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Spatiotemporal Analysis of Property Damage-only Accident Hotspots Using GIS in Sharjah, UAE

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ABSTRACT

Recent research on road-traffic accidents (RTAs) has become a focal point for safety and transportation experts, focusing on understanding their rates, characteristics, causes and effects. A significant development in this field is using Geographic Information Systems (GISs) to analyze RTAs. The primary objective of this study is to introduce a GIS-based approach for the comprehensive analysis of the spatial and temporal distribution of RTAs, specifically Property Damage-only (PDO) accidents. This research also endeavors to pinpoint accident-prone areas, commonly called 'hotspots,' and high-density accident clusters. This was achieved through spatial-autocorrelation analysis, incorporating techniques, including inverse distance weighting, Moran's index and the Getis Ord Gi* statistic. By focusing on eight years of accident data (2015-2022) in the Sharjah Emirate of the United Arab Emirates, this study contributes to a deeper understanding of the distribution of traffic accidents. The analysis of temporal patterns revealed that the monthly distribution of PDO accidents showed the lowest frequencies of incidents in July, August and September throughout the study period. Furthermore, PDO accident frequencies peaked in 2015, followed by a decline until 2018, after which there was a slight increase until the conclusion of the analysis in 2022. Spatial analysis highlighted significant clustering of PDO-related RTAs. Hotspot analysis specifically identified downtown areas of Sharjah city as more prone to PDO accidents than other regions. The findings underscore the effectiveness of the analytical methods employed, which can be utilized for identifying and prioritizing accident hotspots.

Keywords: Road-traffic accidents, Property Damage Only (PDO), Spatial analysis, Hotspot analysis, GIS.

INTRODUCTION

Road-traffic accidents (RTAs) are widespread global hazards, influencing not only countries experiencing rapid urbanization and infrastructure development, but also those during the development phase. These accidents significantly affect roadway safety, sustainability and socio-economic development of countries (Aldala'in et al., 2023). In 2003, the worldwide economic impact of RTAs was estimated to be approximately $518 billion annually (Khasawneh et al., 2022). Also, they result in a vast number of injuries, often with severe and even fatal outcomes. RTAs rank globally as the eighth leading cause of death. Annually, RTAs result in approximately 1.3 million fatalities and 50 million injuries (Alkhadour et al., 2021).

Studying RTA hazards is essential in gaining insights into their origins and consequences. Effectively dealing with RTAs is vital for reducing accident rates. Research endeavors seek to identify the key factors that drive the occurrence and severity of accident-related injuries, including road conditions, drivers' behavior or the environment. Road-safety enhancement can be realized by advancing vehicle-safety features, refining the behaviors of drivers, pedestrians and cyclists, as well as implementing a range of improvements in the geometric design of roadway-safety elements (Obaidat and Ramadan, 2012).

RTAs are categorized into three levels based on the damage caused by an accident: fatal, injury and property damage only (PDO) accidents. PDO-accident level is defined as any collision that occurs without causing losses of lives or injuries; thus, none of the parties involved in the accident are killed or injured (Aljarrah et al., 2019; Wang et al., 2021). The occurrence of the standard type of PDO accidents results in damage to the vehicles involved only. In this study, PDO damage was investigated in depth spatially and temporally.

A key aspect of this investigation is the identification of hotspots for RTAs within different functional classifications of roadways. Hotspots represent specific areas where accidents are concentrated. It is important to note that accidents resulting in PDO can be notably unpredictable, as highlighted by recent research by Zubaidi et al. (2021). This understanding equips traffic authorities with the knowledge to assess the root causes of PDO accidents and formulate effective countermeasures to enhance road safety at these locations. Identifying and addressing these hotspots is a fundamental objective in numerous safety analyses, traffic-improvement programs and ongoing research efforts to create safer and more efficient road networks.

The Geographical Information System (GIS) platform was used to conduct the different intended spatial analyses. It is a powerful platform for analyzing traffic accidents, since it captures, stores and analyzes spatial data, enabling the identification of accident-prone areas and their relationships with various factors (Aghajani et al., 2017; Bounaceur et al., 2022). This spatial analysis aids experts in locating high-accident zones, enabling informed interventions to reduce accident rates (Satria, 2020). It also aids in revealing complex relationships between spatial and related data, enabling better decision-making in accident analysis and road design.

LITERATURE REVIEW

Based on many research results of studies that investigated RTAs in the UAE, the trend in traffic accidents indicates continuously increasing rates in the UAE even after adopting many strict countermeasures across the country to improve road safety and reduce accident rates (Alkheder et al., 2013; Hamad, 2016).

