ACTA SCIENTIARUM POLONORUM Acta Sci. Pol., Administratio Locorum 24(4) 2025, 667–685.
https://czasopisma.uwm.edu.pl/index.php/aspal plISSN 1644-0749 eISSN 2450-0771 DOI: 10.31648/aspal.10685

ORIGINAL PAPER
Received: 14.10.2024 Accepted: 09.07.2025

ROAD ACCIDENT: A REVIEW OF THEIR OCCURRENCE FACTORS

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ABSTRACT

Motives: The transportation system is the backbone of human society and, if improperly handled, has the potential to become its most destructive component. A road accident occurs when the system controlling the vehicle is unable to carry out one or more tasks necessary to ensure safe and incident-free travel.
Aim: This review article aimed to investigate the factors contributing to road accidents throughout the world. By examining a wide range of contributing elements, this study provides a comprehensive understanding of the multifaceted nature of road safety.
Results: Aspects related to humans, vehicles, and environments have been found to be the causes of accidents; identifying these aspects beforehand can help prevent accidents in the future. Several factors, including driver behavior, road design, and vehicle condition, play crucial roles in accident frequency and severity. Addressing these interconnected factors is key to improving global road safety.

Keywords: road accidents, road safety, transportation, vehicle

INTRODUCTION

It is indisputable that in the current era, transportation systems raise living standards for people and support national economic expansion. Transportation systems facilitate individuals' global task fulfillment by facilitating the movement of products and people, unavoidably seen as a representation of a country's social cohesion and sense of self. The infrastructure supporting transportation is getting bigger and more intricate every day due to population growth and increased competition to offer opulent travel services.

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Thus, the transportation system is the most vital component of human society and has the possibility to become the most dangerous component if handled improperly (Ashraf et al., 2019).

The primary causes of traffic accidents are poor road infrastructure upkeep and a dearth of effective and coordinated enforcement. Currently, one of the most significant concerns for social policy and health in all of the continents' nations is the high rate of road accidents. According to Goniewicz et al. (2015), there is a traffic fatality every 50 seconds on average and a traffic injury every 2 seconds. According to WHO estimates, about 1.3 million people worldwide lose their lives in traffic accidents every year, and between 20 and 50 million have serious injuries that require costly, long-term medical treatment. Apart from emotional distress and agony, traffic accidents also cause substantial social and economic damage, amounting to 1–3 percent of the gross domestic product (GDP) of most countries (WHO, 2013). It is possible to successfully avert many of the effects of road accidents; nevertheless, this calls for ongoing efforts to develop new techniques and initiatives focused at enhancing road traffic safety (Goniewicz et al., 2015).

The urgency of addressing road safety is further emphasized by the growing demand for more efficient and sustainable transportation systems in urban areas. With the rapid urbanization and expansion of metropolitan regions, cities are facing significant challenges in managing transportation systems that not only accommodate increasing population densities but also reduce environmental impacts and enhance quality of life. As urban sprawl continues, the complexity of transportation networks increases, often resulting in outdated infrastructure and increased risk of accidents. Furthermore, the integration of emerging technologies, such as autonomous vehicles and intelligent transportation systems, requires careful consideration of safety measures, infrastructure adaptation, and policy development (Elvik et al., 2009). Given these complexities, there is a critical need for comprehensive studies to identify the key factors contributing to traffic accidents and develop strategies to mitigate these risks, ensuring that future transportation systems are both efficient and safe for all users. Thus, this article was written to provide studies on the known contributing factors on the occurrence of traffic accidents.

MATERIALS AND METHODS

The known factors impacting the frequency of traffic accidents, including the statistics on some of the incidents that have been reported, were the main emphasis of this review paper. A detailed literature review was conducted to fully investigate this subject (Chand et al., 2024). A simple procedure was created based on these categories to collect pertinent research papers, proceedings, and reports from online sources (Google Scholar, ScienceDirect, Scopus, Web of Science, and Wiley Online Library) that were published within 2000–2022. Terms like "factor," "road accident," and "traffic crash" and other similar terms have been utilized throughout the assessment process without regard to language or time constraints. To ensure that the content fits the review article's topic, all of the retrieved papers had been screened, reviewed and examined on its titles, abstracts, and full texts, by the authors (Tavakkoli et al., 2022).

