Road Accident Hotspots on Jordan’s Highway

Subjects: Engineering, Civil
Contributor: Shatha Aser Aldala’in, Nur Sabahiah Abdul Sukor, Mohammed Taleb Obaidat, Teh Sabariah Binti Abd Manan

One of the primary objectives of transportation engineering is to increase the safety of road infrastructure. This research seeks to determine the relationship between geometric design parameters in relation to road accident criteria based on accident hotspots on Jordan’s Desert Highway.

Keywords: road accident hotspots ; geometric design ; structural equation modeling

1. Introduction

The growing number of road accidents has a significant impact on the road safety, sustainability, and socioeconomic development of countries. The World Health Organisation's report in 2021, approximately 1.3 million individuals are involved in road accidents annually, with 90% of fatalities occurring in countries categorized as low- and middle-income. Road safety analysis has emerged to assist local authorities in implementing appropriate measures to reduce the number of road accidents.

Highway 15 in Jordan (also known as the Desert Highway connecting Aqaba to Amman, 420 km) is a South–North link that receives 1,825,000 million vehicles per year. The desert highway recorded 107 fatal accidents in 2019. The alarming increase in road accident deaths and injuries in recent years has led to the identification of road accident hotspots. Therefore, accident route identification is a critical step toward total road safety improvement. This can be achieved via hazard metric assessment for accident hotspots, marking them for further investigation and improvement.

In the context of road safety, a cost-benefit analysis primarily examines the benefit of higher security or decreased risk. Improving road safety can provide significant economic benefits to Jordanians. Several economic gains can be realized by reducing the number of road accidents, injuries, and fatalities. Here are a few ways that improved road safety can benefit the Jordanian community: lower healthcare costs, enhanced tourism and investment, increased productivity, and lower vehicle repair costs. A total of 161,511 road accidents were recorded in 2019, resulting in 633 fatalities and 17,013 injuries, with an estimated total loss equivalent to $456.99 million US dollars.

According to many studies, Zhao et al. (2021), AlKheder et al. (2022), Galante et al. (2022), Gargoum et al. (2022), Khedher and Yun (2022), and Macedo et al. (2022)), bettering road design is the only way to increase road safety and decrease the frequency and severity of accidents. Jordan is one of the developing countries that is facing a high number of road accidents. Furthermore, the roads in Jordan experience serious geometric design problems.

A “hotspot” (also known as a black spot) is the category assigned to a road location that has recorded high numbers of accidents compared to other locations. Generally, accident-prone location(s) will be identified during the initial phase of the road safety management process. The identification of road accident hotspots is a systematic method for identifying road segments with a high accident risk that exceeds the standard limit of road safety. The GIS software is a large geographic database and is a useful tool to determine hotspots. It can visualize accident locations (mapping) and run spatial analysis (spatial clustering) on traffic accidents.

Despite the fact that the aforementioned studies drew attention to clusters of road accidents, they did not conduct statistical significance tests to analyze their spatial distribution. In this context, very few studies have attempted to comprehend the spatial distribution of road accidents in Jordan, even though there is a great deal of accident data. In many previous studies, road accident counts were frequently used to assess a position’s safety issues. Prior studies have indicated that the absence of a severity index for road accidents poses a challenge in discerning the occurrence of a high or low cluster. There is a consensus that accidents of a more severe nature are accorded greater significance in the determination of accident hotspots, as per accident expenditures. In order to identify hotspot locations, it is recommended to assign weights based on the severity index, as suggested by.

2. Road Accident Hotspots

The spatial clustering of hotspots can be mapped in point forms using statistical mapping approaches (tools or programs in the GIS), such as K-means, Moran I Incremental Spatial Autocorrelation Method Statistics on Getis Ord Gi, Moran I Incremental Spatial Autocorrelation Method, and Kernel Density Estimation (KDE).
In their study, Manap et al. utilized Getis-Ord Gi* to detect 25 hotspots along the North–South Expressway in Kuala Lumpur. The study was based on a case analysis spanning from 2016 to 2019 which encompassed over 47,359 accidents. Sixty-four percent of the total hotspots were located at exit ramps, existing interchanges, rest areas, or slip roads, which had a total of 16 hotspot locations. The study found that accident hotspots occurred when traffic flow was disrupted. Bil et al. identified the road accident hotspots using Getis-Ord Gi* from another perspective. Between 2010 and 2018, a total of 55,296 road accidents were analyzed in rural sections of the primary roads (3933 km) of the Czech road network. The road network’s length was found to be covered with identified road accident hotspots, ranging between 6.8% and 8.2%. The proportion of road accidents occurring in hotspots exhibited a consistent trend of approximately 50% over an extended period. Spatiotemporal crash patterns were examined, and three types of hotspots were discovered: those that emerge, those that persist, and those that vanish. Only 100 hotspots exhibited stability throughout the complete nine-year duration.