Alkheder et al. (2013) analyzed the relationship between car accidents and drivers' citizenship for all types of vehicles involved in the study period between 2007 and 2010. The analysis claimed that the driver has a very critical role in car-accident responsibility due to the high control level of the road. Analysis results indicated that the local drivers' nationality represents the highest involvement rate in car accidents, with 30.02%, followed by Pakistanis with 21.26 %. In industrial- and construction-vehicle accidents, the most contribution in these types of vehicles is made by Pakistanis and Indian drivers.

Another study by Hamad (2016) investigated RTA trends in Sharjah, UAE, from 2001 to 2014. Results revealed that the trends during the study period indicated increasing trends accompanied by increased deaths and injuries caused by vehicle accidents. Moreover, results agreed with the previously obtained ones, where UAE citizens caused about 27% of the accidents, followed by Pakistanis with 19%.

Furthermore, a study performed by Hammoudi et al. (2014) evaluated factors causing RTAs among drivers in

Abu Dhabi city, UAE. Results illustrated that the main reasons for PDO road-traffic accidents in the UAE were tailgating and entering the road without checking whether there were other vehicles and drivers' distractions from using a mobile phone while driving. On the other hand, the causes of injuries due to traffic accidents were driving without wearing a seat belt, driving at high speeds and reckless driving.

Besides analyzing RTA trends and contributing factors, previous studies also investigated the spots of their clustering using various hotspot-analysis techniques. The most widely used techniques included Kernel density, kriging and inverse distance weight interpolation approaches (Bíl et al., 2019; Colak et al., 2018; Kang et al., 2018), as well as Moran's index spatial and Getis-Ord Gi* statistic hotspot-identification approaches (Cheng et al., 2019; Choudhary et al., 2015; Manap et al., 2021; Tola et al., 2021).

Research Gap, Goal and Specific Objectives

While numerous studies have addressed Fatal and Injury (FI) RTAs in the United Arab Emirates (UAE), there is a lack of research focusing exclusively on PDO accidents. Previous research has generally aggregated PDO accidents with more severe incidents, potentially ignoring the unique patterns pertinent to PDO incidents alone. Although PDO accidents are less severe, their higher frequency offers invaluable insights into daily driving behaviors and conditions that are not typically mirrored in the more severe and less frequent FI accidents. Additionally, the rapid urbanization of Sharjah presents specific challenges that necessitate localized analysis to understand better and mitigate accident hotspots.

Subsequently, the main goal of this study is to perform spatial and temporal analysis of PDO accidents in Sharjah city, UAE, utilizing GIS to reveal patterns and trends that may differ from broader RTA analyses. To attain the main study objective, the specific objectives are to:

1- Map the spatial distribution and temporal trends of PDO accidents in Sharjah city from 2015 to 2022. This includes creating detailed maps visually representing accidents' concentration and dispersion over time and space.
2- Apply spatial-autocorrelation techniques and hotspot-analysis tools to identify and characterize areas of high accident frequency, thereby locating regions within Sharjah city that require targeted interventions.
3- Compare the spatial patterns of PDO accidents identified in this study with existing RTA trends in similar urban environments, utilizing the results to refine local traffic-safety measures.
4- Translate the findings of the spatiotemporal and hotspot analyses into actionable recommendations for urban planners and traffic-safety authorities, aiming to reduce PDO accident rates and enhance road safety in Sharjah city.

Through the analyses and due to the lack of cost-related data (i.e., cost of repair as a severity indicator for PDO accidents), the number of parties involved was deployed as a surrogate measure of severity.

METHODOLOGY

The adopted methodological framework in this study to develop the proposed approach comprises three main steps, as depicted in Figure 1. The first step is data collection. The second step is data pre-processing, which consists of data cleansing, filtering and creating a geo-database for conducting the study analyses. The third step is data analysis, which is split into two stages. The first stage is a descriptive, explanatory analysis of the obtained PDO dataset from the previous step. The second stage involves investigating PDO accidents using hotspot analysis.