RESULTS

Road accidents

An unanticipated, uncontrollable incident that causes property damage or bodily injury due to an object's or person's action or reaction is called an accident. According to Ahmed et al. (2023), a road accident occurs when the road vehicle driver system is unable to do one or more tasks that are required to complete the route safely and without incident. When it comes to unnatural mortality, road accidents rank 8th globally for people of all ages, 1st for those between the ages of 5 and 29, and 4th for those between the ages of 30 and 44 (WHO, 2018). One of the primary adverse effects of road transportation is suffering and significant losses in human capital for the community

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at large (Calvo-Poyo et al., 2020). Road accidents have therefore been a hot topic for academic and industry research in recent years. It is mostly concentrated due to the requirement for safety conditions and vehicle automation.

William Haddon devised an analytical method in the early 1960s and 1970s to facilitate the identification of the root causes of traffic incidents. This model, dubbed "Haddon's Matrix" (Table 1, Appendix), shows how three components – human factors, equipment and vehicle factors, and environmental factors – interact at different stages of the event, namely the pre-, event, and post-event phases (Haddon, 1968). Haddon's model makes it feasible to implement the right treatments at each stage to lower the rates of harm associated with road accidents. A road collision can be avoided in the pre-event period by taking a variety of steps. During the event phase, interventions are implemented with the goal of preventing injuries from occurring or, if they do, reducing the severity of the injuries sustained by the victims. All measures taken to lessen a road accident's detrimental impacts are included in the post-event phase (Haddon, 1999). The practical use of Haddon's model resulted in advancements in the comprehension of human behaviors related to traffic and the identification of the variables influencing the quantity and degree of physical harm. Among the causes of accidents, the human aspect is one of the most significant. The framework of road safety is influenced by a variety of human and environmental elements, including weather, traffic congestion, and road quality, as well as vehicle characteristics including age, sex, and driver condition (McCarty and Kim, 2024), as shown in Table 2 (Appendix).

Human factors

According to extensive study on road safety, there is a direct correlation between driver behavior and accidents. Human behavior has been found to be responsible for over 70% of accidents, highlighting its importance in this field (Abdullah & Sipos, 2022; Chand et al., 2021). Goniewicz et al. (2015) stated that the largest influence on the likelihood of accidents occurs from the actions of specific groups of road users, both protected and unprotected. These behavioral patterns offer opportunities for improving road safety in addition to offer academic knowledge.

Age

Age plays a role in the likelihood of a traffic collision (Clarke et al., 2006; Williams, 2003). It is a popular belief that young individuals are more prone than older drivers to traffic infractions like intoxicated driving, speeding, pressure to be inspired, and excitement. When compared to older drivers, younger drivers – especially those between the ages of 15 and 24 – often show a combination of zeal and risk-taking, which increases their likelihood of participating in unsafe driving practices (e.g., underestimating the risks associated with using a mobile phone while driving or failing to recognize the effects of doing so) (Jannusch et al., 2021; Noland & Oh, 2004).

In contrast, some studies shown that older people are significantly more prone to serious injuries even if they are generally more cautious drivers (Aguero-Valverde & Jovanis, 2006; Huang et al., 2010; Wier et al., 2009). Elderly people have a higher risk of accidents and serious crashes because they are more likely to be fatigued and to have medical conditions such as arthritis, hypertension, heart disease, stroke, etc. These conditions make it difficult for elderly people to estimate their speed, the distance between vehicles, turns, and the vehicle itself when braking or overtaking them. According to Cicchino and McCartt (2015), drivers 70 years of age or older make judgments errors that result in 97% of crashes. These errors can be attributed to a variety of factors, including poor surveillance, misjudging the distance between vehicles, medical issues, and daydreaming among senior drivers. Furthermore, aging also has an impact on the visual system, which can lead to devastating road accidents by misreading signs, missing traffic signals at crossings, and missing pedestrians or oncoming vehicles (Parker et al., 2000). One of the main reasons older drivers have accidents is visual impairment (Hoffman et al., 2005). In a similar vein, extended driving at night is also influenced

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by light conditions, which limits the capacity of senior drivers to drive attentively (Campagne et al., 2004).

Gender

Numerous studies have focused on the differences between male and female drivers. The notion that driving behavior differs greatly between men and women has been validated by the research findings. Regardless of age, male drivers have a much greater accident rate than their female counterparts (Åkerstedt & Kecklund, 2001; Al-Balbissi, 2003; Oltedal & Rundmo, 2006). Particularly men are more likely to drive aggressively, disregard traffic laws, and forget about safety measures like seatbelts (Romano et al., 2012; Vlahogianni & Golias, 2012). On the other hand, women are thought to mature psychologically more quickly than men, despite the fact that they are normally more cautious when driving (Goralzik & Vollrath, 2017; Morgan & Mannering, 2011). Furthermore, it is disrupting that men, particularly those in their 30s, tend to disobey traffic laws (Awialie Akaateba & Amoh-Gyimah, 2013). The results support the well-established notion that male drivers are more likely than female drivers to be involved in road accidents. There exists a noteworthy disparity in the accident rate between male and female drivers, with the former having an average 3.17 times greater rate than the latter. There are various reasons why female drivers have fewer accidents. Lower driving speeds, traveling shorter distances, driving on less hazardous routes, and cautious driving are some of the most convincing arguments (Ashraf et al., 2019).

