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# Bus Drivers' Perspectives on Factors Contributing to Road Traffic RTAs on Prithvi and Mugling-Narayanghat Highway Segment in Nepal

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**ABSTRACT**

Road traffic accidents (RTAs) remain a leading cause of mortality and injury worldwide, with low- and middle-income countries disproportionately affected despite having a smaller share of the global vehicle fleet. This study investigates the factors contributing to RTAs on Nepal's Prithvi Highway and the Mugling-Narayanghat road segment, with a specific focus on driver behavior, infrastructure deficiencies, environmental conditions, and vehicle-related issues. Data were collected through a structured questionnaire survey from 210 bus drivers who regularly operate along these routes. The reliability of the instrument was confirmed using Cronbach's alpha, and data were analyzed using the Relative Importance Index (RII) to rank the severity of contributing factors and one-way ANOVA to examine differences across demographic groups. Results reveal that human factors, particularly speeding, drunk driving, and driver distractions, are the most significant contributors to accidents, followed by infrastructure factors such as narrow roads and inadequate signage, adverse weather conditions like rain and fog, and vehicle-related issues, including defective tires. ANOVA results indicate significant variations in accident-related risk perceptions based on drivers' age, education level, and years of experience, with younger drivers more prone to distraction and older drivers more affected by poor road conditions. This study provides novel empirical evidence from the perspective of road users, offering practical insights for developing targeted road safety interventions. Recommendations include enhanced driver training, road infrastructure upgrades, regular vehicle maintenance, and awareness campaigns to for reducing RTAs.

## 1. INTRODUCTION

Road traffic accidents (RTAs) are a major global public health concern. Millions of people are injured or killed in road accidents each year, making it one of the leading causes of death and disability globally. RTAs are responsible for an estimated 1.35 million fatalities and up to 50 million non-fatal injuries each year [1]. These accidents can have far-reaching consequences not only for the people involved but also for their families, communities, and the economy [2]. In 2021, there were approximately 1.19 million fatalities attributed to RTAs, with a corresponding rate of 15 deaths per 100,000 individuals. As of 2019, road traffic injuries persist as the primary cause of death among individuals aged 5 to 29 and rank as the 12th leading cause of death across all age groups. 92% of these fatalities occur in low- and middle-income countries [3]. Despite these nations having less than 1% of the world's motor vehicles, the risk of death from RTA is three times higher compared to high-income countries [3]. This disparity emphasizes the urgent need for comprehensive road safety measures, particularly in regions with limited resources.

Globally, occupants of four-wheel vehicles make up 30% of the total fatalities, followed by pedestrians at 23%. Users of powered two- and three-wheelers represent 21% of the fatalities, while cyclists contribute 6% to the total [3]. Factors such as human behavior, road infrastructure, and vehicle design are responsible for RTAs. Human factors are a major contributor to RTAs all over the world [4]. A study [5] reports that "at least 80% of road traffic accidents can be attributed to human behavior and error". Driving under the influence of drugs or alcohol, speeding, and distracted driving are all common causes of RTAs.

Road traffic accidents typically result from a combination of factors, including vehicle conditions, environmental influences, and driver behavior [6]. Therefore, managing and reducing risky driving behaviors is crucial for preventing accidents and enhancing overall road safety [7]. Road traffic deaths are a critical global public health issue, prompting urgent efforts to implement measures that enhance road safety and reduce fatalities worldwide [8]. Drunk driving, distractions, and speeding are major risk factors in road accidents, while helmets, seat belts, and airbags significantly reduce mortality rates. Road traffic systems are complex and dangerous, requiring effective, sustainable measures to reduce accidents [9]. Policymakers, automobile manufacturers, public health experts, and communities must collaborate to tackle this global health issue. Importantly, road accident deaths are preventable through road safety mechanisms and their proper implementation, emphasizing the need for collective action to save lives [10].

Road accidents in Nepal are a serious public health and economic concern, causing substantial loss of life and productivity. Vulnerable road users, such as pedestrians, cyclists, and two-wheeler riders, account for a significant share of casualties. Young individuals, particularly those under 26, are disproportionately affected, making up a large portion of victims. A major contributing factor to these accidents is driver-related offenses, including violations, drunk driving, overloading, and speeding, which together are responsible for most fatal incidents on the country's roads. Enhancing road safety in Nepal demands stricter penalties for risky driving behaviors, adoption of advanced vehicle safety technologies, robust transportation policies, accreditation of pre-hospital care providers, and thorough safety audits [11].

Road safety has been a critical focus of scientific research, particularly road accidents, which cause significant social impacts through fatalities and disabilities, and economic burdens due to compensation costs for damages to individuals and property [12]. In recent years, there has been a growing emphasis on improving road safety, with various initiatives and policies aimed at reducing the number of RTAs and the injuries and fatalities that result from them. Nonetheless, despite these efforts, RTAs continue to be a major cause of death and injury worldwide [13]. Road design and maintenance, driver, pedestrian, and other road user behavior, and the enforcement of traffic laws and regulations could contribute to accidents and fatalities on the road. Road traffic accidents are a major global concern, demanding research to analyze contributing factors and improve safety measures. This study aims to identify factors influencing accidents from bus drivers' perspectives and examine the relationship between drivers' demographic profiles and these factors, providing insights to enhance road safety.

## 2. LITERATURE REVIEW

Traffic crashes are caused by various factors, including vehicle conditions, road geometry, traffic patterns, environmental influences, and human behavior. Each factor contributes to crashes to varying degrees, impacting road safety [14]. Traffic crashes are a leading cause of death in developing countries [15].

Human factors play a significant role and are responsible for the majority of road accidents worldwide [16]. Human factors significantly contribute to RTAs, with non-adherence to traffic rules and law enforcement exacerbating the issue [17, 18]. Driver negligence, lack of attention, young driving, speeding, reckless driving, distracted driving, and driving under the influence of drugs or alcohol [19]. Some major driver-related factors responsible for RTAs are:

**Fatigue and Sleepiness:** Fatigue and sleepiness are common human factors that can impair driving performance and raise the risk of an accident. Drivers who are tired or sleepy are more likely to make mistakes, react slowly, and have microsleeps.

**Aggressive Driving:** Another human factor that can lead to RTAs is aggressive driving, which includes tailgating, cutting off other drivers, and aggressive passing.

