

An Analysis into the Spatial Distribution of Trauma Incidents and Ambulance Functionalities in Karachi

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Abstract— Ambulance service system plays a vital role in the health and wellbeing of a civilized society. In a metropolitan city like Karachi, several types of incidents occur daily which require emergency response, so that the affected people may be transported by ambulances to hospitals. There are various ambulance services run by philanthropic societies in Pakistan that perform their duty amicably. Edhi Foundation is one of the largest ambulance services in Pakistan. Information provided by EDHI foundation indicates that there are only three major government hospitals i.e. Civil Hospital, Abbasi Shaheed Hospital and Jinnah Hospital that provide their services to handle such cases. However, the response and transit times of these ambulances is hampered due to traffic jams, unavailability of multiple ambulances at risk prone areas, lack of knowledge about shortest routes and facilitating hospitals results in a higher rate of pre-hospital deaths. Therefore, it seemed necessary to propose an efficient emergency response system based on spatial distribution of incidents and optimal utilization of road network. This study aimed to highlight the spatial distribution of trauma-related incidents along with Edhi ambulance coverage in Karachi. Data of three most frequent incidents, i.e., road traffic accidents (RTA), gunshots and blasts was collected for the period of July 2014 to December 2014 from Edhi foundation's manual logs. This data was converted from handwritten logs to a geodatabase. Edhi ambulance posts in Karachi and major hospitals were also mapped. Various analyses were performed on the geodatabase to highlight the hot spot zones with recurring cases of incidents and their town-wise distribution, along with the temporal trends of various types of incidents. Recommendations were given to reallocate the existing standby positions of ambulances to the zones of higher incident rates, and to provide an optimized response time for the ambulances to facilitate the cases using road network coverage analysis. Out of coverage and distant areas of Karachi are also identified using the results of this study.

Index Terms—Hot spots, RTA (Road traffic accident), Geo-information System, Emergency response time.

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I. INTRODUCTION

Edhi Foundation was founded in 1951 by Abdul Sattar Edhi. It was the first welfare center established in Karachi named after Edhi. Edhi Foundation is one of the largest non-profit and non-governmental organization across Pakistan. It provides 24 hours emergency and non-emergency services to the public. The Edhi ambulance service is also one of the largest ambulance services not only in Pakistan but also around the world. Besides emergency response, the other services provided by Edhi Foundation include medical care, air ambulance and orphanages. The Foundation also offers free social services to the poor community. Karachi, the biggest city of Pakistan, has 78 Edhi ambulance posts across its urban landscape with 118 ambulances to cater for any emergency. On an average 6,000 calls per day are recorded by the foundation. However, the time taken for picking the patient from the point of incident and dropping the patient to the hospital has seen a steady increase due to ever-increasing traffic, lack of well-distributed hospitals for such purposes and a flawed placement of posts with respect to the spatial frequency of incidents in the city. The objectives of the study are:

- To identify the zones with higher incident rates in Karachi.
- To analyze the temporal trends of various types of incidents.
- To analyze Ambulance service coverage
- To explore Emergency response time, and closest facility using GIS
- To propose optimal path for Ambulance service with respect to time.

II. METHODOLOGY

A. Study Area

Karachi was selected as a study area to analyze emergency management system of Edhi Foundation. Divided into 18 towns and 6 cantonments, Karachi is the 7th largest city in the world with a population of nearly 15 million as per the 2017 census. It is situated at **24.91°** North latitude, **67.08°** East longitude (Fig. 1). Karachi has one of the highest crime rates and heaviest traffic flow among the cities of Pakistan.

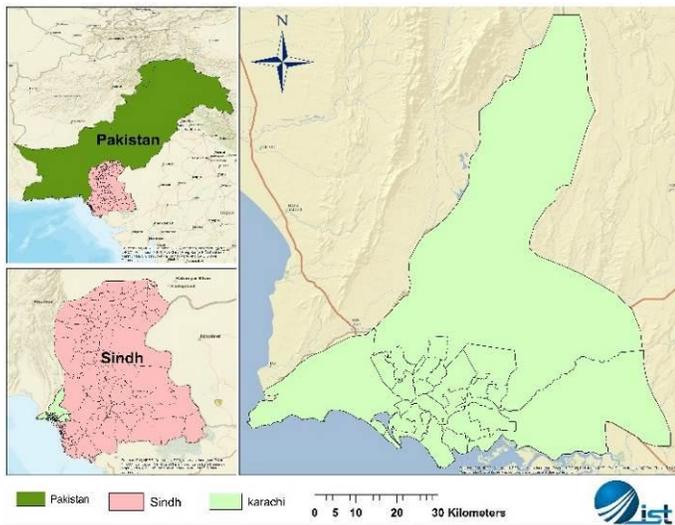


Fig.1. Map showing town-wise distribution of Karachi

B. Data Collection

Call records are manually maintained on log books by Edhi control room which contain the following attributes:

- i) Location of incidents i.e. (town/road/roundabout/street)
- ii) Time of incident
- iii) Type of incident i.e. gunshot, road accident, blast, etc.
- iv) No. of casualties/injuries
- v) Name of the hospital where the patient was dispatched.
- vi) Vehicle by which victim dispatched.

