Research Inventy: International Journal of Engineering And Science
Vol.14, Issue 11 (November 2024), PP 82-92
Issn (e): 2278-4721, Issn (p):2319-6483, www.researchinventy.com

Examination of Traffic Accidents Using Traffic Accident Report Forms

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Abstract: *This study analyzes data from 941 traffic accidents that occurred in the rural areas of Zonguldak province between 2016 and 2022. These accidents were assessed through the detailed information provided in traffic accident report forms, enabling comprehensive evaluations across various categories. Basic statistical methods were employed to examine the distribution and characteristics of accidents based on factors such as proximity to residential areas, state road numbers, road platform types, horizontal alignment, vertical alignment, time of day, weather conditions, road surface conditions, and accident types. The analysis categorizes the traffic accidents under these variables to identify patterns and interpret the underlying causes. The findings aim to provide insights into the relationships between this categories and accident risk, contributing to a better understanding of how design elements influence traffic safety. Special attention was given to state road networks, which play a critical role in rural transportation infrastructure, and the interaction between road geometry and environmental factors like weather and surface conditions.*

Keywords: *Traffic accident, road platform, horizontal line, vertical line, time of day, weather conditions.*

Date of Submission: 20-11-2024 Date of acceptance: 02-12-2024

I. INTRODUCTION

Traffic accidents remain a significant cause of death, particularly among younger age groups, in Europe. Although the number of accidents has steadily declined in the most developed countries over the past decade, substantial efforts in prevention and road planning continue to be made to further reduce both their frequency and severity (Briz-Redón et al., 2019). According to the World Health Organization's 2023 data, approximately 1.19 million people lose their lives in traffic accidents every year. Additionally, 20 to 50 million people are seriously injured or disabled due to traffic accidents (URL-1). The United Nations General Assembly has set an ambitious target to halve the number of deaths and injuries resulting from traffic accidents by 2030 (Nations and Assembly, 2020). Every year, approximately 1.19 million people's lives are lost due to traffic accidents (Özbek, 2022). These numbers are quite high, and in this context, many people from various disciplines are working to reduce these figures.

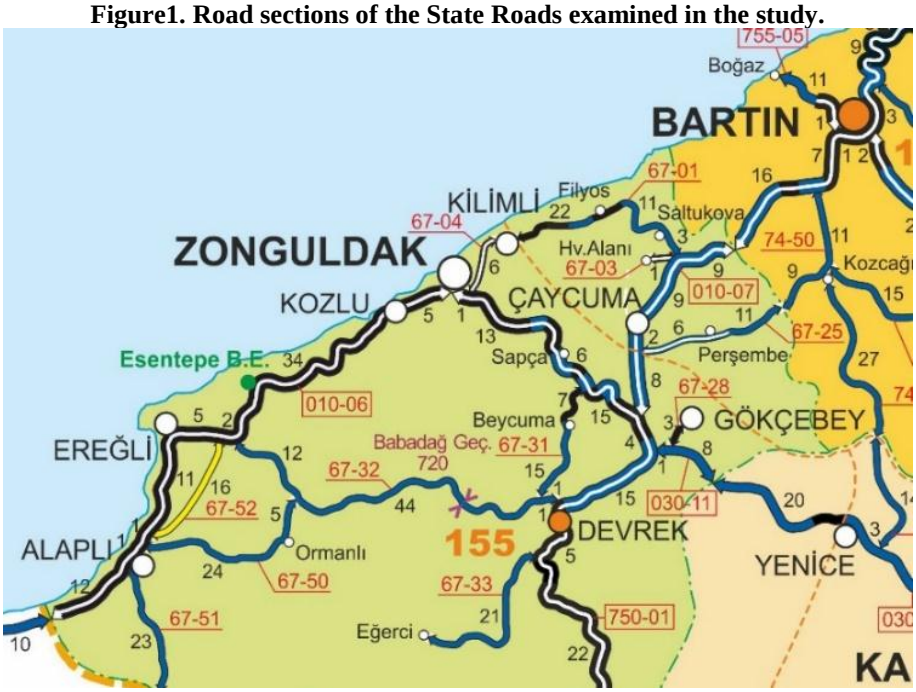
The main factors in the occurrence of traffic accidents can be grouped into human (pedestrian, passenger, and driver), vehicle, road, and environmental factors (Bulak, 2010). The degree to which each factor influences traffic accidents depends on the type of accident. Unlike human or vehicle-related factors, road-related factors can be controlled by planners and designers, making studies on these factors particularly important.

II. MATERIALS AND METHOD

1.1 Study Area

This study requires traffic accident data for Zonguldak province (including all districts). Zonguldak is a city located in the Western Black Sea region of Turkey with a population of 591,492. For this study, it was considered that obtaining traffic accident data from the State Roads in Zonguldak would provide more reliable results, so efforts were made to access this type of data. A map of the road section under study is presented in Figure 1.