**Lack of Training and Experience:** Drivers who lack proper training and experience are more likely to make mistakes and become involved in accidents. This is especially true for inexperienced and young drivers.

**Distracted Driving:** Distracted driving is a major cause of RTAs. This can include anything that diverts a driver's attention away from the road, such as texting, eating, or adjusting the music.

**Speeding Driving:** Speeding is a major contributor to RTAs [19]. Overspeeding is defined as driving at speeds exceeding the posted speed limit, increasing the risk of accidents and compromising road safety [20]. Drivers who drive faster than the posted speed limit have less time to react to changing road conditions and are more likely to lose control of their vehicles. Overspeeding significantly increases the risk of injuries and fatalities [21]. In 2019, speeding was responsible for 26% of all road fatalities in the United States, with more than 25 deaths occurring daily [22]. A 1% increase in a driver's average speed raises their risk of fatal injury by 4% [23].

**Impaired Driving:** Impaired driving, which includes driving while under the influence of drugs or alcohol, is a major contributor to RTAs. Drivers who are impaired have slower reaction times and poor judgment, which can lead to accidents. Driving under the influence of alcohol is a significant threat to road safety in Nigeria. The maximum authorized BAC is 0.5 g/l, with proposed reductions to 0.2 g/l for novice drivers and 0.01 g/l for commercial drivers. Alcohol impairs vision and judgment, and increases tendencies for speeding, contributing to accidents. It has been demonstrated that laws prohibiting drunk driving reduce the number of alcohol-related accidents. Stricter drunk driving laws and their effective implementation are linked to lower rates of alcohol-related fatalities [24].

**Seat Belt Use While Driving:** Seat belt laws have been shown to reduce the number of injuries and fatalities in accidents [25]. Seatbelt users have a lower risk of most major RTAs [26].

**Cell Phone Use While Driving:** Laws prohibiting the use of cell phones while driving can have an impact on road safety. A study conducted in the United States of America revealed that the prohibition on using handheld cell phones while driving is significant in improving traffic safety [27].

### 2.1 Road infrastructure factors

Road infrastructure factors such as road type, geometric design, traffic control, lighting, and road environment are critical in determining road safety outcomes and significantly influence the occurrence of traffic accidents [28]. Inconsistent road geometry can cause significant variability in speed and introduce unexpected elements for drivers, increasing the likelihood of RTAs [29]. Such irregularities create confusion and affect drivers' ability to react safely [30]. During the early days of motorization, highway design standards advanced with the introduction of design manuals [31]. The road environment significantly influences driver behavior and, consequently, crash rates. Factors such as road geometry, signage, markings, and lighting play crucial roles in shaping drivers' choices and actions. Some of the road infrastructure factors are:

Road Geometry: Road geometry, which includes alignment, gradient, and cross-sectional design, can influence driver behavior. Poor road geometry is a significant risk factor for accidents [32].

Road Conditions: Poor Road conditions, such as potholes, uneven surfaces, and a lack of signage, can also play a role in vehicle accidents. Poor road infrastructure was found to be a significant factor in road accidents in low- and middle-income countries.

Road Signage and Markings: Proper Road signage and markings at hazard locations can help drivers navigate and avoid potential hazards, reducing the risk of accidents [33].

### 2.2 Weather related factors

Weather conditions such as heavy rain, snow, and fog can heighten the risk of vehicle accidents [34]. Furthermore, rainy weather reduces pavement skid resistance and vehicular stability, such as braking stability and steering operation. Key weather factors influencing crash likelihood and severity include visibility, temperature, wind speed, precipitation, and moisture. These variables are critical as their unpredictable interactions can drastically alter accident probabilities. Considering these factors in road safety measures is essential to minimize risks and enhance driving conditions [35].

### 2.3 Vehicular factors

Although numerous passive and active safety features have been incorporated into vehicles in recent years, such as airbags and collision warning systems, the incidence of crashes has not diminished. Vehicle mechanical characteristics and driving environment design significantly contribute to road accidents. Poorly maintained vehicles and the absence of modern safety features like lane assist, brake assist, electronic stability control, and Anti-lock Braking System increase accident risks [36]. Additionally, poorly designed driving environments exacerbate driver fatigue, a major factor in vehicle accidents, particularly in heavy-duty vehicles. Driver fatigue results from prolonged driving in suboptimal conditions, affecting both commercial and passenger vehicle drivers [37]. Improving vehicle maintenance standards and incorporating advanced safety features, along with designing ergonomic driving environments that minimize fatigue, are essential to enhancing road safety and reducing accident rates.

Geometric deficiencies on roads can affect driver behavior, potentially leading to RTAs. Poor road design or conditions may influence drivers' decisions, increasing the risk of accidents [38]. Human error, including speeding, distractions, alcohol consumption, traffic rule violations, fatigue, and drowsiness, is a primary cause of RTAs. According to study [4], cell phone use while driving is a major distraction, reporting a significant increase to 11% over the past decade. They emphasize that mobile phone usage raises the likelihood of road accidents by four times. Research carried out [39] shows that about 25% of road accidents involving heavy trucks and passenger vehicles result from driver distractions caused by mobile phones. A study [40] investigated distractions among novice and professional drivers using accelerometers and cameras. Their findings identified risky behaviors like eating, calling, or texting as significant contributors to road accidents. These activities notably increase accident risks, especially among inexperienced drivers.

Factors contributing to RTAs in low- and middle-income countries are driver behavior, inadequate road infrastructure, poor vehicle maintenance, and a lack of traffic law enforcement [10]. The author also emphasizes the significance of addressing social and cultural factors like attitudes toward road safety and risk-taking behavior. Driver behavior, such as speeding and reckless driving, road infrastructure, such as poor road design and maintenance, vehicle-related factors, such as defective brakes and tires, and environmental conditions, such as weather and visibility, were all major contributing factors [41]. The study highlights the importance of targeted interventions aimed at reducing the specific causes of RTAs in different contexts, as well as the need for a comprehensive approach to road safety that addresses these multiple factors. Poor road infrastructure, insufficient traffic management, driver behavior, vehicle defects, and environmental conditions are the major factors contributing to RTAs [42]. They also emphasize the need for additional research to better understand the causes of RTAs, as well as to develop effective interventions to prevent or reduce the occurrence of accidents. Similarly, several key factors, including driver behavior, vehicle design, road design, and environmental conditions such as weather and lighting, are responsible for RTAs [43].

