivers: tourist bus, mini-bus, big bus and micro-bus drivers. The statistical values reported include the Sum of Squares (Sum Sq), Mean Square (Mean Sq), *F*-value and significance level (Pr(>F)).

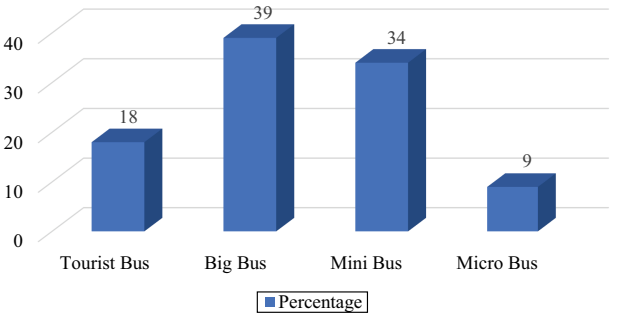

Figure 1. Types of bus drivers

4.1 Human factors contributing to RTAs

Human-related factors, such as speeding, overtaking at high speeds, reckless driving, fatigue and drunk driving, are among the most commonly perceived causes of accidents. Among tourist bus drivers, drunk driving (Pr = 0.01) and unhealthy competition between buses (Pr = 0.01) are statistically significant contributors to accidents. Similarly, mini-bus drivers identify loud music or headphone use (Pr = 0.03), roadside obstacles (Pr = 0.01) and rain, sleet, snow or fog (Pr = 0.03) as significant factors. For big bus drivers, loud music or headphone use is statistically significant (Pr = 0.02), while micro-bus drivers highlight drunk driving (Pr = 0.00), unhealthy competition (Pr = 0.02) and limited visibility (Pr = 0.04) as critical factors.

Speeding is a concerning factor across all bus types, but its significance varies. For tourist bus drivers, speeding has an *F*-value of 0.96 and Pr = 0.33, indicating a lower level of perceived impact. Similarly, mini-bus drivers report an *F*-value of 0.72 and Pr = 0.40 for speeding, while big bus drivers have an *F*-value of 2.96 and Pr = 0.09, suggesting a relatively higher influence but not statistically significant. Micro-bus drivers show the least concern for speeding (Pr = 0.81). Drunk driving is statistically significant among tourist bus drivers (Pr = 0.01) and micro-bus drivers (Pr = 0.00), while it is not significant for mini-bus (Pr = 0.75) and big bus (Pr = 0.64) drivers. This suggests that smaller public transport vehicles are more susceptible to alcohol-related incidents. Similarly, reckless driving is not identified as a statistically significant issue across any of the driver categories.

4.2 Road and environmental factors

The impact of environmental and road-related factors varies across bus types. For mini-bus drivers, the presence of roadside obstacles is a significant concern (Pr = 0.01), along with adverse weather conditions such as rain, sleet, snow or fog (Pr = 0.03). Micro-bus drivers also report limited visibility as a significant factor (Pr = 0.04). However, poor and defective road surfaces, narrow bridge approaches and inadequate or masked signs are generally not perceived as significant across all categories, with *p*-values ranging from 0.46 to 0.74.

Rain and slippery roads are not statistically significant among tourists (Pr = 0.29), mini (Pr = 0.31), big (Pr = 0.73) and micro-bus (Pr = 0.73) drivers, suggesting that weather conditions may not be a primary concern for these drivers. However, poor visibility at blind corners has a relatively lower *p*-value (Pr = 0.12 for tourist bus drivers and Pr = 0.06 for mini-bus drivers), indicating its importance. Unregulated parking, another road-related factor, is not statistically significant for any driver type, with *p*-values of 0.57 (tourist), 0.34 (mini), 0.71 (big) and 0.84 (micro). Similarly, narrow bridge approaches and steep gradients are not perceived as significant contributors to RTAs, with *p*-values above 0.22 across all categories.

