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Spatial Accessibility of Emergency Facilities to Road Accident Victims in Federal Capital City

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Abstract

This paper studied the spatial accessibility of emergency facilities to road accident victims in Federal Capital City to determine the sufficiency of existing emergency health care facilities and rescue facilities in servicing accident victims. This is useful for developing means of saving the lives of accident victims in the Federal Fapital City (FCC). The data used comprised of Nigerian Sat II 2013 multispectral imagery (5 m multispectral and 2.5 m Panchromatic) of FCC obtained from the National Space Research and Development Agency (NARSDA), coordinates of seventy (70) accident black spots, five (5) zebra points and sixteen (16) emergency health care facilities obtained from Federal Road Safety Commission (FRSC). ArcGIS 10.0 software was used to display, visualize, identify and extract features from the imagery, and create maps from different layers of the spatial data, choose colors and symbols, create buffer zones, analyze spatial relationships, and design map layouts. Purposeful sampling method was adopted to administer 99 questionnaires to accident victims in the hospitals within the FCC. The spatial data were used to determine the time of rescue, type of rescue and coverage time of rescue operation. The statistical data were used to assess the spatio-temporal distribution of accidents and determine the level of response by the rescue teams. The results show that accident victims have adequate access to health facilities but inadequate access to zebra points, and passers-by have more effective accident response than the government action agencies. Specific points for the creation of additional zebra points were identified through buffering, and the creation of sustainable Good Samaritan programs and training for community persons in first aid were suggested. Meanwhile, further research to determine the impact of time of rescue, type of rescue and category of hospital on the accident victims was suggested.

Keywords

Accident, Accessibility, Emergency Facility, Rescue, Geographic Information

System (GIS)

1. Introduction

1.1. Background

The incessant demolition by the Federal Capital Development Authority (FCDA) in a bid to conform to the Federal Capital Territory (FCT) master plan has resulted in inbound traffic in the morning and outbound traffic in evenings as compared to outer fringe to inner core movement at the initial stage of relocation to FCT. This peak period movement inundates the traffic landscape with Road Traffic Crash (RTC) along the traffic corridors (Balogun, 2006).

The rapid growth of the city, increase in the number of vehicles, traffic jams, over speeding and bad driving have resulted to an increase in death toll arising from road accidents which is becoming a major source of grief in a number of homes in FCC and Nigeria in general. This increase necessitates the need for developing means of saving the lives of accident victims. Minimum reduction of medical response time can be statistically associated with an average decrease of the probability of death by one third, both on motorways and conventional roads (Sánchez-Mangas, García-Ferrrer, De Juan, & Arroyo, 2010; Thakare, Shete, & Bijwe, 2021; Dinesh, Sujesh, & Kumar, 2021). Studies follow a similar format of analysis, which consist of collecting incident data pertaining to an "accident black spots" and the distance to the nearest medical facility (Stephen et al., 2018; Fshatsyon, Febretensay, & Juremalani, 2018; Patel et al., 2018). The study utilizes the concepts of Global positioning System (GPS), GIS, Remote Sensing and Conventional Methods in order to identify RTC black spots in the FCC and analyze the pattern of distribution of RTC black spots, FRSC zebra points and emergency health care facilities as well as establish the Time of travel from the RTC black spots to emergency health care facilities and convert the results to useful data in determining the sufficiency of existing emergency health care facilities and rescue facilities in servicing RTC victims within the study area.

Geospatial analysis based system can be used to propose emergency response plan for RTC in Nigeria which can considerably reduce response time and facilitates resource optimization. RTC response measures are gradually being developed to deal with each incident in an effective and timely manner (Morichi, 1995; Monia, 2021; Golakiya, Barib, Patkarc, & Dhamaniyad, 2019). Studies such as Spatial analysis of road traffic accidents in the Western and North Western Health Boards Report and GPS-GIS integrated systems for transportation engineering have also used these technologies for identifying RTC black spots and determining effective strategies for calculating time of travel to emergency facilities (Hogan, 2002; Sivaram & Kulkarni, 2009). Various applied research studies in the domain of health, archaeology, environment, tourism, and even vehicle routing have utilized satellite imagery and spatial vector data available on Google

earth and Google maps to find solutions to their problems (Contini, Bellezza, Christou, & Kirchsteiger, 2000; Yunus & Abdulkarim, 2022; Aule, Jibril, Garba, & Adewuyi, 2022).

Scholars use different approaches to carry out accessibility studies (Sellinger & Martin, 2014; Olawole, Arilesere, & Aguda, 2015; Obasanjo & Francis, 2015; Sunday & Ademola, 2016; Maqboo, Sethi, & Singh, 2019; Sagir, Enedah, Ono, Ojiako, & Igbokwe, 2021; Daudu, Jibril, & Yashi, 2022). Nevertheless, questions about the service coverage exist, such as how well the coverage matches the RTC black spots distribution (*i.e.*, service demands), and how quickly the ambulances/ Zebra points serve the black spot. In Nigeria the public may question the amount of time required for an FRSC ambulance to arrive after calling for service. Few studies have investigated RTC in FCC by examining the occurrence of crash and shortest path using LBs (Alade & Adepoju, 2010). GIS has become a popular tool to measure accessibility and analyze the location and service coverage problem.

The proposed indicators in this study differ from previous work in that this study replaces the centroids of the service areas as regard to health facility taking into consideration spatial distribution in order to visualize the service response performance over space and time. It also demonstrates time of travel from zebra points to RTC black spots and from RTC black spots on each road to the closet health care facility, which has not been visualized in previous studies.

The scope of the study is limited to FCC. It focuses on spatial analysis of road traffic crash black spots and proximity to rescue and medical facilities using Remote Sensing and Geographic Information System (GIS).

1.2. Access to Emergency and Travel Time Analysis

Churches in Location Modeling and GIS maintained that accessibility is a measurement to represent the number of ambulance locations required to provide service, the ambulance locations establish the population that the ambulance can serve within a response-time criterion (Churches, 1997). Radke & Mu (2000) used the spatial decomposition approach to predict accessibility to social services. Their model provided equal access to the public and accommodated underserved regions by measuring accessibility and evaluating the availability of ambulance services. Ganeshkumar & Ramesh, (2010) used Bangalore, India, accident data collected from the Assistant Police Commissioner Office, traffic police stations and emergency health care facilities in the study of Emergency Response Management and Information System to analyze optimal route from accident black spot to emergency health care facilities. The work demonstrated that GIS and GPS can be used successfully in optimization of routes in carrying of accident victims. This study ravels that in majority of the cases victims are admitted to hospitals which are located far away from accident spots rather than admitting them to the nearest hospitals.