Distracted driving

Driver fault is a significant cause of traffic accidents based on the analysis on road accidents and fatality cases (Chand & Bhasi, 2019; 2023). Several studies have unequivocally shown that driving while distracted results in drivers losing concentration on the road, focusing their attention on other things instead of operating a vehicle, and forming false impressions. According to Yamada et al. (2008), vehicles that perform below the standards necessary for the traffic situation do in fact cause accidents. A recent study has confirmed that evaluating a driver's mental state is necessary for safer driving because humans have a limited capacity for processing information. Further cognitive resources are claimed by engaging in non-driving related activities (Chihara et al., 2020). Therefore, if the quantity of information being processed rises, the driver's attentional margin shrinks (Ortega et al., 2021). Sullman et al. (2015) noted that younger drivers had a higher likelihood of being distracted when it comes to driving age. It's true that young people use and engage with their phones far too frequently. Young individuals use social media platforms more often when driving, according to certain studies with young participants (17–25 years old) (Albert & Lotan, 2018; Gauld et al., 2017). The study conducted by Gauld et al. (2017) yielded descriptive findings that showed that 80.7% of the participants were messaging and talking, 73.7% were having phone conversations, 53.5% were on Facebook, 41.2% were on Snapchat, and 30.7% were reading emails. Simons-Morton et al. (2014) looked at professional drivers and amateur drivers (aged 16–17) who had recently obtained their driver's license in their inquiry into driver distraction. Accelerometers and cameras were employed to identify distracted driving behaviors. They discovered that engaging in activities that divert attention, such as eating or using a phone for texting or calls, increases the risk of road accidents. In order to prevent accidents and uphold road safety, those activities should not be allowed while operating a vehicle. According to Chand and Bhasi (2019), driver attention from cell phones and other electronics in vehicles was found to be a contributing factor in around 25% of traffic incidents involving big trucks and passenger cars.

An increasing amount of study has examined the risk factors associated with technology-based distractions, especially the usage of mobile phones, and how they affect driver performance and road safety. These distractions have gained popularity in recent years (Ortega et al., 2021). According to numerous studies, using a phone while operating a vehicle is the

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main source of driver distraction that causes accidents (Sullman, 2012; Lee et al., 2013; Xiao & Shi, 2015, WHO, 2018). According to a study done in Australia, driver attention caused 13.6% of significant road accidents (McEvoy et al., 2007). Similarly, based on an observational study conducted in the United States, texting or making phone calls ranked among the most observed distractions, 32.7% had engaged in distracted driving and talking on the phone (Huisingh et al., 2015). In terms of predictors for these kinds of secondary tasks, a study conducted in the UK on visible driving distractions discovered that age is a significant predictor for the majority of secondary tasks that were observed, including using a cell phone (Sullman et al., 2015). In addition, a recent study found that throughout the course of 2017–2019 in Spain, 8.33% of the drivers were involved in significant accidents, and 12.82% of these drivers were young drivers (less than 25 years old) (García-Herrero et al., 2021).

Food-related conditions have an impact on drivers as well and have been linked to an increase in road accidents. Hungry people can perform less well cognitively and physically, which might distract drivers. This is one understudied cause of impaired driving. People drive when hungry for a variety of reasons, such as lifestyle decisions, religious beliefs, and food insecurity. Fasting-induced hunger raises the risk of an accident in Turkey by 25% (Gulek, 2024). Nevertheless, there was a greater chance of an accident while driving after eating or drinking. When compared to driving normally, there were more crashes in the critical event and a considerably higher perceived driver's effort when eating or drinking while driving (Young et al., 2008). The driver should also take food consumption into account. After eating, drowsiness following food consumption may occur in drivers. High-fat foods that raise blood levels of the lassitude-inducing hormone cholecystokinin, as well as foods high in carbohydrates and high-glycemic drinks, may cause drowsiness and raise the risk of an accident (Reyner et al., 2012).