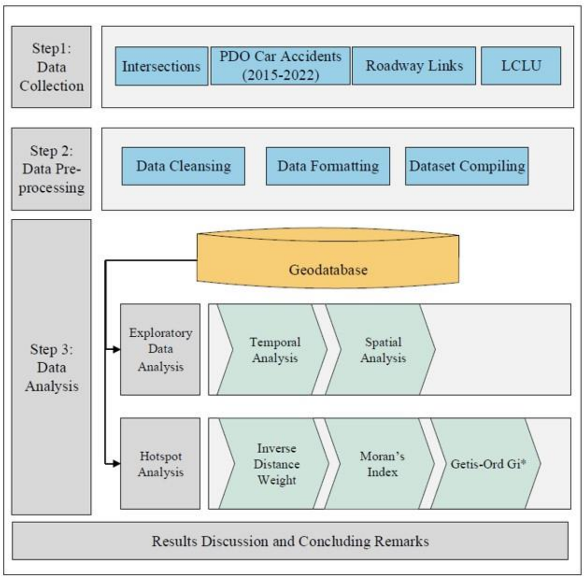


Figure (1): Methodology framework

Study Area

The geographic scope of this analysis covers the city of Sharjah. Sharjah is placed along the Arabian Gulf's northern coast, with the coordinates of 25.3° N 55.5° E (demonstrated in Figure 2). It is considered the country's cultural capital. Also, it is the third-largest city in the country, with an area of 2,590 km^2 in 2015 and a population of 1,405,843. In Sharjah, the climate is subtropical-arid, with warm winters, very hot summers and a desert climate. Its land is typified as dry with low rainfall rates. Furthermore, July and August are the hottest months, with a maximum temperature rate above 45°C. The temporal scope of this study is from 2015 to 2022.

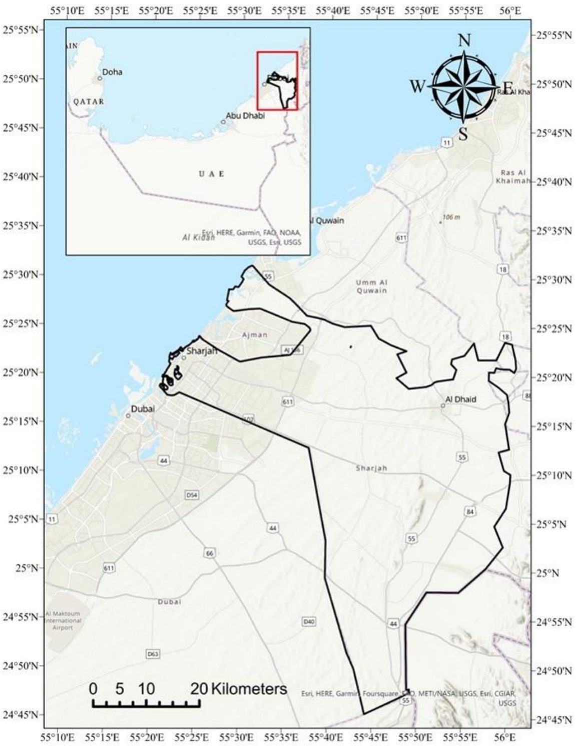


Figure (2): Location of the study area (Sharjah city)

Data Collection

The study utilized data collected from various sources to conduct spatiotemporal and hotspot analyses of Property Damage-only (PDO) accidents, considering road facilities, intersection types and land-use land cover. To do so, around one million PDO records have been collected from Saaed and Rafid traffic-management agencies for the study area in the study period from 2015 to 2022. Each record had additional attributes, such as the number of involved parties, date, longitude and latitude, road-surface conditions and ambient weather conditions. Road and land-use land cover (LULC) data was obtained from the Sharjah Department of Town Planning and Surveying. Road data and intersection characteristics were also incorporated into the dataset.

Data Pre-processing

The pre-processing-data step consisted of multiple processing functions, such as data correction, dataset combination, cleansing and data formatting for the PDO and road data to be compatible with the required analyses. This step involves three main stages: cleaning the datasets, formatting the GIS of the data and compiling the final roadway, accident and intersection dataset. Usually, datasets are not error-free. Thus, quality checks were performed on the data collected after collecting the required dataset. PDO records with no or insufficient coordinates were removed from the dataset. After reviewing each record separately, the data was examined to be located inside the study-area boundaries.

Subsequently, regarding road data, roadway data was located outside the study area; thus, it was excluded from the compiled dataset. Also, internal or private use-only roads were erased, since they are considered out of the scope of this study. One of the challenges faced while processing the road data is missing information and null values in many fields, such as road name, number, type, width, …, etc. To overcome this challenge, it was necessary to rebuild the road data with the attributes that would help perform spatial analyses and find the contributing factors in PDO accidents. The new road dataset included the road name, number, type, speed limit, lane width, number of lanes and presence of facilities, such as parking, footpath, shoulder and median.

The last step was carrying out spatial analysis. The targeted data was stored in a GIS format file. Road LULC data was gathered in shapefiles, while PDO records from both sources were in Excel spreadsheets with latitude and longitude attributes for each record. Using the appropriate geoprocessing tool in Arc Pro 3.0 software, these records have been converted from Excel sheets into shapefile GIS, formatted and georeferenced.

As a result of this process, a new geo-database was created. The junction data was also established based on road data provided by the Sharjah Department of Town Planning and Surveying using the Google Earth application. Creating and categorizing this data was essential to achieve one of the study objectives mentioned previously. Junctions were classified into five categories: interchange, signalized intersection, unsignalized intersection, signalized roundabout and unsignalized roundabout.