Estochen, Strauss, & Souleyrette (2008) in an Assessment of Emergency Re-

sponse Vehicle Pre-Deployment Using GIS Identification of High-Accident Density Locations identified the potential benefits of emergency vehicle pre-deployment. The research concluded that GIS can be used to assess existing service areas, to identify potentially underserved areas, and to evaluate the implications of potential changes in EMS systems. Arosanyin (2005) in Reducing Road Injury Severity in Nigeria Through Improved Post Impact Care and Observation, depicts that the medical response to road crash victims can be viewed as a chain comprising about six links namely, the role of bystanders or lay witnesses, access to emergency medical system, emergency rescue services, pre-hospital medical care, hospital trauma care and rehabilitative psychological care. However, Application of GIS and GPS on operations for Hazardous Materials Transportation Incident in Malaysia presents a case study on Madurai in which most of the emergency situations arise due to road and fire accident for which a detailed GIS database of transportation network, accident locations, hospitals, ambulance locations, police and fire stations was prepared and spatial analysis carried out for accident records of years 2004-2008 by using Arc GIS 9.3 (Ismail, 2011). The study concluded that Geographic Information System (GIS) and Global Positioning System (GPS) are the effective tools to manage and organize complex data sources such as road network and then derive them to the shortest route, minimum traffic and risk analysis for the evaluation of risk involved.

Asogwa (1992) in a review on Road traffic accidents in Nigeria suggested that emergency telephone number of emergency services such as fire fighters, road safety commission and emergency medical service should be created where there is none and should be widely publicized and accessible. And since FRSC, fire fighter, rescuers, police and coastguards in some areas may arrive at the scene before emergency medical service personnel, it is important that fire fighters be trained in the provision of basic life support techniques. Balogun (2006) in his study, Modeling Road Traffic Crash in Abuja with GIS/Remote Sensing Technology attempted to answer where, when and how Road Traffic Crash (RTC) occurred, the study merged both spatial and attributes data using Arc View and subjected this to spatial analysis of coverage, overlay and queries. The study submits that crashes are associated with areas of intense activities and suggested that FRSC should be proactive in accident prevention, responsive to the dynamics of accident causative factors and reactive to rescue accident victims.

Quiroga & Bullock (1999) in Travel Time Information Using GPS and Dynamic Segmentation Techniques, a methodology for travel time studies was presented and updated. Pour & Yue (2012) in the study "The Role of Geographic Information Systems in Road Emergency Services Location and Black Spot" used police accidents data from 2006 to 2009 collected by Khuzestan Police Officers. The study recognized that time is a crucial factor in dealing with medical emergencies resulting from road traffic accidents. New EMS locations were recommended in the study according to 15 minute response time by GIS network analysis and with attention to crash black spots. For decreasing response time

less than 15 minutes, it is essential to decrease distance of EMS locations or re-analyze GIS data.

In summary, the nearest emergency health facility is commonly determined by travel distance. Using distance is simple and easy, but it only captures proximity between population and service providers. Only using the closest facility without taking into consideration their spatial distribution is not an effective measure of spatial accessibility because overlapping catchments exist. For example, this is often the case for health care service, in which patients bypass the nearest service in order to choose another service from within the service area. Accessibility has to be looked at in terms of spatial distribution so as to capture exact information provided by the location information and general pattern.

1.3. Study Area

The study area is the Federal Capital City (FCC) located within the Federal Capital Territory (FCT) Abuja Municipal Area Council (AMAC) as shown in **Figure 1**. The study area (FCC) falls within the Gwagwa plains with terrain elevation ranging between 305 m in the west to 610 m in the east (Ojigi, 2005). The soil structure of the area is thin with texture generally stony to gravelly sand with smaller occurrences of loam. The two main types of soils in FCT are the sedimentary belt in the southern and south-western extremities of the territory and the pre-Cambrian Basement complex rock country which accounts for more than 80 percent of the territory. Having a unique feature (the rain increases from the south of the territory to the north) due to the influence of Jos plateau.

At the moment, FCC is the commercial hub of the Federal Capital Territory. The bulk of Federal institutions, ministries, and embassies are located within the confines of the FCC. The new Kubwa expressway has significantly eased traffic from Zuba, Kubwa and Gwarinpa into the city, but residents coming in from Karu and Nyanya to the east still spend about an hour or more commuting. A new 10-lane expressway is constructed from Gwagwalada to the Abuja City Gate monument; this road also links the Nnamdi Azikiwe Airport to the main city (Wikipedia, 2013).

The Federal Capital Territory, Abuja has 13 government hospitals, spread across the 6 area councils, namely, General hospitals, Abuja Area Municipal Council (AMAC) located in Nyanya, Abaji, Gwagwalada, Kwali, Kuje and Bwari, including those located in the federal capital city.

2. Materials and Methods

The study combined both spatial and attributes data (acquired from both primary and secondary sources) in a GIS environment using ArcGIS 10.0 and then subjected it to spatial buffer. The data comprise of Nigerian Sat II 2013 multispectral imagery (5 m multispectral and 2.5 m Panchromatic) of FCC obtained from the National Space Research and Development Agency (NARSDA), coordinates of seventy (70) accident black spots, five (5) FRSC zebra points, sixteen