Figure1. Road sections of the State Roads examined in the study.



1.2 Method

In the preliminary study, it was found that the information contained in the "Fatal/Injury Traffic Accident Report Forms" is suitable for the scope of the study. The Accident Report Forms, prepared to protect the rights and interests of vehicle owners, drivers, passengers, and pedestrians who have suffered material and immaterial damage due to the accident, are arranged by traffic officers or general law enforcement at the accident scene. These reports are used to evaluate the information that will serve as the basis for judicial investigations and statistical studies (Erdoğan, 2006).

It was found that accident reports are digitally recorded under the Traffic Department of the General Directorate of Security, Ministry of the Interior of the Republic of Turkey, and data related to the reports were requested through an official letter. After obtaining the accident reports, all headings of the raw data were compiled and organized in the format shown in Table 1. A dataset with different characteristics for each accident was obtained. Then, the number of accidents for each of these headings was determined and interpreted through graphs and tables.

1.3 Literature Review

The relationship between traffic accidents and road geometry, as well as environmental factors, is a frequently discussed topic in the literature. Zegeer et al. (1988) examined the effects of horizontal curves and vertical slopes on accident risk and noted that these features, particularly in rural areas, increase accident rates. Hauer (1999) emphasized the importance of statistical modeling in better understanding the relationship between road design and accidents.

Gross and Jovanis (2007) demonstrated that adherence to geometric design standards for state roads in rural areas plays a critical role in reducing traffic accidents. Similarly, Quddus (2008) studied the effects of weather and road surface conditions on accident frequency and severity, finding that these factors have an increasing effect on accident risk.

In Turkey, Güler and Yıldırım (2019) revealed that narrow roadways and insufficient road width contribute to increased accident types such as side collisions and rollovers. Furthermore, Doğan et al. (2021) highlighted the significant role of winter conditions and slippery road surfaces in the occurrence of accidents.

These findings underscore the importance of studies on the impact of road geometry and environmental factors on traffic safety. The study conducted in Zonguldak aims to contribute to these topics at a regional level and can serve as an important reference for improving the safety of rural roads.

III. RESULTS AND DISCUSSIONS

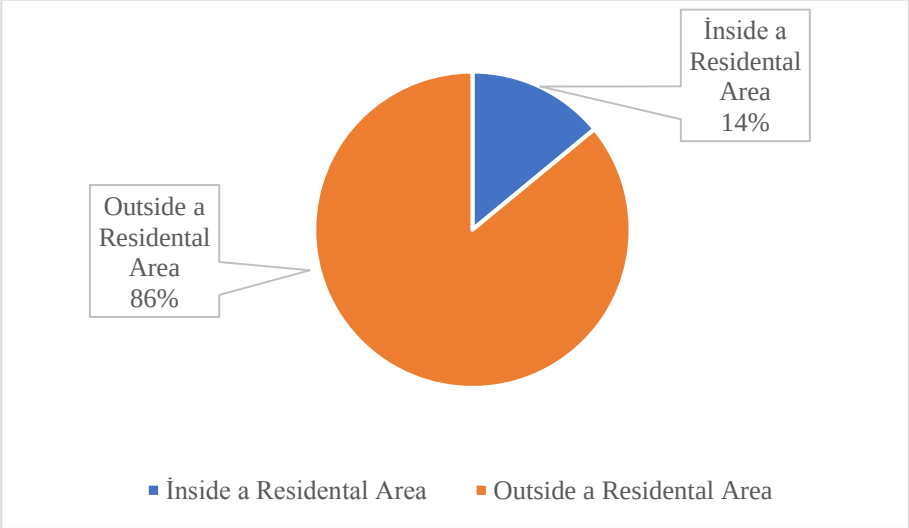
In the study on traffic accidents, basic descriptive statistics were determined using the information from the traffic accident report forms of the 941 accidents selected for the study. As a result of these accidents, a total of 18 people lost their lives, and 1.697 people were injured. All of these accidents occurred on divided roads. Of

the roads, 99.6% are asphalt paved, 0.3% are surface treated, and 0.1% are paved with cobblestones. The number of accidents by residental areas is presented in Table 1, and the corresponding graph is shown in Figure 2.

Table1. Number of accidents by residental area.

	Number of accidents	Percentage of total number (%)
Inside a residental ares	132	14.0
Outside a residental ares	809	86.0
Total	941	100

Figure2. Number of accidents by residental area.

