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TRAFFIC SAFETY AND RISK ASSESSMENT OF KONYA DISTRICTS

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Highlights

- Determining the risky districts in terms of traffic accidents in Konya
- Analyzing traffic accidents depending on the population
- Types of traffic accidents and the effect of age factor on traffic accidents

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ABSTRACT: Road traffic accidents are a major problem worldwide, causing both loss of life and permanent disability. In order to prevent and reduce these losses and damages, it is very important to determine the causes of traffic accidents. Analyzing the population under the influence of traffic accidents can more realistically reflect the risk situation of the region in terms of traffic safety. The aim of this study is to analyze the situation of Konya districts in terms of traffic safety. For this purpose, the traffic accidents that occurred in 2019-2023 in 28 districts of Konya, excluding the central districts, were examined and the risk situation of the districts in terms of traffic safety was determined by the relative risk ratio. According to the results of the analysis, the districts with high relative risk value were determined as the most risky districts in terms of traffic safety. These districts are Ereğli, Karapınar, Seydişehir, Ilgın, Akşehir, Güneysınır, Beyşehir, Kadınhanı and Cumra. Yalıhüyük was found to be the district with the lowest risk. It was found that in the districts defined as high-risk, traffic accidents occurred mostly where the speed limit was 50 km/h. The relative risk rate was high in Ereğli, Karapınar, Seydişehir, Ilgın and Akşehir districts in all the years analyzed. For this reason, the types of accidents in these districts were studied and it was found that the most frequent type of accident was the side-on collision. In addition, it was found that the drivers involved in the most traffic accidents in these districts were drivers between the ages of 18 and 29. Such analyses are an important resource for the creation and implementation of traffic safety policies.

Keywords: *Traffic Accident, Relative Risk Ratio, Traffic Safety, Road Safety, Konya*

1. INTRODUCTION

Every year, road traffic accidents cause many deaths, serious injuries and financial losses. According to the World Health Organization (WHO) [1], approximately 1.19 million people lose their lives in road traffic accidents every year, and between 20 and 50 million people are injured, many of them with permanent disabilities. Road traffic accidents cause significant economic losses to individuals, families and countries. The cost of road traffic accidents is equivalent to 3% of gross domestic product in most countries. Road traffic accidents are the 12th leading cause of death worldwide. 82% of the traffic accidents that occurred in Turkey in 2023 resulted in material damage and 18% resulted in death or injury. As a result of these accidents, 350,855 people were injured and 6548 people lost their lives. Traffic accidents accounted for 1% of the causes of death in Turkey in the last five years [2]. Traffic safety analysis has emerged in order to understand the causes of traffic accidents and to contribute to the determination of appropriate measures to eliminate or reduce the occurrence of traffic accidents [3,4]. In order to prevent traffic accidents and to determine the necessary measures, accidents should be analyzed in detail.

Many causal factors such as human factors, environmental conditions, road, traffic characteristics, temporal-spatial factors, vehicle types of cause traffic accidents [5]. Although traffic accident statistics provide a general idea of traffic safety, each accident has its own unique reasons for occurrence. Sometimes a single factor causes an accident, and sometimes accidents can occur as a result of the interaction of several factors. Among the causes of traffic accidents, the human factor plays an important role [6,7] Factors such as driver inattention [8], speeding [9] or drunk driving [10] can cause accidents. In addition, road and traffic characteristics also play a role in the occurrence of accidents [11,12,13].

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For example, narrow and winding roads, areas with poor visibility are the points where accidents are common. Spatial impact also plays a big role in the realization of traffic accidents [14]. Therefore, it is necessary to analyze traffic accidents from a spatial point of view.

Spatially assessing accidents is an important step for identifying areas with high accidents, safe traffic regulations and infrastructure developments [15,16]. For example, measures such as widening narrow and winding roads or increasing visibility can help reduce accidents [17]. In addition, regular maintenance and updating of traffic signs and signaling systems is also effective in preventing accidents. For this reason, analyzing the places where accidents occur and making the necessary improvements is of great importance in terms of traffic safety.

To significantly reduce the number of accidents, it is necessary to determine exactly where and when accidents occur frequently [18,19,20]. Considering traffic accidents in the context of spatial and/or temporal dimensions helps to create the best and most consistent solutions [21].

It is important to analyze traffic accidents in two different categories, urban and extra-urban, to reach the right solution. Since the composition of urban vehicles and extra-urban vehicles are very different from each other, and the cross-section and geometric standards of urban and extra-urban roads are different, it is important to analyze them separately in order to reach the right solution [22,23]. Owing to the unique dynamics of traffic flow in rural areas as opposed to urban environments, the analysis of accidents in these regions requires special attention [24,25]. Mason et al. [26] have indicated that individuals in rural areas are 3.2 times more likely to die in road-related accidents than in urban residents. Baviskar & Kadam [27] highlighted the significance of rural road safety assessments, stating that the majority of fatal accidents occur on these roads. Tajnik & Luin [28] analysed traffic crashes in rural areas by examining a wide range of variables including driver characteristics, vehicle conditions and environmental factors. The study revealed that speeding contributes significantly to fatal accidents. It emphasizes the need for targeted safety measures by highlighting daily and weekly patterns of accident occurrences, with increased frequency during nighttime and afternoon peak hours.

