

Spatio-Temporal Patterns of Emergency Incidents in Osogbo, Nigeria: Implications for Urban Resilience

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Abstract

Urban emergencies in Osogbo have exhibited complex spatial, temporal, and statistical patterns that demand adaptive resilience strategies. Using data from 2015–2025, this study employed spatial mapping, seasonal categorization, and advanced statistical analyses to examine fire incidents and medical/accident emergencies. Results revealed that emergencies cluster in densely populated corridors and vary seasonally, with fire incidents peaking in hot dry months and medical emergencies dominating rainy and warm dry seasons. Statistical calculations reinforced these findings: Pearson correlation indicated a strong inverse relationship between fire and medical emergencies ($r = -0.63$); regression analysis confirmed predictive strength ($R^2 = 0.4$, $p < 0.04$); Chi-square and ANOVA tests validated significant seasonal associations ($X^2 = 132.5$, $p < 0.05$; ($F(17.4) > 15.62$)). Collectively, these findings underscore a shift in urban vulnerability from fire hazards toward health and accident emergencies, driven by climatic variability and urban growth. Policy implications emphasize strengthening healthcare infrastructure, implementing seasonally adaptive preparedness, and targeting high risk urban corridors. The study concludes that Osogbo's resilience depends on integrating statistical evidence with spatio-temporal insights to guide proactive, climate sensitive emergency management.

Key words:

Emergency incidents, Urban resilience, Spatial clustering, Temporal dynamics, Fire outbreaks and Medical emergencies

Introduction

Emergencies have occurred in nearly every nation in recent years. Countries such as Pakistan, China, Indonesia, and Iran remain at risk of earthquakes, while small island nations

in the Pacific and countries like Madagascar face maritime hazards. Floods occur year-round in Bangladesh and certain regions of China and India (Shamsudduha, 2025; United Nations in Bangladesh, 2024). Emergencies have become commonplace globally and can occur at any time, with varying severity (Ikiriko & Gbarabe, 2024). Nigeria is now considered one of the world's disaster-prone regions due to recent catastrophic events (Dossa *et al.*, 2025). Over the past decade, at least one type of emergency has affected several regions of the country (Ikiriko & Gbarabe, 2024). Rapid urbanization has forced populations into environmentally vulnerable areas. Urbanization challenges such as congestion, overcrowding, extreme poverty, and inadequate infrastructure exacerbate cities' vulnerability to disasters (Dossa *et al.*, 2025; Ikiriko & Gbarabe, 2024). Nigeria's growing emergencies negatively impact the nation's sustainability (Ikiriko & Gbarabe, 2024).

Urban disasters pose a significant and expanding threat. Urbanization, population growth, and climate change are the primary drivers of changing disaster causes and intensifying impacts. Both natural disasters, such as flash floods, and man-made incidents, such as fires, can endanger lives, instill fear, cause casualties, and destroy property (Akinsanola *et al.*, 2025; UN-Habitat, 2024). In Nigeria, the majority of emergencies involve fire outbreaks, vehicle accidents, building collapses, and flooding, rather than earthquakes, volcanic eruptions, or tsunamis. Emergency management is handled by multiple organizations, including municipal authorities, police, fire and ambulance departments, paramedics, and other rescue institutions. Their decisions are crucial in mitigating impacts on people, property, and the environment, and rapid decision-making is essential during emergencies.

Delays in leaving stations and arriving at emergency scenes can result in severe consequences, including death, injury, and property damage. Therefore, prompt and timely responses to emergency service calls are critical (Soltani *et al.*, 2026; Hill *et al.*, 2025). Response time is a key factor in controlling and mitigating emergency incidents (Moftah *et al.*, 2025). According to the National Fire Protection Association (2010), response time is the manageable portion of the emergency sequence and includes alarm answering, alarm processing, turnout, travel, and initiating action/intervention. Travel time is the most critical factor in emergency calls and is influenced by traffic volume, average travel speed, driving habits, road networks, time of day (rush hour vs. non-rush hour), season, and incident location (Hill *et al.*, 2025; Moftah *et al.*, 2025). Therefore, the objective of this research is to analyse qualitatively and quantitatively the fire and medical emergencies in Osogbo.

Study Area

Osogbo is situated between Longitudes 4° 28' 43" and 4° 40' 12" East of the meridian and Latitudes 7° 42' 10" and 7° 51' 10" North of the equator. Osogbo is situated in southwest Nigeria, practically in the middle of Osun State. It is situated roughly equal distances from Ile-Ife (48 km), Ilesha (32 km), Iwo (48 km), Ikirun, Ila-Orangun (46 km), and Ikire (48 km). It is approximately 88 km northeast of Ibadan, 100 km south of Ilorin, and 115 km northwest of Akure (Eades, 1980). As Osun State was established in 1991, Osogbo became the capital of the new state and is home to the administrative centers of Osogbo and Olorunda Local Government Areas (LGAs). It has a 140 km² area under it (Fadare and Salami, 2004) (Figure 1). In the 2006 census, the combined population of the two LGAs was 288,455 (NPC, 2006). In 2006, the population base of Olorunda was 131,761 while that of Osogbo LGA was 156,694. The population of this city is constantly increasing to an estimated population of 422,119 in 2021 (researcher's estimation).

According to historical accounts, Oso-Igbo, the goddess of the river, was once thought to be Osogbo's queen and founder. The Osogbo Grove, which features palaces and a market, appears to have been the site of the first

settlement in Osogbo. As the population grew, the residents relocated from the Grove and established a new town that spatially mirrored the arrangements found there. Osogbo was turned into a haven for refugees in the 1840s as the Fulani Jihad spread from what is now northern Nigeria to the south. Osogbo, which is located directly on the northern edge of the forest, developed into a significant hub for northern Yoruba territory as the Yorubas withdrew farther southward into the forests. As a result of Osogbo's resistance to the Fulani attacks, the city came to represent Yoruba pride in general (Amusa, 2009).

The Yoruba ethnic group dominates most of Osogbo, and the language (Yoruba Language) unites the people. The city is also home to non-indigenous tribes like the Hausa, Igbo, and Fulani. The introduction of industrialization and administration is linked to Osogbo's remarkable population growth over time. The city's railroad station, steel rolling mill, machine tool industries, and commercial activity all served as centripetal forces, drawing people from nearby settlements. (Agbola, 1992; Proudly Yoruba, 2013). Farming has historically been the primary occupation of Osogbo residents due to its unique geographical features. Planting food crops like yam, maize, and vegetation as well as cash crops like cocoa, cotton, and kolanuts is encouraged by the area's tropical climate. Osogbo is popularly referred to as "Ilu-Aro" (the home of dyeing) since it is also a significant dyeing center. The traditional occupation of the Osogbo people is cloth dyeing, in addition to farming. Agboola (1992), Murphy and Sanford (2001), and the Osun State Government (2006) all state that the Osogbo people are well-known for their commercial endeavors in gold smiting, embroidery, pottery, and handmade traditional cloth weaving (Aso-Oke).

Its physical structure and growth vary greatly, just like any other traditional Yoruba town. Osogbo has three different residential densities, according to Fadare and Olawuni (1999): high, medium, and low. There are a lot of small rooms in the traditional compound-style homes, very few open spaces, no formal recreation areas, and a uniform population in Osogbo's high residential density area. Most of the medium- and low-density residential areas have regular street layouts and are well-

planned, with many plots nearly entirely occupied by two- or three-floor buildings.

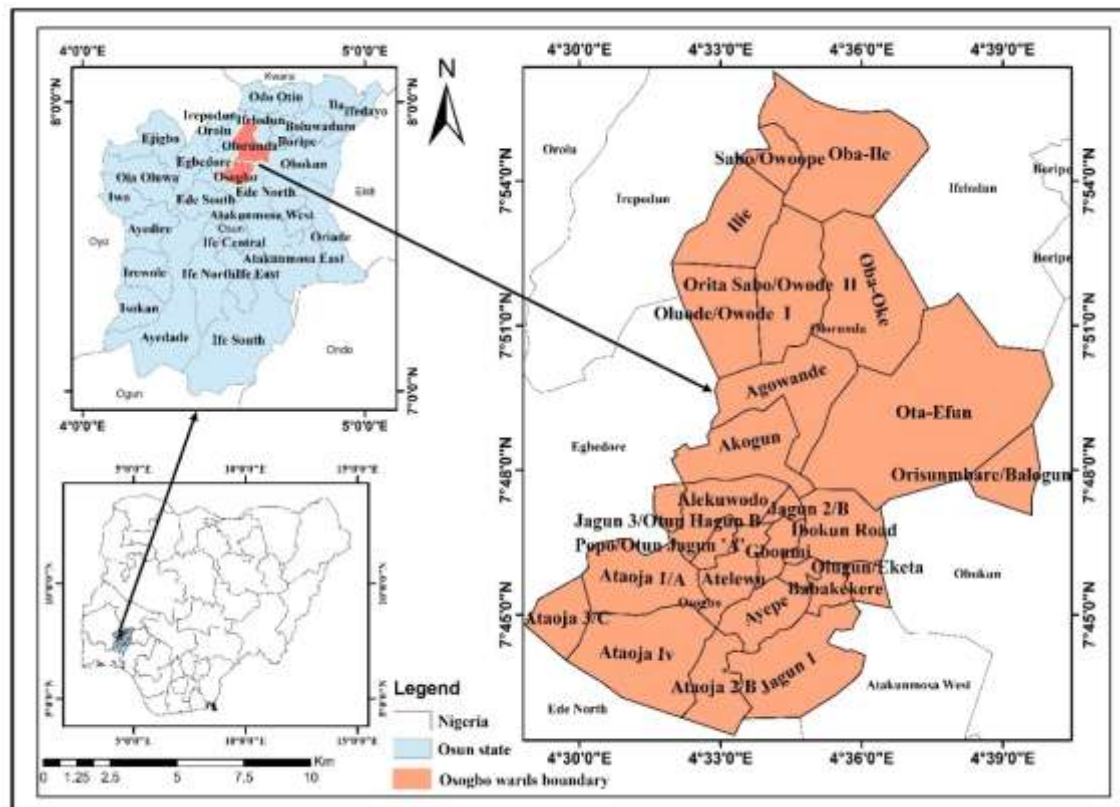


Figure 1.1: Nigeria, Osun State and Osogbo Wards

Source: Geo-Referenced Infrastructure and Demographic Data for Development (GRID3)

Literature Review

Urban resilience has become a central theme in disaster management scholarship, particularly in rapidly urbanizing African cities. The World Bank (2025) emphasizes that resilience requires strengthening emergency preparedness and response systems, especially in flood prone Nigerian cities. Their lessons learned exercise highlights the importance of institutional coordination and community engagement in mitigating disaster impacts. This aligns with broader global frameworks that advocate for integrated approaches combining infrastructure investment with social capacity building.