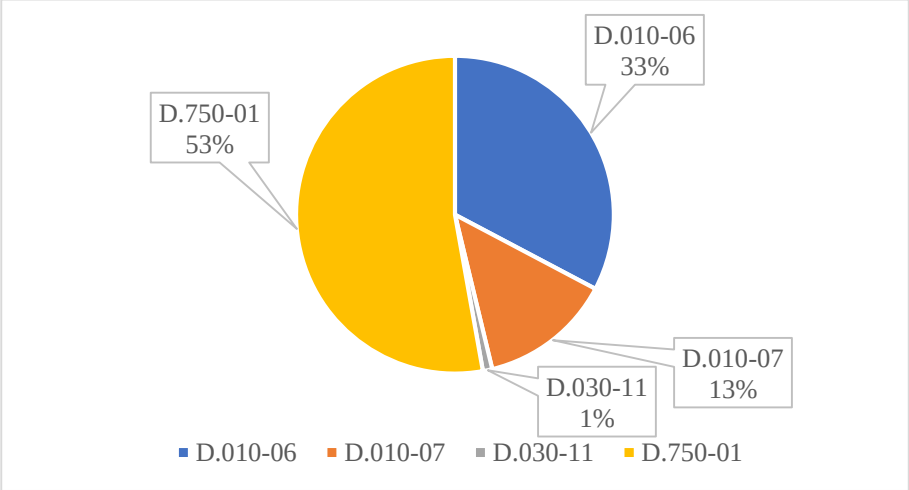


According to Table 1 and Figure 2, it has been determined that 14% of the accidents occurred within residental areas, while 86% took place outside residental areas. This indicates that roads outside residental areas carry a higher risk for traffic accidents. Accidents within residental areas generally occur in regions with heavy pedestrian and vehicle traffic. Although the frequency of accidents within residental areas is lower compared to roads outside settlements due to lower speed limits, these accidents can still result in serious consequences such as injuries and fatalities. The high proportion of accidents outside residental areas may be attributed to the fact that these roads typically have higher speed limits, longer distances, and different geometric features. On roads outside residental areas, such as state roads, non-compliance with speed limits, geometric elements that restrict visibility (curves, steep slopes, etc.), and insufficient traffic control measures increase the risk of accidents. Particularly in rural areas, the physical conditions of the roads and driver behavior are key factors influencing accidents. As previously mentioned in the study, four different state roads were examined. The number of accidents on these roads is presented in Table 2 and Figure 3.

Table2. Number of accidents by state roads.

Number of state road	Number of accident	Percentage of total number (%)	Total Length of the Section (km.)	Number of Accidents per Kilometer (Acc./km.)
D.010-06	308	32.7	71	0.23
D.010-07	127	13.5	28	0.22
D.030-11	9	1.0	9	1.00
D.750-01	497	52.8	82	0.16
Total	941	100	190	

Figure3. Number of accidents by state roads.

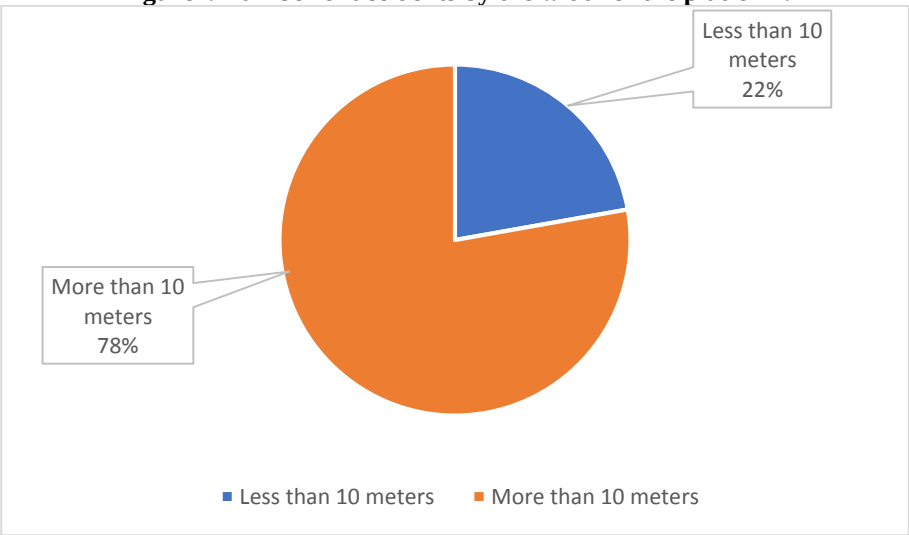


As seen in Table 2 and Figure 3, when the number of accidents is analyzed by state road numbers, the highest number of accidents occurred on the D.750-01 section. A total of 497 accidents took place on this section, accounting for 52.8% of all accidents. Additionally, this section is the longest, with a length of 82 kilometers, which may support the high number of accidents. Based on this information, the number of accidents per kilometer for the D.750-01 section was calculated as 0.16, making it the section with the lowest accident rate per kilometer. On the D.010-06 section, 308 accidents occurred, representing 32.7% of all accidents. This section is the second longest, with a length of 71 kilometers, resulting in 0.23 accidents per kilometer. On the D.010-07 section, 127 accidents occurred, accounting for 13.5% of the accidents. This section is 28 kilometers long, with 0.22 accidents per kilometer. Finally, on the D.030-11 section, a total of 9 accidents occurred, representing 1% of the accidents. This road is 9 kilometers long, with 1 accident per kilometre. The accident report forms contain data indicating the width of the platform in a general sense and provided in Table 3 and Figure 4 to offer some insights.