To reduce the risk of accidents, this study focuses on the importance of designing and maintaining safe road environments, improving driver education and training, and developing effective policies and regulations. Likewise, driver-related factors, such as speeding, distraction, and impaired driving, were found to be the most frequent causes of serious road accidents [44]. To improve road safety, targeted interventions that address the underlying causes of traffic accidents, along with comprehensive road safety policies that address the multiple causes of RTAs, such as improving driver education and training, improving vehicle safety features, and upgrading road infrastructure, are vital [26].

## 3. MATERIALS AND METHODS

The Prithvi Highway, a vital transportation route in Nepal, connects Kathmandu to Pokhara, playing an important role in linking the nation's capital with its major tourist hub. Spanning approximately 200 kilometers of uneven terrain, the highway is renowned for its scenic beauty. Similarly, the 36-kilometer Mugling to Narayanghat road segment, another important stretch of this highway, connects Kathmandu and Pokhara to the southern plains, serving as a lifeline for trade and commerce. This segment faces issues such as frequent congestion, landslides during the monsoon, and maintenance challenges, all of which contribute to RTAs and decreased efficiency. To study the factors contributing to accidents along these routes, primary data was collected through a questionnaire survey targeting experienced bus drivers (Big Bus, Mini Bus, Micro Bus, and Tourist Bus) who regularly travel these routes. Drivers departing from Pokhara for Kathmandu and Chitwan with over a year of experience were included as respondents. Table 1 outlines the population and sample distribution for three types of buses: big buses, including tourist buses (410), minibusses (309), and microbuses (211). The sample consists of 139 buses, divided into 95 big buses and 44 tourist buses, along with 82 minibusses and 22 microbuses. All samples were selected using random sampling techniques, ensuring a representative subset for each category to support the analysis and study of the overall population. Random sampling minimizes bias and ensures a sufficiently large, representative sample, enhancing the reliability and validity of research findings for achieving study objectives [45].

A rigorous protocol was followed to ensure the confidentiality and integrity of responses, including a briefing on study objectives and measures to prevent duplication during the survey period. A structured questionnaire was developed comprising thirty-five independent variables, with road traffic accidents as the dependent variable. Based on the literature from the studies [1, 10, 28]. A five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) was used to capture respondents' perceptions regarding various factors contributing to RTAs, ensuring a standardized method of data collection. The data collection instruments were validated through a pilot test conducted before data collection. This ensured the questionnaire was clear and appropriate for gathering the required data, and that the language used was suitable and easily understood by respondents, enhancing the overall reliability and effectiveness of the instrument.

**Table 1.** Population and sample

| SN | Types of Buses | Population | Sample | Sampling Technique |
|---|---|---|---|---|
| 1 | Big Buses, including Tourist Buses | 410 | 139 | Random sampling |
| 2 | Mini Bus | 309 | 82 | Random sampling |
| 3 | Micro Bus | 211 | 22 | Random Sampling |

Data analysis was carried out using R statistical software. The study employed Cronbach's alpha to assess the internal consistency of the data, excluding factors with low reliability. Additionally, the Relative Importance Index (RII) was used to identify the most significant variables contributing to RTAs, while an ANOVA test evaluated the significance of these factors based on drivers' demographic profiles.

## 4. RESULTS AND DISCUSSION

### 4.1 Demographic profile of respondent

Table 2 presents a detailed analysis of respondents based on their demographic characteristics, driving experience, and road accident patterns, offering valuable insights into factors influencing road safety. The age distribution indicates that the majority of respondents (49%) fall within the age group of 31-42 years. This is followed by 43-55 years (29%) and 18-30 years (19%). Only 4% of the respondents are aged above 55, reflecting that most drivers are in their active working years. In terms of education, a significant proportion of respondents (53%) have education levels below SLC (Secondary Level Certificate). Those who have completed SLC/SEE represent 28%, while respondents with intermediate-level education account for 17%. Only 2% hold a bachelor's degree, suggesting that many drivers have minimal formal education. Regarding the type of bus driving, 39% of respondents drive big buses, Mini-bus drivers account for 34%, and tourist bus drivers represent 18%. The smallest proportion, 9%, are micro-bus drivers. The majority of respondents (57%) have over 12 years of driving experience, 19% have 10-12 years of experience, while those with 4-6 years and 7-9 years account for 12% and 7%, respectively. Only 6% have less than three years of driving experience.

**Maximum Road Accident Timing in a Day**

Accidents on this highway primarily occur between 9-11 AM, accounting for 63% of incidents, followed by 4-6 PM (14%) and 12-3 PM (8%). Fewer accidents are reported after 6 PM (7%) and during early morning hours (5-9 AM), which make up just 3% of the total. These findings highlight a greater likelihood of accidents during peak travel hours, emphasizing the need for targeted safety measures and traffic management during the busiest times of the day.

**Table 2.** Participants' demographics

| Demographic Profile | N | % |
|---|---|---|
| **Age of Respondent** | | |
| 18-30 | 45 | 19 |
| 31-42 | 118 | 49 |
| d43-55 | 70 | 29 |
| Above 55 | 10 | 4 |
| **Education Level of Respondents** | | |
| Bachelors | 5 | 2 |
| Intermediate | 42 | 17 |
| SLC/SEE | 67 | 28 |
| Under SLC | 129 | 53 |
| **Type of Bus Driving** | | |
| Tourist Bus | 44 | 18 |
| Big Bus | 95 | 39 |
| Mini Bus | 82 | 34 |
| Micro Bus | 22 | 9 |
| **Years of Driving Experience** | | |
| 3 or fewer | 15 | 6 |
| 4 to 6 years | 28 | 12 |
| 7 to 9 years | 16 | 7 |
| 10 to 12 years | 45 | 19 |
| More than 12 years | 139 | 57 |
| **Maximum Road Accident Time in a Day** | | |
| 5 to 9 AM | 8 | 3 |
| 9 to 11 AM | 152 | 63 |
| 12 to 3 PM | 19 | 8 |
| 4 to 6 PM | 35 | 14 |
| After PM | 17 | 7 |
| Others | 12 | 5 |
| **Maximum Road Accident Season in a Year** | | |
| Rainy Season | 141 | 58 |
| Festive Season | 82 | 34 |
| Winter Season | 20 | 8 |
| **Major Factors Contributing to RTAs** | | |
| Human Factor | 59 | 24 |
| Vehicular Factor | 49 | 20 |
| Road Infrastructure Factor | 123 | 51 |
| Environmental Factor | 12 | 5 |

**Maximum Accident Seasons in a Year**

The rainy season sees the highest percentage of road accidents (58%), attributed to slippery roads and poor visibility. The festive season follows with 34%, likely due to increased travel and celebrations. Winter accounts for only 8%, indicating relatively safer driving conditions during this period.