Data relevant to the study was extracted from the books which include:

| Data | Quantity/Source |
|-----------------|--|
| Incident Spots | July -December 2014 By Edhi Control Room |
| Ambulance Posts | Address of All Karachi Posts By Edhi Control Room |
| Hospitals | 3 Major hospitals 14 Other hospitals Digital Globe |

C. Methodological framework

Following is the methodological framework that was adopted to conduct this research work.

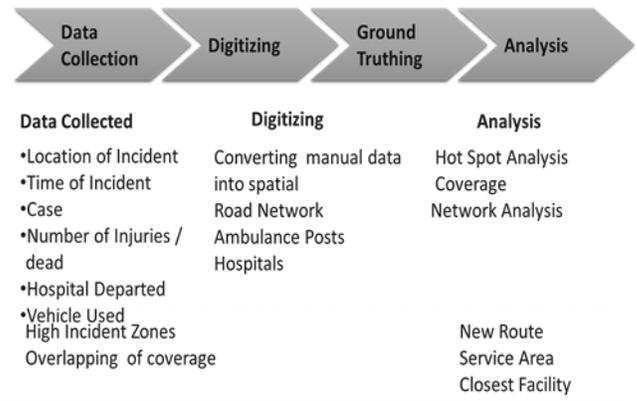


Fig.2. Methodological framework

To analyze the emergency management system geospatial data is required. Therefore, the manual data was converted into digital and spatial format and compiled in a geodatabase, marking and mapping the hospitals, Edhi Ambulance posts and digitization of road network using GIS.

D. Ground Truthing

Field survey was conducted for the validation of Ambulance posts locations provided by Edhi Foundation.

E. Analytical Phase

In the analytical phase, location based GIS operations were performed, i.e., hot spot analysis, town wise distribution and quantification of incidents, road network analysis, shortest and closest path for emergency evacuation, nearest ambulance posts from the incident location. Edhi ambulance coverage zones were also identified in the study area. An analytical report was also prepared to document the research work and findings.

III. AMBULANCE WORKFLOW

Following is the work flow of Edhi Ambulance management system

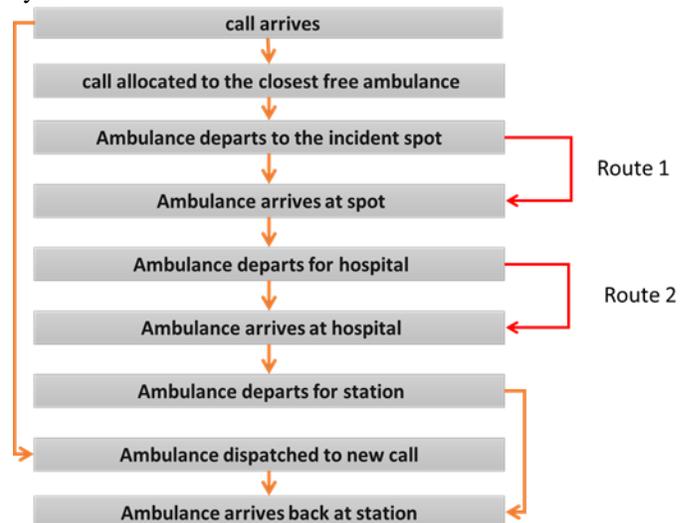


Fig.3. Ambulance flow from post to incident spot then back to the ambulance post

It was noted that not every hospital in the city accepts trauma patients, especially gunshot or blast victims from emergency response teams. Therefore, the patients had to be transported to distant hospitals compounding logistic problems for the ambulance units.

IV. ROAD NETWORK

The road network was manually digitized for the city using Geo-Eye satellite image as a base. The roads were categorized as Major, Minor and Streets and a network dataset was generated so that response and evacuation times for emergency responses may be analyzed.

V. RESULTS AND DISCUSSION

In six months (July to December 2014), there were 5405 incidents recorded in the city. Most incidents were concentrated in the central and southern parts of Karachi (Fig. 4).

Following are GIS maps and layouts that were prepared during the study.