Table3. Number of accidents by the width of the platform.

	Number of accidents	Percentage of total number (%)
Less than 10 meters	209	22.2
More than 10 meters	732	77.8
Total	941	100

Figure4. Number of accidents by the width of the platform.

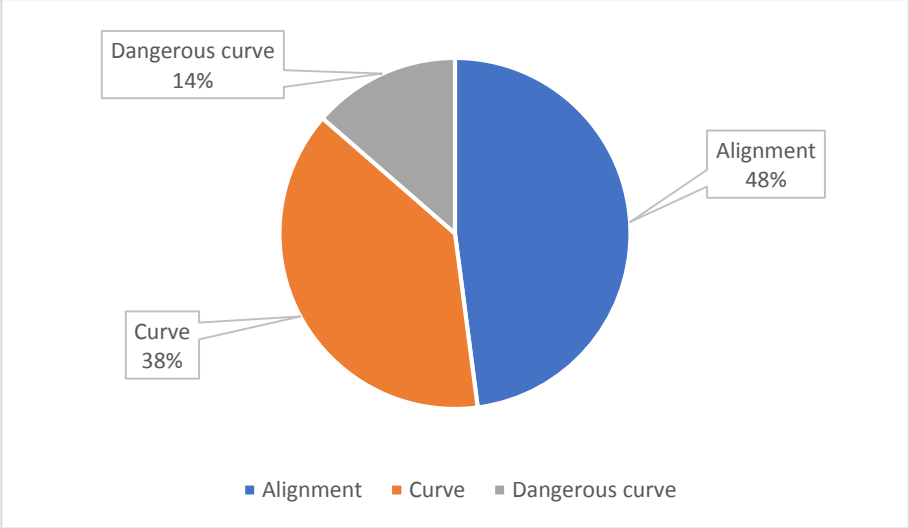


As seen in Table 3 and Figure 4, 732 of the accidents, which constitute 77.8%, occurred on roads with a platform width of over 10 meters. The remaining 209 accidents occurred on roads with platforms less than 10 meters wide. Table 4 and Figure 5 present the number of accidents according to the horizontal line.

Table4. Number of accidents according to the horizontal line.

	Number of accidents	Percentage of total number (%)
Alignment	346	36.8
Curve	467	49.6
Dangerous curve	128	13.6
Total	941	100

Figure5. Number of accidents according to the horizontal line.

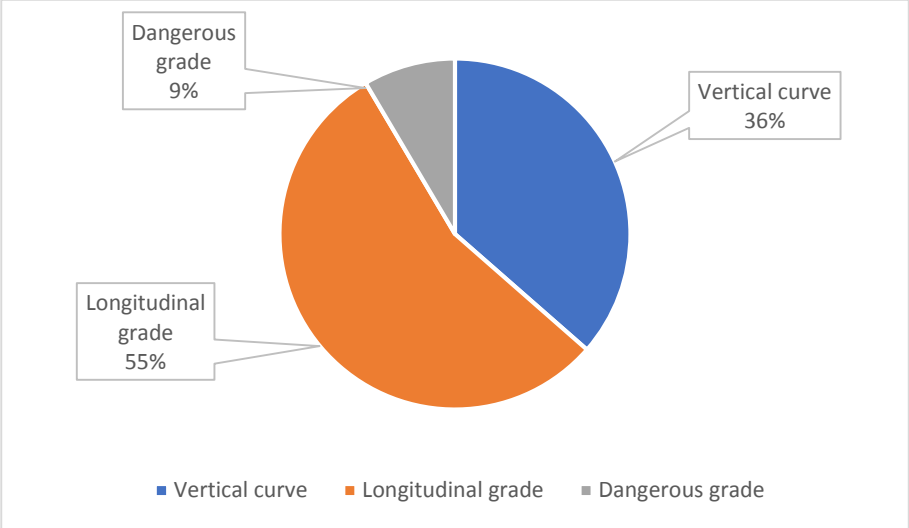


As presented in Table 4 and Figure 5, it was determined that 49.6% of the accidents occurred on horizontal curves, 13.6% on dangerous curves and 36.8% on alignments. The high rate of accidents occurring on horizontal curves (49.6%) indicates that such sections pose special risks in terms of driving dynamics. Accidents on horizontal curves can generally be associated with the design features of the curve and drivers not proceeding at a speed appropriate to this design. Excessive speed in particular can lead to an increase in centrifugal force and the risk of vehicles going off the road. Accidents occurring on dangerous curves (13.6%) indicate that these sections are critical points in terms of both geometric design difficulties and driving safety. Dangerous curves generally include risk factors such as narrow radius curves, sudden changes in direction or insufficient visibility. In such sections, drivers' failure to predict road conditions or failure to comply with speed limits increases the risk of accidents. Accidents that occurred in intersections (36.8%) show that although such sections give the impression of a flat road, factors such as inattention, excessive speed and incompatibility with the physical conditions of the road are effective in accidents. In flat sections, drivers can often lose speed control or cannot concentrate due to the monotonous structure of the road. Fatigue, especially in long distances, is one of the important causes of such accidents. The fact that the majority of accidents occur on horizontal curves indicates that measures should be taken to increase driving safety in such sections. The number of accidents by vertical line is presented in Table 5 and Figure 6.