Table 3. Contributing factors of RTAs from the perception of different bus driver types

Variables	Sum Sq	Mean Sq	*F*-value	Pr(>*F*)
Tourist bus				
Speeding driving	0.14	0.14	0.96	0.33
Overtaking at high speed	0.25	0.25	1.72	0.19
Reckless/careless driving	0.01	0.01	0.07	0.79
Fatigue driving	0.07	0.07	0.50	0.48
Drunk driving	0.96	0.96	6.61	0.01*
Driving while using a cell phone	0.26	0.26	1.78	0.18
Loud music/headphones	0.03	0.03	0.17	0.68
Overloading (hanging on the roof)	0.01	0.01	0.10	0.75
Unhealthy competition between buses while driving	1.12	1.12	7.67	0.01*
Wrong overtaking and wrong turning	0.35	0.35	2.43	0.12
Unregulated parking	0.05	0.05	0.32	0.57
No respect for traffic rules by pedestrians	0.01	0.01	0.10	0.76
Road lane discipline is not maintained	0.02	0.02	0.14	0.71
Slippery road due to rain	0.17	0.17	1.14	0.29
Weather problem	0.16	0.16	1.13	0.29
Limited visibility	0.31	0.31	2.16	0.14
The presence of roadside obstacles	0.11	0.11	0.74	0.39
Dazzling sun	0.01	0.01	0.04	0.85
Rain, sleet, snow or fog	0.54	0.54	3.68	0.06
Poor and defective road surface	0.03	0.03	0.18	0.67
Inadequate or masked signs or road markings	0.08	0.08	0.55	0.46
Narrow bridge approaches	0.14	0.14	0.93	0.34
Poor visibility at blind corners	0.36	0.36	2.49	0.12
Poor shoulders	0.13	0.13	0.86	0.35
Unforgiving side-drains	0.00	0.00	0.00	0.97
Inadequate safety barriers at steep vertical drops	0.02	0.02	0.16	0.69
Unscientific location of passing bays in single-lane roads	0.00	0.00	0.01	0.92
Lack of climbing lanes	0.10	0.10	0.68	0.41
Steep gradients at numerous sections	0.22	0.22	1.50	0.22
Narrow sections in built-up	0.00	0.00	0.01	0.94
Defective tires	0.03	0.03	0.19	0.66
Defective lights or indicators	0.21	0.21	1.44	0.23
Defective brakes	0.00	0.00	0.03	0.86
Defective steering	0.05	0.05	0.32	0.57
Defective mirrors	0.00	0.00	0.03	0.86
Mini bus				
Speeding driving	0.16	0.16	0.72	0.40
Overtaking at high speed	0.69	0.69	3.10	0.08
Reckless/careless driving	0.00	0.00	0.01	0.91
Fatigue driving	0.36	0.36	1.61	0.21
Drunk driving	0.02	0.02	0.10	0.75
Driving while using a cell phone	0.06	0.06	0.27	0.60
Loud music/headphones	1.06	1.06	4.77	0.03*
Overloading (hanging on the roof)	0.05	0.05	0.23	0.63
Unhealthy competition between buses while driving	0.07	0.07	0.32	0.57
Wrong overtaking and wrong turning	0.20	0.20	0.89	0.35
Unregulated parking	0.21	0.21	0.93	0.34
No respect for traffic rules by pedestrians	0.13	0.13	0.59	0.45
Road lane discipline is not maintained	0.12	0.12	0.54	0.46
Slippery road due to rain	0.23	0.23	1.02	0.31

(*continued*)