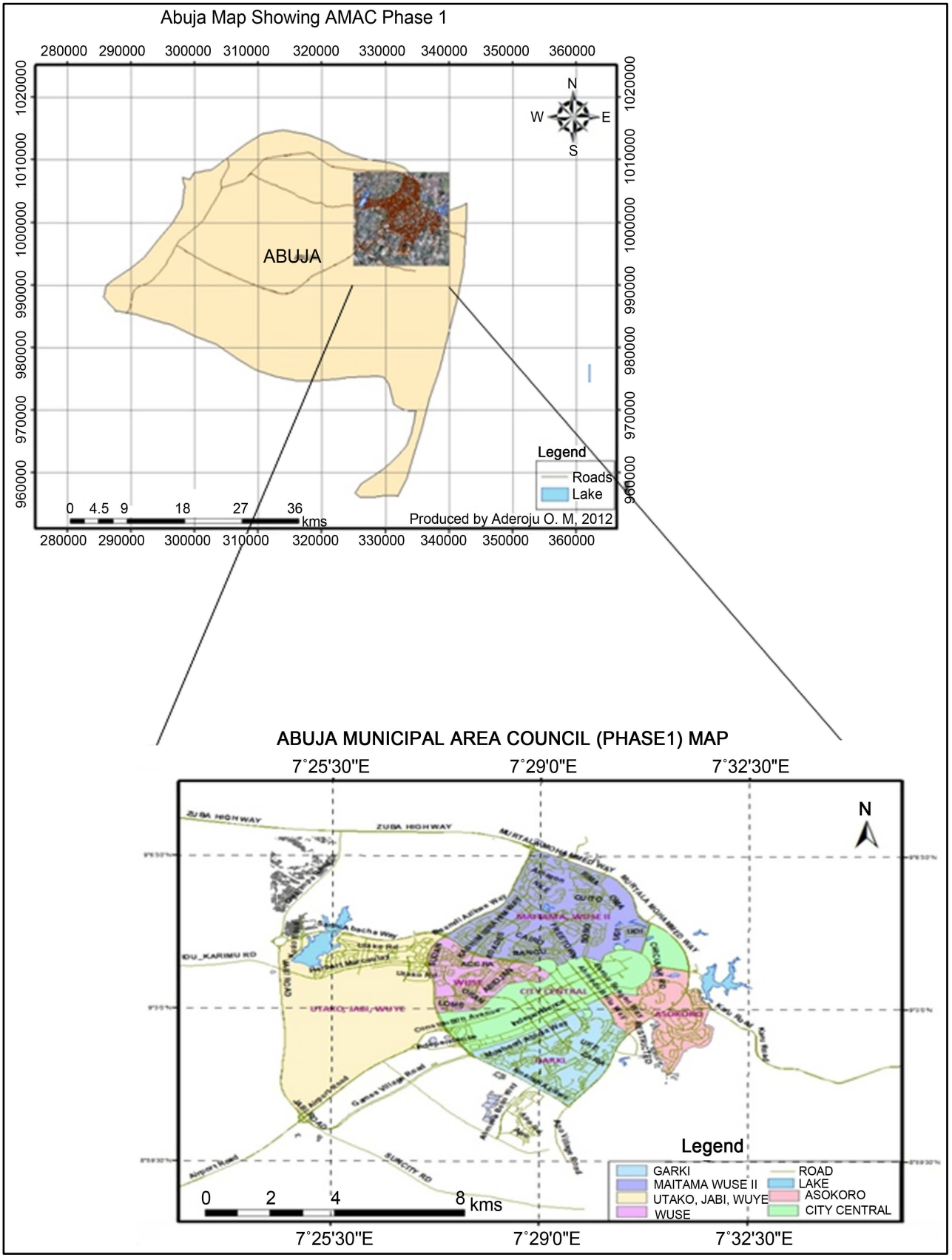

Figure 1. Federal capital city. Source: NARSDA, 2012.

(16) emergency health care facilities obtained from FRSC and road network digitized from the satellite imagery. A site survey of the study area was carried out to obtain the coordinates of accident black spots, hospital locations and zebra points collected from FRSC with the use of a GARMIN 76S GPS for validation.

Arc GIS 10.0 software was used to display Nigeria Sat II imagery in three bands (Red, Green and Blue) (Figure 2). It then combined the three bands to produce a true colour image of the study area (multispectral band) which enhanced the ability to visualize, identify and extract features from the imagery.

It was projected to WGS 1984, Universal Transverse Mercator, Datum 100 Minna-Nigeria, Zone 32P via the data frame property of the software. The imagery was georeferenced by the collection of the X and Y coordinates of T-junctions (roads) and identifiable buildings via the use of Garmin Global Positioning System device during the field work (ground thruthing exercise). The points collected where then used to geo-reference the image. At the end of the geo-referencing, an image clipping operation was performed using the Arc GIS 10.0 software in the arc toolbox to extract the area of interest. This was done to obtain a rectified map and to aid the visibility of the features to be digitized. Through the digitizing process, a personal geo-database for each feature of interest was created in the Arc Catalogue of the ArcGIS software. The features created were projected to WGS 1984, Universal Transverse Mercator, Datum 100 Minna-Nigeria Zone and later imported into the ArcMap environment as shape files (.shp).

The creation of database was carried out after geo-referencing in Arc-Catalog, after which feature dataset and feature classes were fashioned out. Four Layers were extracted from the satellite imagery via a digitization operation; FCT roads, river channels, FCT Boundary, and the various Districts.

The Zebra points, Black spots and Hospital coordinates were first recorded

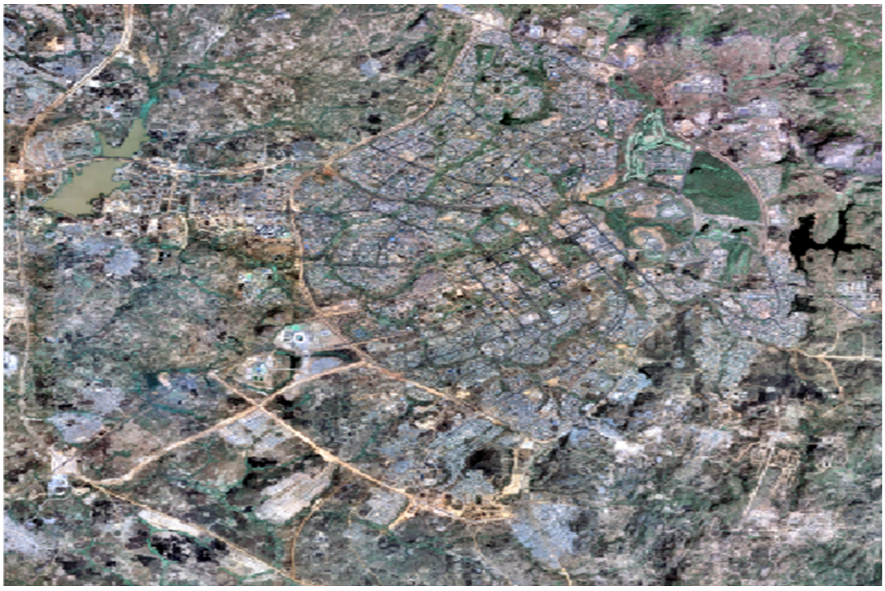

Figure 2. Nigerian sat II image of FCC. Source: NASRDA, 2013.

into the Microsoft excel document. It was then converted to the .csv file delimited format and subsequently imported into the ArcGIS software as longitude and latitude coordinates. Then it was converted to an event file and tied to the coordinate system of the data frame property and finally exported into the map layer as a shape (.shp) file. The feature overlay function was used to produce a single map (Figure 3).

The basic spatial analysis employed for this work was done in ArcMap environment. In Arc Map, the study was able to create maps from different layers of spatial data, choose colors and symbols, create buffer zones, analyze spatial relationships, and design map layouts. The Arc Map interface contains a list (or table of contents) of the layers in the map, a display area for viewing the map, and menus and tools for working with the map. In Arc Toolbox, tools were used to convert spatial data from one format to another as well as to change the map projection of data.