The main causes of traffic accidents in rural areas include mass travel, lower grade roads, and poorer safety awareness among travelers. Additionally, the lack of traffic safety facilities contributes significantly to the high accident rates. Specific factors identified are not yielding to other vehicles, not keeping a safe distance, and speeding. These issues are due to drivers' bad habits and non-compliance with traffic safety laws, highlighting the need for improved road safety education and infrastructure [29]. The primary causes of traffic accidents in rural areas include collisions, particularly side impacts, head-on collisions, and trailing collisions, which account for nearly 80% of casualties. Most accidents occur on straight and curved roads, with over 95% of casualties happening in these conditions. Additionally, the lack of roadside protection, lighting, and physical isolation significantly contributes to the severity of accidents. Driving without a license and the prevalence of motorcycles also play a crucial role in rural traffic accidents [30]. Dissanayake & Ratnayake [31] identifies several critical factors contributing to traffic accidents in rural areas, including driver-related issues such as alcohol involvement, lack of seat belt usage, excessive speed, and driver ejections. Additionally, single-vehicle crashes tend to have higher severities compared to two-vehicle and animal-vehicle crashes. Roadway geometry factors, such as sharp curves and steep grades, also play a significant role in increasing crash severity on rural highways. Delayed emergency response times further exacerbate the situation.

Traffic accident analysis plays a critical role in the decision-making process of local governments. Accident data is used as a key indicator for planning and implementing safety measures, especially in densely populated areas. When analyzing traffic accidents, focusing on the number of accidents relative to the population can provide researchers with more reliable and comparable results. This approach is an important method for measuring the effectiveness of traffic safety policies, especially in areas with variable population density and traffic [32]. Comparisons between districts based directly on the number of accidents can often be misleading because they ignore important factors such as population density, traffic flow, and road use habits. Accident statistics adjusted for population allow for a more accurate assessment of safety.

In addition, traffic accident rates per capita provide a realistic basis for shaping local governments' policies and practices regarding traffic safety. These rates play a critical role in determining the specific measures and interventions that can be implemented in a particular district. For example, districts with low population densities but high accident rates per capita may require different types of traffic safety strategies compared to counties with dense populations but lower accident rates. Such data-driven approaches enable local governments to be more strategic and effective in improving traffic safety and reducing accidents.

As a result, the use of normalized accident rates according to the county population in the analysis of road traffic accidents allows county governments and local policymakers to make more informed decisions. This approach is an important step in shaping traffic safety strategies according to real needs. Such analysis is expected to enable more effective planning and implementation of traffic safety policies and practices.

In this study, the traffic safety situation of 28 districts of Konya province (excluding the central districts) has been evaluated. The aim was to analyze the traffic accidents that occurred in these districts between 2019 and 2023, and to determine the high-risk districts. It emphasizes that a significant number of traffic accidents also occur in rural areas, highlighting the need for detailed accident analyses for rural areas, like those conducted for urban centers. This study highlights the importance of conducting a comprehensive analysis of traffic accidents at the district level and provides a basis for future research.

2. MATERIAL AND METHODS

Konya is the 6th most populous province of Turkey and has a population of 2,320,241 in 2023. The population of Konya is about 2.7% of the total population of Turkey. Konya province ranks 7th in the number of road accidents that occurred in Turkey in 2022 [2]. Konya province is the largest province in Turkey with an area of 38873 km^2 and has 31 districts.

The aim of this study was to analyses the traffic safety status of Konya districts. In order to evaluate the road traffic accidents that occurred in the districts, road traffic accident data for the years 2019-2023 in Konya were requested from the Turkish National Police Traffic Presidency [33]. The traffic accident data used in the study consists of data from fatal and injury accidents. It does not include data on accidents resulting in material damage.

The coordination of traffic movement in the central districts is carried out through a network of urban roads connected to each other. On the contrary, the traffic flow in the districts other than the central districts relies heavily on the connectivity provided by intercity roads. For this reason, the traffic flow of the districts other than the central districts differs from each other. As a result of this difference in traffic patterns, the focus of the research is on the analysis of the remaining 28 districts, excluding the central districts (Karatay, Meram, Selçuklu), which exhibit a more integrated traffic flow system among themselves.