Intoxication

Intoxicated driving is a dangerous habit; intoxicated drivers overestimate their own talents (Van Dyke & Filmore, 2014), show excessive boldness (Jordan et al., 2019), and are more likely to experience false memory (Kloft et al., 2021). As a result, they may appraise the traffic situation incorrectly. Certain drugs and alcohol depress the central nervous system, changing drivers' awareness and impairing their ability to focus and control their behavior. This raises the possibility of a road accident resulting in death or serious injury (Brubacher et al., 2016; Drummer & Yap, 2016; Lin et al., 2022; Yap & Drummer, 2016). Moreover, it impairs drivers' capacity to regulate their posture, impairs reaction to impulses, perception, and psychomotor function, and impairs visual acuity, perception, and environmental awareness (Lin et al., 2022). Furthermore, drivers with a positive blood alcohol content (BAC) exhibit obvious impairments in information processing and decision-making (George et al., 2005; Liu & Fu, 2007). Drunk drivers cause more motor vehicle crashes (MVCs) than drivers without alcohol, even with little higher blood alcohol content (0.01–0.03%) (Phillips & Brewer, 2011; Zhang et al., 2014). In addition to raising the probability of MVCs, drunk driving causes an increase in fatal collisions (Culhane et al., 2019; Sutlovic et al., 2014). According to Zador et al. (2000), drivers with BACs less than 0.1% were more likely to cause fatal injuries to other people on the road as well as to themselves.

As noted by Taylor et al. (2010), more investigation into dangerous behaviors clarifies the alarming connection between alcohol use and accident risks. This relationship has been confirmed in several international settings, such as Nepal and Nigeria (Manandhar, 2022; Owoaje et al., 2005). Police reports also highlight the important role alcohol plays in occurrences involving both fatalities and serious injuries (Prijon & Ermenc, 2009). Worrisomely, shift workers and younger drivers are particularly vulnerable to the cognitive deficits brought on by fatigue, which are similar to those brought on by alcohol (Lowrie & Brownlow, 2020). For example,

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a driver is fifty times more likely to fall asleep at 2:00 am than they are at 10:00 am (Bharadwaj et al., 2021). According to a 5-year analysis of French police records by Reynaud et al. (2002), 9.8% of accident fatalities had a BAC above the legal limit, while 31.5% of victims had a positive BAC. Another French study that supported the negative effects of alcohol use (Philip et al., 2001) found that there was an increased probability of fatalities or serious injuries in crashes involving exhaustion and alcohol. According to Lin et al. (2022), victims of alcohol-impaired driving also face increased chances of cardiac arrest, hospitalization, hypotension, and Glasgow Coma Scale (GCS) scores.

Violation

Errors and infractions are the two main traits of drivers that appear to be the cause of accidents. Violations are intentional behaviors to get around the system, whereas errors are defects in human judgment and behavior based on the circumstances. Traffic law infractions frequently exacerbate the frequency of accidents. Drivers who are involved in accidents most frequently violate the rules of safe driving. Even though they are thought to be unimportant, safety precautions like wearing seat belts and not eating while driving seem to go unnoticed. Driving offenses account for 56.064% of accidents in South Korea. Furthermore, since 2012, a steady rise in violations of safe driving practices has been noted. The following infractions are also classified as severe: running red lights, driving too close to oncoming traffic, driving at intersections incorrectly, and encroaching on the median strip (Ashraf et al., 2019).

Experience

There is a widespread belief that increased driving experience reduces the frequency of collisions because it improves the ability of drivers to assess dangerous circumstances (Ashraf et al., 2019; McCartt et al., 2003). Drivers with experience avoid dangerous situations and commit fewer infractions. Moreover, psychological moods and personality features, including a penchant for risk, have the ability to significantly change a driver's driving behavior (Alavi et al., 2017; Magaña et al., 2020), suggesting a strong correlation between psychology and road safety. Adolescent drivers are especially vulnerable due to their inexperience behind the wheel and their propensity to utilize louder music and mobile phones (Bener et al., 2006; Gershon et al., 2019). Experienced drivers, on the other hand, demonstrate greater caution, indicating that experience may lessen recklessness (Borgialli et al., 2000; Nordfjærn et al., 2012).

Vehicle factors

Vehicle malfunctions are considered "vehicle" traffic safety factors when they result in accidents. While new cars offer a high degree of safety for both the driver and the passengers, it is crucial for the driver to understand the systems in both new and used cars, how they operate, and whether or not they are operational when it comes to technical examinations. At the very least, daily or seasonal vehicle maintenance can simply prevent or remove them (Gorzelańczyk et al., 2023).