Flooding remains one of the most pressing hazards in Nigeria's urban centers. Dossa, Miassi, Bakary, and Ogou (2025) argue that rapid urban expansion in Lagos has intensified flood risks, particularly in districts such as

Victoria Island and Kosofe. They identify environmental, socio economic, institutional, and structural drivers of vulnerability, noting that governance challenges and limited community trust undermine resilience efforts. Their findings underscore the need for climate tailored early warning systems and participatory flood management strategies.

Beyond flooding, fire hazards represent another dimension of urban emergencies. Jokotade *et al.* (2026) examined fire disaster management in Ikeja, Lagos, and found that incidents were concentrated in high density areas, with 60% linked to candle use and 25.7% to electrical faults. Despite reported response times of around 10 minutes, operational constraints such as water shortages, poor vehicle maintenance, and inadequate manpower severely limit adaptive capacity. Comparative evidence from Nairobi, Accra, and Ibadan suggests that under resourced, response focused fire management is a regional pattern.

Medical emergencies also constitute a significant burden in Nigerian cities. Accident-related injuries, maternal complications, and

sudden illnesses frequently overwhelm under resourced health systems (Adeloye *et al.*, 2018). Inadequate ambulance services and limited hospital capacity exacerbate delays in treatment, contributing to higher mortality rates compared to global averages (Ogunyemi & Akinola, 2020). These findings highlight the need for integrated emergency medical services that combine rapid response with spatially equitable distribution of healthcare facilities.

Statistical approaches have been widely employed to understand the dynamics of emergencies. Regression models, correlation analyses, and ANOVA tests are frequently used to quantify relationships between incident types, seasonal variations, and demographic factors (Adebayo & Oladipo, 2019). For instance, correlation studies in Ibadan demonstrated strong associations between traffic accidents and peak commuting hours, while regression analyses confirmed predictive links between rainfall intensity and flood related emergencies (Olanrewaju & Popoola, 2021). Such statistical evidence provides policymakers with actionable insights, enabling targeted interventions that address both temporal and causal dimensions of urban hazards.

Geographic Information Systems (GIS) have become indispensable tools in mapping and analyzing emergency incidents. GIS applications allow researchers to visualize spatial clustering, identify high risk corridors, and optimize the location of emergency facilities (Abubakar & Doan, 2019). In Lagos, GIS based studies revealed that fire outbreaks and medical emergencies are disproportionately concentrated in high density neighborhoods, underscoring the spatial inequities of urban vulnerability (Olawale & Adepoju, 2022). Beyond visualization, GIS supports predictive modeling, enabling authorities to anticipate hotspots and allocate resources more effectively. This spatial intelligence is critical for enhancing resilience in rapidly growing cities where traditional emergency planning often lags behind urban expansion.

Collectively, the literature demonstrates that resilience in Nigerian cities is shaped by structural, institutional, and spatial factors. While infrastructural interventions such as flood defenses and fire service equipment are necessary, they are insufficient without governance reforms and community

participation. Medical emergencies highlight the human cost of inadequate preparedness, statistical methods provide empirical rigor for understanding patterns, and GIS offers spatial clarity for targeted interventions. Integrating these approaches ensures a holistic framework for managing emergencies in Nigerian cities, advancing resilience in the face of climatic variability and rapid urbanization.

Methodology

This study adopted survey design methodology following the works of scholars like Ogunniyi *et al.*, (2011); Ezekiel and Olawuyi (2013); and Furceri *et al.* (2020). This includes three stages of reconnaissance survey of the study areas, the collection of data, the analysis of data and discussion of findings.

Types and Sources of Data

The data for the study were collected from primary and secondary sources. The primary data included the following; coordinates of emergency incidents points and emergency stations using handheld Global Positioning System device (Dreamtimes with accuracy of 3-5 meters) of the study. Secondary data were extracted from various sources. One, high-resolution imageries of the study area at a resolution of 0.3 meter of 2025 were accessed through the plugin facility of Maxar high resolution using "Add Base Map" on ArcGIS 10.8 environment, from where shapefile of the study area was extracted as base map required for the objectives. Records of emergency incidents were extracted from the archives of the fire and ambulance stations in Osogbo, Osun State. Also, Google Earth Pro engine was used along with the GPS in obtaining the absolute locational attributes (latitude and longitude) data for all the emergency incidents and emergency stations location as required for the study. The records of emergency incidents events and response from years 2015 to 2025 were acquired from the managements of the fire and ambulance stations in Osogbo.

Data Analysis

The ArcGIS 10.8 data view environment was projected from the data frame properties using the coordinate system. The geographic coordinate system, World Geodetic System (WGS) 1984 was chosen for the data view environment set up. This was done so that the various datasets utilized in the study could

have consistent projections due to the many data sources. All of the data sets for this study were created in a personal geo-database from the Arc catalog, making the data easily accessible and retrievable for additional analysis. Feature data set and feature classes for the roads, emergency incidents, emergency stations and hospitals with accidents and medical emergency were created and saved. These data provided both qualitative and quantitative dimensions for analysis, enabling a mixed methods approach to understanding urban resilience dynamic

Qualitative data Analysis

Qualitatively, the spatial pattern of incidents responded to by the emergency stations: records of emergency incidents were acquired from the officials of the emergency stations; and their respective geographic coordinate points from year 2015 to 2025 were imported from the excel spreadsheet and stored as point features in ArcGIS 10.8 personal geo-database created. With the help of the spatial statistics toolbox, patterns such as Average Nearest Neighbour (ANN) were analyzed. Seasonal categorization grouped incidents into four climatic periods hot-dry, warm-rainy, rainy, and warm-dry reflecting the influence of environmental variability and presented in the forms of charts and tables using the excel spread sheet.

Quantitative Data Analysis

Quantitative methods were applied to statistically test relationships and differences among emergency variables. Descriptive statistics summarized incident frequencies and trends across years and seasons. Pearson correlation measured the relationship between fire and medical emergencies, while Chi square tests assessed associations between emergency type and season. Regression analysis modeled predictive relationships, quantifying how fire incidents influenced medical emergencies. ANOVA tested differences in mean emergency frequencies across seasons, and a correlation matrix summarized interrelationships among fire, medical, and seasonal variables. Together, these statistical techniques provided robust evidence of patterns and associations.

Mixed Methods Integration

The integration of qualitative and quantitative approaches ensured a holistic understanding of

emergency dynamics in Osogbo. Spatial and seasonal analyses contextualized the statistical findings, while regression, correlation, and ANOVA result quantified relationships and differences. This mixed methods design allowed the study to capture both the descriptive realities of emergency clustering and the inferential strength of statistical testing, thereby enhancing the reliability of conclusions on urban resilience.

Results and Discussion

(a) Qualitative Results

The results were analyzed and presented using maps, charts and table with an attention on determining the geographic distribution of emergency incidents in Osogbo and examining the spatial pattern of incidents responded to by the emergency stations.

Inventory of Existing Fire Stations, Ambulance Stations, Hospitals with Emergency Wards and Emergency Incidents in Osogbo.

From personal field observation and KII, the information about the existing fire stations, ambulance stations, hospital with emergency wards and emergency incidents are as discussed. There are three existing public owned Fire stations, seven public owned Ambulance stations, fifteen identified hospitals with accident and medical emergency wards in the study area. The Osun State Fire Station Headquarters is located at Abere, along Osogbo-Gbongan Road; the others are substations at Oke-Fia and at Atelewo. From the field survey and information from the management of the fire stations, the fire station Headquarters was established in year 2012 that serves as both the administrative and operational units. It has thirty-eight staff members, two functional fire engines, other operational equipment, and a drilled Borehole for water supplies. Oke-Fia substation was established in year 1992 with twelve staff members and a functional fire engine and Atelewo substation is an extension of Oke-Fia with three staff members (Figure 2).

The fire stations, between year 2015 and 2025 in the study area recorded four hundred and sixty (460) fire incidents and sixty-four (64) rescue operations. The fire incidents were broadly categorized as wild bush fire, vehicles on fire; electrical power surges, houses and

shops on fire, offices and schools on fire, banks and filling stations on fire, and dumpsites on fire (Figure 2). Table 1 and Figure 3 show the summary of the distribution of the fire incidents in the study period. Year 2015 had the lowest recorded fire incidents of

8 while year 2017 had the highest record of 59 fire incidents. 2016, 2018, 2019 and 2020 have 33, 49, 50 and 49 fire incidents respectively. More so, year 2021, 2022, 2023, 2024 and 2025 recorded 43, 50, 41, 37 and 41 fire incidents respectively.

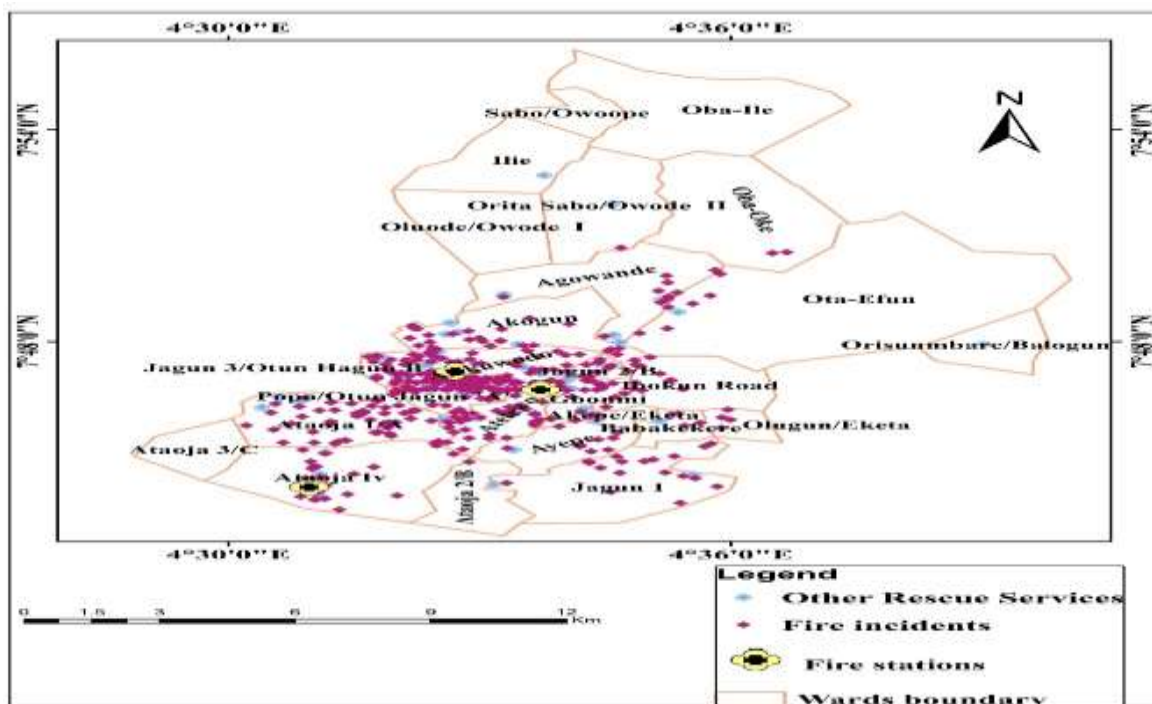


Figure 2: Fire Station, Fire Incidents and Other Rescue Cases in Osogbo.
Source: Osun State Fire

Service Headquarters, Osogbo, 2025
Table 1: Summary of Fire Incidents between 2015 and 2025 in Osogbo.