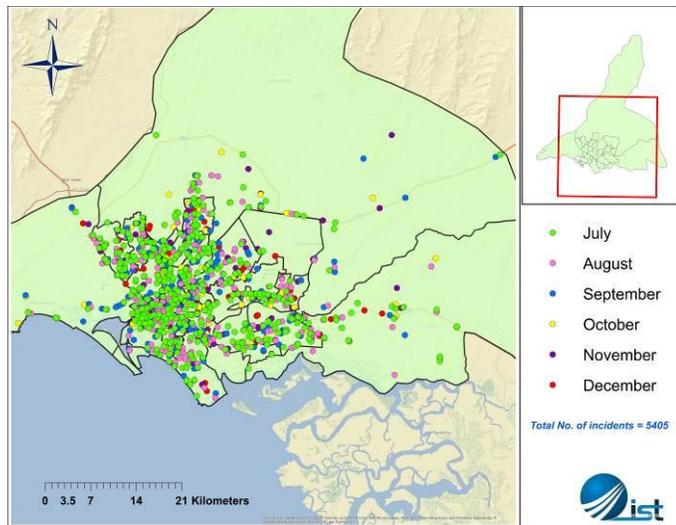


Fig.4. Map showing the incident locations from July to December `14

A. Road Traffic Accidents

In the six months of observed data, 63% of the total number of incidents requiring medical emergency response was registered as RTA. It may be observed from the town-wise distribution of RTAs (Fig. 5) that the **Central and Cantonment** areas of the city recorded minimum accident cases compared to the peripheral towns like Orangi and Landhi, etc. This may be due to traffic congestion, heavy commercial activity and resultant low vehicular speeds in the central regions as well as strict traffic regulations in the cantonments. On the contrary, traffic is comparatively sparse in the high accident areas resulting in high speed collisions that seek medical attention.

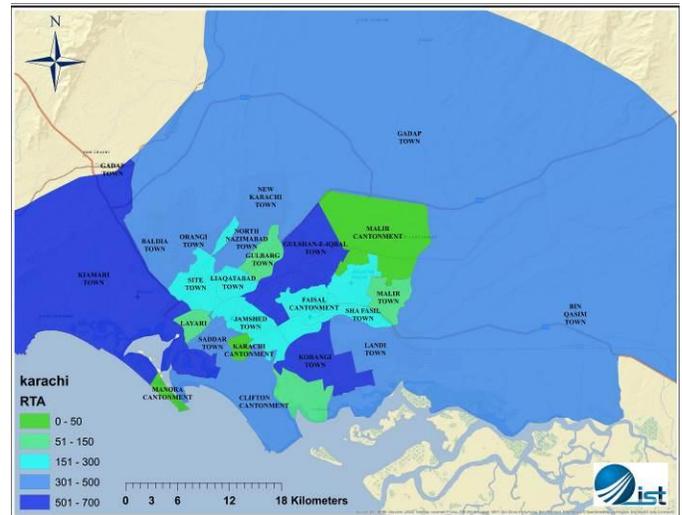


Fig.5. Map showing high road accident zones

A further analysis of data compiled from Edhi Foundation’s records revealed that during the period, a total of 4213 persons including women and children were attended to by the ambulance service as a result of these RTAs. Out of these a total of 255 persons or 6 % of the total perished on the spot or on their way to the hospital. Figure 6 shows the month-wise distribution of injured or deceased persons due to RTAs.

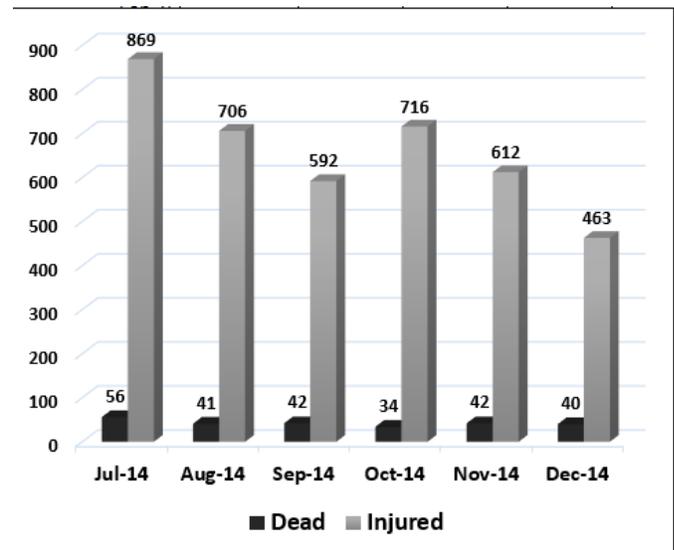


Fig.6. Month-wise Comparison of Deceased and Injured in RTA

B. Gunshots

There were 1,119 cases registered as Gunshots/Target Killing from July to December 2014 that sought emergency response. These incidents resulted in 1002 deaths while 1455 were injured. Figure 7 shows both the month-wise and town-wise distribution of these incidents. Maximum cases were recorded in Orangi Town and Lyari areas whereas minimum were recorded in Defence, Clifton and Malir Cantonments.