Vehicle state

Inadequate maintenance and the absence of contemporary safety systems like lane and brake assist, electronic stability control, and an anti-lock braking system are among the mechanical aspects of the vehicle that cause accidents on the road that contribute to this factor (Cicchino, 2017). Another crucial element is the design of the driving environment. Particularly in heavy-duty vehicles, the inadequate design of the driving environment contributes to driver weariness, a significant risk factor in auto accidents. For both commercial and passenger cars, the design should minimize the driver's weariness from prolonged driving (Rong et al., 2020). According to the Federal Highway Administration's Large Truck Crash Causation Study, which was carried out by the U.S. Department of Transportation between 2001 and 2003, weariness is a contributing factor in 13% of fatal crashes involving at least one large truck (FMCSA,

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2007). The primary ergonomic risk factors, according to Chand et al. (2023), are long driving hours, poor human–machine interface, improper driving posture, vibration from poor road conditions, driver fatigue, and age. They also noted that ergonomic analysis of the driving environment is crucial for increasing productivity and lowering musculoskeletal disorders (MSDs) of drivers.

Elvik et al. (2004) investigated the impact of vehicle speed on the quantity and severity of injuries and found a significant statistical correlation between vehicle speed and road accidents, according to the power model for speed and accidents. This study also shows that although there may not be a linear relationship, the likelihood of a road accident increases exponentially with speed. Numerous studies have examined the impact of driving speed in road accidents and have demonstrated that greater driving speeds are linked to increased accident likelihood and severity (Aarts & Van Schagen, 2006; Ashraf et al., 2019). Speeds are directly connected with the possibility of an accident occurring as well as the severity of the events; a 1% increase in mean speeds increases the risk of serious injuries by 3% and the probability of a fatal crash by 4% (Ahmed et al., 2023).

Mode of transport

Depending on the mode of transportation, there were also varying risks of road accidents. Vulnerable road users (VRUs), such as bicycles, pedestrians, and motorcyclists, suffer serious injuries and pass away more frequently in traffic incidents than drivers do. This is due to the fact that VRUs typically suffer more serious injuries than car occupants when they lack the protection provided by a metal framework (Rifaat et al., 2011). Furthermore, because VRUs are small and poorly visible, car drivers may find it difficult to recognize or perceive them in traffic, which could worsen the severity of an accident if one occurs (Lin et al., 2022; Rogé et al., 2017; Wood, 2020). In addition, according to Konkor (2021), Ghanaian citizens who commuted by motorcycle or tricycle were more likely to be involved in an accident than their counterparts who drove. The three most common forms of transportation for daily commuting in Ghana are vehicles, motorcycles/tricycles, and bicycles, as is the case with many developing countries. In northern Ghana, where riding constituted around 60% of all commutes until recently, it is especially significant to go by bicycle.

Aldred et al. (2020) examined the potential harm to other individuals by contrasting six distinct vehicle kinds and dividing road types (main vs. small roads in urban vs. rural environments) in the United Kingdom. When compared to automobiles or vans, buses and lorries were found to have a significantly higher risk of fatalities among other road users (ORUs). Motorcycles are in the middle of the risk spectrum when it comes to automobiles and vans. The least danger is associated with cycling per km. Apart from trucks, major roads increase the danger of ORU fatalities. In rural locations, there is a higher per-kilometer risk of fatalities from vehicles or vans to ORUs. There may be a connection between faster speeds and greater risk because it is often higher on main highways, however not for vehicles.

Environmental factors

An automobile accident was caused in part by the condition of the environment. A few factors that affect road accidents are the kind of road, population density, traffic volume, and weather. External factors like the weather can have an impact on the probability and severity of crashes (Bergel-Hayat et al., 2013). Research conducted on individual roads, sections, etc. at the micro level typically include elements of design uniformity, visibility, lane and shoulder widths, curvature, and layout when it comes to the problems that are directly related to roads (Calvo-Poyo et al., 2020).

Traffic situation

One of the most important road-related elements influencing road accidents is the volume of traffic on the roads (Ashraf et al., 2019). The impact of lighting conditions and traffic volume on road accidents is examined by Golob and Recker (2003). A substantial correlation has been found between driving

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speed and traffic collisions based on traffic volume measurements taken before the accident happened. The analysis also considers the role that wet roads have in multiple vehicle and hit-and-run accidents. Furthermore, a stronger correlation was observed between high traffic volume and accident severity than with driving speed. Chen and Chen (2011) and Chen et al. (2019) have conducted additional study on truck accidents involving single and multiple vehicles that are caused by high traffic volumes and wet roads. Study results suggest that snow road surface should be modeled in single and multi-vehicle crashes as random characteristics. The relationship between traffic volume and accident-injury severity is found to be complex in light traffic. Studies show that although there is a significant correlation between high traffic volume and accident frequency, there is less of an effect on the severity of injuries. When two drivers are involved in a rear-end collision, it is discovered that traffic flow exacerbates the severity of their injuries.