Questionnaires were designed and administered to all the hospitals in the study area. A total of 99 accident victims were willing to take the questionnaires administered out of the 100 questionnaires prepared. Purposeful sampling was adopted in line with the total population sampling method to self-administer the questionnaire to RTC victims in the selected hospitals within the study areas. This method of sampling focused on accident victims within the FCC hospitals. The data from the questionnaire was used to determine the time of rescue, type

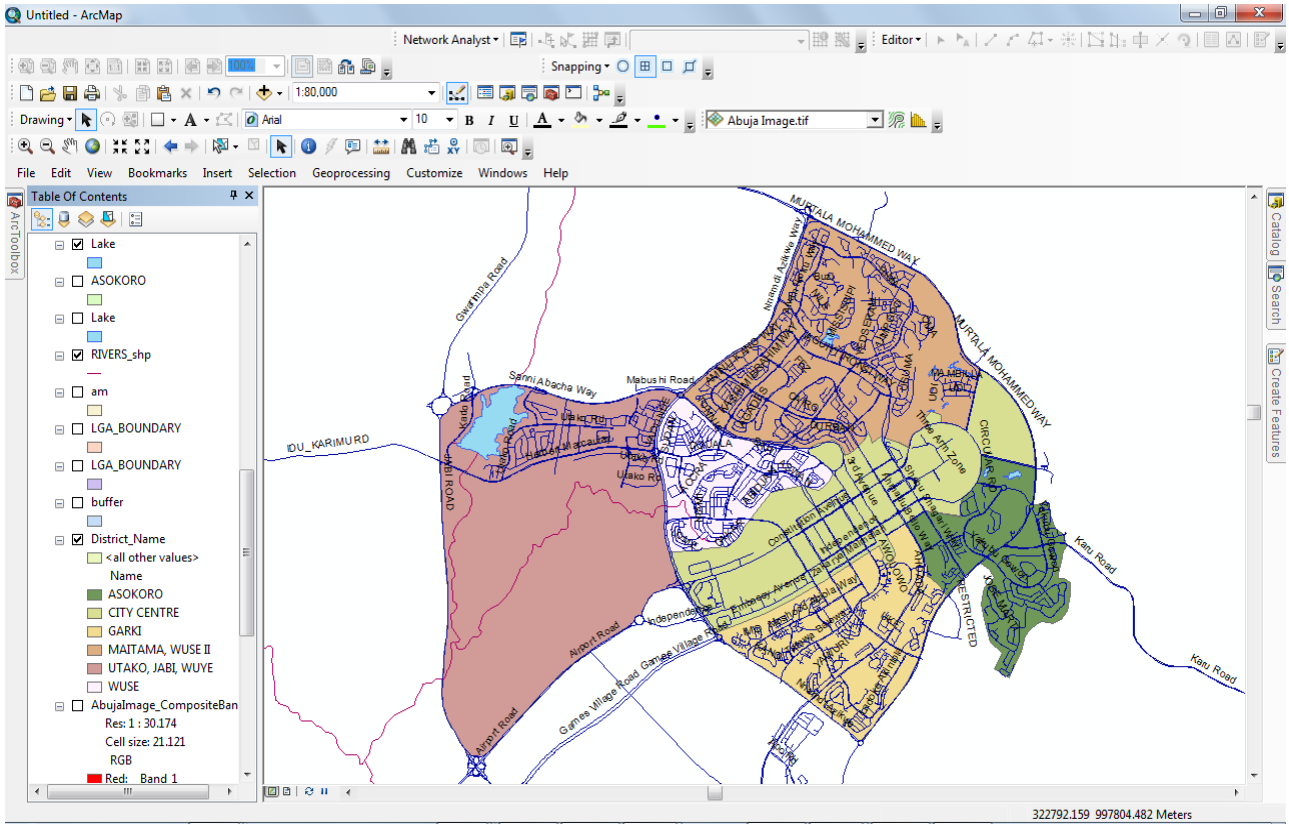

Figure 3. Overlay of digitized features on the study area. Source: Field work, 2013.

of rescue and coverage time of rescue operation.

Questionnaires obtained from field work were analyzed in Microsoft excel software's to graphically display opinion of the respondents concerning the study area with respect to spatio-temporal distribution of RTC in FCC District, types of rescue. Statistical presentations were made after the retrieval of administered questionnaire to determine the level of response by the FRSC rescue team, members of the public and police, and the spatio-temporal distribution of RTC in the study area.

3. Results and Discussion

3.1. Spatial Accessibility of Emergency Facilities to Accident Victims

Analysis of the spatial accessibility to emergency facilities by accident victims was done in terms of time, distance and type of rescue. Figure 4 and Figure 5 are the results of 5 minutes, 10 minutes and 15 minutes accessibility from accident black spots to health facilities and zebra points respectively. The result reveals that 34% of the victims could be conveyed to the nearest hospital within 5 minutes, 29% of the victims could be conveyed to the nearest hospital within 10 minutes while 37% of the victims could be conveyed to the nearest hospital

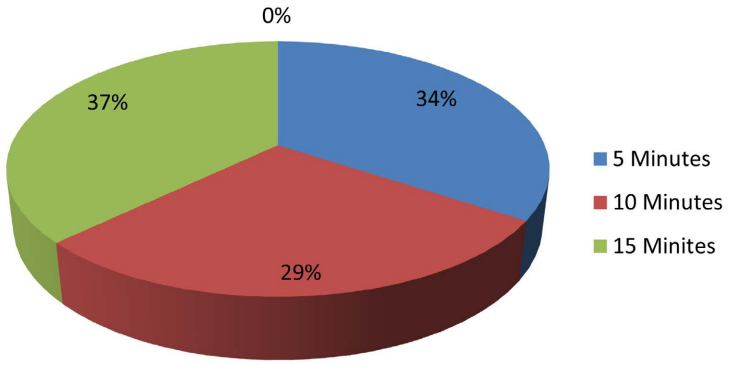

Figure 4. Accessibility of victims from black spots to health facilities.

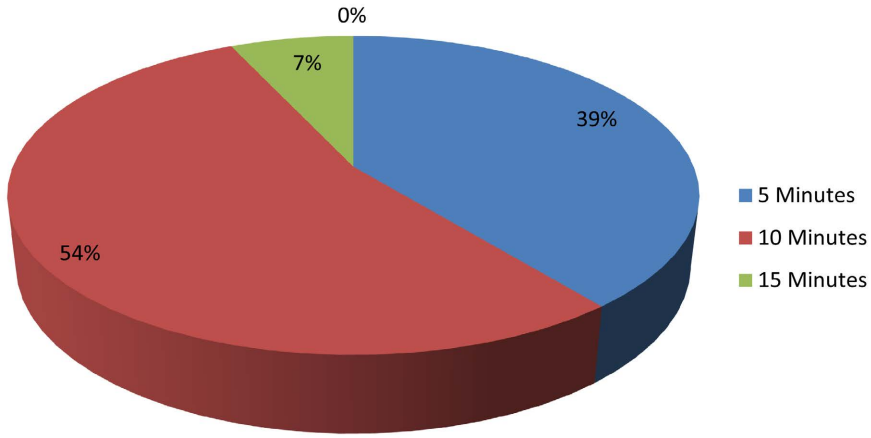

Figure 5. Accessibility of victims from black spots to zebra points.

within 15 minutes. This trend of accessibility implies that, the victims have similar rate of accessibility to health facilities irrespective of the differences in their distances. However, accessibility to health facilities increases with distance. Alternatively, 39% of the victims were found to be 5 minutes away from the nearest FRSC zebra points, 54% of the victims were 10 minutes away from the nearest zebra points while 7% of the victims were 15 minutes away from the nearest zebra point. Thus, accessibility to zebra points decreases with increasing time. This suggests the need for additional zebra points in the area for effective rescue operations.