In order to determine the traffic safety status of 28 districts of Konya outside the central districts, traffic accidents for the years 2019-2023 were examined. In Konya, 61.1% of the traffic accidents in the last five years took place in the central districts and 38.9% in the districts outside the central districts (Table 1). This shows that the share of districts in traffic accidents should not be ignored. According to the population distribution of Konya in the last five years, 60.9% of the population lives in the central districts (Karatay, Selçuklu and Meram) and 39.1% in other districts (Table 2). It is interesting to note that the accident statistics and the population distribution of the last five years are the same in Konya. This confirms that there is a very strong relationship between population and traffic accidents. According to the linear regression analysis, the R^2 value, which shows the strength of the relationship between the variables, was obtained as 0.895 for both central districts and other districts. The relationship between population and traffic accidents depends on factors such as population density, urbanization rate, economic development and infrastructure quality. In general, as the population increases, traffic accidents increase, but this increase can be controlled by traffic management and safety measures. Therefore, it is important to develop strategies that will reduce accidents depending on the population in both central and rural areas.

Table 1. Traffic accidents in Konya province [14]

Year	Number of accidents in the central districts	* Number of accidents in districts	Accident in the central districts (%)	*Accident in districts (%)
2019	3096	2118	59,4	40,6
2020	2335	1682	58,1	41,9
2021	3099	1992	60,9	39,1
2022	3481	1958	64,0	36,0
2023	4385	2575	63,0	37,0
Average			**61,1**	**38,9**

* Number of accidents in 28 districts of Konya outside the central districts

Table 2. Population distribution of Konya by years [2]

Year	Population in the central districts	*Population in districts	Population in central districts (%)	*Population in districts (%)
2019	1.346.330	886.044	60,3	39,7
2020	1.359.251	890.769	60,4	39,6
2021	1.390.051	886.966	61,0	39,0
2022	1.409.919	886.428	61,4	38,6
2023	1.419.031	901.210	61,2	38,8
Average			**60,9**	**39,1**

* Population data of 28 districts of Konya outside the central districts

It is planned to conduct accident analyzes in order to determine the effectiveness of the population in traffic accidents. When Table 1 and Table 2 are evaluated together, there is a one-to-one relationship between the population and the number of traffic accidents in Konya. In this study, it was decided to use the relative risk ratio to determine the population at risk.

The relative risk ratio is used in various fields such as road traffic accidents, natural disasters and health problems. Particularly in the field of road safety, the identification of areas of relative risk contributes to the adoption of preventive measures and the development of road accident prevention policies [34].

The relative risk ratio is the ratio of the observed rate to the average rate calculated for the whole data set. If this ratio is less than 1, it indicates a lower risk than the average, and if it is greater than 1, it indicates a higher risk than the average [34,35,36]. Rather than just interpreting the results in terms of the number of accidents, the relative risk ratio also allows the accidents to be evaluated in terms of the number of people they affect [22,37].

In this study, the accident and population values of each district in the five-year period were determined and the relative risk ratios (RRR) were calculated (Equation 1).

$$RRR = \frac{\frac{Number\ of\ traffic\ accidents\ in\ the\ analyzed\ district}{population\ of\ the\ analyzed\ district}}{\frac{(Total\ number\ of\ traffic\ accidents\ in\ all\ districts - number\ of\ traffic\ accidents\ in\ the\ analyzed\ district)}{(Total\ population\ of\ all\ districts - population\ of\ the\ analyzed\ district)}}$$

3. RESULTS AND DISCUSSION

The relative risk ratios of Konya districts, which were generated using the traffic accident data that occurred between 2019 and 2023, were visualised using ArcGIS software (Figure 1). High-risk districts with a relative risk ratio greater than 1 are Ereğli, Karapınar, Seydişehir, Ilgın, Akşehir, Güneysınır, Beyşehir, Kadınhanı and Çumra. The medium-risk districts are Çeltik, Kulu, Tuzlukçu, Sarayönü, Yunak, Doğanhisar and Cihanbeyli. The district with the lowest risk is Yalıhüyük, which has never had a traffic accident with fatalities or injuries.

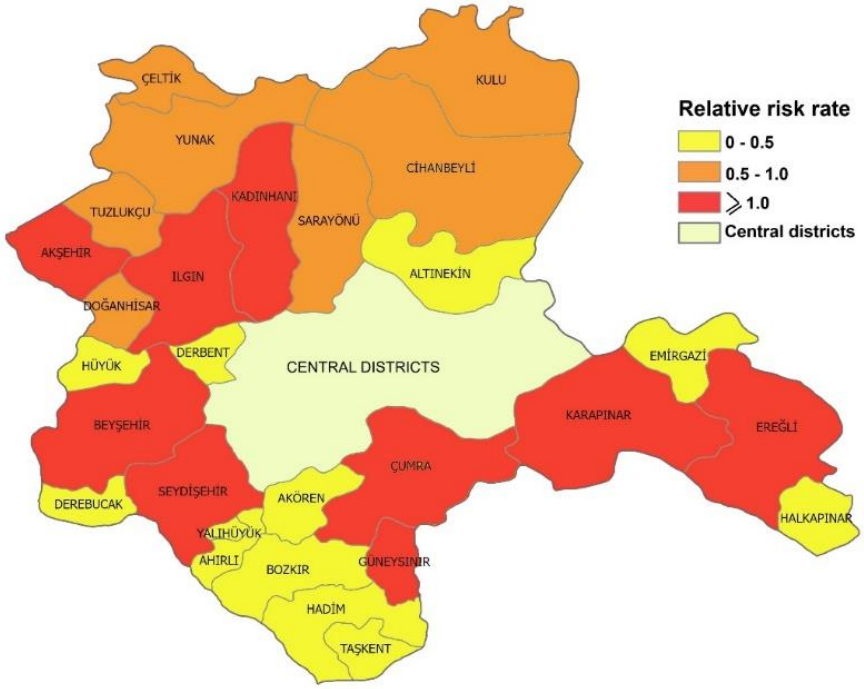


Figure 1. Distribution of districts according to relative risk ratios (Central districts are excluded from the analysis)