**Contributing Factors to Accidents**

The leading factor contributing to road traffic accidents is road infrastructure (51%), reflecting challenges such as poorly maintained roads or inadequate safety measures. Human factors, including driver behavior, account for 24% of accidents, while vehicular issues, such as mechanical failures, contribute to 20%. Environmental factors, like weather conditions, play the smallest role at 5%.

### 4.2 Reliability test of the factors

Table 3 evaluates the reliability of various factors contributing to RTAs, using raw alpha and standardized alpha values as key indicators. The alpha values range between 0.830 and 0.850, reflecting high internal consistency across all variables. Among them, variables like Speeding Driving (V1), Wrong Overtaking and Turning (V10), and Defective Brakes (V33) exhibit the highest reliability with raw alpha values of 0.850, indicating excellent measurement consistency. A majority of variables, including Overtaking at High Speed (V2), Drunk Driving (V5), and Defective Tires (V31), show strong reliability with raw alpha values of 0.840, while variables such as fatigued driving (V4), Loud Music/Headphones (V7), and Defective Lights or Indicators (V32) demonstrate slightly lower but still high reliability at 0.830. The standardized alpha values closely match the raw alpha values, indicating minimal variability in item scales or response patterns and reinforcing the robustness of the scale. Additionally, the average inter-item correlation (average_r) remains consistent at 0.13 across most variables, further supporting the internal cohesion of items within each construct.

Table 4 provides detailed descriptive statistics for 35 variables (V1 to V35) based on responses from 243 participants. It includes key measures such as the mean, median, standard deviation (SD), skewness, kurtosis, and standard error (SE), offering insights into the central tendency, variability, and distribution of responses. The mean scores predominantly cluster around 4, with medians generally at 4 or 5, indicating that most respondents leaned towards agreement or positive ratings on a typical 5-point scale. Variables such as V3, V5, and V13 exhibit the highest mean scores, reflecting consistently favorable evaluations, while others like V7 and V18 show relatively lower mean values, suggesting areas of less consensus or importance. The SD values range from 0.62 (V13) to 1.18 (V18), highlighting varying levels of response consistency, with lower SDs indicating more uniform agreement among participants. Skewness is predominantly negative across the variables, indicating a clustering of responses toward higher ratings. For instance, V5 (-1.56) and V34 (-1.61) display strong negative skewness, suggesting that most responses were at the upper end of the scale. Kurtosis values are generally near zero, signifying distributions close to normal; however, variables such as V5, V19, and V34 exhibit high positive kurtosis, indicating a sharper peak in the response distribution. The standard errors (ranging from 0.04 to 0.08) are uniformly low across all variables, suggesting that the mean estimates are precise and reliable.

**Table 3.** Reliability test of respondents

| Variables | Symbol | Raw_alpha | Std. alpha | SE | Var.r |
|---|---|---|---|---|---|
| Speeding driving | V1 | 0.85 | 0.84 | 0.018 | 0.13 |
| Overtaking at high speed | V2 | 0.84 | 0.84 | 0.019 | 0.12 |
| Reckless/careless driving | V3 | 0.84 | 0.84 | 0.018 | 0.12 |
| Fatigue driving | V4 | 0.83 | 0.83 | 0.018 | 0.11 |
| Drunk driving | V5 | 0.84 | 0.84 | 0.019 | 0.12 |
| Driving while using a cell phone | V6 | 0.84 | 0.84 | 0.019 | 0.12 |
| Loud music/headphones | V7 | 0.83 | 0.83 | 0.017 | 0.11 |
| Overloading (hanging on the roof) | V8 | 0.83 | 0.83 | 0.018 | 0.11 |
| Unhealthy competition between buses while driving | V9 | 0.84 | 0.84 | 0.018 | 0.12 |
| Wrong overtaking and wrong turning | V10 | 0.85 | 0.84 | 0.017 | 0.13 |
| Unregulated parking | V11 | 0.84 | 0.83 | 0.019 | 0.12 |
| No respect for traffic rules by pedestrians | V12 | 0.84 | 0.84 | 0.018 | 0.12 |
| Road lane discipline is not maintained | V13 | 0.84 | 0.83 | 0.019 | 0.11 |
| Slippery road due to rain | V14 | 0.84 | 0.83 | 0.019 | 0.12 |
| Weather problem | V15 | 0.83 | 0.83 | 0.018 | 0.11 |
| Limited visibility | V16 | 0.83 | 0.83 | 0.018 | 0.11 |
| The presence of roadside obstacles | V17 | 0.84 | 0.83 | 0.018 | 0.11 |
| Dazzling sun | V18 | 0.83 | 0.83 | 0.017 | 0.11 |
| Rain, sleet, snow, or fog | V19 | 0.84 | 0.83 | 0.019 | 0.11 |
| Poor and defective road surface | V20 | 0.84 | 0.84 | 0.018 | 0.12 |
| Inadequate or masked signs or road markings | V21 | 0.84 | 0.83 | 0.019 | 0.12 |
| Narrow bridge approaches | V22 | 0.83 | 0.83 | 0.018 | 0.11 |
| Poor visibility at blind corners | V23 | 0.83 | 0.83 | 0.018 | 0.11 |
| Poor shoulders | V24 | 0.84 | 0.83 | 0.018 | 0.11 |
| Unforgiving side-drains | V25 | 0.83 | 0.83 | 0.018 | 0.11 |
| Inadequate safety barriers at steep vertical drops | V26 | 0.84 | 0.83 | 0.018 | 0.11 |
| Unscientific location of passing bays in single-lane roads | V27 | 0.84 | 0.83 | 0.018 | 0.11 |
| Lack of climbing lanes | V28 | 0.84 | 0.84 | 0.018 | 0.12 |
| Steep gradients at numerous sections | V29 | 0.83 | 0.83 | 0.017 | 0.11 |
| Narrow sections in built-up | V30 | 0.84 | 0.83 | 0.019 | 0.11 |
| Defective tires | V31 | 0.84 | 0.83 | 0.019 | 0.11 |
| Defective lights or indicators | V32 | 0.83 | 0.83 | 0.018 | 0.11 |
| Defective brakes | V33 | 0.85 | 0.84 | 0.018 | 0.12 |
| Defective steering | V34 | 0.84 | 0.83 | 0.019 | 0.11 |
| Defective mirrors | V35 | 0.84 | 0.83 | 0.017 | 0.11 |