Table5. Number of accidents according to the vertical line.

	Number of accidents	Percentage of total number (%)
Vertical curve	343	36.5
Longitudinal grade	518	55.0
Dangerous grade	80	8.5
Total	941	100

Figure6. Number of accidents according to the vertical line.

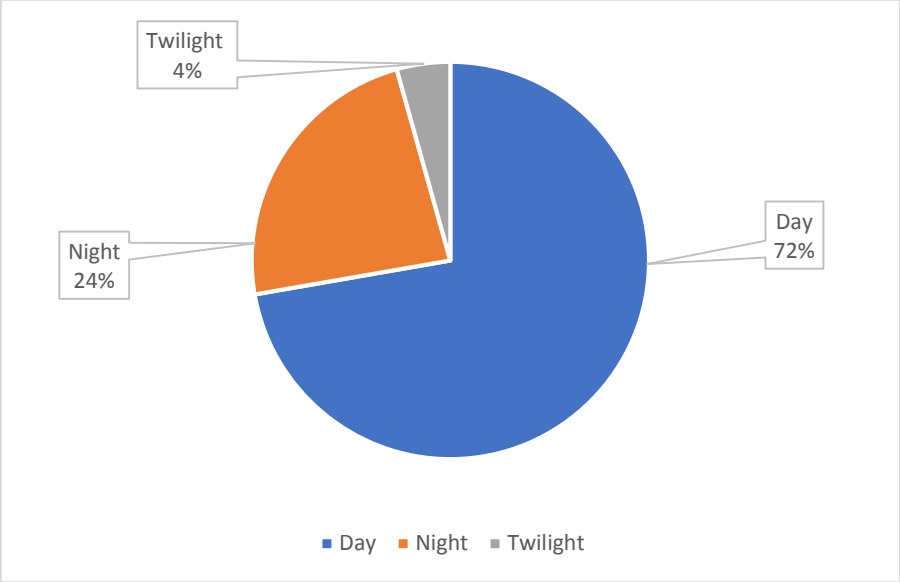


According to Table 5 and Figure 6, 55% of accidents occur on longitudinally sloped sections, while 8.5% occur on critically sloped sections. Additionally, 36.5% of accidents take place on vertical curves. These findings indicate that sloped sections pose a higher risk for traffic safety. The high proportion of accidents on longitudinally sloped sections highlights the impact of such areas on driving safety. Longitudinal slopes can directly influence vehicle speeds. During downhill driving, factors such as increased vehicle speed, extended braking distances, and loss of speed control by drivers may contribute to accidents. On the other hand, on uphill sections, vehicles may experience insufficient engine power, leading to speed reductions and consequently driving difficulties. The combination of longitudinal slopes and deficiencies in road design exacerbates the frequency of such accidents. Accidents occurring on critically sloped sections account for 8.5%. Critically sloped sections are roads with high gradients and often limited visibility. In these areas, drivers may struggle to anticipate road conditions and control their speeds. The risk of vehicle skidding is particularly high on such slopes, especially in rainy or icy weather. Therefore, to prevent accidents on critically sloped sections, improvements in road design, additional warning signs, and measures to enhance driver attention are required. Accidents on vertical curves make up 36.5% of the total, indicating that these sections are among the most challenging for drivers. Vertical curves typically involve significant changes in road gradient combined with bends. In these areas, drivers may find it difficult to maintain speed control, and the slope characteristics of the road can increase the risk of vehicle skidding. Restricted visibility on curves and the combined effect of slope gradients can make it challenging for drivers to maintain an appropriate speed for the road conditions. Table 6 and Figure 7 present the number of accidents based on time of day.

Table6. Number of accidents based on time of day.

	Number of accidents	Percentage of total number (%)
Day	680	72.3
Night	220	23.4
Twilight	41	4.4
Total	941	100

Figure7. Number of accidents based on time of day.