To show the difference between the number of accidents and the relative risk ratio in assessing road traffic accidents, the number of accidents and the relative risk ratios calculated for the districts over the 5-year period are shown in Figure 2. Districts with a relative risk ratio greater than 1 were defined as high-risk. Accordingly, nine districts were found to be at risk. The districts of Çeltik and Kulu, whose relative risk ratios are close to the line of 1, seem to be candidates to become high-risk districts in the future if no measures are taken against road traffic accidents. Ereğli is the district with the highest value in terms of both the number of accidents and the relative risk ratio. The fact that there are few traffic accidents in the district in terms of numbers does not mean that there is no risk situation for the district. The situation that best explains this is that of Güneysınır. Although the number of accidents in the district was low, the relative risk rate was high (Figure 2).

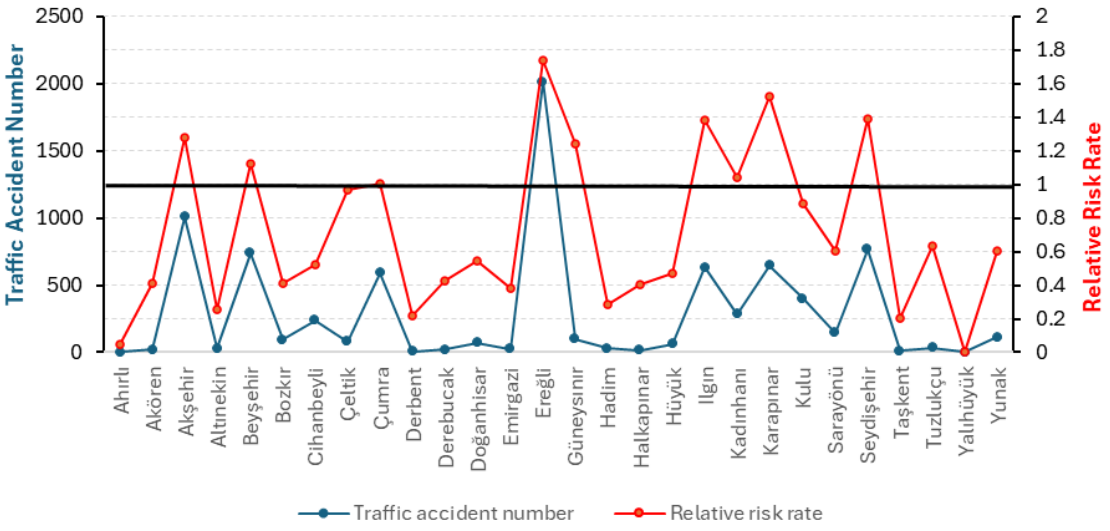
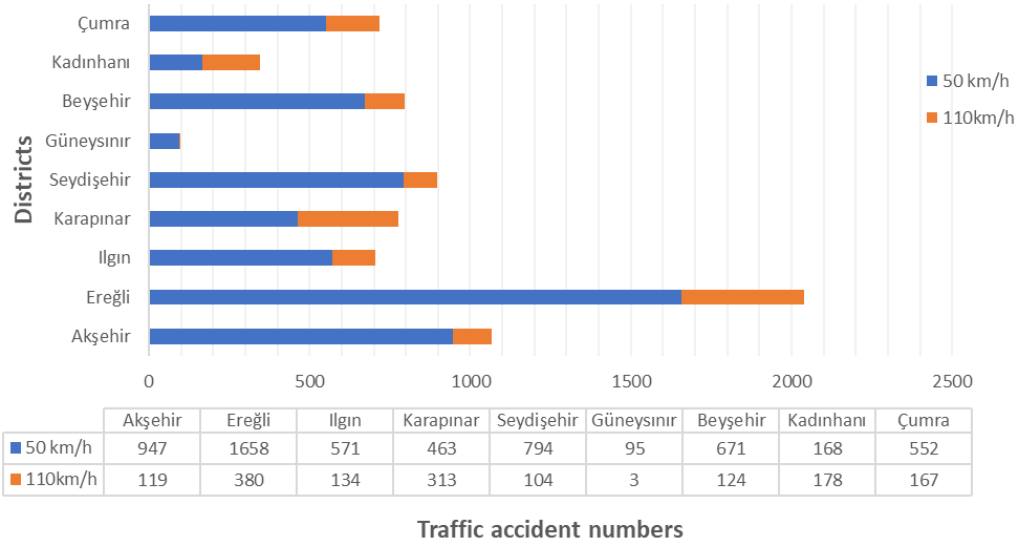