**Table 4.** Descriptive statistics

| Factors | N | Mean | SD | Median | Skew | Kurtosis | SE |
|---|---|---|---|---|---|---|---|
| V1 | 243 | 4.04 | 1.06 | 4 | -0.94 | 0.34 | 0.07 |
| V2 | 243 | 4.31 | 0.77 | 4 | -1.02 | 0.99 | 0.05 |
| V3 | 243 | 4.47 | 0.77 | 5 | -1.30 | 0.79 | 0.05 |
| V4 | 243 | 3.78 | 1.05 | 4 | -0.53 | -0.66 | 0.07 |
| V5 | 243 | 4.50 | 0.75 | 5 | -1.56 | 2.41 | 0.05 |
| V6 | 243 | 4.25 | 0.74 | 4 | -0.73 | 0.12 | 0.05 |
| V7 | 243 | 3.50 | 1.16 | 4 | -0.26 | -1.07 | 0.07 |
| V8 | 243 | 3.81 | 1.10 | 4 | -0.80 | -0.13 | 0.07 |
| V9 | 243 | 4.36 | 0.87 | 5 | -1.45 | 1.82 | 0.06 |
| V10 | 243 | 4.36 | 0.72 | 4 | -1.05 | 1.39 | 0.05 |
| V11 | 243 | 4.05 | 0.86 | 4 | -0.56 | -0.47 | 0.06 |
| V12 | 243 | 4.43 | 0.65 | 5 | -0.81 | -0.05 | 0.04 |
| V13 | 243 | 4.51 | 0.62 | 5 | -0.87 | -0.28 | 0.04 |
| V14 | 243 | 4.40 | 0.69 | 5 | -0.85 | 0.07 | 0.04 |
| V15 | 243 | 3.88 | 0.86 | 4 | -0.54 | -0.09 | 0.06 |
| V16 | 243 | 4.09 | 0.83 | 4 | -0.69 | -0.03 | 0.05 |
| V17 | 243 | 4.34 | 0.72 | 4 | -0.86 | 0.37 | 0.05 |
| V18 | 243 | 3.67 | 1.18 | 4 | -0.62 | -0.55 | 0.08 |
| V19 | 243 | 4.43 | 0.81 | 5 | -1.53 | 2.43 | 0.05 |
| V20 | 243 | 4.37 | 0.78 | 5 | -1.35 | 2.26 | 0.05 |
| V21 | 243 | 4.21 | 0.79 | 4 | -0.90 | 0.77 | 0.05 |
| V22 | 243 | 4.11 | 0.82 | 4 | -0.74 | 0.08 | 0.05 |
| V23 | 243 | 4.17 | 0.79 | 4 | -0.75 | 0.15 | 0.05 |
| V24 | 243 | 4.05 | 0.83 | 4 | -0.68 | -0.01 | 0.05 |
| V25 | 243 | 4.04 | 0.81 | 4 | -0.58 | -0.12 | 0.05 |
| V26 | 243 | 4.07 | 0.84 | 4 | -0.84 | 0.50 | 0.05 |
| V27 | 243 | 4.13 | 0.72 | 4 | -0.79 | 1.37 | 0.05 |
| V28 | 243 | 4.10 | 0.71 | 4 | -0.49 | 0.15 | 0.05 |
| V29 | 243 | 3.96 | 0.92 | 4 | -0.91 | 0.59 | 0.06 |
| V30 | 243 | 4.42 | 0.79 | 5 | -1.35 | 1.35 | 0.05 |
| V31 | 243 | 4.12 | 0.92 | 4 | -0.93 | 0.36 | 0.06 |
| V32 | 243 | 4.15 | 0.88 | 4 | -0.76 | -0.25 | 0.06 |
| V33 | 243 | 4.44 | 0.79 | 5 | -1.34 | 1.13 | 0.05 |
| V34 | 243 | 4.49 | 0.78 | 5 | -1.61 | 2.45 | 0.05 |
| V35 | 243 | 3.9 | 1.07 | 4 | -0.68 | -0.66 | 0.07 |

Table 5 highlights the ranking of factors contributing to RTAs based on their Relative Importance Index (RII), providing valuable insights into the critical issues that must be addressed to improve road safety. The analysis identifies "Road lane discipline not maintained" as the most significant factor, with an RII of 0.902, indicating the importance of maintaining proper lane discipline. It is closely followed by "Drunk driving" (RII = 0.900), emphasizing the impact of alcohol consumption on RTAs. "Defective steering" ranks third (RII = 0.898), reflecting the vital role of vehicle maintenance in preventing accidents. Similarly, "Reckless/careless driving" (RII = 0.895) and "Defective brakes" (RII = 0.888) secured prominent positions. These findings suggest that regular vehicle inspections and driver training programs focusing on responsible driving practices could significantly enhance safety outcomes.

Other remarkable factors include "No respect for traffic rules by pedestrians" and "Rain, sleet, snow, or fog," both with an RII of 0.886, ranking sixth and seventh, respectively. Pedestrian awareness campaigns and improved visibility measures during adverse weather conditions are essential for addressing these concerns. Additionally, "Narrow sections at built-up areas" (RII = 0.885) and "Slippery road due to rain" (RII = 0.879) further highlight infrastructure-related challenges, emphasizing targeted improvements in road design and maintenance to reduce accident-prone zones. Lower-ranking factors, such as "Defective tires" (RII = 0.823), "Narrow bridge approaches" (RII = 0.822), and "Lack of climbing lanes" (RII = 0.820), while less critical than the top factors, still represent significant safety risks. These issues indicate the need for infrastructure upgrades and the promotion of regular vehicle maintenance among drivers. Additionally, factors like "Speeding driving" (RII = 0.808) and "Unregulated parking" (RII = 0.810) suggest that stricter enforcement of traffic rules and improved highway planning are crucial for reducing accidents.