Furthermore, a common distance of 2 km was used based on a constant speed of 60 km per hour. Buffer analysis was employed to map the identified accident black spots in the study area that fall within two kilometers (2 km) from the general hospitals as well as zebra points. The creation of the buffer zones indicates that general hospitals which are assumed to be adequately equipped in the study area are fairly sufficient to service accident victims within sufficient time and efficient coverage of rescue operation. In addition, they are relatively cheaper than their private counterparts. The result indicates that, 71.4% of the black spots are accessible to the six (6) General hospitals within 2 km (Figure 6).

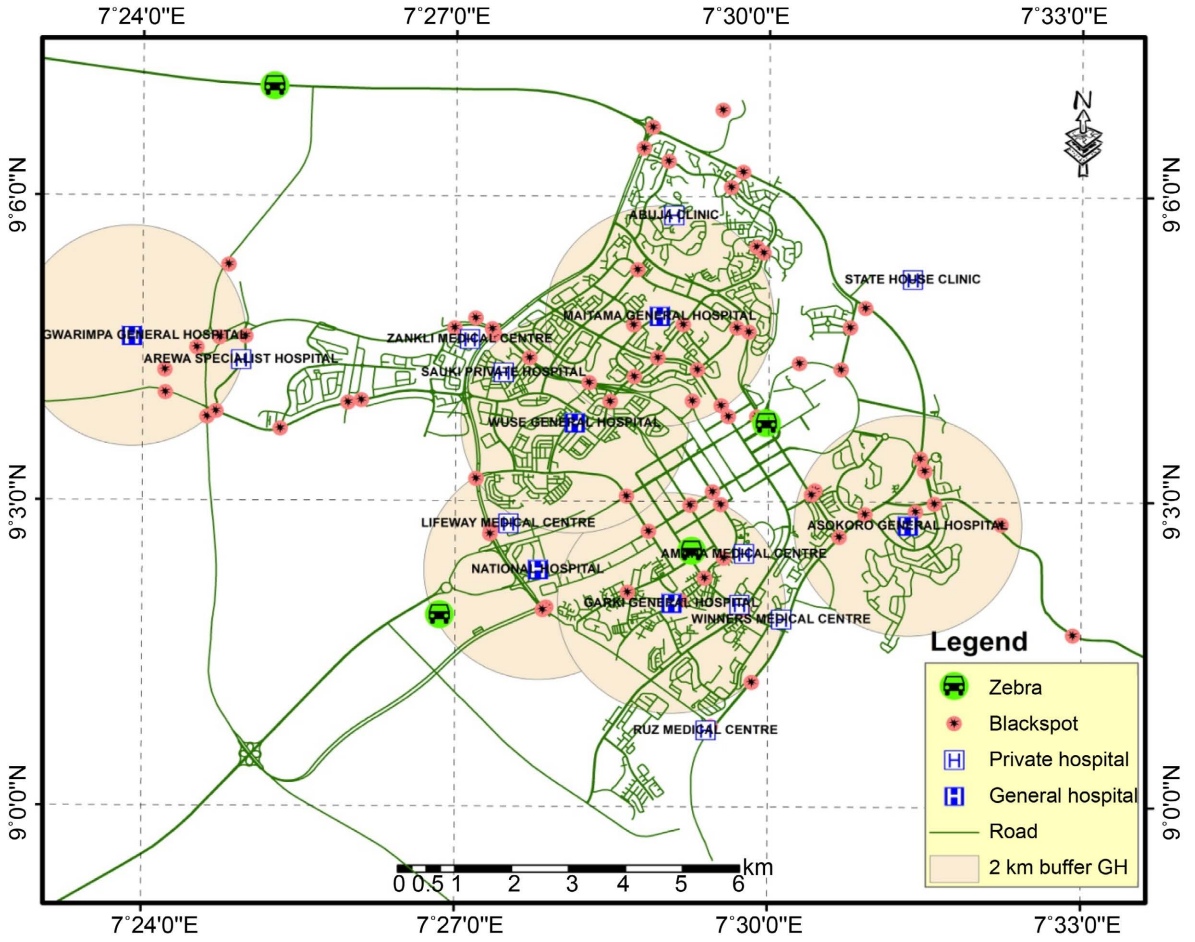

Figure 6. 2 km buffer of hospital facilities to RTC black spots.

Almost all of the remaining 29.6% of the black spots are accessible to the ten (10) private hospitals that are located in between the general hospitals within 2 km. This shows that the accident victims have 100% access to health facilities in FCC. Therefore, there is 100% possibility of saving the victims within 2 km distances on account of health facilities. However, the few zebra points available are only accessible to 38.6% of the accident black spots within 2 km distance (Figure 7). The remaining 61.4% of the accident black spots are inaccessible within 2 km. This implies that a greater number of the accident victims in the FCC are likely to be left unattended to or at best they can be attended to long after the accident may have occurred, if they survive the accident after a long distance. Based on this result, a buffer was created for the exiting zebra point and possible zebra point using 2 km accessibility distance from the nearest black spots taking into consideration areas that have less coverage and major road networks at an average speed of 60 km/hour. The results suggest that five (5) additional zebra points would be effective in terms of proximity to accident in the area and would considerably improve spatial coverage for response times (Figure 7). The five additional points if created can reduce the level of inaccessibility by 48.6%. This means that only 12.8% of accident victims can be rescued at distances longer than 2 km.