Figure 2. Comparison of the traffic accident numbers and relative risk ratios of districts

The establishment of appropriate speed limits and the mitigation of speeding behavior are pivotal components of risk regulation strategies and are regarded as critical priorities for effective intervention. Recent experience with speed limit increases has confirmed the positive relationship between speed and injury. Lowering speed limits has been shown to significantly contribute to a reduction in traffic fatalities and injury accidents, highlighting its effectiveness as a crucial measure in enhancing road safety [38, 39, 40]

The relationships between the speed limits of the roads where traffic accidents occur in the districts defined as high-risk (relative risk rate ≥1) and traffic accidents were analyzed. According to this, traffic accidents occurred more on roads with speed limits of 50 km/h and 110 km/h. 70% of traffic accidents occurred on roads with speed limit of 50 km/h, and 18% on roads with speed limit of 110 km/h. The numerical distribution of traffic accidents in each district according to these speed limits is shown in Figure 3. Roads with a speed limit of 50 km/h are generally roads in the district center, while roads with a speed limit of 110 km/h are interurban roads. The common situation in the districts other than Karapınar and Kadınhanı is that traffic accidents occurred on roads with a speed limit of 50 km/h. This explains why the vast majority of accidents in these districts occurred in the district centers. In Karapınar district, the number of accidents on 50 km/h and 110 km/h roads was close to each other. For this reason, it is necessary to take precautions both on the roads in the center of Karapınar and on the highways. It was found that traffic accidents in Kadınhanı district generally occur on roads where the speed limit is 110 km/h. This situation shows that more priority should be given to traffic safety on intercity roads in Kadınhanı district. Measures such as stricter speed enforcement, speed cameras, improved signage and better lighting should be implemented. These could include reducing the speed limit in accident-prone areas, installing warning signs about potential hazards, and adding physical barriers or guardrails to prevent run-off-road accidents. Additionally, improving road conditions, such as resurfacing or better marking lanes, along with periodic traffic safety audits, would help reduce the risk of accidents on intercity roads.

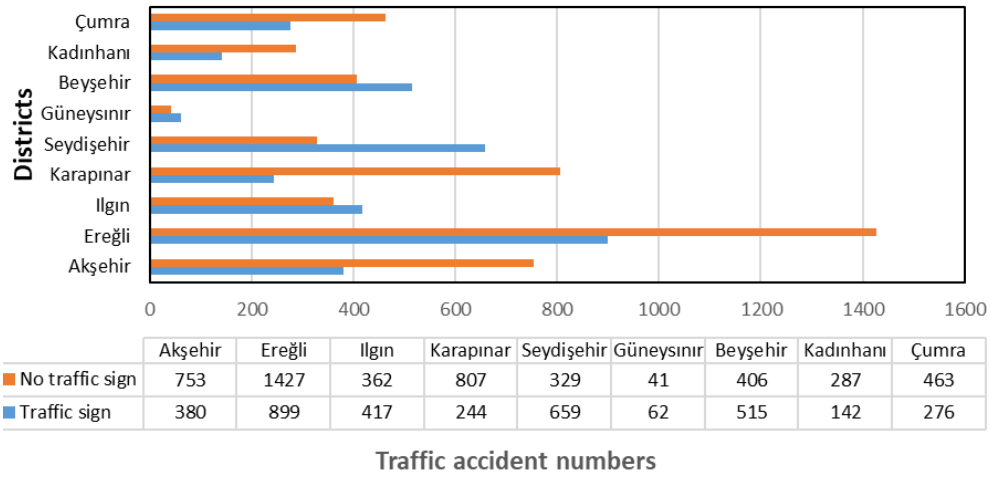


	Akşehir	Ereğli	Ilgın	Karapınar	Seydişehir	Güneysınır	Beyşehir	Kadınhanı	Çumra
50 km/h	947	1658	571	463	794	95	671	168	552
110km/h	119	380	134	313	104	3	124	178	167

Figure 3. Distribution of the traffic accident numbers according to the speed limits of risky districts

Traffic signs are one of the most important factors in ensuring the safe and orderly flow of traffic by correctly directing pedestrians and drivers in traffic. Studies have been carried out in different provinces to measure the level of awareness of traffic signs [41, 42,43, 44]. Both human-related factors (age, gender, education level, etc.) and the regional difference factor are highly effective on traffic sign awareness [45]. In this study, in order to investigate the effect of traffic signs on accidents, it was examined whether traffic signs were present at the locations of traffic accidents in the districts. It is an expected result that the number of accidents is high in places where there are no traffic signs. However, an unexpected result is that there are too many accidents despite the presence of traffic signs. Although there are traffic signs in Beyşehir, Seydişehir and Ilgın districts, there are more traffic accidents in these districts (Figure 4). Traffic