The analysis also reveals behavioral factors, such as "Driving using a cell phone" (RII = 0.849), "Fatigue driving" (RII = 0.756), and "Overloading" (RII = 0.763), as contributors to accidents. These findings point to the need for public awareness campaigns and policy measures to control distracted and unsafe driving practices. Environmental and visibility issues, including "Weather problems" (RII = 0.777), "Dazzling sun" (RII = 0.735), and "Loud music/headphones" (RII = 0.700), further emphasize the diverse range of challenges affecting road safety.

### 4.3. Significant factors contributing RTAs

Road traffic accidents are influenced by multiple factors tied to demographic characteristics such as vehicle type, driver education, age, and years of experience. Among bus types, behavioral and environmental factors significantly contribute to accidents. Tourist bus drivers are prone to drunk driving and unhealthy competition between vehicles, both of which are highly significant. Similarly, loud music or headphone use among big and minibus drivers increases accident risks, as does the presence of roadside obstacles and adverse weather conditions. For microbus drivers, drunk driving, unhealthy competition, and limited visibility are notable contributors.

Drivers' education levels play a critical role in accident causation. Those with a bachelor's degree are more likely to engage in speeding and overtaking at high speeds, behaviors that are exacerbated by infrastructure issues such as narrow bridge approaches and defective tires. Conversely, drivers with secondary education (SEE/SLC) or below often encounter risks stemming from poor infrastructure, such as unscientific passing bay locations and a lack of climbing lanes on single-lane roads. These findings suggest that higher education correlates with riskier driving behaviors, while lower education amplifies vulnerabilities linked to external factors, necessitating tailored interventions for each group.

Age also significantly impacts accident risks. Younger drivers aged 31-42 years often face distractions like loud music or headphones and exhibit risky behaviors such as wrong overtaking or turning. Drivers aged 43-55 years frequently struggle with maintaining road lane discipline, while those above 55 years are particularly affected by poor and defective road surfaces. This age-related differentiation highlights the need for age-specific training and awareness campaigns to address unique challenges faced by drivers in various age brackets, reducing the likelihood of accidents.

The level of driving experience also influences accident causes. Drivers with fewer years of experience (4-6 years) are more affected by environmental factors, such as narrow bridge approaches and poor weather conditions. Those with moderate experience (7-9 years) face risks associated with behavioral factors like drunk driving, cell phone use, and unhealthy competition. Highly experienced drivers with more than 12 years on the road often succumb to fatigue, driving, and distraction due to cell phone use. This underscores the importance of promoting consistent safe driving practices, regardless of experience level, and addressing fatigue through regulated work hours.

**Table 5.** Ranking of factors contributing to road traffic accidents

| Factors | | RII | Rank |
|---|---|---|---|
| Road lane discipline is not maintained | V13 | 0.902 | 1 |
| Drunk driving | V5 | 0.900 | 2 |
| Defective steering | V34 | 0.898 | 3 |
| Reckless/careless driving | V3 | 0.895 | 4 |
| Defective brakes | V33 | 0.888 | 5 |
| No respect for traffic rules by pedestrians | V12 | 0.886 | 6 |
| Rain, sleet, snow, or fog | V19 | 0.886 | 7 |
| Narrow sections in built-up | V30 | 0.885 | 8 |
| Slippery road due to rain | V14 | 0.879 | 9 |
| Poor and defective road surface | V20 | 0.873 | 10 |
| Unhealthy competition between buses while driving | V9 | 0.872 | 11 |
| Wrong overtaking and wrong turning | V10 | 0.872 | 12 |
| The presence of roadside obstacles | V17 | 0.867 | 13 |
| Overtaking at high speed | V2 | 0.862 | 14 |
| Driving while using a cell phone | V6 | 0.849 | 15 |
| Inadequate or masked signs or road markings | V21 | 0.843 | 16 |
| Poor visibility at blind corners | V23 | 0.834 | 17 |
| Defective lights or indicators | V32 | 0.830 | 18 |
| Unscientific location of passing bays in single-lane roads | V27 | 0.826 | 19 |
| Defective tires | V31 | 0.823 | 20 |
| Narrow bridge approaches | V22 | 0.822 | 21 |
| Lack of climbing lanes | V28 | 0.820 | 22 |
| Limited visibility | V16 | 0.817 | 23 |
| Inadequate safety barriers at steep vertical drops | V26 | 0.815 | 24 |
| Unregulated parking | V11 | 0.810 | 25 |
| Poor shoulders | V24 | 0.809 | 26 |
| Speeding driving | V1 | 0.808 | 27 |
| Unforgiving side-drains | V25 | 0.807 | 28 |
| Steep gradients at numerous sections | V29 | 0.792 | 29 |
| Defective mirrors | V35 | 0.780 | 30 |
| Weather problem | V15 | 0.777 | 31 |
| Overloading (hanging on the roof) | V8 | 0.763 | 32 |
| Fatigue driving | V4 | 0.756 | 33 |
| Dazzling sun | V18 | 0.735 | 34 |
| Loud music/headphones | V7 | 0.700 | 35 |

The timing of accidents adds another layer of complexity. Early morning accidents (5-9 AM) are often linked to dazzling sunlight and a lack of climbing lanes. As the day progresses, midday (12-3 PM) accidents are largely caused by speeding and infrastructure issues like unforgiving side drains. Evening hours (4-6 PM) see weather-related problems and roadside obstacles as major contributors, while nighttime and early morning hours (12-5 AM) are marked by limited visibility, unhealthy competition, and poor road shoulders. These findings call for time-specific interventions, such as installing reflective road markings, improving lighting, and enforcing traffic regulations during high-risk hours.

Seasonal variations further exacerbate accident risks. During the rainy season (Jestha-Bhadra), accidents are commonly caused by slippery roads, defective tires, and fatigued driving. In the festive season (Ashoj/Kartik), increased traffic and poor vehicle maintenance result in issues like defective brakes and slippery roads. Winter months (Mangshir-Falgun) see a prevalence of speed-related accidents due to icy conditions and defective tires, while other seasons (Chaitra/Baishak) pose challenges such as poor visibility and inadequate shoulders. Seasonal preparedness, such as timely road maintenance and public awareness campaigns, is essential to mitigate these risks.