Weather condition and time of travel

The main environmental elements influencing the probability and severity of crashes include visibility, temperature, wind speed, precipitation, and moisture, as stated by Bergel-Hayat et al. (2013). Given that these variables can drastically alter the likelihood of an accident and that their interactions are unknown, they should be regarded as extremely critical. Rain is widely thought to have a direct impact on how frequent accidents occur on highways. Eisenberg (2004) discovered a negative correlation between precipitation and the monthly total of serious crashes in the US between 1975 and 2000. According to the findings, the likelihood of a car accident rises with the amount of time since the last precipitation. Similarly, Keay and Simmonds (2006) conducted an evaluation of the impact of rain on road accidents in Melbourne from 1987 to 2002 and confirmed that rain increases the risk of road accidents. Additionally, there is a variation in the risk of injury and mortality depending on the time of night (Connor et al., 2002). The probability of a road accident increases by 5.6 times when driving between 2:00 and 5:00 in the morning. The researchers have several theories as to why there are more accidents at night. The most common causes include tiredness and low visibility (Åkerstedt et al., 2001). Nevertheless, another research indicates that nighttime accidents are more closely associated with nighttime road usage than with nighttime darkness.

Road infrastructure and geometric characteristics

In addition to meteorological conditions, other important considerations include road infrastructure and geometric properties. A primary factor in the frequency of road traffic collisions (RTCs) and their consequences is inadequate and unsafe road infrastructure. According to studies by Rahil et al. (2014) and Pembuain et al. (2018), road geometry and infrastructure have a major impact on RTC incidences. Geometric design aims to minimize costs and environmental harm by optimizing safety and efficiency (Jima & Sipos, 2022). In addition to its design features, a road's state of conservation can affect how often accidents happen (Calvo-Poyo et al., 2020).

Most of the time, fundamental physical characteristics of roads include things like road width, curbs, traffic separators, cross slope, and road margins. Furthermore, there is a significant influence of many road factors on accident rates, including intersections, geometry formation, pavement type, average speed limit, road lanes, breadth, and length of the road section (Greibe, 2003; Karlaftis & Golias, 2002; Vorko-Jović et al., 2006). On straight roads, road accidents affected both distance traveled and speed. The risk of fatal injuries was highest for the longest distance (Kamat et al., 2012). According to a study, two-lane rural roadways lower crash rates by 44% when compared to high crash-rate infrastructure (Polus et al., 2005). Whereas land use, points of entry, and the existence of a median reduced the likelihood of severe crashes, horizontal curves, concrete shoulder width, terrain category, and side friction proved to be related with more severe crashes (Anarkooli et al., 2019; Hosseinpour et al., 2014). In addition, Othman

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et al. (2009) discovered that large-radius right-turn bends present a higher danger than left curves while changing lanes. Conversely, curves that are steeper on the left or right, though, pose greater risks. Furthermore, it was discovered by Othman et al. (2010) that overtaking on right bends was dependent on the radius and how it interacted with the state of the road. Conversely, left curves were more prone to super-elevation issues.

Geurts et al. (2005) looked at how certain road segments affected the number of accidents in a periurban area of Belgium. They found that the most common causes of accidents that happened in the "black" zones were left turns, collisions with pedestrians, vehicles running off the road, and precipitation. The primary causes of accidents outside of the specified "black" zones are head-on collisions, left turns at traffic signal crossings, and drunk driving. Pedestrians, cyclists, and motorcyclists are just a few of the road users whose safety is greatly impacted by road design. When building roadways, it is crucial to keep everyone's safety in mind. Streets, bike lanes, safe crossings, and other traffic calming measures are crucial for lowering the risk of accidents for drivers. Then, there are dangerous cars that are either poorly made or do not adhere to basic safety standards. It goes without saying that vehicle safety is crucial to preventing road accidents and lowering the likelihood of them occurring (Ahmed et al., 2023). In Singapore, road crashes at crossroads account for about 35% of all recorded accidents. The severity of crashes at intersections is determined in part by the kind of vehicle, the type of road, the type of collision, the characteristics of the driver, and the time of day (Tay & Rifaat, 2010). An Ethiopian study (Abebe, 2019) found that horizontal curves with greater degrees of curvature have a higher risk of major crashes than curves with lower degrees of curvature. The analysis conducted by Jima and Sipos (2022) utilizing data on road traffic crashes in Budapest from 2017 to 2021 found the geometric configurations of straight and one-lane roads experienced a high number of crashes. All three of the road's lanes and the horizontal bend, however, had significant levels of severity. According to the regression model, factors such as speed, road geometry, collision, and light conditions all significantly affect the number of road accidents. The most likely cause of the disaster was a rear-end collision between the vehicle and a vehicle carrying a person. Road traffic deaths are positively and significantly correlated with horizontally curved geometry, according to the Multilayer Perceptron Artificial Neural Network. Road pavement condition, stopping sight distance issues, and inappropriate use of traffic signs were the main causes of traffic crashes at intersections, horizontal curves, and straight road geometric formations, respectively.