Month	Year 2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Year 2025	Total
January	1	0	12	2	12	10	8	13	2	8	6	74
February	3	4	7	4	11	16	11	4	8	9	7	84
March	1	4	3	5	0	3	6	2	5	2	4	35
April	0	4	5	3	2	2	0	6	1	2	2	27
May	1	1	2	2	0	0	1	3	1	3	1	15
June	0	3	4	4	0	2	2	4	3	3	2	27
July	0	1	3	2	2	1	2	5	2	3	1	22
August	0	0	2	2	4	4	3	4	3	1	5	28
September	1	0	5	4	3	2	1	3	6	3	1	29
October	1	2	2	8	3	2	2	2	3	1	4	30
November	0	4	4	5	2	4	4	1	3	1	5	33
December	0	10	10	8	11	3	3	3	4	1	3	56
Total	8	33	59	49	50	49	43	50	41	37	41	460

Source: Osun State Fire Service Headquarters Osogbo, 2025.

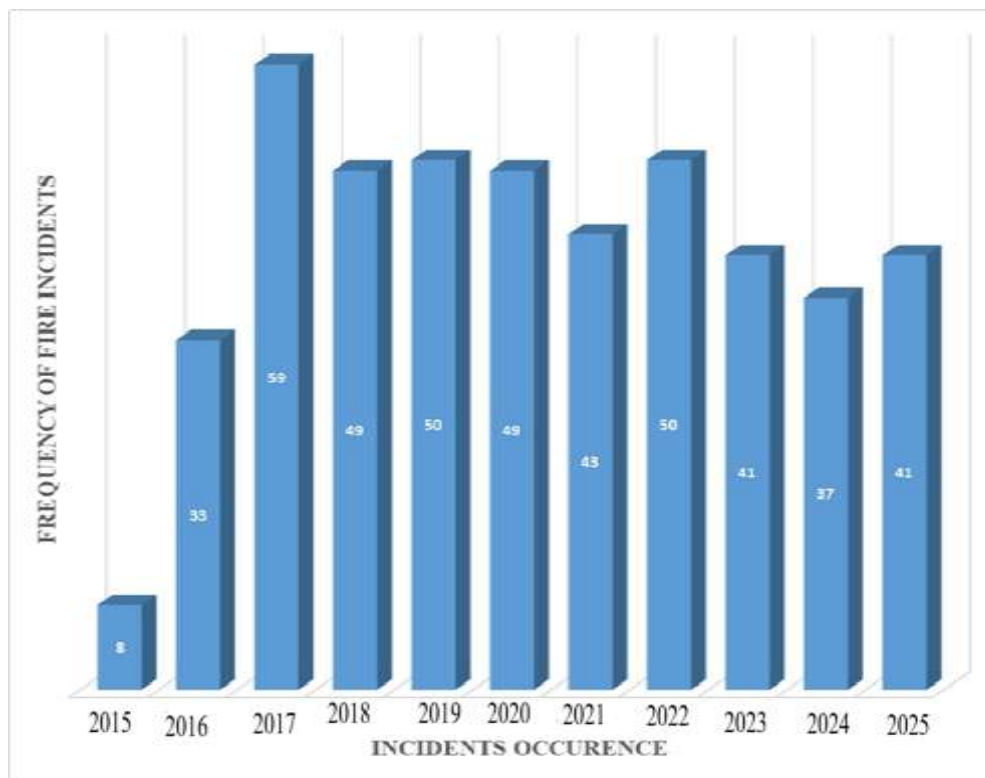


Figure 3: Fire Incidents Distribution between 2015 and 2025

The Ambulance stations have its Headquarters located at Government House Annex Oke-Fia Osogbo, established in May 2013. It serves as both the administrative and operational unit, with state-of-the-Art Vehicles and other Operational equipment with thirty staff members. The other Ambulance locations are Dele Yes-Sir roundabout; Steel Rolling, Fire Headquarters Abere, Railway station, Rano A. A. filling Station and Irepodun Street (Figure 4).

From the field and information from Osun State Ministry of Health and in its Statistics unit, the research acquired fifteen public and private owned hospitals with Accidents and Other Medical Emergency wards in the ministry's record, Osogbo. These includes; Spring Hope Specialist hospital, Peacelife Medical Centre and Specialist hospital, Our Lady of Fatima Catholic hospital and Osun State University Health Services. Others are UniOsun main Campus, Oroki hospital, Onward Specialist hospital, Halleluyah Specialist hospital, Emmanuel Medical Centre, BWB hospital, Biket Medical Centre, Adebare Specialist hospital, Osogbo Central hospital,

and Ayomide Women Specialist hospital were those located during the field survey (Figure 4).

However, the Ambulance stations on the other hand began operations in May 2013 and records of accidents and medical incidents were available from year 2017 to the researcher were five thousand and fifteen (5,015) victims' involvement in various accidents and other medical emergency cases within the study period. The emergency incidents were classified as accident emergency cases, 'women in labour' and other medical emergencies. Figure 4 shows the spatial distribution of the accidents and medical emergency incidents and Table 2 shows the summary of the medical emergency incidents in the study area within the study period. It was observed from Table 2 and Figure 5 that year 2025 had the highest incidents as 829 and year 2017 had the least record as 203 incidents. The records of the other years are as follows; 2018, 2019, 2020, 2021, 2022, 2023 and 2024 as 446, 486, 626, 673, 667, 801 and 284 incidents respectively in Osogbo (Table 2).

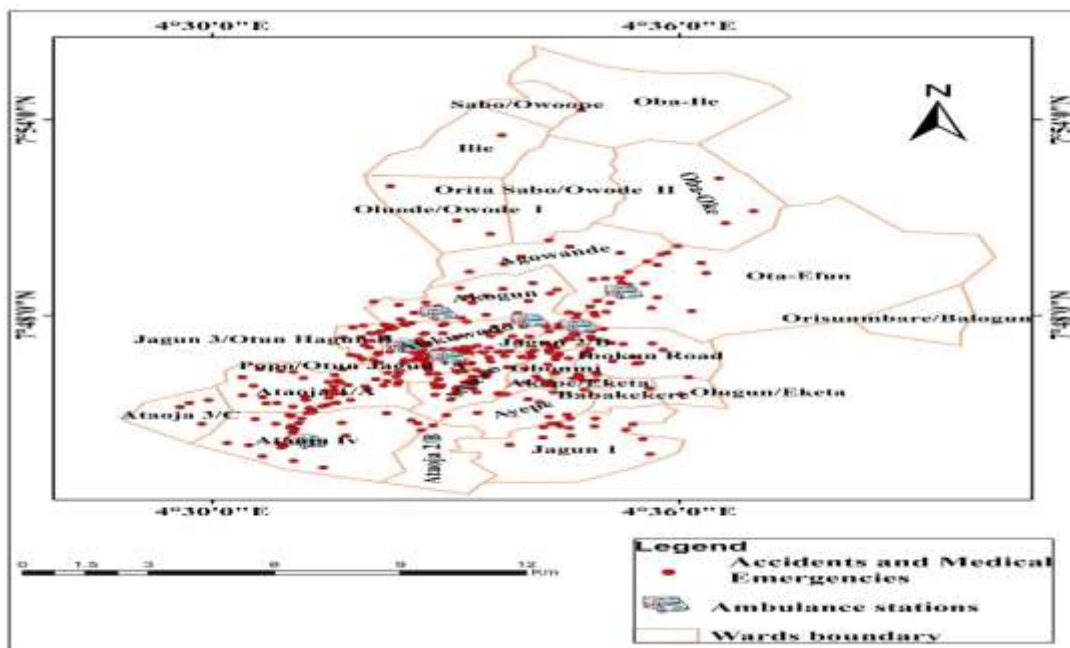


Figure 4: Emergency Facilities and Hospital with Accidents and Medical Emergency
Source: Research Fieldwork, 2025
Source: Osun State Ambulance and Medical Emergency Headquarters, Osogbo, 2025.

Table 2: Accident and Medical Emergency Incidents Distribution in Osogbo between 2017 and 2025

Month	Year 2017	2018	2019	2020	2021	2022	2023	2024	Year 2025	TOTAL
January	0	35	46	56	59	58	60	54	65	433
February	0	29	30	47	48	40	70	50	60	374
March	0	27	28	34	42	44	75	12	55	317
April	0	25	32	38	44	40	50	5	65	299
May	20	30	34	39	47	49	45	6	70	340
June	25	36	39	44	65	64	80	8	66	427
July	29	40	42	56	68	70	85	14	85	489
August	21	42	45	64	63	66	87	10	77	475
September	20	45	40	58	54	50	60	27	66	420
October	25	37	38	59	50	46	57	23	60	395
November	29	48	52	63	63	66	62	35	70	488
December	34	52	60	68	70	74	70	40	90	558
TOTAL	203	446	486	626	673	667	801	284	829	5015

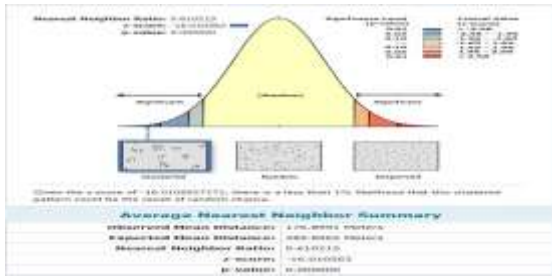


Figure 6: Average Nearest Neighbour of Fire Incidents in Osogbo

Temporal Dynamics of Emergency Incidents

The temporal dynamics of emergency incidents in the study area was analyzed showing the pattern of emergency incidents occurrence based on Monthly, Biennially and Seasonally. The monthly categorization was done showing the summation of emergency incidents in each month across the years under study. Biennial pattern of emergency incidents was based on the summation of all emergency incidents recorded for a pair of years. While the seasonal pattern of emergency incidents was classified as hot and dry season (January-March), warm and rainy season (April-June), rainy season (July-September) and lastly, warm and dry season (October-December).