Table 3. Continued

Variables	Sum Sq	Mean Sq	*F*-value	Pr(>*F*)
Weather problem	0.00	0.00	0.02	0.90
Limited visibility	0.01	0.01	0.03	0.86
The presence of roadside obstacles	1.60	1.60	7.18	0.01*
Dazzling sun	0.15	0.15	0.69	0.41
Rain, sleet, snow or fog	1.12	1.12	5.05	0.03*
Poor and defective road surface	0.02	0.02	0.11	0.74
Inadequate or masked signs or road markings	0.04	0.04	0.20	0.66
Narrow bridge approaches	0.00	0.00	0.01	0.91
Poor visibility at blind corners	0.79	0.79	3.55	0.06
Poor shoulders	0.15	0.15	0.68	0.41
Unforgiving side-drains	0.25	0.25	1.12	0.29
Inadequate safety barriers at steep vertical drops	0.30	0.30	1.34	0.25
Unscientific location of passing bays in single-lane roads	0.01	0.01	0.04	0.85
Lack of climbing lanes	0.02	0.02	0.08	0.78
Steep gradients at numerous sections	0.03	0.03	0.12	0.73
Narrow sections in built-up	0.01	0.00	0.02	0.88
Defective tires	0.00	0.00	0.01	0.92
Defective lights or indicators	0.02	0.02	0.09	0.76
Defective brakes	0.06	0.05	0.25	0.62
Defective steering	0.01	0.01	0.04	0.84
Defective mirrors	0.38	0.38	1.72	0.19
Big bus				
Speeding driving	0.71	0.71	2.96	0.09
Overtaking at high speed	0.66	0.66	2.75	0.10
Reckless/careless driving	0.00	0.00	0.01	0.92
Fatigue driving	0.59	0.59	2.49	0.12
Drunk driving	0.05	0.05	0.22	0.64
Driving while using a cell phone	0.67	0.67	2.80	0.10
Loud music/headphones	1.25	1.25	5.23	0.02*
Overloading (hanging on the roof)	0.05	0.05	0.20	0.65
Unhealthy competition between buses while driving	0.43	0.43	1.78	0.18
Wrong overtaking and wrong turning	0.17	0.17	0.72	0.40
Unregulated parking	0.03	0.03	0.14	0.71
No respect for traffic rules by pedestrians	0.01	0.01	0.04	0.85
Road lane discipline is not maintained	0.39	0.39	1.63	0.20
Slippery road due to rain	0.03	0.03	0.12	0.73
Weather problem	0.37	0.37	1.54	0.22
Limited visibility	0.01	0.01	0.04	0.85
The presence of roadside obstacles	0.43	0.43	1.79	0.18
Dazzling sun	0.04	0.04	0.18	0.67
Rain, sleet, snow or fog	0.07	0.07	0.28	0.60
Poor and defective road surface	0.13	0.13	0.55	0.46
Inadequate or masked signs or road markings	0.00	0.00	0.00	0.96
Narrow bridge approaches	0.03	0.03	0.13	0.72
Poor visibility at blind corners	0.12	0.12	0.49	0.48
Poor shoulders	0.00	0.00	0.01	0.91
Unforgiving side-drains	0.64	0.64	2.66	0.10
Inadequate safety barriers at steep vertical drops	0.09	0.09	0.36	0.55
Unscientific location of passing bays in single-lane roads	0.00	0.00	0.01	0.91
Lack of climbing lanes	0.33	0.33	1.36	0.24

(*continued*)