Population density

Population density has a significant influence on the incidence of accidents, according to research published in Noland and Quddus (2004). Spoerri et al. (2011) stated there is a correlation between a decline in population density and a rise in accidents. According to Ashraf et al. (2019), higher population density is associated with fewer accidents, while lower population density is linked to more accidents. These findings are consistent with prior studies and indicate that locations with higher population densities have fewer casualties overall, while those with lower densities have more casualties.

CONCLUSION

Regardless of the level of motorization development, there is always a need to improve road traffic safety and reduce both the number and severity of injuries caused by accidents. This study identifies three main factors – environment, vehicles, and human behavior – as the primary causes of road accidents, suggesting that addressing these areas can help reduce future incidents. However, given the complexity of these factors, it is important to investigate all aspects of the transportation system to fully understand and prevent accidents. This study fills a crucial gap by offering a thorough examination of these contributing factors and calling for more research on global

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policies to evaluate their effectiveness. Such efforts are essential to gaining a deeper understanding of road safety and ultimately improving traffic safety worldwide. Comparing road safety policies across different regions can also provide valuable insights into the effectiveness of various approaches. For example, countries with high traffic safety standards show lower accident rates due to their strict enforcement of road safety laws and public awareness campaigns, compared to developing nations that often face challenges due to inconsistent enforcement and infrastructure limitations. By examining these differences, this study contributes to a more nuanced understanding of what works in road safety and highlights the need for tailored, context-specific solutions to minimize the occurrence of traffic accidence.

Author contributions: The authors have approved the final version of the article. The authors contributed to this work as follows: G.Y., Y.A.N., G.R., G.N., and G.M. developed the concept and designed the study, G.Y. and Y.A.N. collected the data, G.Y. analyzed and interpreted the data, G.Y. drafted the article, G.Y. and G.R. revised the article critically for important intellectual content

Supplementary information: This article was done during the study period with the scholarship that was given by the Ministry of Public Works, Indonesia, to the one of the authors (Yuliani, G.). The authors would also like to deliver gratitude to the Faculty of Civil and Environmental Engineering, Bandung Institute of Technology, and the Directorate General of Highways, Ministry of Public Works, Indonesia, for the support in preparing the article.

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APPENDIX

Table 1. Haddon's matrix of road accidents factors

Phase	Factors		
	Human	Vehicle	Environment
		Pre-event	
Accident prevention	Degree of training, observance of regulations (speed, alcohol), prophylactic examinations, current state of health (fatigue, sleep), execution of regulations by the police	Method of exploitation, technical status, lighting, breaks, tires, speed, performance of MOT tests	Road design, state of road infrastructure, lighting, atmospheric conditions, speed limits, facilities for pedestrians
		Event	
Injury prevention during accidents	Age, gender, state of health (chronic diseases), mechanism of injury	Modern devices for passive and active safety, vehicle size	Safety zones, roadside embankments/guard rails in the road infrastructure
		Post-event	
Sustaining life and decreasing disability	Skill of providing first aid by witnesses or participants of the accident, state of health of victims, severity of injuries, skills and knowledge of paramedics and physicians	Access to the victims, hazards on the part of the vehicle (fire, explosion)	Notification system, emergency medical service response, co-operation between rescue services, accessibility of emergency equipment, place of rehabilitation and treatment

Source: Haddon (1968).