signs, especially mandatory and warning signs, can reduce traffic accident rates, but low visibility and invalid signs increase accident rates [46, 47]. The higher number of traffic accidents in Beyşehir, Seydişehir, and Ilgın districts, despite existing traffic signs, suggests the need for more effective signage. Warning signs for sharp curves, intersections, and pedestrian crossings should be more prominent in high-risk areas. Speed limit signs should be larger, illuminated, or placed at regular intervals, especially in accident-prone zones. Variable Message Signs (VMS) could provide real-time road updates, while clearer lane markings and directional signs can reduce confusion at junctions. Reflective or illuminated signs would improve visibility at night. Therefore, these districts should be inspected to ensure that traffic signs are clear and correctly positioned. In addition, it would be appropriate to measure the level of awareness of traffic signs among road users and take the necessary solutions.



	Akşehir	Ereğli	Ilgın	Karapınar	Seydişehir	Güneysınır	Beyşehir	Kadınhanı	Çumra
No traffic sign	753	1427	362	807	329	41	406	287	463
Traffic sign	380	899	417	244	659	62	515	142	276

Figure 4. Distribution of the traffic accident numbers in the districts according to the traffic sign situation

In order to evaluate the change in risk situations for the districts over the years, the relative risk ratios of Ereğli, Karapınar, Seydişehir, Ilgın, Akşehir, Güneysınır, Beyşehir, Kadınhanı and Çumra districts with a relative risk ratio above 1 were calculated separately on a yearly basis (2019-2023). In Ereğli district, the relative risk rate has been quite high in all years. The risk situation continues every year in Karapınar, Seydişehir, Ilgın and Akşehir districts. For Beyşehir and Kadınhanı districts, it is seen that the risk situation has increased in recent years and precautions should be taken (Figure 5).

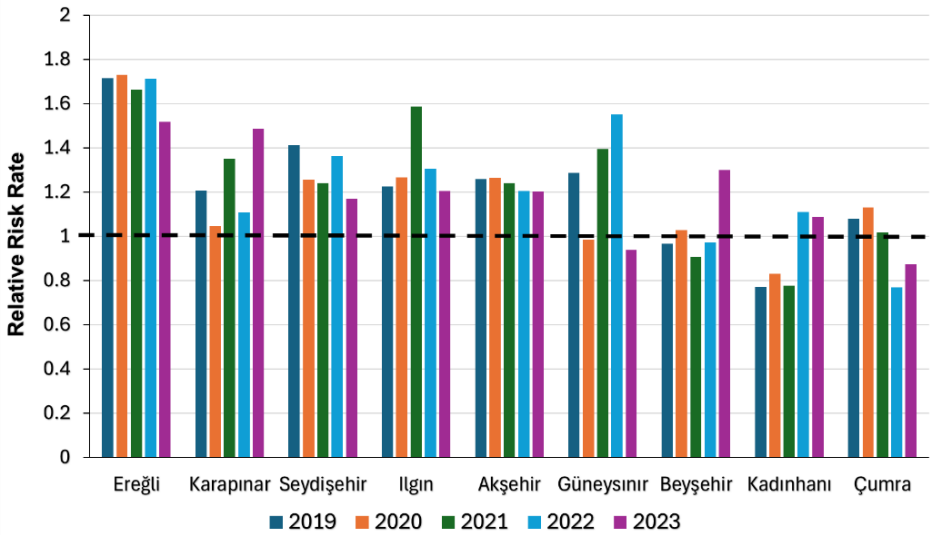


Figure 5. Relative risk rates of risky districts by years

In order to analyze in more detail, the situation of the districts whose risk status continues every year for five years, traffic accidents that took place between 2019-2023 in Ereğli, Karapınar, Seydişehir, Ilgın and Akşehir districts were examined according to the types of accidents. Although the population numbers of these districts vary, there are similarities between the types of accidents. According to the types of accidents, the most common accidents occurred in the form of side-on collisions (Figure 6). Accidents in the form of side collisions occur due to reasons such as the driver's inability to adjust his speed according to the conditions required by the road, weather and traffic, non-compliance with the rules of priority of passage at intersections, and sometimes the absence of additional lanes in a way that does not disturb the traffic flowing from the connection roads to the main road. Then there are accidents in the form of run-off-road and pedestrian collision. It is seen that measures for pedestrians should be increased in ensuring traffic management in these districts.