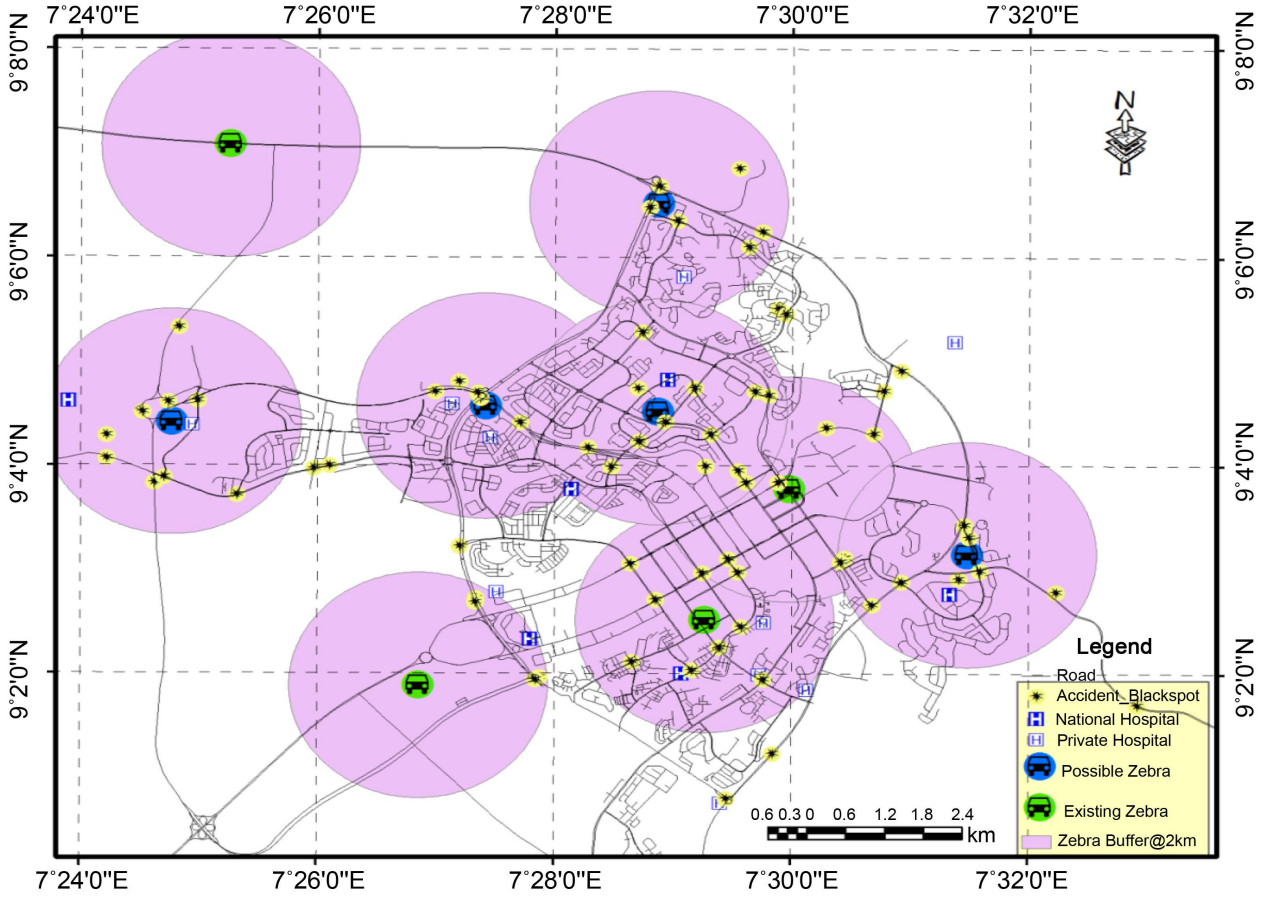

Figure 7. Existing and possible zebra point.

3.2. Accessibility to Emergency Facilities through the Rescue Operations

Analysis of the questionnaire was used to determine the rate of accessibility to rescue operations in terms of their spatial and spatio-temporal distributions in the FCC. Subsequently, the result of the analysis was used to determine the effectiveness of FRSC zebra rescue team. The respondents were distributed in the various emergency health care facilities in FCC (Figure 8). The questionnaires were administered to accident victims within the study area that the hospitals management granted access to during the field exercise. The result of the questionnaire analysis shows that majority of the accident victims are taken to general hospitals. This pattern of distribution of the accident victims aligns well with the spatial accessibility of the general hospitals in relation to the accident black spots.

The result of the spatio-temporal distribution of accident victims shows that road accidents in the study area occur mostly during the day time (between 0601 and 1800 hours) with Wuse and Jabi having the highest amount of road accidents, while Asokoro recorded the least amount of road accident occurrence (Figure 9). Similarly, the highest number of night time accidents (between 1801 and 0600 hours) was recorded at Wuse, while the lowest was recorded at Asokoro. This generally implies that the highest amount of accident in FCC is recorded in Wuse, both in the day and night times. The general trend of occurrence of accident is constant in Wuse, Garki and Maitama both in the day and night times. Jabi records the highest amount of accidents during the day than it does in the night. Asokoro and CBD have similar situation which interchanges between day and night time. This can be attributed to higher level of activity in the day than in the night time. This situation is constant in three locations and

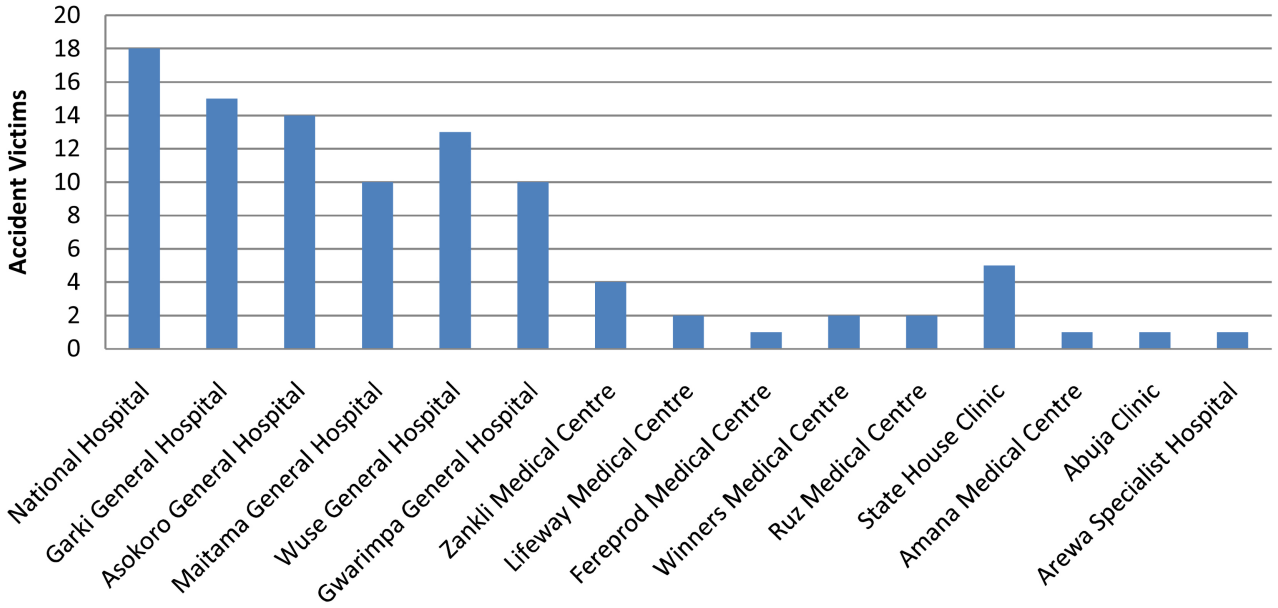

Figure 8. Accident victims in hospitals.

interchanges in the three other locations in the FCC.