Choudhary et al. compared statistical techniques in the town of Varanasi using five years of accident data (2009–2013). Using Getis Ord Gi*, Kernel Density Estimation, and Moran’s I, the spatial clustering of road accidents and the spatial densities of hotspots were analyzed. With a variety of severity grading systems, this approach assessed the impact of minor and property-damage-only accidents on overall outcomes. The z-value, which is associated with statistical significance, was used to rank hotspots using Gi*. Based on pixel values collected from various locations, K was used to rank hot spots. The hot spot analysis results identified specific road segments and intersections with a high concentration of hotspots. The study conducted by Rahman et al. investigated the incidence of fatal road accidents in Bangladesh through the utilization of a novel newspaper-based approach that employed grids to establish a comprehensive database of road traffic fatalities. The Getis-Ord Gi* was employed to delineate spatiotemporal hotspots and trends. The results indicate discernible trends in road accident occurrences between urban and rural regions of Bangladesh, with Dhaka and Sir Aqan in the northern part of the country exhibiting elevated incidence rates.

The study conducted by Hazaymeh et al. investigated the temporal and spatial patterns of traffic accidents in Irbid Governorate over a period of five years, from 2015 to 2019, based on available data. The study utilized the Global Moran I index and hotspot analysis (Getis-Ord Gi*) techniques in ArcGIS to identify the road accident hotspots. The research findings revealed a significant rise of 38% in a year-on-year comparison. The analysis of severe road accidents led to the identification of hotspot locations. The Irbid Governorate’s internal road network, which has the area’s highest traffic volume, was found to be the primary site of minor road accidents. The research used Getis-Ord Gi* and spatial autocorrelation at 90% and 95% confidence intervals to identify a clustering trend among arterial and internal road network segments.

The National Highway (NH-66) in Alappuzha, Kerala, India, is an 8 km flat stretch. To begin, accident data from the NHAI office and the police station in the area above was gathered. The data were then analyzed using the severity index. The severity index method was used to pinpoint the location of the hotspot. Short-term and long-term measures were implemented depending on the severity of the accident. After considering short-term steps, a total of ten hotspots and estimates of their locations were discovered.

A recent study conducted by Al-Rousan et al. aimed to investigate the characteristics of distracted-driving accidents on countryside and suburban roads in Jordan. The researchers utilized independent sample t-tests and descriptive analysis to analyze the data. However, the spatial dimension of traffic accidents was ignored in these analyses. To date, there have only been a handful of studies that have attempted to map out where exactly in Jordan car accidents tend to occur. The study conducted by Alkhadour et al. employed the nearest neighbor index analysis to examine road accidents recorded in Amman, Jordan. The findings of the study suggest the existence of spatial aggregation and recurrent occurrences of vehicular collisions within the analyzed area. The findings of the study confirm that regions with a notable frequency of vehicular collisions were primarily clustered in residential, commercial, and industrial areas located within and near the central regions of the examined locality.

3. Road Geometric and Road Safety

Alghafli et al. conducted a study with the aim of examining how conditions of geometric roads affect safety performance indicators, including severe accidents and property damage. The researchers utilized a negative binomial regression model in order to attain this objective. According to the research findings, a considerable number of collisions and incidents of disregarding traffic signals occur at intersections where minor streets intersect with three or four major roads. One potential solution to address this issue involves the expansion of the number of lanes on minor streets, thereby transforming them into major streets. Consequently, the minor street’s capacity to manage augmented traffic originating from major streets experiences a substantial enhancement. The results indicate that the velocity of traffic is a significant factor in the decline of safety outcomes observed at these intersections.

Islam et al. have studied various factors that can influence the frequency of accidents. These factors include sight distance, the number of lanes, median width and type, superelevation, shoulder and lane width, gradient, horizontal and vertical alignment, and curve radius. The absence of a reliable methodology for assessing the correlation between road
geometric design and safety, coupled with the interaction between geometric design components and other contributing factors, has led to an increased incidence of traffic accidents.

The study conducted by Jung et al. \[61\] was a quantitative investigation aimed at assessing the adequacy of Korea's primary road safety policy and identifying additional measures necessary for freeway sections featuring combinations of vertical and horizontal curves. The severity of cluster-based crashes was determined by using binomial logic regression and K-means clustering to analyze the effects of causal factors. Consequently, six models for predicting crash severity were developed using cluster analysis. One cluster contained information on the action, driver age, traffic management parameters, and crash prevalence, which was compared to the entire data model. The results indicate that a multidirectional approach to main road safety policies is necessary, particularly with regard to curve alignment possibilities, in order to improve current policies.