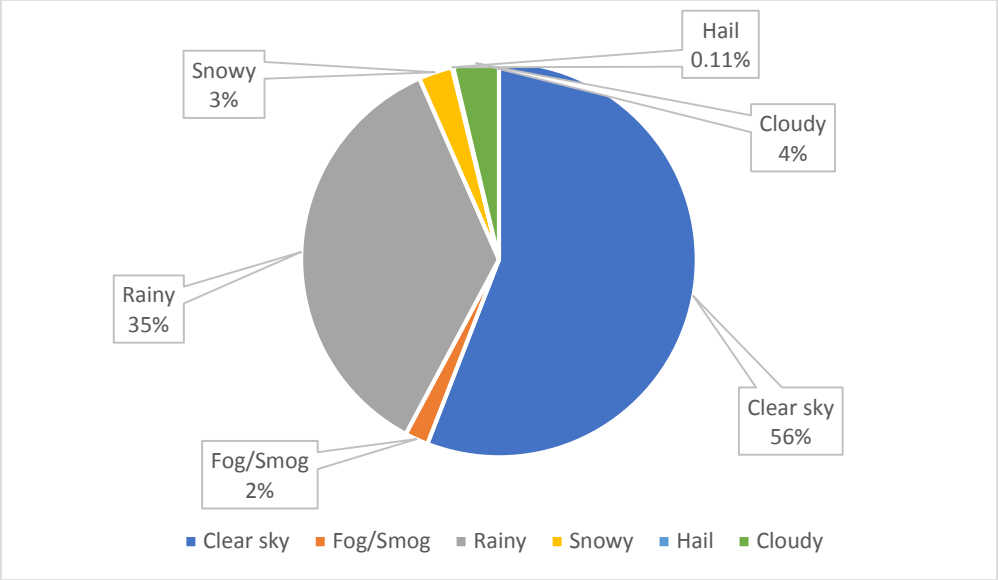


As seen in Table 6 and Figure 7, it was determined that 72.3% of accidents occurred during daylight hours. This high proportion may be attributed to the increased traffic volume typically observed during these hours. Accidents occurring at night account for 23.4% of the total. Nighttime accidents are generally associated with factors such as insufficient lighting and reduced visibility. The decreased perception and reaction times for drivers, especially in rural areas, are key contributors to the higher occurrence of nighttime accidents. Accidents during twilight hours have the lowest proportion, at 4.4%. However, this time period presents unique risks due to transitional lighting conditions, which combine the challenges of both day and night driving. During twilight, drivers may struggle to adapt to changing light levels, potentially leading to visual perception errors. In particular, the ineffective use of vehicle headlights or misjudgment of visibility distances during this period can increase the likelihood of accidents. The distribution of accidents based on lighting conditions is a critical factor that should be considered in road safety strategies. Table 7 and Figure 8 present the number of accidents categorized by weather conditions.

Table7. Number of accidents by weather conditions.

	Number of accidents	Percentage of total number (%)
Clear Sky	526	55.9
Fog/Smoke	18	1.9
Rainy	335	35.6
Snowy	26	2.8
Hail	1	0.1
Cloudy	35	3.7
Toplam	941	100

Figure8. Number of accidents by weather conditions.