Data Analysis

The data-analysis stage is one of the critical parts of the study that will play a significant role in achieving the study's primary goal and objectives. This stage consists of two parts.

Exploratory Data Analysis

Firstly, exploratory data analysis (EDA) was conducted to summarize, visualize and become fully aware of the data's main characteristics (Makaba et al., 2020). This part contained simple spatial, temporal and demographic statistical analyses to better understand the PDO data trends. Also, relations between the PDO accident frequency and top causes, such as the driver at fault's age, gender and nationality, were identified (Chance Scott et al. 2016).

Hotspot Analysis

Secondly, a hotspot analysis of PDO accidents was performed to analyze the PDO-accident patterns and identify accident-prone locations in the study area. Specifically, this analysis helps detect the sites of accumulation of a high number of accidents or a high number of involved parties as accident-prone locations. To conduct the analysis, specific spatial-analysis techniques were carefully selected to align with the data's unique characteristics and the research objectives, including Moran's index, Getis-Ord Gi* statistic and Inverse Distance Weighting (IDW). Moran's index was chosen for its robust capabilities in measuring spatial autocorrelation, providing a macroscopic overview of accident dispersion or clustering. The Getis-Ord Gi* statistic was particularly suited for isolating localized clusters of high incident frequency, thereby facilitating the precise identification of hotspots. Due to its direct applicability to point-based geographical data, IDW was utilized to graphically represent the spatial intensity of PDO accidents. These techniques were preferred for their computational efficiency, interpretive clarity and being strong precedent in traffic-accident spatial analysis, ensuring that the study's findings are reliable and actionable.

The global Moran's index is among the well-known and powerful spatial-autocorrelation processing approaches used to identify the presence of clustering of the prespecified criteria (Zahran El-Said et al., 2019). Global Moran index was utilized twice to investigate the PDO-accident clusters based on the total-accident frequencies and again for the total number of parties. Moran's index statistic was computed using the GIS Pro 3.0.3 software according to Equation (1):

$$I = \frac{n \sum_{i=1}^{n} w_{ij}(x_i - \bar{\bar{x}})(x_j - \bar{\bar{x}})}{(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij})(\sum(x_i - \bar{\bar{x}})^2)} \quad (1)$$

where w_{ij} is the proximity weight of locations i and j with $w_{ii} = 0$, $\bar{\bar{x}}$ is the global mean value, x_i is the severity index at location i and n is the total number of accident locations. A grid-based approach was employed to discretize the study area into uniform spatial units (cells). Each spatial cell in this grid represents a distinct location and the indices i and j correspond to these units. Subsequently, the Getis-Ord Gi* statistic was applied. Getis-Ord Gi* statistics helped investigate the presence of a spatial pattern for an arbitrary variable, which helps detect high-risk clusters (i.e., high values of data-point densities in a given vicinity of a point). Getis-Ord Gi* statistic creates a new output-feature class for every accident with a Z score and associated P-value. Thus, statistically, hotspots are identified as locations with high values and surrounded by high-valued neighbors. The local sum of values of a feature and its neighbors is proportionally compared with the sum of all features. If the local sum obtained highly differs from the expected local sum, it is considered a statistically significant high clustering. Getis-Ord Gi* statistic and its standardized Z scores based on expected values E(Gi*) and the variances (VAR(Gi*)) were computed using GIS Pro 3.0.3 software as follows:

$$G_i^*(d) = \frac{\sum_{j=1}^{n} w_{ij}(d)x_j}{\sum_{j=1}^{n} x_j} \quad (2)$$

$$Z(G_i^*) = \frac{G_i^* - E(G_i^*)}{\sqrt{VAR(G_i^*)}} \quad (3)$$

where d is the distance threshold, w_{ij} is the weight of the target neighbor pair, x_j is the severity index at location j. Also, the IDW-interpolation technique was employed to illustrate and visualize the hotspot-analysis results. IDW estimates point values by averaging the values of sample data points in the neighborhood of each processing point. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process. IDW technique was implemented using the GIS Pro 3.0.3 software and computed as follows (Blanco et al. 2018):

$$u(x) = \begin{cases} \frac{\sum_{j=1}^{n} w_i(x)\, u_i}{\sum_{j=1}^{n} w_i(x)}, d(x,x_i) \neq 0 \; for\ all\ i \\ u_i \qquad , d(x,x_i) = 0 \; for\ all\ i \end{cases} \qquad (4)$$

where $w_i(x) = \frac{1}{d(x,x_i)^p}$, u is the interpolated value, x is the given point value and n is the number of samples.