Table 3. Continued

Variables	Sum Sq	Mean Sq	*F*-value	Pr(>*F*)
Steep gradients at numerous sections	0.01	0.01	0.04	0.83
Narrow sections in built-up	0.13	0.13	0.53	0.47
Defective tires	0.01	0.01	0.06	0.81
Defective lights or indicators	0.08	0.08	0.35	0.56
Defective brakes	0.07	0.07	0.28	0.60
Defective steering	0.16	0.16	0.66	0.42
Defective mirrors	0.66	0.66	2.78	0.10
Micro bus				
Speeding driving	0.00	0.00	0.06	0.81
Overtaking at high speed	0.27	0.27	3.41	0.07
Reckless/careless driving	0.01	0.01	0.13	0.72
Fatigue driving	0.20	0.20	2.47	0.12
Drunk driving	0.81	0.81	10.32	0.00**
Driving while using a cell phone	0.00	0.00	0.05	0.82
Loud music/headphones	0.06	0.06	0.78	0.38
Overloading (hanging on the roof)	0.02	0.02	0.21	0.65
Unhealthy competition between buses while driving	0.45	0.45	5.69	0.02*
Wrong overtaking and wrong turning	0.07	0.07	0.88	0.35
Unregulated parking	0.00	0.00	0.04	0.84
No respect for traffic rules by pedestrians	0.02	0.02	0.28	0.60
Road lane discipline is not maintained	0.17	0.17	2.21	0.14
Slippery road due to rain	0.01	0.01	0.12	0.73
Weather problem	0.07	0.07	0.87	0.35
Limited visibility	0.32	0.32	4.11	0.04*
The presence of roadside obstacles	0.08	0.08	1.00	0.32
Dazzling sun	0.07	0.07	0.87	0.35
Rain, sleet, snow or fog	0.00	0.00	0.06	0.80
Poor and defective road surface	0.00	0.00	0.02	0.88
Inadequate or masked signs or road markings	0.01	0.01	0.11	0.74
Narrow bridge approaches	0.02	0.02	0.24	0.62
Poor visibility at blind corners	0.00	0.00	0.04	0.84
Poor shoulders	0.01	0.01	0.10	0.75
Unforgiving side-drains	0.08	0.08	1.02	0.31
Inadequate safety barriers at steep vertical drops	0.16	0.16	2.04	0.16
Unscientific location of passing bays in single-lane roads	0.03	0.03	0.41	0.52
Lack of climbing lanes	0.02	0.02	0.20	0.66
Steep gradients at numerous sections	0.28	0.28	3.50	0.06
Narrow sections in built-up	0.16	0.16	2.00	0.16
Defective tires	0.06	0.06	0.70	0.40
Defective lights or indicators	0.10	0.10	1.23	0.27
Defective brakes	0.00	0.00	0.02	0.88
Defective steering	0.08	0.08	0.98	0.32
Defective mirrors	0.02	0.02	0.21	0.64

4.3 Vehicle-related factors

Vehicle technical issues, such as defective brakes, steering, mirrors and tires, generally do not appear as major contributors to RTAs in this study. Defective mirrors have a lower *p*-value for big bus drivers (Pr = 0.10) and mini-bus drivers (Pr = 0.19), suggesting some concern, but they are not statistically significant. Micro-bus drivers also report an *F*-value of 1.72 for defective mirrors, but with a *p*-value of 0.19, it remains insignificant. Defective lights or indicators are

also not a statistically significant issue across all driver types, with *p*-values ranging from 0.23 to 0.76. Similarly, defective brakes, steering and tires do not appear to contribute significantly to accidents based on driver perceptions, with all *p*-values above 0.40.

The perceptions of different bus driver groups indicate variations in risk factors. Tourist bus and micro-bus drivers report a statistically significant concern regarding drunk driving, while mini-bus and big-bus drivers do not. Loud music and headphones are significant concerns for mini-bus and big bus drivers, but not for tourist and micro-bus drivers. Roadside obstacles are significant for mini-bus drivers, while unhealthy competition between buses is a major concern for both tourist and micro-bus drivers. While speeding and overtaking at high speeds are common across all driver types, they do not appear as statistically significant contributors based on *p*-values. However, their relatively high *F*-values indicate a notable perception of risk. Environmental factors, such as rain and fog, are more significant for mini-bus and micro-bus drivers than for big-bus and tourist bus drivers.

This study highlights that human factors, particularly drunk driving and unhealthy competition, play a critical role in RTAs among Nepalese bus drivers. While environmental factors such as limited visibility at blind corners and adverse weather conditions contribute to accidents, their statistical significance varies by bus type. Road conditions and vehicle-related issues, though perceived as contributing factors, do not appear as major causes based on statistical analysis. These findings emphasize the need for targeted interventions such as stricter enforcement of drunk driving laws, better regulation of competition among buses and improved road visibility to mitigate RTAs in Nepal.