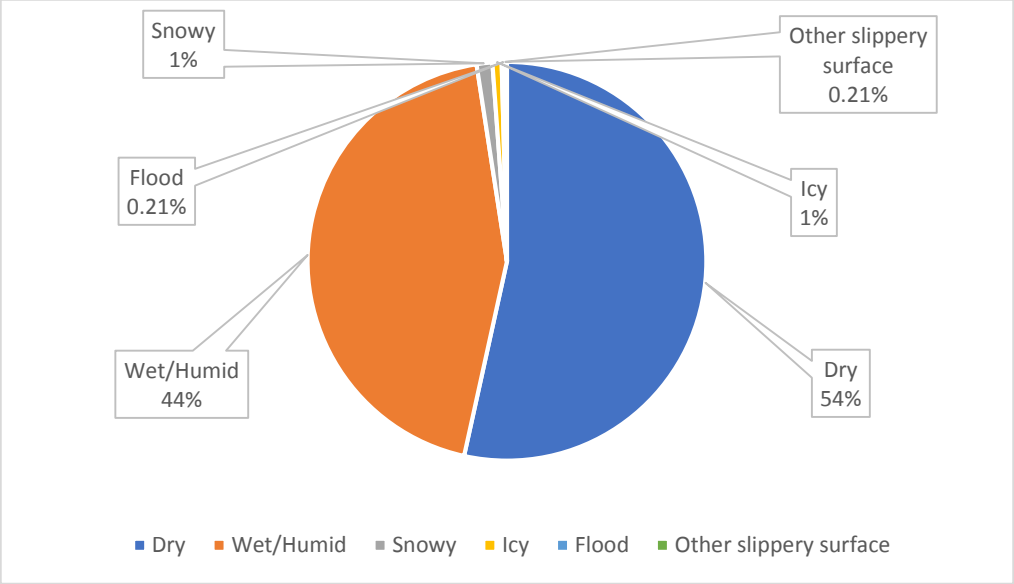


As presented in Table 7 and Figure 8, 55.9% of accidents occurred in clear weather, 35.6% in rainy weather, 3.7% in cloudy weather, 2.8% in snowy weather, 1.9% in foggy or smoky conditions, and 0.1% during hailstorms. The high proportion of accidents in clear weather (55.9%) suggests that even under ideal driving conditions, other factors may significantly contribute to accidents. The 35.6% share of accidents occurring in rainy weather can be attributed to the increased slipperiness of the road surface and reduced visibility caused by rain. During rainy conditions, drivers may struggle to maintain control due to extended braking distances, slippery roads, and water puddles, which negatively affect vehicle traction and stability. Accidents in cloudy weather account for 3.7%, while snowy weather conditions are responsible for 2.8% of accidents. Cloudy weather is often associated with reduced light conditions and restricted visibility. Snowy conditions can decrease a vehicle's traction, leading to skidding and braking challenges. In foggy and smoky conditions, accidents represent 1.9% of the total. These conditions significantly reduce visibility, posing a major threat to drivers. In foggy or smoky weather, road boundaries and other vehicles may become invisible, making it difficult for drivers to adjust their speed and maintain safe distances. Finally, accidents during hailstorms account for only 0.1%. Hail is a rare but hazardous weather event that can severely disrupt driving conditions. However, since hailstorms are typically short-lived, their contribution to overall accident statistics remains minimal. Table 8 and Figure 9 present the number of accidents categorized by road surface conditions.

Table8. Number of accidents by road surface conditions.

	Number of accidents	Percentage of total number (%)
Dry	503	53,5
Wet/Humid	415	44.1
Snowy	12	1,3
Icy	7	0,7
Floody	2	0,2
Other slippery surface	2	0,2
Total	941	100

Figure9. Number of accidents by road surface conditions.