Analysis of the results of the questionnaires was carried out to determine the effectiveness of the FRSC zebra rescue team. The result indicates that rescue operation by FRSC ranks second to that by passersby, while police ranked third with little or no presence (Figure 10). This means that passers-by are more effective in terms of road accident response than the government action agencies. It also implies that coverage by the action agencies is not sufficient. This result is alarming considering the fact that most people have little or no idea on how to perform first aid and as it's generally alleged that most medical facilities in Nigeria demand for the presence of a police or FRSC official before attending to victims. Moreover, these passersby might not have an idea on which is the nearest medical facility from the accident location where time is of critical importance. This result reveals the need for more physical and visible presences of the road accident emergency action agencies in the FCC, especially in areas prone to accident. The implication is the critical need for improvement in emergency service delivery among the government action agencies.

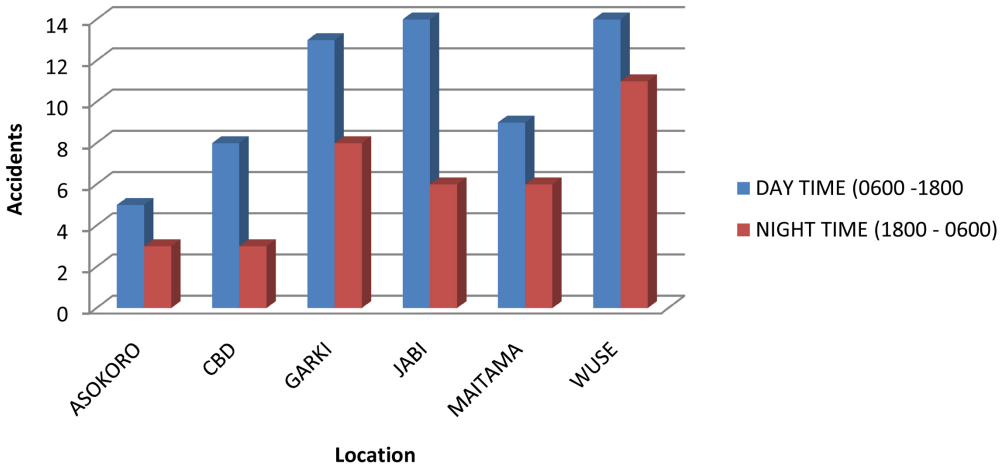

Figure 9. Spatio-temporal distribution of accidents in FCC.

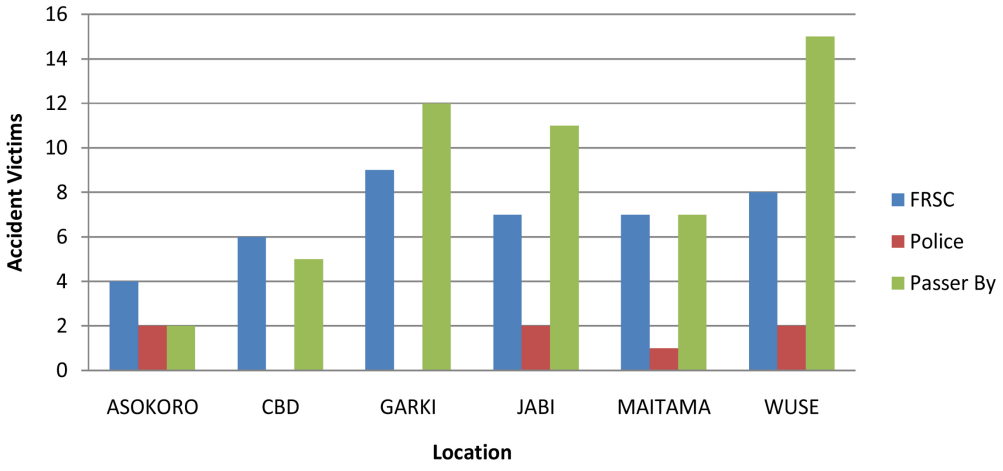

Figure 10. Response to accident victims.

4. Conclusion

This paper offers a creative and realistic graphical presentation of the road accident black spots where FRSC rescue zebra points and emergency health care facilities in the study area were overlaid using GIS software program (ArcGIS 10.0) to provide stakeholders with a better understanding of the accident victims' accessibility to emergency facilities. It further analyzed accessibility of FRSC zebra points to black spots and from the black spots to health centers using a 2 km distance and as well determine areas that could be accessed within given travel time using speed limits so as to establish the coverage of existing emergence health centers and rescue vehicle. The work has developed a foundation for the analysis and presentation of the RTC emergency situation in the Federal Capital City using geospatial technique by examining the spatial distribution of emergency health care facilities and zebra points as well as their proximity to RTC black spots with logical conclusion that health centers in the study area can sufficiently service RTC black spots in FCC, but the FRSC zebra point are insufficient which renders rescue operation inefficient and thereby exposes RTC victims to more danger. The time of occurrence of the accidents and type of rescue operation analysis provided another dimension to the study of accessibility to emergency facilities. Generally, the study portrays the multidimensional nature of accessibility studies.

5. Recommendations

1) To ascertain the effectiveness of the rescue operations, further research should be conducted to determine the impact of time of rescue, type of rescue and type of hospital attended on the accident victims.

2) The Management of FCC should dedicate a lane to emergency vehicles so as to speed up rescue operations and conveyance of accident victims to health care centers.

3) More zebra points should be created to service areas found outside the zebra point 2 km response target.

4) Since passersby are usually involved in road accident rescue operation, Good Samaritan programs and training for community persons in first aid should be developed and sustained.

Conflicts of Interest

The authors declare that they have no conflict of interest regarding the publication of this paper.

References

Alade, T., & Adepoju, M. O. (2010). *Real Time Model for Road Safety and Access to Emergence Service* (pp. 14-18). Resource Paper for NASRDA Crime Mapping Training for Security Agencies.

Arosanyin, G. T. (2005). Reducing Road Injury Severity in Nigeria through Improved

Post Impact Care: An Observation. *Indian Highways Journal, 33,* 15-30.

Asogwa, S. E. (1992). Road Traffic Accidents in Nigeria. *Accident Analysis & Prevention, 24,* 149-155. http://www.ncbi.nlm.nih.gov/pubmed/1558622 https://doi.org/10.1016/0001-4575(92)90031-D

Aule, D. S., Jibril, M. S., Garba, B. D., & Adewuyi, T. O. (2022). The Proximity of Road Traffic Crash Black Spots to Federal Road Safety Commission Zebra Location/Emergency Health Care Facilities in Federal Capital City, Abuja, Nigeria. *Land Science, 4,* 1-13. https://doi.org/10.30560/ls.v4n1p1

Balogun, S. A. (2006). *Spatio-Temporal Analysis of Motor Vehicle Related Accident in Abuja*. PhD Thesis, Federal University of Technology Minna.

Churches, R. L. (1997). *Location Modeling and GIS*. John Wiley & Sons.