In conclusion, road traffic accidents are a multifaceted problem influenced by behavioral, environmental, temporal, and seasonal factors. Understanding how these factors vary across demographics, such as vehicle type, education, age, and experience, is crucial for designing effective interventions. Time-specific and season-specific strategies, coupled with targeted awareness campaigns and infrastructure improvements, can significantly reduce accident rates. A collaborative effort between policymakers, transport authorities, and drivers is essential to create safer roadways and protect lives. The summary of significant factors contributing to RTAs is shown in Table 6.

**Table 6.** Summary of significant factors contributing to RTAs

| Demographic Profile | Factors | Df | Sum Sq | Mean Sq | F Value | Pr(>F) |
|---|---|---|---|---|---|---|
| **Types of Bus Driving** | | | | | | |
| Tourist Bus | V5 | 1 | 0.96 | 0.96 | 6.61 | 0.01* |
| | V9 | 1 | 1.12 | 1.12 | 7.67 | 0.01* |
| Big Bus | V7 | 1 | 1.25 | 1.25 | 5.23 | 0.02* |
| Mini Bus | V7 | 1 | 1.06 | 1.06 | 4.77 | 0.03* |
| | V17 | 1 | 1.6 | 1.6 | 7.18 | 0.01* |
| | V19 | 1 | 1.12 | 1.12 | 5.05 | 0.03* |

| | | | | | | |
|---|---|---|---|---|---|---|
| Micro Bus | V5 | 1 | 0.81 | 0.81 | 10.32 | 0.00** |
| | V9 | 1 | 0.45 | 0.45 | 5.69 | 0.02* |
| | V16 | 1 | 0.32 | 0.32 | 4.11 | 0.04* |
| **Education Level of Bus Drivers** | | | | | | |
| Bachelors | V1 | 1 | 0.14 | 0.14 | 7.88 | 0.01* |
| | V2 | 1 | 0.3 | 0.3 | 16.7 | 0.00** |
| | V22 | 1 | 0.08 | 0.08 | 4.44 | 0.04* |
| | V31 | 1 | 0.12 | 0.12 | 6.56 | 0.01* |
| SEE/SLC | V27 | 1 | 1.04 | 1.04 | 5.16 | 0.02* |
| | V28 | 1 | 0.89 | 0.89 | 4.46 | 0.04* |
| Under SEE/SLC | V28 | 1 | 1.12 | 1.12 | 4.45 | 0.04* |
| **Age Categories Drivers** | | | | | | |
| 31 to 42 years | V7 | 1 | 0.98 | 0.98 | 3.96 | 0.05* |
| | V10 | 1 | 1.01 | 1.01 | 4.07 | 0.05* |
| | V29 | 1 | 1.06 | 1.06 | 4.28 | 0.04* |
| 43 to 55 Years | V7 | 1 | 1.01 | 1.01 | 4.76 | 0.03* |
| | V13 | 1 | 0.98 | 0.98 | 4.61 | 0.03* |
| Above 55 Years | V20 | 1 | 0.23 | 0.23 | 5.8 | 0.02* |
| **Years of Experience of Drivers** | | | | | | |
| 4 to 6 Years | V22 | 1 | 0.99 | 0.99 | 10.08 | 0.00** |
| 7 to 9 Years | V5 | 1 | 0.29 | 0.29 | 5.2 | 0.02* |
| | V6 | 1 | 0.24 | 0.24 | 4.4 | 0.04* |
| | V9 | 1 | 0.43 | 0.43 | 7.76 | 0.01* |
| | V11 | 1 | 0.21 | 0.21 | 3.89 | 0.05* |
| | V16 | 1 | 0.29 | 0.29 | 5.21 | 0.02* |
| | V19 | 1 | 0.42 | 0.42 | 7.7 | 0.01* |
| | V24 | 1 | 0.25 | 0.25 | 4.53 | 0.03* |
| | V26 | 1 | 0.21 | 0.21 | 3.82 | 0.05* |
| 10 to 12 Years | V4 | 1 | 1.04 | 1.04 | 7.07 | 0.01* |
| | V8 | 1 | 0.97 | 0.97 | 6.61 | 0.01* |
| | V12 | 1 | 0.66 | 0.66 | 4.49 | 0.04* |
| Greater than 12 Years | V4 | 1 | 3.81 | 3.81 | 16.14 | 0.00** |
| | V6 | 1 | 1.26 | 1.26 | 5.35 | 0.02* |
| **Time of Accidents in a Day** | | | | | | |
| 5 to 9 AM | V18 | 1 | 0.16 | 0.16 | 5.06 | 0.03* |
| | V28 | 1 | 0.17 | 0.17 | 5.35 | 0.02* |
| 9 to 11 AM | V13 | 1 | 0.96 | 0.96 | 4.04 | 0.05* |
| | V21 | 1 | 1.25 | 1.25 | 5.31 | 0.02* |
| 12 to 3 PM | V1 | 1 | 0.46 | 0.46 | 6.21 | 0.01* |
| | V25 | 1 | 0.47 | 0.47 | 6.36 | 0.01* |
| 4 to 6 PM | V15 | 1 | 0.56 | 0.56 | 4.52 | 0.03* |
| | V17 | 1 | 0.8 | 0.8 | 6.44 | 0.01* |
| | V21 | 1 | 0.56 | 0.56 | 4.57 | 0.03* |
| 6 to 12 PM | V13 | 1 | 0.43 | 0.43 | 6.79 | 0.01* |
| | V25 | 1 | 0.33 | 0.33 | 5.3 | 0.02* |
| 12 to 5 AM | V7 | 1 | 0.17 | 0.17 | 3.93 | 0.05* |
| | V9 | 1 | 0.31 | 0.31 | 7.22 | 0.01* |
| | V10 | 1 | 0.21 | 0.21 | 4.93 | 0.03* |
| | V16 | 1 | 0.19 | 0.19 | 4.36 | 0.04* |
| | V24 | 1 | 0.33 | 0.33 | 7.79 | 0.01* |
| **Season of Accidents in a Year** | | | | | | |
| Rainy Season (Jestha to Bhadra) | V4 | 1 | 2.56 | 2.56 | 12.08 | 0.00** |
| | V7 | 1 | 2.36 | 2.36 | 11.16 | 0.00** |
| | V12 | 1 | 1.02 | 1.02 | 4.82 | 0.03* |
| | V14 | 1 | 1.47 | 1.47 | 6.94 | 0.01* |
| | V31 | 1 | 1.41 | 1.41 | 6.65 | 0.01* |
| Festive Season (Ashoj/Kartik) | V4 | 1 | 2.1 | 2.1 | 10.61 | 0.00** |
| | V7 | 1 | 2.29 | 2.29 | 11.55 | 0.00** |
| | V14 | 1 | 0.8 | 0.8 | 4.02 | 0.05* |
| | V33 | 1 | 0.84 | 0.84 | 4.25 | 0.04* |
| Winter ( Mangshir to Falgun) | V1 | 1 | 0.37 | 0.37 | 4.97 | 0.03* |
| | V31 | 1 | 0.45 | 0.45 | 6.02 | 0.01* |
| Other (Chaitra/ Baishak) | V23 | 1 | 0.02 | 0.02 | 4.9 | 0.03* |
| | V24 | 1 | 0.02 | 0.02 | 5.53 | 0.02* |