Table 2. Some factors related to road accidents

Factor(s)	Findings summary	Reference(s)
1	2	3
	Human Factors	
	Age	
Young drivers	Young people are prone to pressure and excitement from inspiration, making poor decisions during emergencies, and engaging in risky driving practices	Clarke et al. (2006); Jannusch et al. (2021); Noland & Oh (2004); Williams (2003)
Old drivers	Old drivers tend to have judgmental errors and medical events during driving	Aguero-Valverde & Jovanis (2006); Huang et al. (2010); Wier et al. (2009)
	Gender	
Male drivers	Male drivers frequently disregard safety precautions, drive aggressively, and violate traffic restrictions	Awialie Akaateba & Amoh-Gyimah (2013); Åkerstedt & Kecklund (2001); Al-Balbissi (2003); Awialie Romano et al. (2012); Goralzik & Vollrath (2017); Morgan & Mannering (2011); Oltedal & Rundmo (2006); Vlahogianni & Golias (2012)
	Distracted driving	
Mobile phone usage	Mobile phone use while driving leads to higher accident rates	García-Herrero et al. (2021); Huisingh et al. (2015); Lee et al. (2013); McEvoy et al. (2007); Sullman et al. (2015); Sullman (2012); WHO (2018); Xiao & Shi (2015)

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cont. Table 2

1	2	2
Food-related distraction	Hunger impairs mental and physical function, increasing the likelihood of an accident	Gulek (2024)
	Driving after intoxication or eating increases the probability of an accident	Young et al. (2008)
	A higher accident risk is associated with post-meal tiredness	Reyner et al. (2012)
	Intoxication	
Alcohol use	Road accidents are more likely to occur when drivers are influenced by alcohol and other substances, which also change their state of consciousness and impair their attention span and behavioral control	Bharadwaj et al. (2021); Brubacher et al. (2016); Culhane et al. (2019); Drummer & Yap (2016); Liu & Fu (2007); George et al. (2005); Lowrie & Brownlow (2020); Lin et al. (2022); Manandhar (2022); Owoaje et al. (2005); Philip et al. (2001); Phillips & Brewer (2011); Prijon & Ermenc (2009); Reynaud et al. (2002); Sutlovic et al. (2014); Yap & Drummer (2016); Zhang et al. (2014)
	Violation	
Traffic law violation	Infringement of safe driving practices	Ashraf et al. (2019)
	Experience	
Inexperienced driver	Inexperienced drivers have a higher tendency to indulge in risky scenarios	Bener et al. (2006); Gershon et al. (2019)
	Inexperienced drivers exhibit less restraint	Borgialli et al. (2000); Nordfjærn et al. (2012)
	Vehicle Factors	
	Vehicle state	
Vehicle design	Both commercial and passenger car designs should minimize the amount of weariness that long-term driving causes to the driver	Rong et al. (2020)
Power model	Strong statistical correlations between vehicle speed and traffic accidents are demonstrated by the power model for speed and traffic accidents	Elvik et al. (2004)
	Mode of Transport	
Vulnerable Road User (VRU)	VRU sustained a higher rate of accidents compared to car drivers	Rifaat et al. (2011)
	VRU sustained a lower rate of accidents compared to car drivers	Aldred et al. (2020); Konkor (2021)
	Environmental Factors	
	Traffic Situation	
High traffic volume	High traffic volume = high accident severity	Golob & Recker (2003)
	High traffic volume = high accident frequency	Chen & Chen (2011); Chen et al. (2019)
	Weather Condition and Time of Travel	
Precipitation	The lengthening of time since the previous precipitation increases the potential of a road accident	Eisenberg (2004)
	Rain increases the frequency of road accidents	Keay & Simmonds (2006)

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cont. Table 2

1	2	2
Night travel	The probability of a traffic accident increases by 5.6 times when driving between 2:00 and 5:00 in the morning	Connor et al. (2002)
	Low visibility conditions and sleepiness during night travel	Åkerstedt et al. (2001)
	Road Infrastructure and Geometric Characteristics	
Specific road segment and design	The longest distance on straight roads presented the highest risk of fatal injury	Kamat et al. (2012)
	Rural two-lane roadways cut collision rates by 44%	Polus et al. (2005)
	The probability of severe crashes was shown to be lower in situations with land use, access points, and a median present than in situations with horizontal curvature, paved shoulder width, terrain type, and side friction	Anarkooli et al. (2019); Hosseinpour et al. (2014)
	During lane changes, large-radius right-turn curves were more hazardous than left-turn curves. Both left and right bends have sharper curves that are riskier	Othman et al. (2009)
	The radius and how it interacted with the road conditions affected overtaking on right curves, whereas super-elevation had a greater effect on left curves	Othman et al. (2010)
	On horizontal bends with more curvature, severe accidents were more likely to happen	Abebe (2019)
	The geometric configurations of straight and one-lane roads saw a high number of crashes. High road accident severity was observed at the horizontal curve	Jima & Sipos (2022)
	Population Density	
Low-density population	Low-density population = higher accident rates	Noland & Quddus (2004); Spoerri et al. (2011)

Source: own elaboration.

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