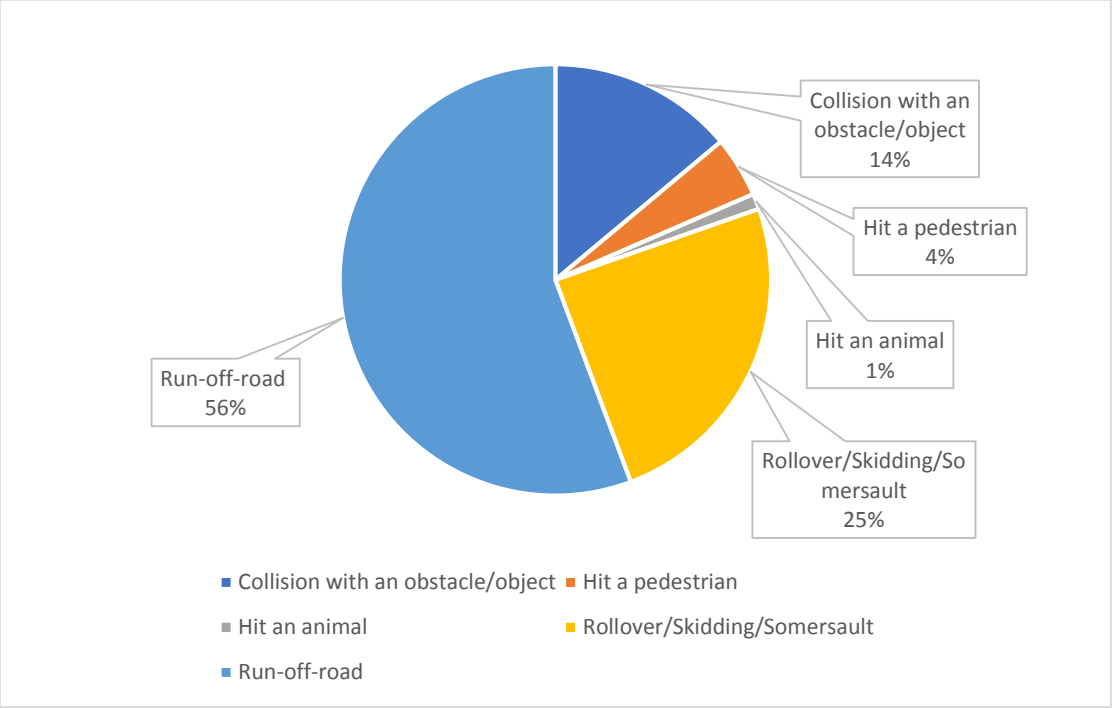


According to Table 8 and Figure 9, 53.5% of traffic accidents occurred on dry roads, while 44.1% occurred on wet or damp roads. Additionally, 2.4% of accidents occurred on roads with snow, ice, flooding, water puddles, and other slippery surfaces. This distribution clearly demonstrates the impact of road surface conditions on traffic safety. The 53.5% of accidents on dry roads suggests that even under ideal driving conditions, accidents can still occur. While dry road surfaces are typically perceived as safer by drivers, the highest accident rate was observed on these surfaces. This indicates the influence of driver errors and environmental factors. Accidents on wet and damp roads account for 44.1% of the total. The wetness of the road surface, caused by rain, snow, fog, or evaporation, increases the risk of skidding and losing vehicle control. On wet roads, braking distances are longer, and vehicles tend to skid. Additionally, drivers may not accurately assess the level of slipperiness, further increasing the risk of accidents. On wet roads, particularly in curves, failure to adhere to speed limits and weakened vehicle traction are key causes of accidents. Accidents on snowy, icy, flooded, or other slippery surfaces constitute a low percentage, 2.4%. However, accidents in these conditions tend to have more serious consequences. On snowy and icy roads, the risk of skidding is very high, and drivers face significant challenges with speed and braking. On such slippery surfaces, vehicle traction decreases, which can amplify the severity of accidents. Flooding and water puddles can obstruct the road, leading to loss of control and potentially more dangerous outcomes, such as vehicles being submerged in water. Table 9 and Figure 10 present information on the number of accidents categorized by accident type.

Table9. Number of accidents by accident type.

	Number of accidents	Percentage of total number (%)
Collision with an obstacle/object	131	13,9
Hit a pedestrian	43	4,6
Hit an animal	11	1,2
Rollover/Skidding/Somersault	232	24,7
Run-off-road	524	55,7
Total	941	100

Figure10. Number of accidents by accident type.



According to Table 9 and Figure 10, when the distribution of accidents by accident type is examined, it is found that 55.7% of accidents were due to running off the road, 24.7% were caused by the vehicle overturning, skidding, or rolling, 13.9% were due to collisions with obstacles or objects, 4.6% involved pedestrian collisions, and 1.2% were due to collisions with animals. The high percentage of accidents caused by running off the road (55.7%) highlights the critical impact of road geometry, driver behavior, and speed control in these types of accidents. Run-off-road accidents often occur on winding roads where drivers exceed speed limits, are distracted, or encounter slippery road conditions. Accidents where the vehicle overturns, skids, or rolls account for 24.7% of the total. These types of accidents are often linked to environmental factors, such as the road's slope and the geometric design of curves, which can cause loss of vehicle control. Collisions with obstacles or objects make up 13.9% of accidents. These typically involve crashes with fixed objects on the road (such as traffic signs, trees and barriers) or moving objects (such as spilled cargo). In these cases, lack of attention by drivers, environmental factors, or unexpected obstacles on the road can contribute to the accidents. Pedestrian collisions account for 4.6% of accidents. These generally occur in urban areas or near pedestrian crossings, often due to drivers not yielding to pedestrians or due to pedestrians' lack of attention. Although the percentage of pedestrian accidents is relatively low, these accidents tend to result in more serious injuries or fatalities. Collisions with animals make up a low percentage (1.2%) of accidents. These typically occur in rural areas or on roads near forests, where animals suddenly enter the road, creating unpredictable situations that can lead to accidents.

IV. CONCLUSION

The results of this study demonstrate how traffic accidents are associated with various road conditions, environmental factors, and driver behavior. The data from 941 accidents included in the study reveal that the majority of the accidents occurred outside residential areas. Specifically, 86% of the accidents took place outside residential areas, while 14% occurred within them. Roads outside residential areas generally have higher speed limits and longer distances, with geometric design features (such as horizontal curves and steep slopes) playing a significant role in the occurrence of accidents. Additionally, inadequate traffic control measures and drivers' non-compliance with speed limits on these roads further increase the risk of accidents.

One of the road sections with the highest number of accidents is the D.750-01 section. This section, with a length of 82 kilometers, accounted for 52.8% of all accidents, and the accident rate per kilometer was 0.16. While the accident rate per kilometer is lower than on other roads, the length of this road contributes to the high number of accidents. Furthermore, the majority of accidents occurred on horizontal curves (especially dangerous curves), indicating that these sections pose special risks. Drivers' failure to adhere to appropriate speeds for the curve design and exceeding speed limits are the primary causes of these accidents.

Road surface conditions also play a significant role in the occurrence of accidents. 53.5% of accidents occurred on dry roads, while 44.1% occurred on wet or damp roads. Wet road surfaces caused by rain or snow increase the risk of skidding and loss of control. Although accidents in snowy or icy conditions are less frequent,

they tend to have more severe outcomes due to the high risk of vehicle skidding. The distribution of accidents in foggy, snowy, and icy conditions underscores the importance of improving road infrastructure and driver awareness in these challenging weather conditions.

In conclusion, to enhance road safety, it is crucial to focus on improving infrastructure and driver education, particularly in areas with horizontal and vertical curves, steep slopes, and dangerous intersections. Strict enforcement of speed limits and better control of road surface conditions outside residential areas will also play a key role in reducing accidents.

Conflict of interest

There is no conflict to disclose.

ACKNOWLEDGEMENT

Traffic Department of the General Directorate of Security, Ministry of the Interior of the Republic of Turkey

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