RESULTS AND DISCUSSION

Exploratory Data Analysis

1) Temporal PDO analysis

The annual analysis of Property Damage-only (PDO) accidents over the study period, as depicted in Figure 3, reveals that in 2015, there were 122,926 recorded PDO accidents. Subsequently, there was a gradual increase, with the figure rising to 127,404 by the close of 2017. However, 2018 witnessed a substantial decline, with only 67,549 PDO accidents reported. It's worth noting that during the data pre-processing stage, a gap of 39 days was identified due to the transitional period in reporting PDO accidents in the Emirate of Sharjah from Saaed and Rafid traffic-management agencies. Also, this major reduction in the PDO accident frequency was attributed to multiple factors. These factors include the implementation of a revised traffic system of black points and fines that substantially increased in 2018, the economic downturn and the COVID-19 pandemic with the associated lockdowns and travel restrictions. Nonetheless, a discernible downward trend in PDO accidents emerged in 2018 and continued through the end of 2022, with the number of reported PDO accidents decreasing to 23,000 by April 2022.

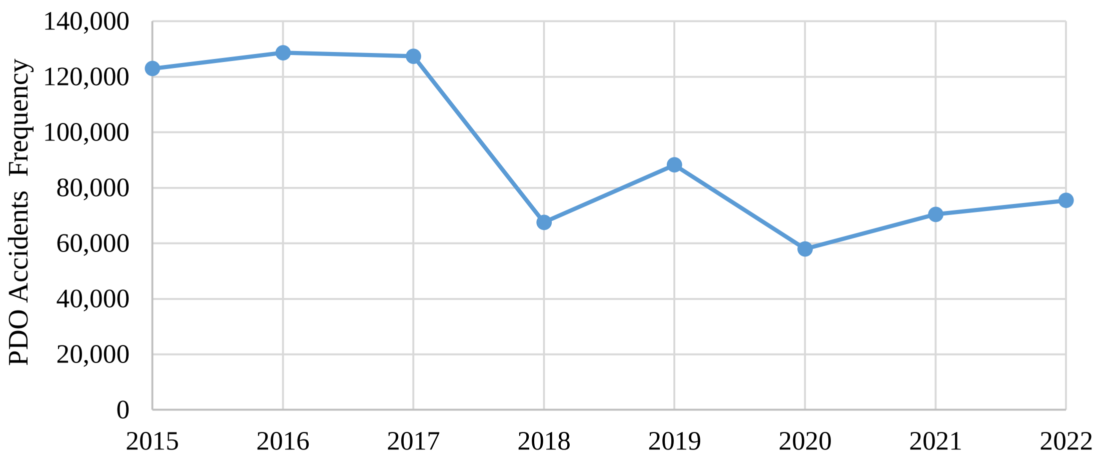
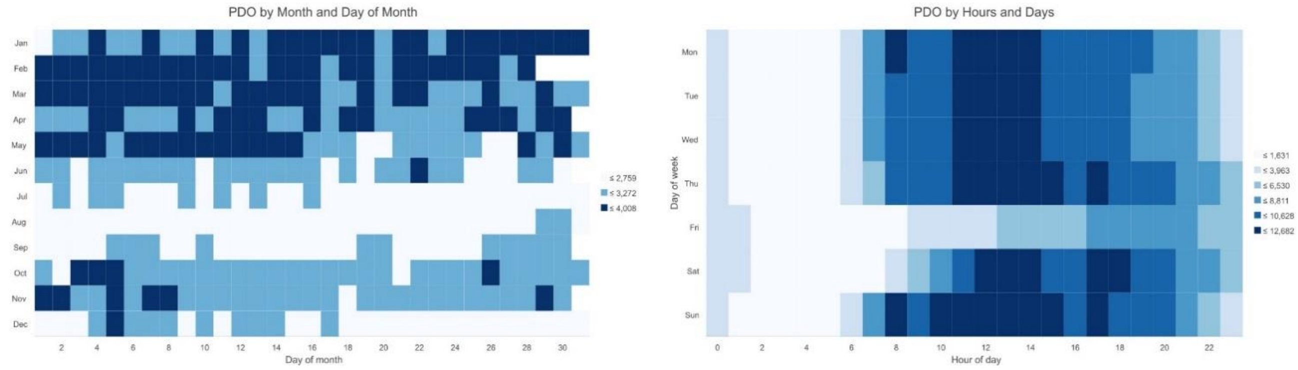


Figure (3): PDO temporal trends

Furthermore, as illustrated in Figure 4 (a), the monthly distribution of PDO records indicates that July, August and September consistently exhibited the lowest accident frequencies throughout the study period. Conversely, during the first half of each year, accident numbers steadily rose, reaching a peak in May. Subsequently, PDO rates began to decline from June onwards, with the lowest accident frequencies occurring in July, August and September. This pattern is attributed to school holidays, during which a significant portion of expatriates and some locals travel outside the country. Additionally, Fridays, designated as the national day off in the UAE, exhibited the lowest accident frequencies during the week. In contrast, Sundays and Mondays consistently recorded the highest PDO-accident frequencies.