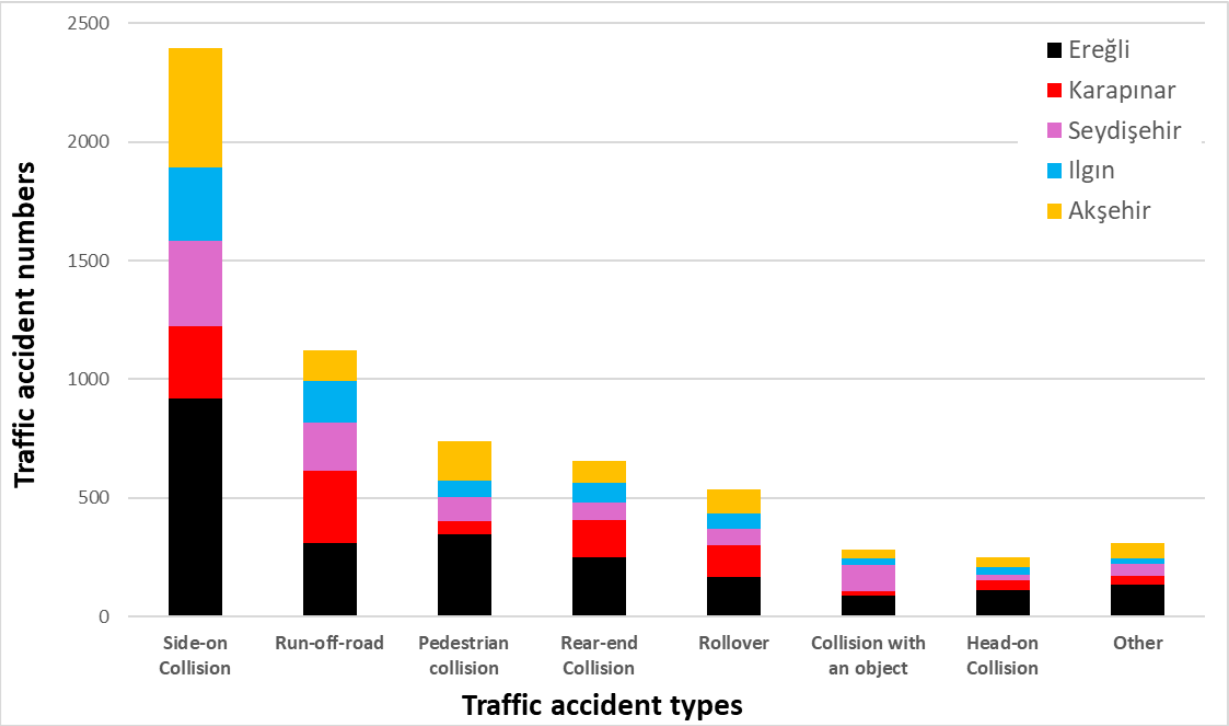


Figure 6. Status of districts according to the types of accidents

In our country, the driver factor ranks first with 88.9% of the fault rate in road accidents [2]. Driver behaviour and skills are important human factors influencing accidents [48]. Driving skills are directly related to driving performance. In addition to driving skills, the most important psychological factor associated with crash risk is negative or deviant driving behavior [49]. Looking at age groups, young drivers are more exposed to and at greater risk of road crashes than older drivers, and road crashes are the leading cause of death among young people [50-53].

The percentages of drivers in five districts defined as high-risk (Ereğli, Karapınar, Seydişehir, Ilgın and Akşehir) to suffer age-related traffic accidents are presented in Figure 7. Young drivers (18-29) were most exposed to accidents in Ereğli district, and drivers over the age of 60 were most exposed to accidents in Akşehir district. The priority risk group for all districts consists of driver profiles between the ages of 18-29. Driving skills are not about driving fast, they are about driving safely. This awareness should be given to young drivers through training and adopted as a safety culture.