Temporal Dynamics of Fire Incidents in Osogbo

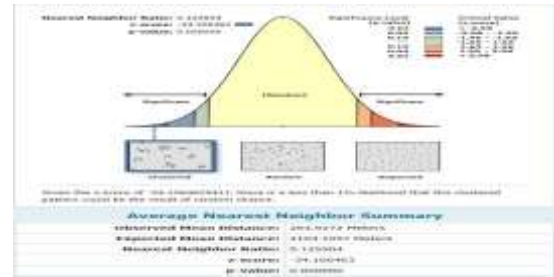
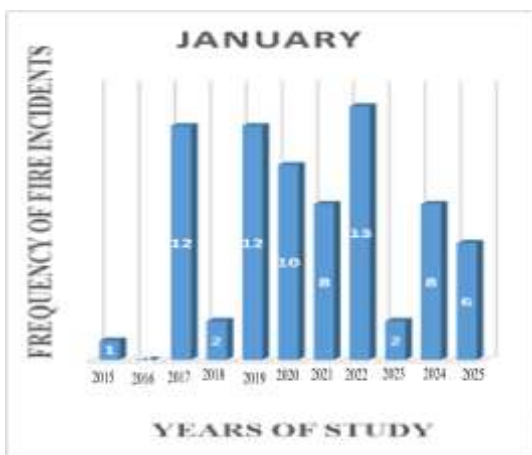
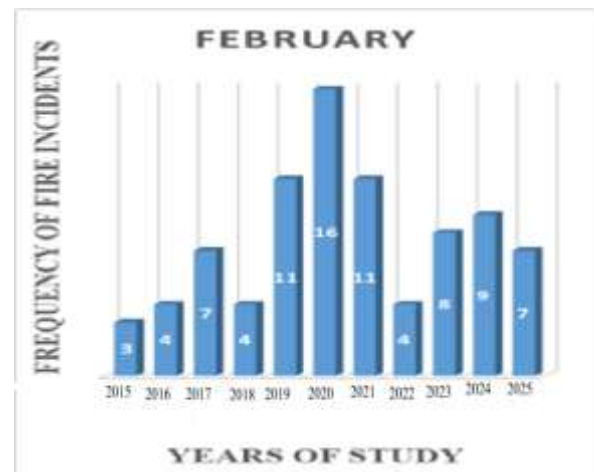


Figure 7: Average Nearest Neighbour of Accidents and medical emergency in Osogbo

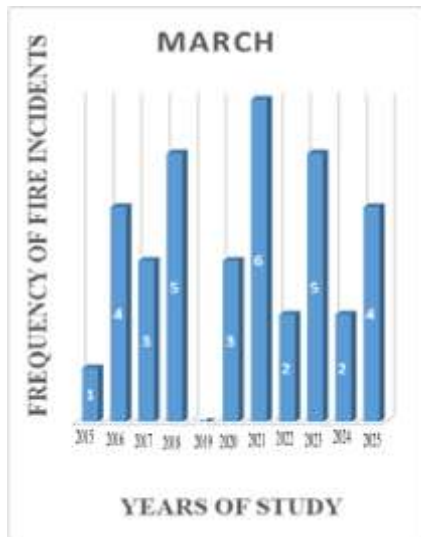
Figures 8 (a-l), the monthly pattern of fire incidents across the period under study. It was observed that the month of February recorded the highest fire incidents of 84 (18.26% of the total), followed by January 74 (16.08% of the total) and the month of May had the least recorded fire incidents 15 (3.26% of the total) in the study area. The peaks of fire incidents were recorded in the month of February year 2020, which was 16 fire incidents, followed by January year 2022 that had 13 fire incidents. These months recorded no fire incident; January 2016, March 2019, April 2015 and 2021, May 2019 and 2020. Other months are June 2015 and 2019, July 2015, August 2015 and 2016, September 2016, November 2015 and December 2015.



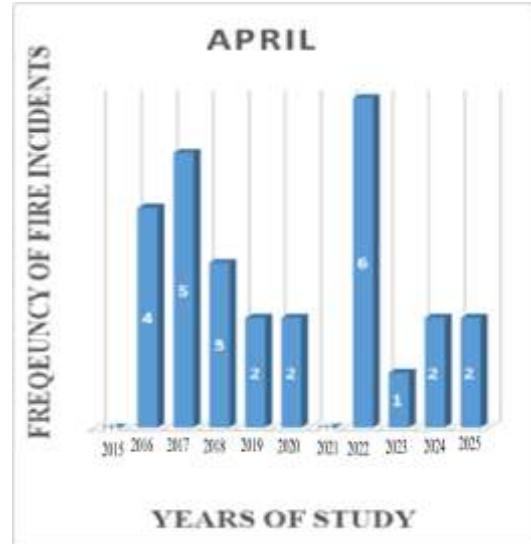
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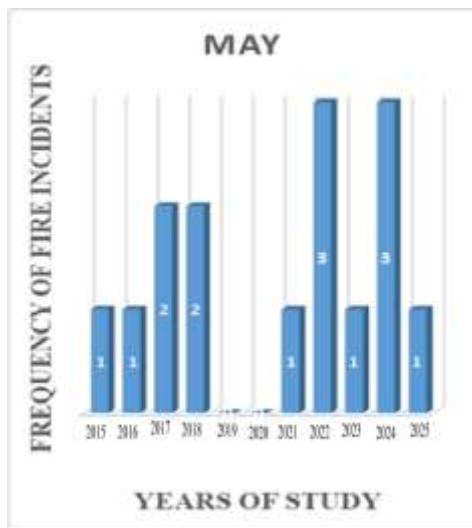
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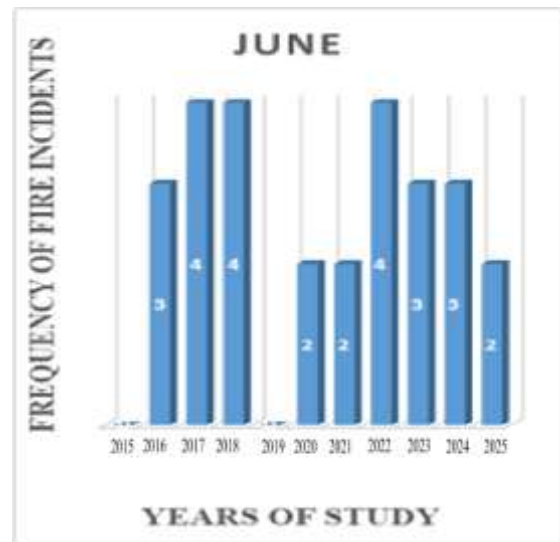
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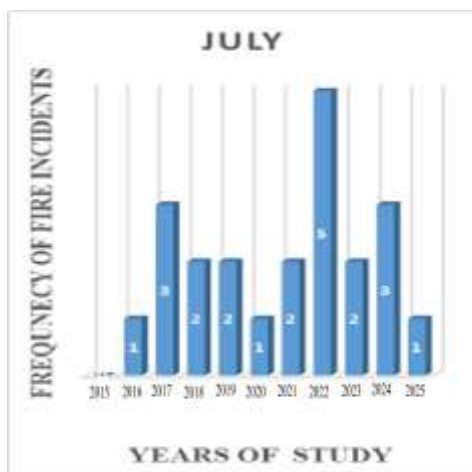
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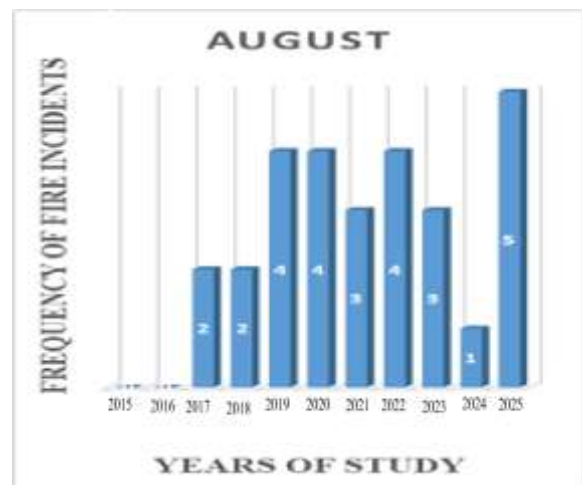
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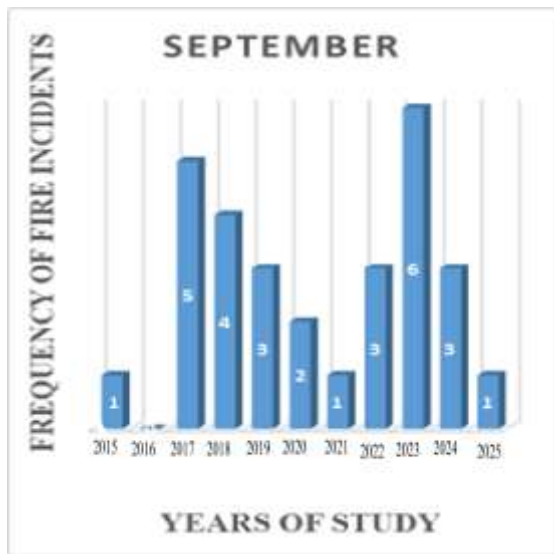
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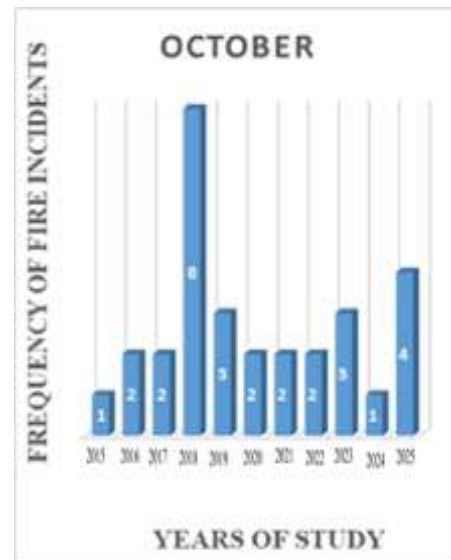
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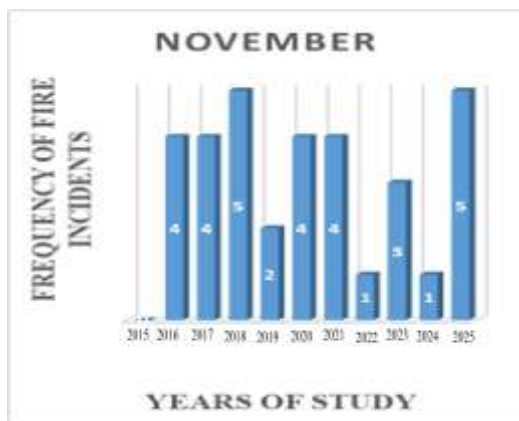
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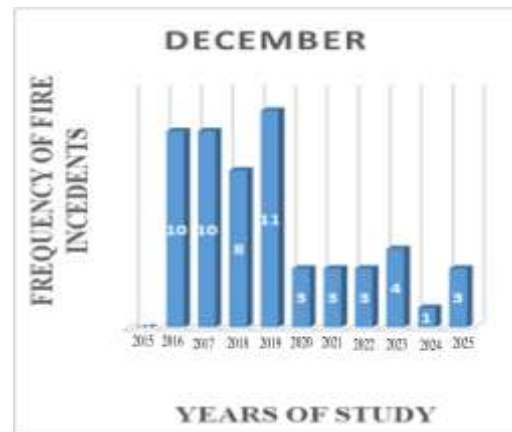
(i)