The analysis presented in Table 6 reveals that multiple demographic and contextual factors significantly influence the likelihood and nature of RTAs on Nepal's highways. A clear pattern emerges, showing that the type of bus driven, whether tourist, big, mini, or micro bus, affected specific risk factors, suggesting that safety interventions should be tailored to vehicle types. For instance, the significant F-values associated with variables such as drunk driving, loud music/headphones, unhealthy competition between buses while driving across bus categories highlight how operational differences impact RTAs causes. Policymakers should thus consider differentiated regulatory frameworks, including vehicle-specific maintenance protocols and driver training modules tailored to each bus category.

Education level also plays a critical role in accident patterns, as indicated by significant variations among drivers with Bachelor's degrees, SEE/SLC, and qualifications below SEE/SLC. This suggests that driver education programs need to be customized based on educational backgrounds. For example, drivers with higher education levels who the study found more prone to risky behavior may benefit from advanced defensive driving and risk perception training, while drivers with lower educational attainment may require foundational training focused on hazard awareness and infrastructure navigation. Implementing tiered educational programs could enhance overall road safety outcomes.

Age and driving experience further influence accident risks, with younger drivers showing higher vulnerability to distractions and risky driving, and older drivers struggling with challenging road conditions. Drivers with varying years of experience also demonstrate differences in their exposure to significant factors such as speeding and fatigue. This emphasizes the need for continuous professional development and refresher courses that address age- and experience-specific risks. Licensing authorities should consider mandatory periodic assessments that reflect these demographic variations, ensuring that drivers maintain competencies appropriate to their age and experience level.

The temporal analysis of RTAs occurrences by time of day and season highlights high-risk periods such as early mornings, festive seasons, and the rainy season. These findings indicate that temporal factors must be integrated into road safety planning. For instance, increased traffic enforcement, targeted awareness campaigns, and enhanced road maintenance should be prioritized during this critical time. Seasonal infrastructure adaptations, such as improved drainage and fog-resistant signage, could mitigate weather-related risks during the monsoon and winter months.

The current research and prior studies share significant similarities, particularly regarding the dominant role of human behavior in RTAs. The study [46] highlighted that over 70% of RTAs are attributed to human factors, aligning with the current research's focus on speeding, reckless driving, and drunk driving as key contributors. Both studies emphasize the importance of driver behavior in accident causation. Similarly, the study [41] underscore the impact of vehicle defects such as faulty brakes and tires, which is consistent with the current study's findings on the role of defective vehicle components in RTAs. Environmental factors such as adverse weather conditions and poor visibility are common factors. The current research finds that weather-related issues, like rain and fog, significantly contribute to road accidents, reflecting the environmental concerns identified by the study [41]. Additionally, both studies recognize infrastructure-related issues, such as poor road surfaces, narrow roads, and inadequate signage, as contributing to accidents. Moreover, both studies stress the importance of addressing these factors through targeted interventions to improve road safety.

Unlike previous research that generally addresses RTAs at national or global levels, this study provides localized, context-specific insights. It uniquely explores how different types of buses tourist, big, mini, and micro perceive with various risk factors, highlighting operational differences rarely examined before. Additionally, the study investigates the influence of driver demographics such as education, age, and years of experience on road accident risks, revealing nuanced patterns, including that higher-educated drivers may engage in riskier behaviors. Temporal factors, including time of day and seasonal variations, are also integrated to better understand RTAs trends. By combining these dimensions, the research offers a comprehensive and detailed understanding of RTAs in Nepal, providing evidence-based recommendations for tailored road safety interventions and policy development specific to the country's unique traffic environment.

## 5. CONCLUSION

This research highlights the complex nature of RTAs, identifying key factors such as human behavior, vehicular factors, environmental conditions, and road infrastructure issues. The findings emphasize the significant role of behavioral characteristics, including road lane discipline, drunk driving, reckless driving, and fatigue, which are major contributors to RTAs. Furthermore, defective vehicle components, such as brakes, emphasize the need for regular vehicle maintenance to ensure road safety. Environmental and weather-related challenges, such as rain, fog, and poor visibility, also emerged as critical contributors to accidents. Infrastructure-related issues, including narrow roads, poor road surfaces, and inadequate signage, are significant factors that intensify accident rates, highlighting the need for targeted improvements in road design and maintenance. Demographic factors, such as age, education, and years of driving experience, were found to influence accident patterns. Younger drivers were found to be more prone to distractions and risky behaviors, while older drivers faced challenges related to road conditions. The educational level also played a role, with those possessing higher education tending to engage in riskier driving behaviors, while lower education levels were associated with vulnerabilities linked to poor infrastructure.

Overall, the study stresses the importance of comprehensive interventions, including public awareness campaigns targeting behaviors such as drunk driving, speeding, and distractions must be sustained to change driver attitudes and habits. Additionally, enhancing enforcement capacity through increased patrols, especially in high-risk zones and during poor weather, is crucial. Finally, fostering collaboration among policymakers, transport authorities, local governments, vehicle operators, and community organizations will enable coordinated and comprehensive road safety strategies. By integrating these measures into Nepal's national road safety framework, the country can significantly reduce the frequency and severity of RTAs, saving lives and improving the safety and efficiency of its highway transportation network.

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