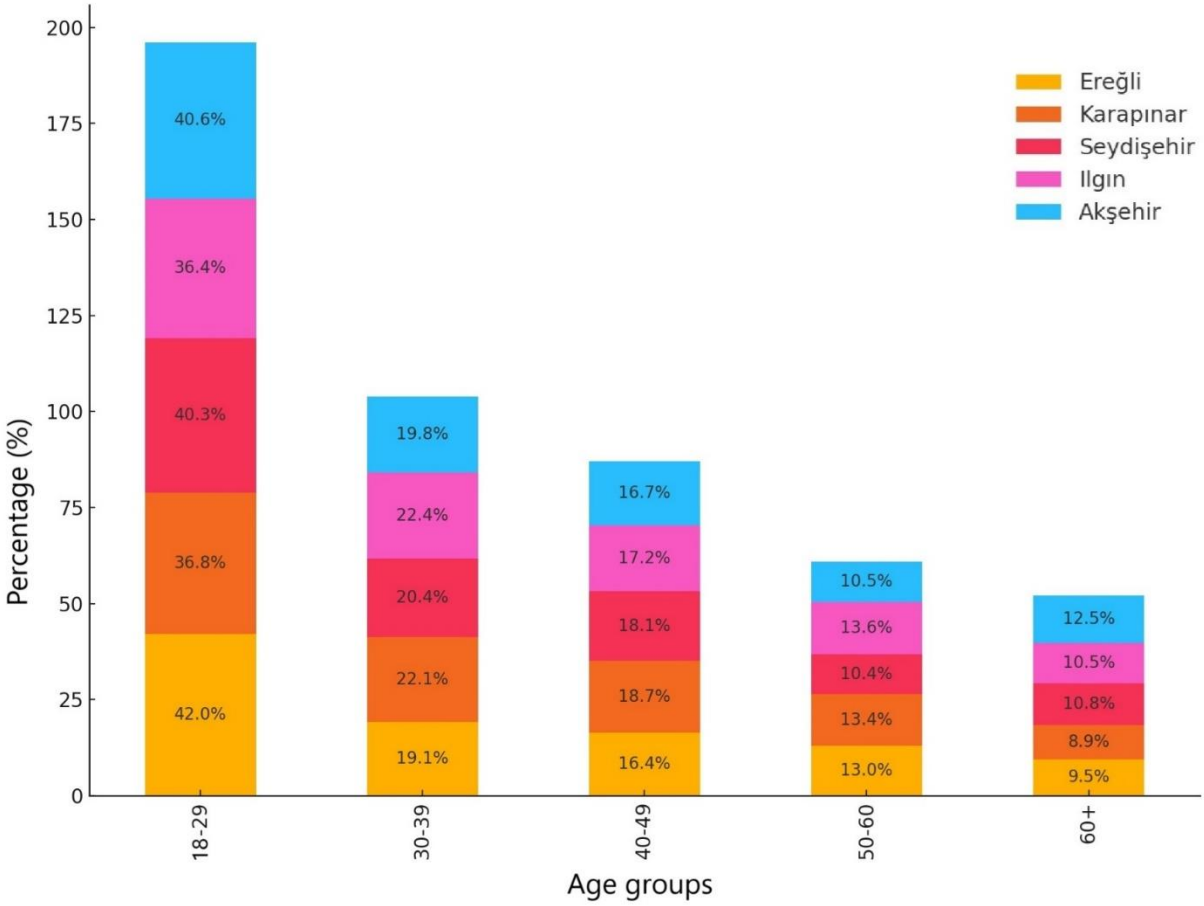


Figure 7. Age distributions of drivers in traffic accidents for districts

4. CONCLUSIONS

Traffic safety studies are typically conducted at a macro level, leaving micro-scale regions like districts less explored. This study aims to address this gap and contribute to literature. By analyzing traffic accidents in smaller areas like districts, the causes can be identified, helping reduce accidents in larger areas like city centers and their connections. This study examines traffic accidents from 2019-2023 in 28 districts of Konya, excluding central districts. Notably, 40% of Konya's traffic accidents occurred in these districts, highlighting the importance of understanding their impact. Thus, a detailed analysis of the cause-and-effect relationship of district-level accidents was conducted.

Between 2019-2023, 61% of Konya's population was in central districts, and 39% in other districts. Traffic accident data showed the same distribution: 61% in central districts and 39% in other districts. This direct correlation between population and accident rates is notable. Future studies could explore similar patterns in other provinces, helping to guide financial support for traffic safety measures.

By analyzing traffic accidents in Konya's districts from 2019-2023 using relative risk ratios, nine high-risk districts were identified: Ereğli, Karapınar, Seydişehir, Ilgın, Akşehir, Güneysınır, Beyşehir, Kadınhanı, and Çumra. Ereğli was found to be the riskiest district. Accidents mainly occurred on roads with speed limits of 50 km/h and 110 km/h. Notably, in Kadınhanı, most accidents were on 110 km/h roads, highlighting the need for safety measures on intercity roads in this district.

The study also examined the impact of traffic signs on accident rates. Despite the presence of traffic signs, Beyşehir, Seydişehir, and Ilgın districts had higher accident rates on signed roads compared to unsigned ones. This suggests the need to assess drivers' awareness of traffic signs and implement appropriate measures in these areas.

The five districts with the highest relative risk (Ereğli, Karapınar, Seydişehir, Ilgın, and Akşehir) consistently maintained their high-risk status over the years, indicating the need for urgent intervention. Analysis showed that side-on collisions were the most common, followed by run-off-road and pedestrian collisions. Drivers aged 18-29 were the most involved in accidents, likely due to speeding tendencies and low risk perception, highlighting the need for targeted safety measures for young drivers. Road safety campaigns should be developed, focusing on educating drivers about the risks associated with speeding and the most common types of accidents. Improvements in road infrastructure, including clearer signage, better lane markings, and enhanced pedestrian safety measures, are also necessary to mitigate accident risks. Speed control interventions, such as the installation of speed bumps, traffic-calming devices, and automatic speed cameras, should be implemented in areas with high accident frequencies.

This study will guide the prioritization of risky districts and the authorities on where security improvements should be implemented. There is a need for risk assessment studies to be carried out with traffic accident data at regional levels. The measures to be proposed will also contribute to region-specific, realistic practices. With such studies, new accident formations can be prevented, and traffic safety management can be carried out proactively.

DECLARATION OF ETHICAL STANDARDS

The author declares that all ethical guidelines including authorship, citation, data reporting, and publishing original research are followed.

DECLARATION OF COMPETING INTEREST

The author declares that there is no conflict of interest.

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DATA AVAILABILITY

All data generated or analyzed during this study are included in this published article.

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