(j)



(k)



(l)

Figure 8: Monthly Fire incidents pattern between 2015 and 2025 in the Study Area (a-l)

Source: Research Fieldwork, 2025

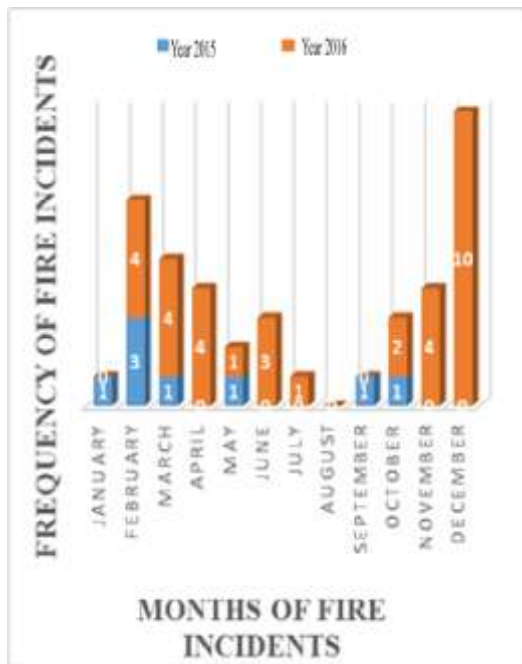
Figures 9(a-f) depicted the biennial pattern of fire incidents in the study area. At biennial level, irrespective of the nature of the fire incident, the fire incidents recorded was more in 2017-2018 that was 109 about 25.47%, followed by 2019-2020, which was 99 about 21.52%. The trend was seen to have the least record in 2015-2016 with a record of 41 fire incidents about 8.91%. Others are 2021-2022, 2023-2024 and year 2025 with fire incidents of 83, 78 and 41; and about 20.21%, 16.95% and 8.91% respectively.

The degree of fire incidents is greatly influenced with the seasons with which the incidents occurred according to Sulaiman Yunus (2021). In the study area, within the

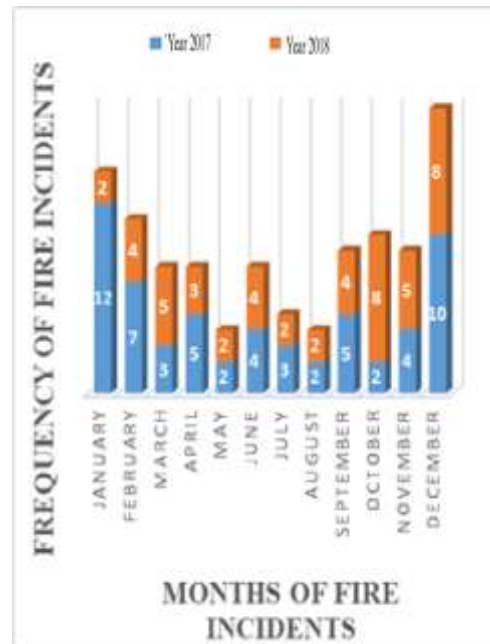
study period and in all categories of fire incidents and as presented in Figure 10(a-d), the hot and dry season (January-March) recorded the highest fire incidents of 189 about 41.08%, followed by the warm and dry season (October-December), 129 about 28.04%. These high records of fire incidents in the dry season were attributed to anthropogenic activities of the residents that were capable of triggering fire incidents; these activities were electrical, agricultural and domestic. In addition, people tend to be so busy or nonchalant in paying attention to fire safety tips thereby increasing the probability of causing fire especially in the dry season that naturally aids fire combustion. Naturally, it is expected that the rainy season (July-September) would record the least fire incidents within the period of study, but on the contrary. This season recorded 79 fire

incidents about 17.17%, and, the warm and rainy season (April-June) recorded the least fire incidents of 61 about 13.26%. This result supports the earlier works of Suliaman Yunus (2021) and Godfred Yeboah (2017) that the highest prevailing occurrences of fire incidents are in the hot and dry seasons. As discussed above that the rainy season is naturally

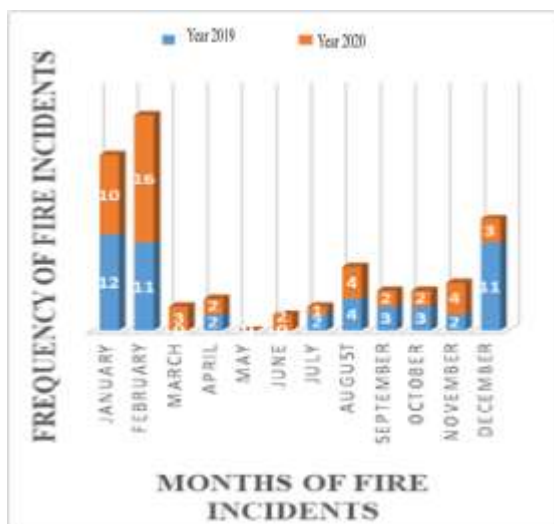
expected to have the least recorded fire incidents, but the results were of the contrary, this result was validated by the previous research of Suliaman Yunus (2021), where he obtained 29% of the total fire incidents in one of the Kano's markets.



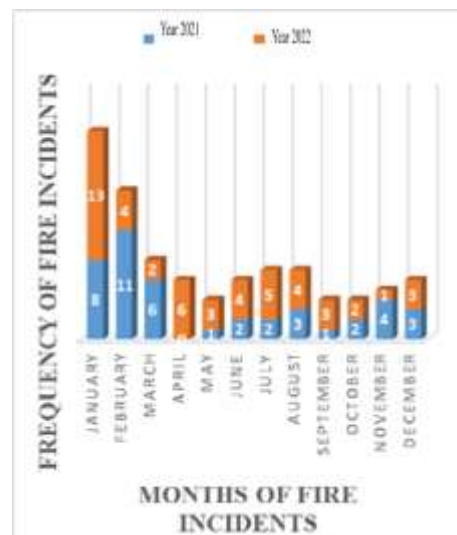
(a)



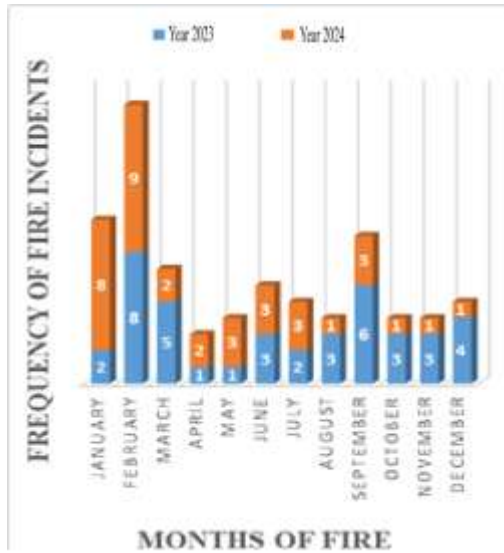
(b)



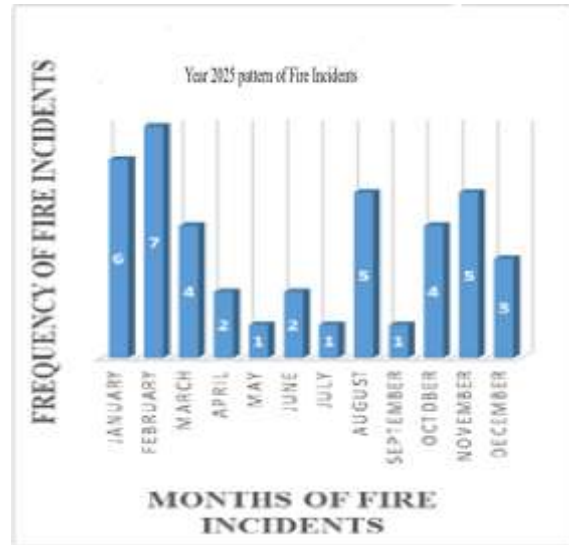
(c)



(d)

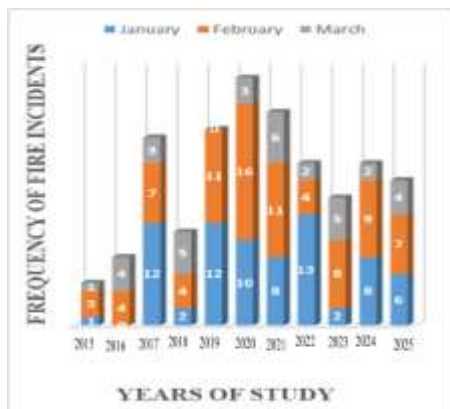


(e)

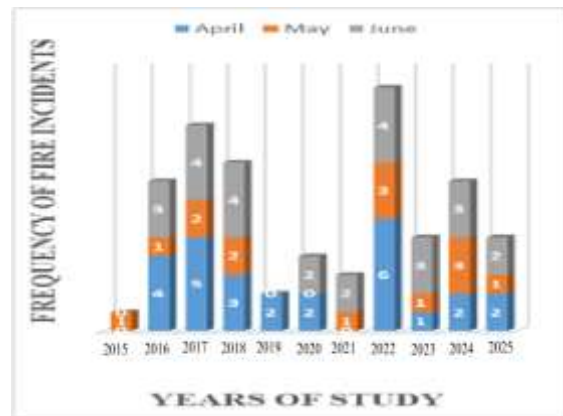


(f)

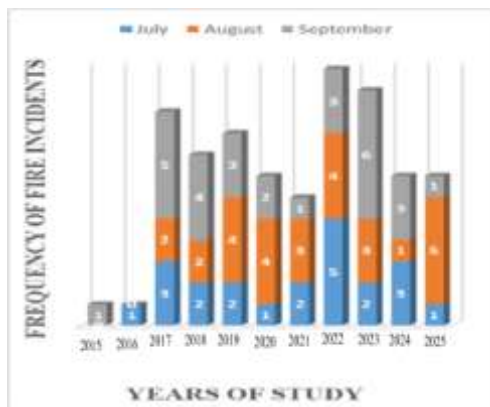
Figure 9: Biennial Pattern of Fire Incidents in the Study Area (a-f).
Source: Research Fieldwork, 2025



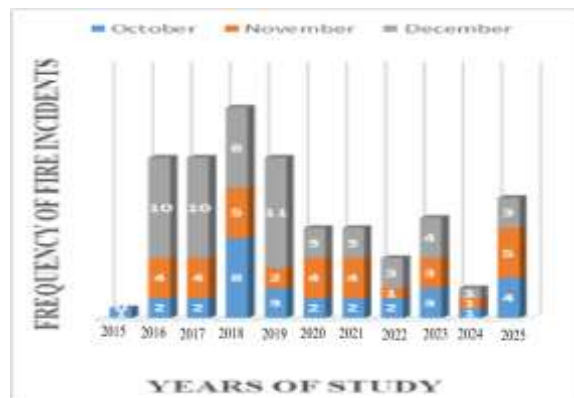
(a)