Figure 4 (b) illustrates that most accidents occurred during daytime hours, particularly between 8 am and 1 pm. Afterward, accident rates slightly diminished until 8 pm. This trend aligns with individuals' typical daily-travel patterns, as roads are commonly utilized for intercity travel, duty-related commuting, social engagements and other purposes during these hours.



(a) PDOs monthly distribution (2015-2022) (b) PDO daily distribution

Figure (4): PDO temporal distribution

Spatial Analysis

A notable trend emerges when analyzing the highest PDO-accident frequencies on highway roads from 2015 to 2022 and considering accident rates per year per kilometer, as indicated in Table 1. Shk. Mohammed bin Zayed road, spanning 13 kilometers in length, stands out with the highest number of PDO accidents recorded over the years, totaling 39,735 PDO accidents, resulting in a PDO rate of 382.1 PDOs per kilometer per year. This can be attributed to its role as a critical road connecting the northern emirates, starting from Dubai, passing through Sharjah and passing through the end route to the emirate of Ras Al Khaimah. Furthermore, it serves as a daily commute route for numerous drivers visiting Dubai for employment, business or other purposes.

Table 1. Highways with the highest PDO frequencies

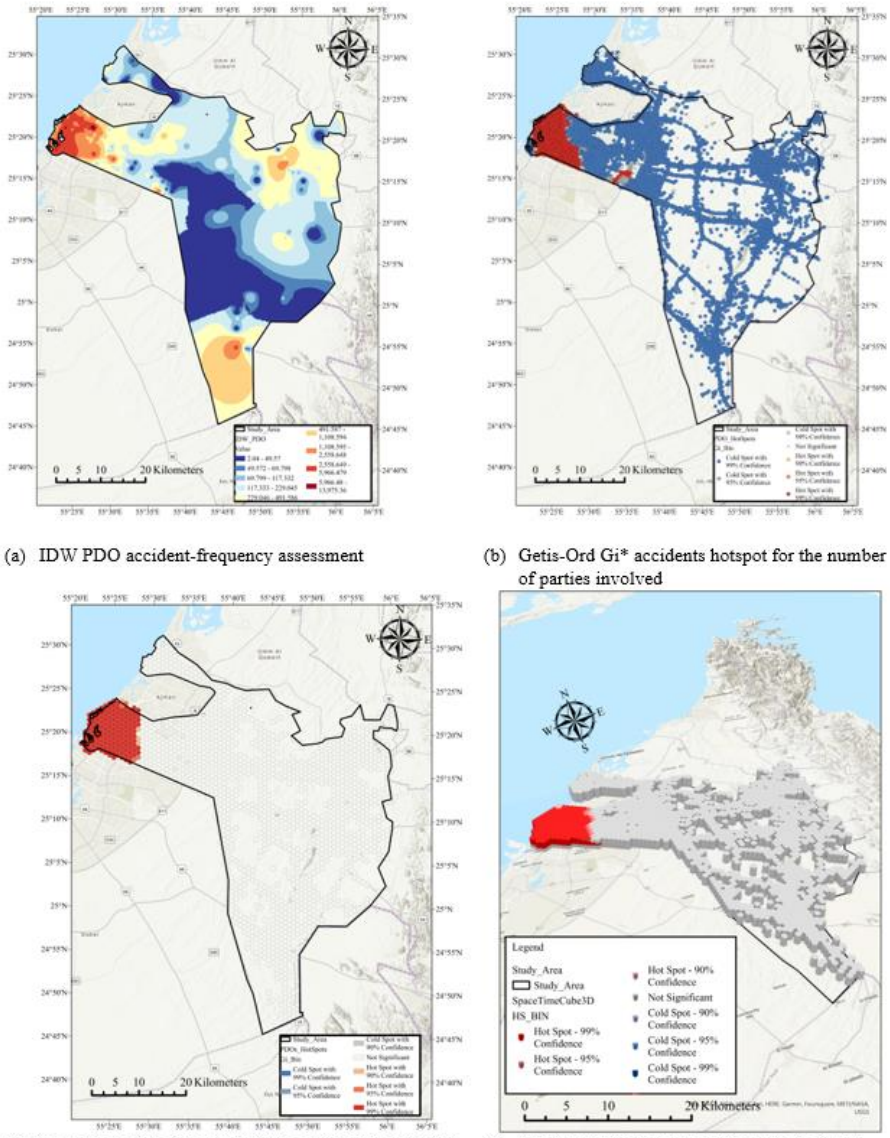
Year	Mohammed Bin Zayed Road	Al Dhaid Road	Emirates Road	Maliha Road	Khor Fakkan Road
2015	6383	3365	1211	2696	34
2016	8858	4657	2822	4635	40
2017	9428	5425	4212	5485	119
2018	5175	2324	1523	2256	46
2019	3764	1766	548	1693	133
2020	2284	1216	436	1143	193
2021	2931	1410	682	1745	316
2022	912	486	237	577	75
Sum (2015-2022)	39735	20649	11671	20230	956
Avg. (2015-2022)	4967	2581	1459	2529	120
Length (km)	13	43	25	62	85
Accident Rate (per km per year)	382.1	60.0	58.4	41.8	1.4