Garnaik \[62\] studied 70 km of roads and found that geometric elements of road alignment, such as superelevation, radius, K-value, distance/visibility of sight and vertical gradient, are very significant in causing accidents on both plain and rolling roads as well as mountainous and steep terrain. Meanwhile, the horizontal arc length, deflection angle, vertical curve length, and rate of change of superelevation are insignificant to accidents on both the highway and mountainous and steep terrain. The study conducted by Lin et al. \[63\] employed a regression model to examine road accidents occurring at intersections during the period spanning from 2018 to 2019. It was found during the observation period that 68% of the surveyed three-way intersections had no recorded incidents of traffic accidents. Consequently, the research employs zero-inflated models to construct a framework that discerns noteworthy factors that impact the gravity of vehicular collisions at three-way intersections. The findings of the study suggest the presence of two discrete classifications of factors that impact the likelihood of vehicular collisions at three-way intersections. The initial classification pertains to the dimensions of the provincial road, encompassing the width of the dividing line, the expanse of the shoulder, and the number of lanes. The subsequent classification pertains to the availability of amenities such as convenience shops, supermarkets, petrol stations, and other points of interest, including public retail markets, at the intersection. Roshandeh et al. \[64\] conducted an investigation into the impact of environmental, traffic, intersectional geometric, and pavement-related factors on the total number of collisions occurring at intersections. The study utilized a Poisson model with random parameters to examine collision data collected from 357 signalized intersections located in Chicago during the period spanning from 2004 to 2010. The findings suggest that the examined variables, specifically the standard of pavement, unilluminated intersections, and the quantity of traffic during the evening rush hour, exert the most notable influence on the frequency of collisions. The results indicate that it is crucial to prioritize the adequate maintenance of pavements and appropriate illumination of intersections to effectively promote safety measures pertaining to highways at intersections.

Retallack and Ostendorf \[65\] demonstrated the relation by analyzing accidents at 120 intersections in Adelaide, Australia. Among more than five million hourly measurements, a dataset of 1629 accidents involving motorized vehicles was discovered. The effects of rainfall were also studied. The correlation between accident frequency and traffic volume was essentially linear for lower traffic volumes, according to the findings. Poisson and negative binomial models exhibited a robust quadratic explanatory component as accident frequency increased at a faster rate with increasing traffic volume. In Abu Dhabi, Alghaffi et al. \[66\] carried out a study using a negative binomial regression model. The study aimed to identify the influence of geometric design conditions, such as the number of lanes in three-leg, four-leg, and other intersection types, on severe accidents, red light violations, safety performance indicators, and property damage. The study indicates that most accidents and traffic light violations take place at intersections with three or four legs where minor streets intersect. Expanding the number of lanes on the minor streets could be a potential solution to this issue, which would effectively transform them into major streets.

In order to ascertain the correlation between road alignment, road geometry, traffic conditions, and crash frequency, Kronprasert et al. \[67\] developed accident prediction models for two-lane rural horizontal curve segments. According to the research, lane width is more crucial than traffic volume, curve radius, and curve type in determining accident frequency. Musa et al. \[68\] also discovered these issues with accident severity by using databases from the public works and police departments, which contained 1067 cases of varying degrees of severity recorded on Malaysian roads between 2008 and 2015. Nine different variables were examined and developed into an ordered regression model for the severity of accidents using these records. The findings showed that poor horizontal alignment had an impact on the model's predictions. In comparison to the absence of such factors, the probability of a more severe accident caused by bad horizontal alignment was correspondingly about 0.4 times lower.

The combination of a horizontal curve and a gentle slope on a mountain highway increases safety, whereas combinations of a horizontal curve and a steep slope or a vertical curve and a horizontal curve increase the risk of an accident. When the concave vertical curve and horizontal curve are combined, the risk is marginally lower than when horizontal curves and convex vertical curves are combined. In mountainous areas, it is advantageous to control vertical slopes and lessen the intersection of vertical curves and horizontal vertical curves \[69\].

The Intersection is the most prevalent location for vehicle accidents. Intersections on single-level highways are among the most hazardous locations for vehicle accidents Alghaffi et al. \[66\]. From the traffic accident database of Harbin, 1758 valid intersection accident samples and nine categories of features were taken in order to study the spatial distribution patterns
of traffic accidents at urban road intersections and identify the critical factors affecting the severity of accidents. The findings demonstrate that the severity, intersection density, and road network density all affect how intersection accidents are distributed spatially. For each of the three types of areas, significant factors include the type of accident, the time of day, and the type of intersection.

References

15. Al-omari, B.; Guzlan, K.; Hasan, H. Traffic Accident Trends and Characteristics in Jordan. 2013. Available online: [https://pdfs.semanticscholar.org/db9e73c8a37e2837b927eb24b2be79de5e5e945.pdf](https://pdfs.semanticscholar.org/db9e73c8a37e2837b927eb24b2be79de5e5e945.pdf) (accessed on 18 July 2022).


Retrieved from https://encyclopedia.pub/entry/history/show/113107