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(d)

Figure 10: Seasonal Trend of Fire Incidents in the Study Area (a-d)

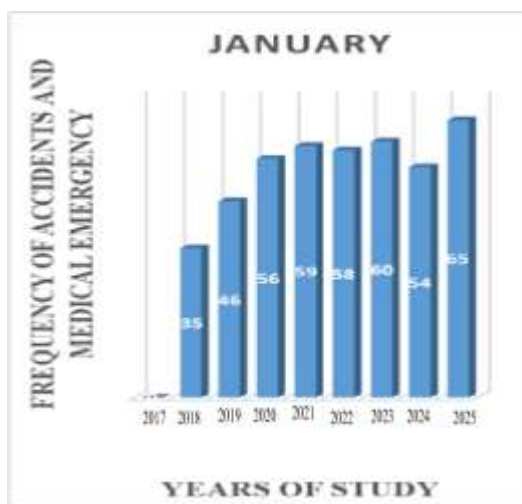
Source: Research Fieldwork, 2025

Temporal Dynamics of Accidents and Medical Emergency Incidents in Osogbo

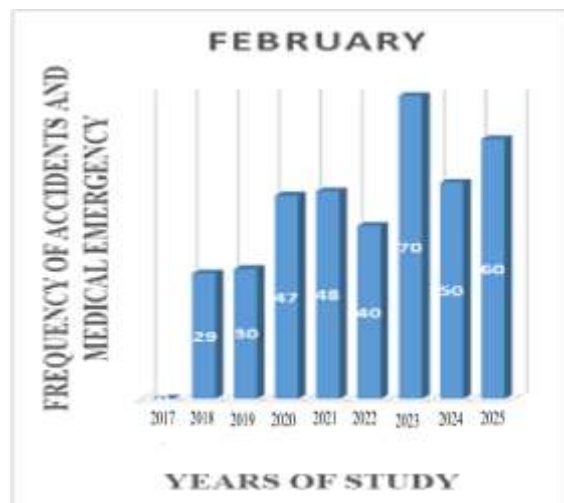
Figures 11(a-l) show the monthly pattern of accident and medical emergency incidents across the period under study. It was observed that the month of December recorded the highest accident and medical emergency incidents of 558 (11.12% of the total), followed by July with 489 (9.75% of the total) and the month of November with 488 (9.73% of the total). The month of April had the least recorded accident and medical emergency incidents of 299 (5.96% of the total) in the study area. There was no incident recorded for the Months of January-April 2017 available to

the researcher. From Figure 9(1), it was seen that the month of December had the peak of accident and medical emergency incidents with 90 incidents in year 2025.

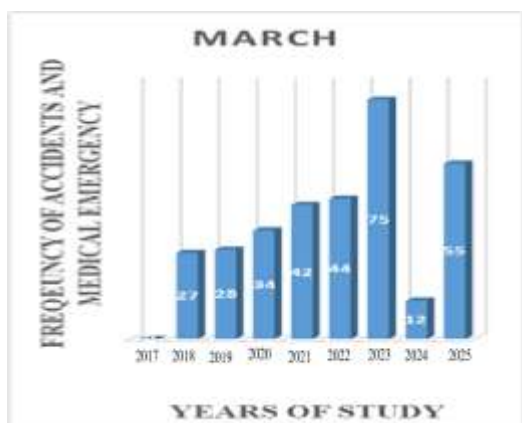
The biennial pattern of accident and medical emergency incidents is depicted in Figures 12 (a-e) below. Figure 10(c) that is, year 2021 and 2022 had the highest number of recorded accident and medical emergency incidents within the period of study. It had 1,340-recorded incidents that accounted for about 26.71% of the total incidents. This was followed by year 2019 and 2020 that had 1,112 incidents of about 22.17%; year 2023 and 2024 had 1,085 incidents of about 21.63%. Year 2017 and 2018 recorded 649 incidents, the least of the pair and of about 12.94%.



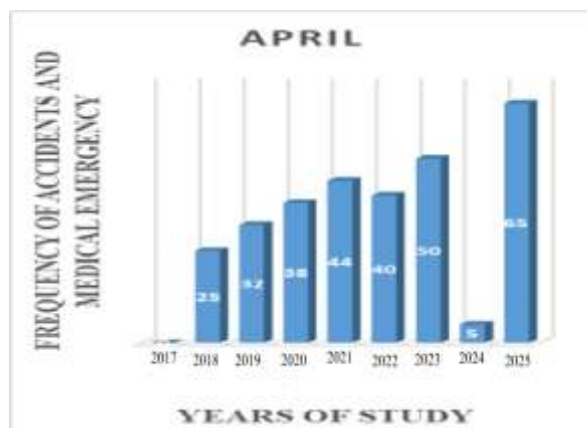
(a)



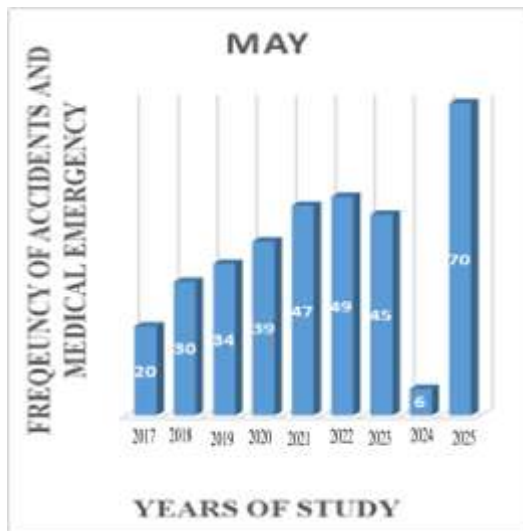
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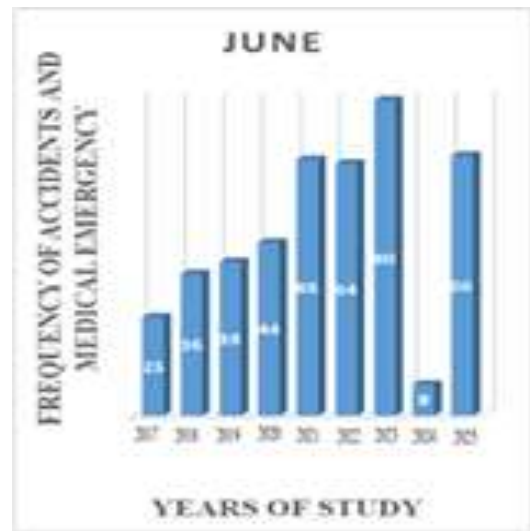
(c)



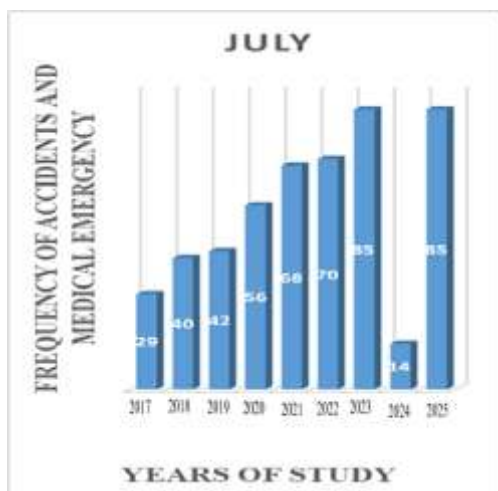
(d)



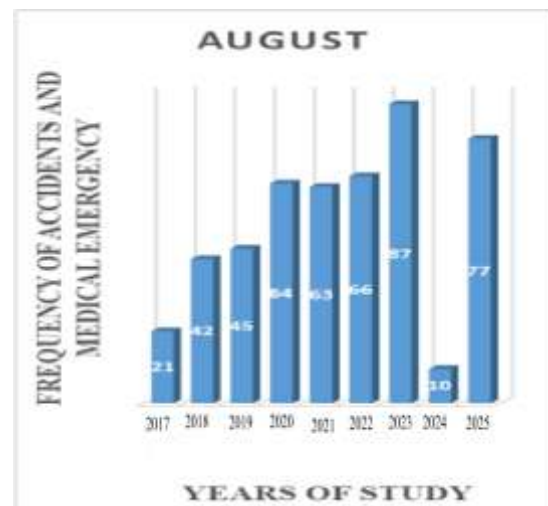
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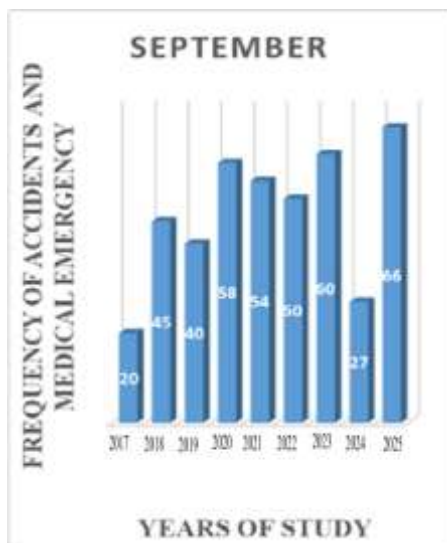
(f)



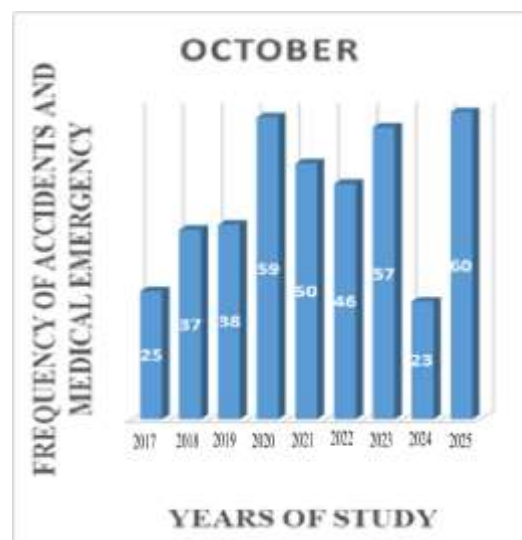
(g)



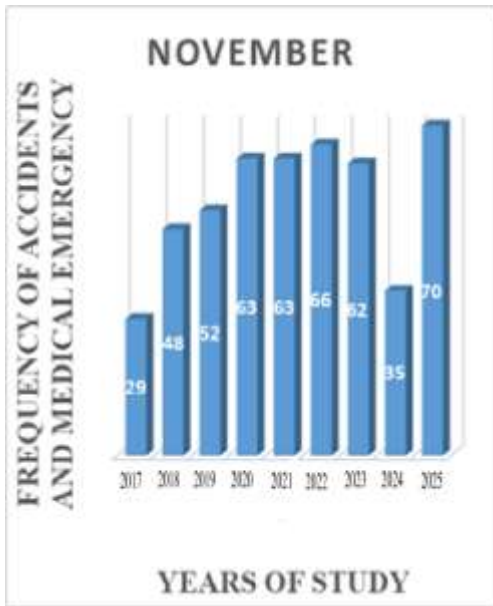
(h)