The second-highest highway in terms of accident frequency and accident rate is Al Dhaid road, stretching across 43 kilometers and recording a total of 20,649 PDO accidents with a rate of 60 PDOs per kilometer per year. Al Dhaid road is a vital link between Sharjah city and Al Dhaid city. Then comes the Emirates road, which recorded a total of 11,671 PDO accidents and an accident rate of 58.4 PDOs per kilometer per year.

Moreover, the analysis incorporates all PDO accidents occurring on minor and major roads across Sharjah-city area. These accidents were collated and their distributions were tabulated in Table 2, revealing significant patterns. Commercial areas, covering an expanse of 97 square kilometers, accounted for a noteworthy 51% of the total PDO-accident frequencies over the eight-year study period, accumulating a total of 453,505 PDO accidents. Meanwhile, industrial areas spanning 142 square kilometers contributed 24% of the total PDO accidents, with a recorded frequency of 213,091 PDOs. Residential areas, encompassing 325 square kilometers, accounted for 23.6% of the total PDO accidents, tallying 208,895 PDO accidents during the same study period.

Table 2. PDOs per area use (2015-2022)

Area Use	No. of Districts	PDOs	Area (km^2)	PDO/km^2	%
Commercial	39	453505	97	4675.3	51
Industrial	19	213091	142	1500.6	24
Residential	118	208895	325	642.8	24
Educational	2	8053	14	575.2	0.9



(a) IDW PDO accident-frequency assessment

(b) Getis-Ord Gi* accidents hotspot for the number of parties involved

(c) Emerging hotspot analysis of space-time cube analysis

(d) 3D visualization of space-time cube hotspot analysis

Figure (5): Hotspot mapping

Hotspot Analysis

IDW hotspot analysis shown in Figure 5 (a) clearly indicates that Sharjah's downtown areas are more PDO accident-prone than the other areas. Then, Moran's index spatial-autocorrelation results were investigated to determine whether the threshold distance was met and accidents were clustered or randomly distributed. Moran's index reported values of 0.398 and 0.405 and z-values of 10.51 and 10.67 for the total-accident frequency and the total number of parties involved, respectively. These results indicate the presence of a significant PDO RTA clustering with a 1% likelihood that this clustered pattern resulted from random chance, since the z-score is higher than 2.58. However, it cannot indicate whether the clusters involve high or low values of clusters.

After confirming the presence of PDO clusters of both accident frequencies and the total number of parties involved, the Getis- Ord Gi* statistic was deployed to investigate high and low values of clustering locations, respectively. Figure 5 (b) shows two red hotspot regions (presented in red): the Sharjah downtown and al Maliha. The rankings were based on each zone's computed z-score. On the other hand, the cold spots (presented in blue) indicate the clustering of low PDO-clustering values.

Subsequently, the spatial distribution of hotspots was investigated temporally using the space-time cube technique. Since the PDO data extended over eight years, it was aggregated over six-month interval groups. The analysis created a grid of hexagons, each being 1 km, as shown in Figure 5(c). Then, the emerging hotspot analysis was conducted to analyze the space-time cubes, which helped identify the temporal trends of clustering occurrence. Analysis results illustrated in Figure 5(d) showed that the trends were stationary over the entire study period.

Comparison with Previous Studies and Practical Implications

Our study's findings resonate with the broader trends identified in previous studies, such as those by Alkheder et al. (2013) and Hamad (2016), highlighting the increasing rates of RTAs in the UAE. However, our focus on PDO accidents through spatial and temporal lenses has uncovered patterns that were not previously detailed. For instance, while Alkheder et al. (2013) pointed to a high involvement rate of local drivers in car accidents, our study offers a more in-depth view, identifying specific temporal and spatial dimensions of PDO-accident occurrences.