Contini, S., Bellezza, F., Christou, M. D., & Kirchsteiger, C. (2000). The Use of Geographic Information Systems in Major Accident Risk Assessment. *Journal of Hazardous Materials, 78,* 223-245. https://doi.org/10.1016/S0304-3894(00)00224-7

Daudu, P. I.-U., Jibril, M. S., & Yashi, J. (2022). Spatial Analysis for Determining Accessibility to Bus Stops in Kaduna Metropolis. *Journal of Geographic Information System, 14,* 78-93. https://doi.org/10.4236/jgis.2022.141005

Dinesh, K. Y., Sujesh, D. G., & Kumar, N. N. (2021). Mitigation of Black-Spot's on Highways by The Application of Safe System Approach. *International Journal of Scientific Research in Science and Technology, 8,* 583-591. https://doi.org/10.32628/IJSRST218492

Estochen, B. M., Strauss, T., & Souleyrette, R. R. (2008). An Assessment of Emergency Response Vehicle Pre-Deployment Using GIS Identification of High-Accident Density Locations. In *Transportation Conference Proceedings* (pp. 221-226). Center for Transportation Research and Education, Iowa State University.

Fshatsyon, B., Febretensay, F. B., & Juremalani, J. (2018). Road Traffic Accident Analysis and Prediction Model: A Case Study of Vadodara City. *International Research Journal of Engineering and Technology, 5,* 191-196.

Ganeshkumar, B., & Ramesh, D. (2010). Emergency Response Management and Information System—A GIS based Software to Resolve the Emergency Recovery Challenges in Madurai City, Tamil Nadu. *International Journal of Geomatics and Geosciences, 1,* 1-13.

Golakiya, H., Barib, C., Patkarc, M., & Dhamaniyad, A. (2019). Study on Acceleration and Deceleration Characteristics of Vehicles Influenced by Crossing Pedestrians at Urban Midblock Sections. *Proceedings of the Eastern Asia Society for Transportation Studies, 12,* 1-18.

Hogan, M. (2002). *Spatial Analysis of Road Traffic Accidents in the Western and North Western Health Boards Report*. Department of General Practice, NUI.

Ismail, H. (2011). Application of GIS and GPS on HAZMAT Operations for Hazardous Materials Transportation Incident in Malaysia. In *Proceedings of Empowering Nation through Geospatial* (pp. 1-14). Malaysia Institute of Transport, University Technologi MARA.

Maqboo, Y., Sethi, A., & Singh, J. (2019). Road safety and Road Accidents: An Insight. *International Journal of Information and Computing Science, 6,* 93-105.

Monia, S. H. (2021). Road Safety in Dhaka: Challenge for Sustainable Development. *Tourism and Sustainable Development Review Journal, 2,* 72-84. http://tsdr.psdku.unpad.ac.id https://doi.org/10.31098/tsdr.v2i1.19

Morichi, S. (1995). Traffic Accident Analysis using GIS Oriented Data. In *The 7th World Conference on Transportation Research (WCTR)*.

Obasanjo, O. T., & Francis, M. (2015). Quality of Intra-Urban Passenger Bus Services in Kaduna Metropolis, Nigeria. *International Journal of Traffic and Transportation Engineering, 4,* 1-7.

Ojigi, M. L. (2005). *Digital Terrain Modeling & Drainage Analysis of the Northern Part of Abuja Phase II Dev. Area, Using Geospatial Techniques* (p. 178). Ph.D. Thesis, Federal University of Technology.

Olawole, M. O., Arilesere, O. A., & Aguda, A. S. (2015). Accessibility to Rural Services: A GIS Based Analysis of Secondary Schools in Ife Region, Nigeria. *Nigerian Geographical Journal, 10,* 110-125.

Patel, M. R., Shukla, R. N., & Golakiya, H. D. (2018). Study of Interaction between Pedestrian and Vehicle at Undesignated Urban Mid-Block Section. *International Research Journal of Engineering and Technology, 5,* 1109-1112.

Pour, A. G., & Yue, W. L. (2012). The Role of Geographic Information Systems (GIS) in Road Emergency Services Location and Black Spot Studies. *ATRF Proceedings, 21,* 135-144.

Quiroga, C. A., & Bullock, D. (1999). Travel Time Information Using Global Positioning System and Dynamic Segmentation Technique. *Transportation Research Record: Journal of the Transportation Research Board, 1660,* 48-57. https://doi.org/10.3141/1660-07

Radke, J., & Mu, L. (2000). Spatial Decomposition, Modeling and Mapping Service Regions to Predict Access to Social Programs. *Geographic Information Sciences, 6,* 105-112. https://doi.org/10.1080/10824000009480538

Sagir, M., Enedah, I., Ono, M., Ojiako, J., & Igbokwe, E. (2021). Spatial Analysis of Healthcare Facilities in Federal Capital Territory, Abuja Nigeria. *Journal of Environment and Earth Science, 11,* 41-47.

Sánchez-Mangas, R., García-Ferrrer, A., De Juan, A., & Arroyo, A. M. (2010). The Probability of Death in Road Traffic Accidents. How Important Is a Quick Medical Response. *Accident Analysis and Prevention Journal, 42,* 1048-1056. https://doi.org/10.1016/j.aap.2009.12.012

Sellinger, M., & Martin, B. (2014). *Measuring Transit Stop Accessibility by Using the Street Network in the Salem-Keizer Region of Oregon, Department of Urban and Regional Planning*. Portland State University College of Urban and Public Affairs.

Sivaram, S. L., & Kulkarni, M. N. (2009). *GPS-GIS Integrated Systems for Transportation Engineering*. Geospatial World.

Stephen, L., Kelakom, G. G., Sojan, J. M., Sreelakshmi, K. S., & Vishnu, N. B. (2018). Identification and Analysis of Accident Blackspots Using GIS. *International Research Journal of Engineering and Technology, 5,* 3455-3459.

Sunday, O. M., & Ademola, O. J. (2016). GIS Application for Determining Public Transport Access Level in the Federal Capital Territory (FCT) Abuja. *Nigerian Journal of Geography and Regional Planning, 9,* 154-163. https://doi.org/10.5897/JGRP2016.0552

Thakare, K. N., Shete, B. S., & Bijwe, A. R. (2021). A Review on the Study of Different Black Spot Identification Methods. *International Research Journal of Engineering and Technology, 9,* 1758-1763. https://doi.org/10.22214/ijraset.2021.38261

Wikipedia (2013). *Abuja*. https://wikipedia.org/wiki/Abuja

Yunus, S., & Abdulkarim, I. A. (2022). Road Traffic Crashes and Emergency Response Optimization: A Geo-Spatial Analysis Using Closest Facility and Location-Allocation Methods. *Geomatics, Natural Hazards and Risk, 13,* 1535-1555. https://doi.org/10.1080/19475705.2022.2086829