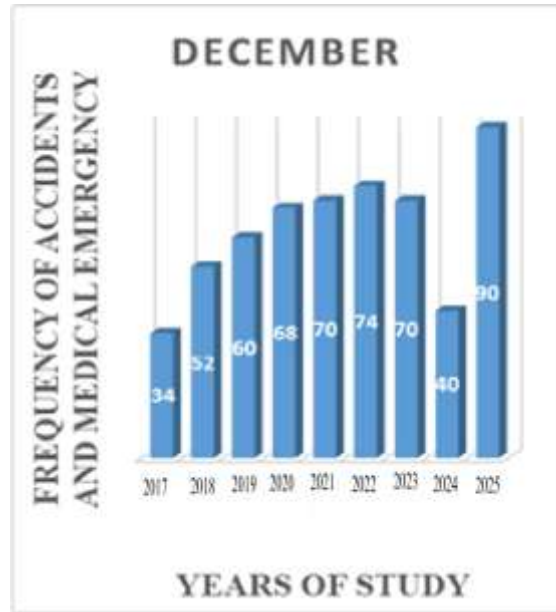
(i)



(j)

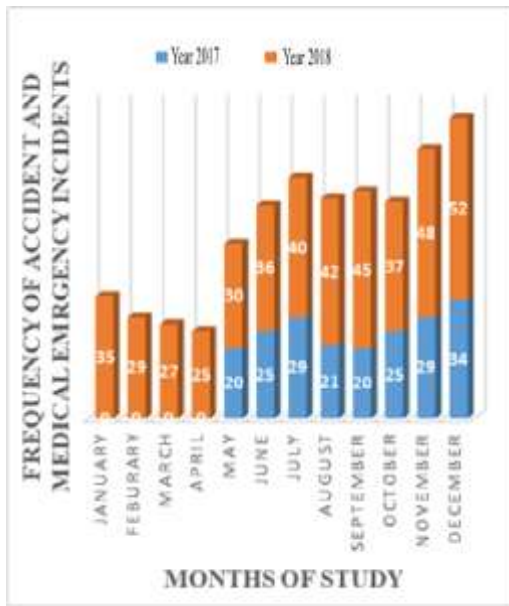


(k)

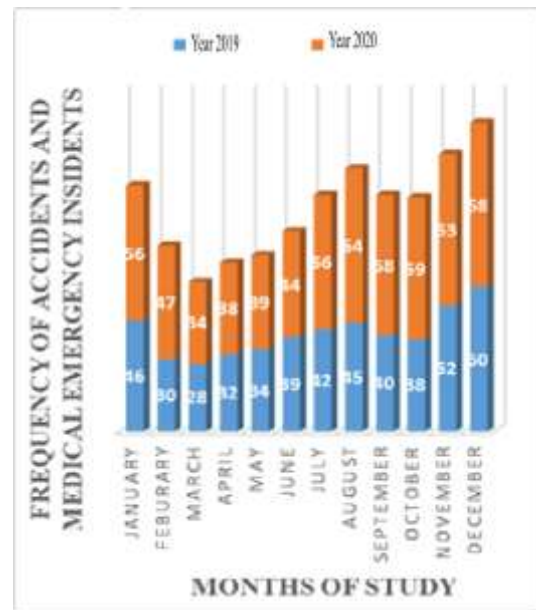


(l)

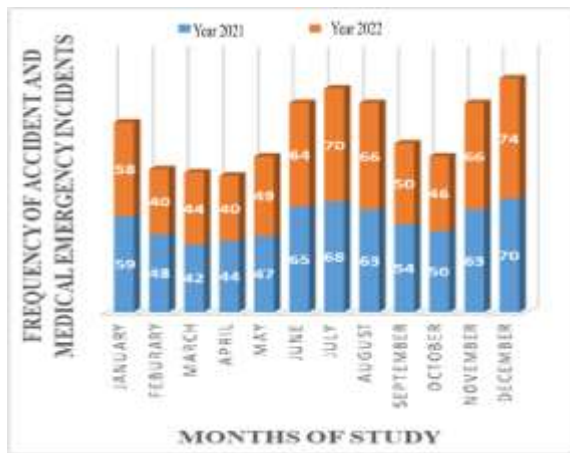
Figure 11: Monthly Accident and Medical Emergency incidents pattern between 2017 and 2025 in the Study Area (a-l) Source: Research Fieldwork, 2025



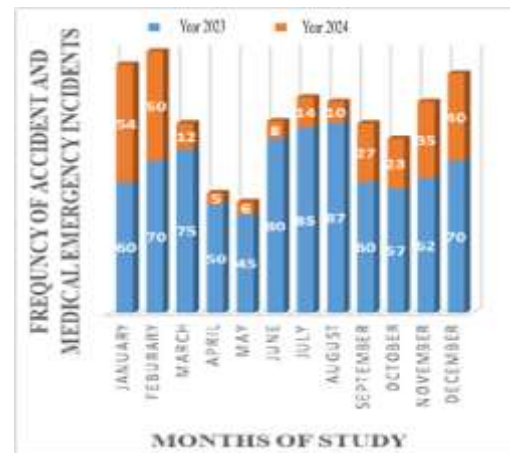
(a)



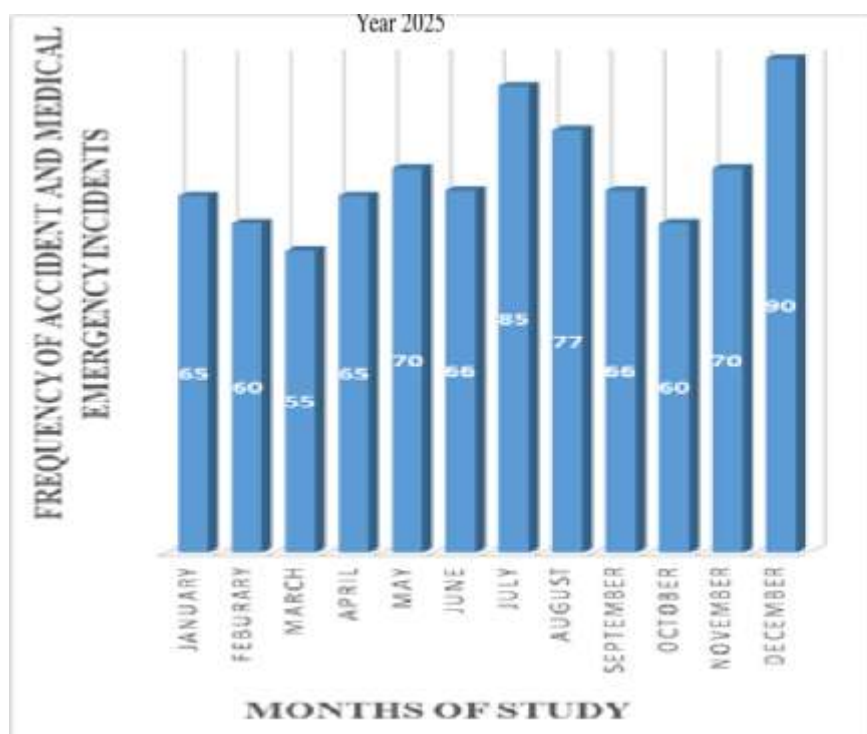
(b)



(c)



(d)



(e)

Figure 12: Biennial Pattern of Accident and Medical Emergency Incidents in the Study Area

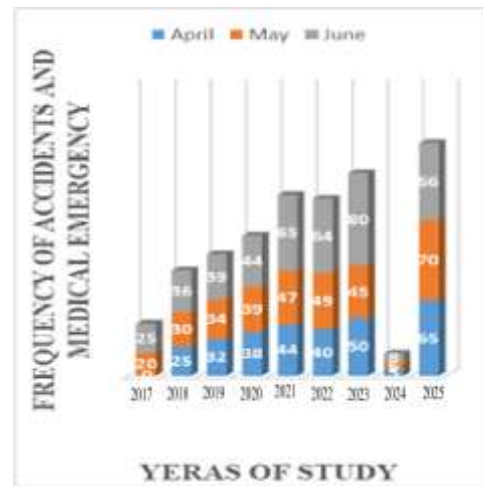
(a-e). Source: Research Fieldwork, 2025

Figures 13(a-d) are the results of the seasonal trends of accident and medical emergency incidents in the study area, within the study period. It was revealed that in all categories of accident and medical emergency incidents, the warm and dry season (October-December)

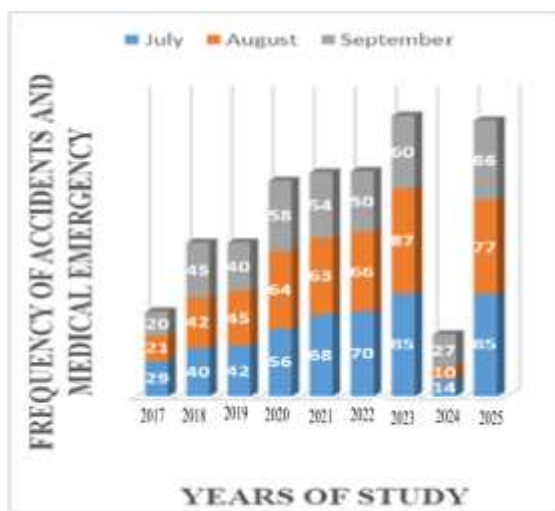
recorded the highest accident and medical emergency incidents of 1,441 of about 28.73%, followed by the rainy season (July-September), 1,348 of about 26.87%. The hot dry season (January-March) recorded 1,124 accident and medical emergency incidents of about 22.41%, while, the warm and rainy season (April-June) recorded the least accident and medical emergency incidents of 1,066 of about 21.24%.



(a)



(b)



(c)



(d)

Figures 13: Seasonal Trends of Accident and Medical Emergency Incidents in the Study Area

(a-d). Source: Research Fieldwork, 2025
(b) Quantitative Results

Quantitative analysis was employed to uncover the statistical relationships and seasonal variations in emergency incidents across Osogbo. By applying descriptive and inferential techniques, the study quantified how different types of emergencies interact, how their frequencies vary across time, and whether significant differences exist among seasons. This approach provided measurable evidence to complement the spatial findings, thereby strengthening the conclusions on urban resilience.