Comparatively, our application of advanced GIS techniques, including the IDW interpolation and Getis-Ord Gi* statistic, provides a novel contribution by not only identifying hotspots, but also offering a predictive insight into potential areas of concern, which were not as explicitly addressed in previous hotspot analyses.

The practical implications of our research extend to several departments and stakeholders concerned with urban planning and public safety. Also, the identified hotspots and the temporal trends of PDO accidents provide urban planners with data-driven evidence to inform the development of infrastructure projects and road-safety improvements, particularly in areas with high traffic volumes and accident rates. Thus, traffic authorities can leverage our findings to modify road designs and implement safety campaigns specifically tailored to address the unique conditions of Sharjah city's roadways. Lastly, our study's insights into the temporal distribution of accidents can guide emergency-response teams in resource allocation and readiness, especially during peak accident times identified in our study.

Our study supplements the existing literature with specific insights into PDO accidents in Sharjah city and provides actionable data for stakeholders dedicated to enhancing road safety and reducing traffic-related property damage.

Limitations and Future-research Directions

While providing insightful analysis into Property Damage-only (PDO) road-traffic accidents in Sharjah city from 2015 to 2022, this study is subject to certain limitations that need to be acknowledged and that opens avenues for future research.

The primary limitation of this study stems from the dataset's temporal scope. Spanning eight years, it encapsulates a period where socio-economic factors, such as population distribution, motor-vehicle ownership and residents' travel habits may have undergone changes. Particularly, the advent of the COVID-19 pandemic in 2019 represents a significant event potentially impacting these variables. The lack of detailed longitudinal data pertaining to these socio-economic factors has precluded a comprehensive time-instability analysis within our study. Furthermore, the assumption that driving habits and infrastructure characteristics in a developed urban area like Sharjah city remain relatively stable over a short period may not fully capture the nuances of urban dynamics.

In light of these limitations, we recommend the following for future research: (1) Future studies should consider incorporating a time-instability analysis to account for changes in socio-economic factors over time. This is particularly pertinent in the context of significant events, such as the COVID-19 pandemic, which might have altered traffic patterns and accident occurrences, (2) Where available, incorporating detailed longitudinal data on factors, such as population growth, changes in motor-vehicle ownership, road-network developments and shifts in travel habits would greatly enhance the robustness of traffic-accident analyses and (3) Extending the dataset to include a wider range of accident types, beyond PDO incidents, could provide- a more comprehensive understanding of traffic accidents and safety in urban areas.

CONCLUSIONS

In conclusion, this study has undertaken a comprehensive spatiotemporal analysis of traffic accidents within the Sharjah Emirate. GIS utilization has demonstrated its effectiveness in the analysis of RTA data, enabling the identification of spatial and temporal patterns and the identification of contributing factors. Moreover, GIS proved to be a valuable tool in identifying accident-prone locations. Traffic and road-safety authorities can readily adopt GIS to monitor and manage traffic-accident trends over short - and long-term periods.

The findings from this study serve as a valuable resource for decision-makers, offering insights into the most significant contributing factors and pinpointing RTA hotspots. This knowledge can inform the implementation of necessary enforcement measures and countermeasures to enhance road safety. Notably, the analysis of nonspatial measures has highlighted specific roads with higher PDO-accident frequencies, such as Shk. Mohammed bin Zayed and Al-Dhaid roads and collector roads, like Al Maliha and Wasit roads, exhibiting the highest PDO-accident counts within the city.

Furthermore, the study has shed light on temporal trends, with lower accident rates observed during July and August, coinciding with summer vacations. The analysis also identified peak periods for PDO accidents, occurring during the daytime between 10 am and 1 pm and in the evening from 4 pm to 7 pm.

Regarding land-use patterns, the study has revealed that commercial areas account for the highest percentage of PDO accidents at 51%, surpassing other land-use categories. Overall, the trend in PDO accidents has exhibited a downward trajectory over the years. While around 123,000 PDO accidents occurred in 2015, a steep decline began in 2018, reaching 60,000 PDO accidents by the end of 2022. That is a 51% reduction in total, which was attributed to multiple factors contributing to this drop. These factors include the implementation of a revised traffic system of black points and fines that substantially increased in 2018, the economic downturn and the COVID-19 pandemic with the associated lockdowns and travel restrictions.

Lastly, the concentration of PDO accidents in the Sharjah-downtown area highlights the need for targeted safety interventions. Based on eight years of comprehensive data, these results offer invaluable insights for road safety authorities and decision-makers. They provide a clear understanding of the causes and consequences of road accidents, facilitating the development of tailored actions and programs to reduce road accidents and enhance overall road safety within Sharjah city.

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