These findings align with previous studies by McCarty and Kim, which revealed that human behavior is responsible for more than 70% of traffic accidents (McCarty and Kim, 2024). Risky behaviors, particularly alcohol consumption, significantly increase accident risks (Taylor *et al.*, 2010). Similarly, fatigue impairs cognition, similar to alcohol, with younger drivers and shift workers being especially vulnerable (Lowrie and Brownlow, 2020). Further, this study aligns with Giri *et al.* (2024), highlighting drunk and reckless driving as major causes and emphasizing regulatory enforcement. Both studies identify infrastructure issues like poor signage and narrow roads, supporting the need for safety audits in road planning and construction. Additionally, they advocate for stricter enforcement, improved safety measures and better infrastructure to reduce RTAs. This emphasizes the dominant role of human error and risky driving practices in traffic incidents. Therefore, addressing behavioral issues through policy, education and enforcement is essential for improving road safety and reducing the incidence of RTAs.

Likewise, the factors contributing to RTAs among bus drivers, categorized by education level, age and driving experience. Drivers with a bachelor's degree were significantly affected by speeding, overtaking, defective tires and narrow bridge approaches, while those with +2 education showed weaker links with overloading and poor lane discipline. SEE/SLC-educated drivers were impacted by unscientific passing bays and a lack of climbing lanes, whereas those below SEE/SLC were mainly affected by infrastructure issues. Age-wise, younger drivers (18–30) showed near-significant tendencies toward unhealthy competition, while those aged 31–42 were significantly influenced by distractions and wrong overtaking. Middle-aged drivers (43–55) were impacted by distractions and poor lane discipline, while older drivers (55+) were mainly affected by poor road surfaces, highlighting infrastructure vulnerabilities. Regarding driving experience, those with three or fewer years showed no significant variables. Drivers with four–six years showed significance only for narrow bridge approaches. In the seven–nine year group, risky behaviors such as drunk driving, phone use and unhealthy competition were significant, along with poor shoulders and weather. Drivers with 10–12 years of experience were influenced by fatigue, overloading, pedestrian behavior and visibility. For

drivers with over 12 years of experience, fatigue remained the only significant factor, suggesting long-term behavioral fatigue despite experience. The findings of this research align with a study conducted in China, which found that drivers' demographic profiles, such as age, driving experience, influence the factors contributing to RTAs (Zheng *et al.*, 2022). Additionally, a study in Ethiopia found that RTAs are significantly influenced by socioeconomic and behavioral factors. Key determinants included income level and driving experience, as well as behavioral aspects such as traffic rule violations and drunk driving, highlighting the need for targeted interventions addressing both economic conditions and driver behavior to reduce accident rates (Getachew *et al.*, 2024).

5. Conclusion

A questionnaire survey was conducted among 243 bus drivers (Big Bus, Mini Bus, Micro Bus, Tourist Bus) who have more than one year of experience traveling through the Prithvi Highway. The sample was purposively selected, and ANOVA analysis in R was used to assess factors influencing road traffic accidents based on the perceptions of different categories of bus drivers. Key findings include human factors like drunk driving, unhealthy competition and loud music/headphones as significant contributors to accidents. Additionally, mini-bus and micro-bus drivers are more concerned about environmental factors such as roadside obstacles and limited visibility at blind corners. The study emphasizes the importance of effective interventions must address these diverse factors through age-specific training, behavior-focused awareness campaigns, seasonal preparedness and infrastructure improvements. A coordinated effort among policymakers, transport authorities and drivers is vital to reduce RTAs and enhance road safety in Nepal.

5.1 Scope for future research

- Future research should consider including a broader range of highway segments and geographic areas to enhance the applicability and representativeness of the results at the national level.
- Future research should consider perspectives from various road users, such as private vehicle drivers, pedestrians and transport authorities, for a more holistic analysis.
- Future research should consider tracking changes in accident patterns, driver behavior and the effectiveness of road safety interventions over time.

Data availability

Data will be available upon request.

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