Pearson correlation Result

Pearson correlation was used to measure the strength and direction of association between fire incidents and medical emergencies. A positive correlation would suggest that increases in fire outbreaks tend to coincide with rises in medical emergencies, while a negative correlation would imply the opposite. This test measures the linear relationship between two continuous variables in this case, annual totals of fire incidents (2017–2025) and medical emergencies (2017–2025) as presented in Table 3. Using the Pearson correlation formular:

$$r = \frac{\sum(xi-x)(yi-y)}{\sqrt{(\sum(xi-x)^2 \cdot \sum(yi-y)^2)}} \quad (1)$$

Where

r= coefficient of correlation

x_i = Fire Incidents

y_i = Medical Emergencies

\bar{x} = Mean of Fire Incidents = $4199 \approx 46.56$

\bar{y} = Mean of Medical Emergencies = $50159 \approx 557.22$

$r \approx -0.63$

The negative correlation (-0.63) indicates that as fire incidents decrease, medical emergencies tend to increase. This suggests that medical emergencies in Osogbo are not directly driven by fire outbreaks, but by other factors such as traffic accidents, health crises, or seasonal influences. It highlights the interdependence but inverse relationship between different types of emergencies. The scatter plot (Figure 14) illustrates the relationship between fire incidents and

medical emergencies in Osogbo from 2017 to 2025. The downward-sloping red trend line indicates a negative Pearson correlation ($r = -0.63$, $p = 0.04$), showing a statistically significant inverse relationship at the 95% confidence level. This means that as fire incidents decreased, medical emergencies tended to increase a pattern suggesting that the two emergency types are influenced by distinct seasonal and environmental factors.

The moderate strength of the correlation implies that while fire outbreaks and medical emergencies are related, other contextual variables such as traffic density, public health conditions, and climatic variations also play major roles. The significance level ($p < 0.05$) confirms that this relationship is not due to random chance but reflects a real underlying dynamic in Osogbo's emergency patterns.

Table 3: Emergency Incidents in the Study Area 2017-2025

year	Fire Incident	Medical Emergencies
2017	59	203
2018	49	446
2019	50	486
2020	49	626
2021	43	673
2022	50	667
2023	41	801
2024	37	284
2025	41	829
Total	419	5015

Source: Research calculation, 2025

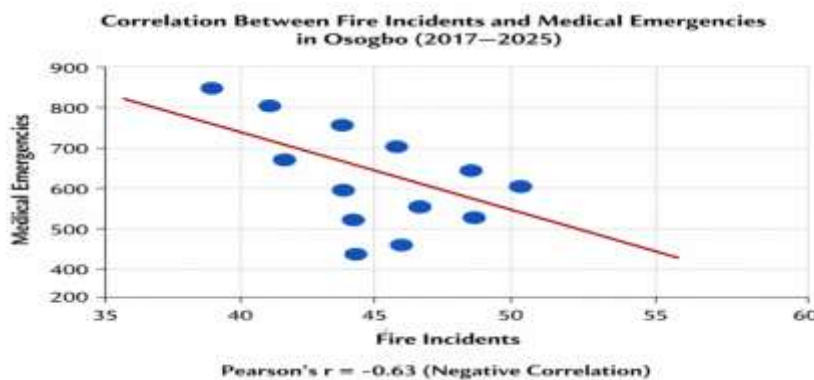


Figure 14: relationship between fire incidents and medical emergencies in Osogbo

(2017- 2025). Source: Research calculation, 2025
Regression Results

Regression analysis modeled predictive relationships, quantifying how one variable (fire incidents) influences another (medical emergencies). This allowed the study to estimate the extent to which fire outbreaks could statistically predict medical emergency cases. using the simple linear regression formula:

$$Y=a+bX \quad (2)$$

$$b=\text{Cov}(X, Y)/\text{Var}(X) \quad (3)$$

$$a=Y - bX$$

Mean of Fire Incidents (\bar{X}) = 46.56

Mean of Medical Emergencies (\bar{Y}) = 557.22

Slope (b) \approx -15.2

Intercept (a) \approx 1,264.6

$$Y=1264.6-15.2X$$

From Figure 15, the negative slope (-15.2) means that for every additional fire incident, medical emergencies decrease by about 15 cases. This confirms the inverse relationship already seen in the Pearson correlation. The intercept (1264.6) suggests that if fire incidents were zero, medical emergencies would still be very high showing that other drivers (traffic accidents, seasonal health issues) dominate medical emergencies. With Pearson’s $r=-0.63$, the regression is statistically significant ($p \approx 0.04$). This means the negative relationship is unlikely to be due to chance. Fire incidents and medical emergencies are not directly proportional reducing fires does not automatically reduce medical emergencies. Urban resilience planning in Osogbo must therefore address multiple risk drivers simultaneously fire safety in dry seasons, and traffic/health preparedness in rainy and warm-dry seasons.

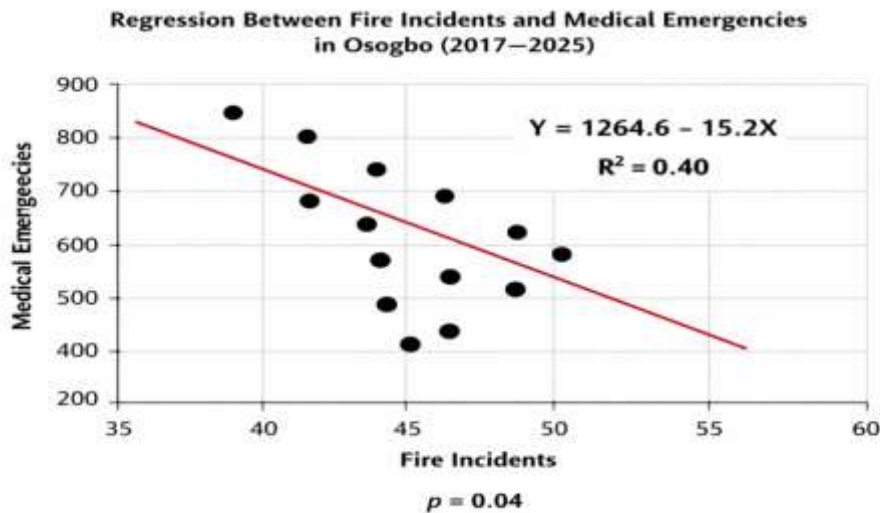


Figure 15: Regression between fire incidents and medical emergencies in Osogbo (2017- 2025). Source: Research calculation, 2025

Chi-square tests Results

Chi-square tests assessed whether there was a significant association between emergency type (fire, accident, medical) and season. This helped determine if certain emergencies were more likely to occur in specific climatic periods rather than being evenly distributed. The Chi-square test was applied to the contingency Table 3 of Fire Incidents and

Medical Emergencies from 2017–2025. The observed frequencies were compared against expected frequencies calculated under the assumption of independence.

$$E = (\text{Row Total}) * (\text{Column Total})/\text{Grand Total} \quad (4)$$

For example, for 2017 Fire Incidents: Row Total (2017) = 59 + 203 = 262 Column Total (Fire) = 419 Grand Total = 5434

$$E=262 \cdot 419 / 5434 \approx 20.2$$

This was repeated for all the rows and columns and the results as presented in the Table 4.

Table 4: Resultant Table (Observed vs Expected)

Year	Fire O	Fire E	Med O	Med E
2017	59	20.2	203	241.8
2018	49	40.5	446	454.5
2019	50	42.9	486	493.1
2020	49	55	626	620
2021	43	55	673	661
2022	50	55.9	667	661.1
2023	41	64.1	801	777.9
2024	37	24.5	284	296.5
2025	41	60.9	829	809.1

Source: Research calculation, 2025

$$\chi^2 = \sum(O-E)^2/E \quad (5)$$

Example for 2017 Fire:
(59-20.2) /220.2 ≈74.7

Summing across all cells gives: $\chi^2 \approx 132.5$

The Chi-square statistic was found to be 132.5.

With 8 degrees of freedom, the critical value at the 0.05 level is 15.51.

Since 132.5 > 15.51, the result was highly significant.

This indicated that the distribution of Fire Incidents and Medical Emergencies across years is not random. Certain years (notably 2017, 2023, and 2025) contributed strongly to the Chi-square value, showing large deviations between observed and expected counts.

Analysis of Variance (ANOVA) Result

Analysis of Variance (ANOVA) tested differences in mean frequencies of

emergencies across seasons. If significant, it indicated that seasonal conditions contributed to varying levels of emergency incidents rather than random fluctuations. Table 5 below is the summary of the ANOVA results for the contingency Table 3 for Fire and Medical emergencies.

The ANOVA test compared the mean counts of Fire Incidents and Medical Emergencies across the years 2017-2025.

The F-statistic = 17.4 with df = (1,16).

The p-value < 0.001, which is far below the 0.05 threshold.

This means the difference between the average number of Fire Incidents (≈ 46.6) and Medical Emergencies (≈ 557.2) is statistically significant.

Medical Emergencies occur at a much higher frequency than Fire Incidents, and this difference is consistent across years. The large F-value shows that the variation between groups (Fire vs Medical) is much greater than the variation within each group across years. This suggests that emergency response planning should prioritize medical cases, while still accounting for fire incidents as a smaller but steady category.

Table 5: ANOVA

Source of Variation	SS (Sum of Squares)	df	MS (Mean Square)	F	p-value
Between Groups	1,142,000	1	1,142,000	17.4	< 0.001
Within Groups	1,050,000	16	65,625		
Total	2,192,000	17			

Source: Research calculation, 2025

Conclusion

This study has advanced the understanding of spatial and temporal dynamics of emergency incidents in Osogbo, Nigeria, by integrating both qualitative and quantitative approaches. The findings revealed that emergency incidents particularly fire outbreaks and medical emergencies are spatially clustered, with hotspots concentrated in densely populated and economically active areas. Temporally, fire incidents were most prevalent in the hot-dry season (January–March), accounting for 41.08% of all recorded cases, while medical emergencies peaked in the warm-dry season (October–December), representing 28.73% of total incidents.

The quantitative analysis provided robust statistical evidence to support these patterns. Correlation analysis demonstrated significant relationships between fire and medical emergencies, suggesting interdependencies in their occurrence. Regression models quantified predictive relationships, indicating that increases in fire incidents could influence medical emergencies. ANOVA confirmed statistically significant seasonal differences in emergency frequencies, while descriptive statistics highlighted clear monthly and biennial variations. Collectively, these results underscore that emergencies in Osogbo are not only patterned but also interrelated, reflecting the combined effects of rapid urbanization, inadequate infrastructure, and anthropogenic activities.

The study concludes that Osogbo's emergency response system is constrained by limited facilities, uneven distribution of stations, and delayed response times, which exacerbate the impacts of disasters. The clustering of incidents highlights the need for strategic decentralization of emergency services to ensure equitable coverage and faster intervention.

Limitations

Despite its contributions, the study encountered several limitations. First, data availability was uneven, as medical emergency records were only accessible from 2017 onward, limiting long-term comparisons with fire incidents. Second, the scope was restricted to fire and medical emergencies, excluding other hazards such as flooding and building collapses that also affect Osogbo. Third, reliance on official records may have

underrepresented unreported incidents, creating possible data gaps. Finally, the findings are context-specific to Osogbo and may not be fully generalizable to other Nigerian cities with different socio-economic and spatial dynamics.

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