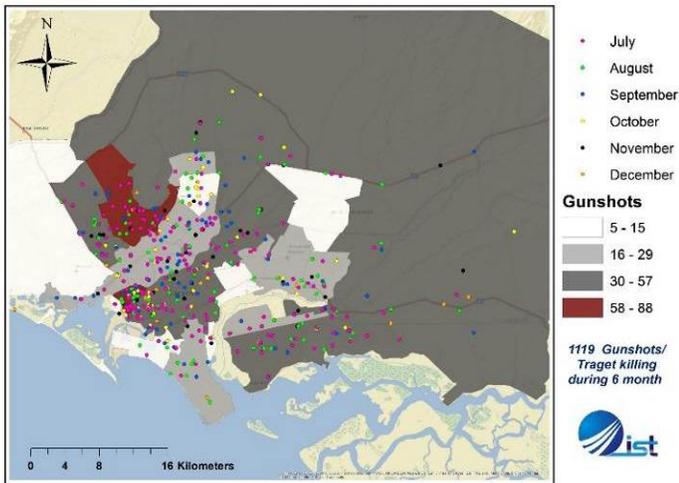


Fig.7. Month-wise & Town-wise Distribution of Gunshot Victims

It may be interesting to note that a “Clean-Up” operation led by Pakistan Rangers and Sindh Police was in progress in Karachi to rid the city of anti-social and criminal elements. A significant decline of almost 70% in the number of targeted killings and gunshot wounds was observed in the data from July to December 14 (Fig. 8).

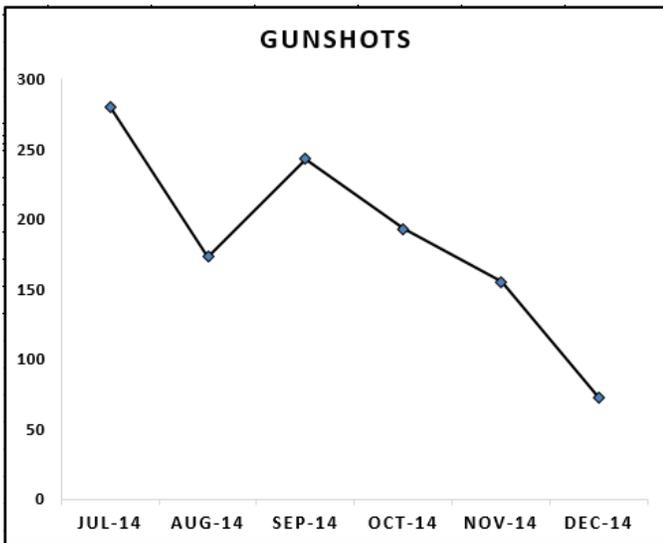


Fig.8. Temporal trend of gunshot wounds / Target Killings

C. Hand Grenade / Blast

In the mentioned period Lyari town was found to be most prone to Blasts and hand grenades. A total of 28 cases were recorded in the city and majority of them recorded from one town (Fig. 9). These incidents resulted in 42 deaths whereas 241 victims were injured.

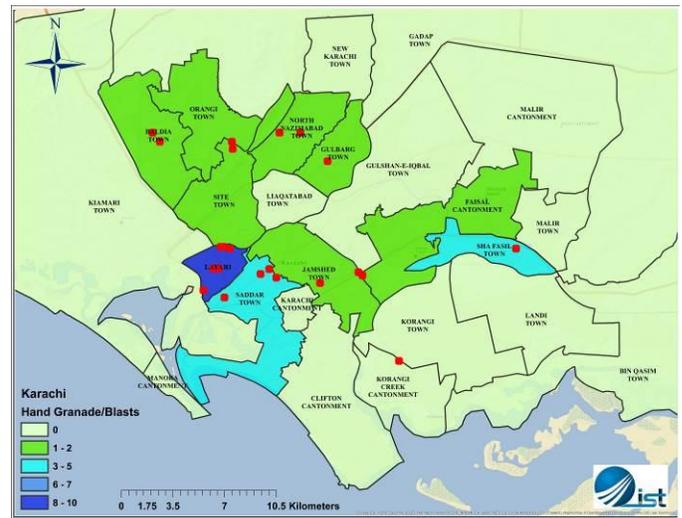


Fig.9. Spatial Distribution of Grenade / Bomb Blasts

D. Edhi Ambulance Posts

The Edhi Foundations have 300 ambulances in Karachi out of which 118 are allocated for emergency response activities while others are associated with Edhi homes. There are 78 ambulance posts spread across the city that provide coverage to the highly urbanized parts of the city at approximately 2 km apart. 84 of these ambulances have real time tracking facility as well. (Fig. 10)

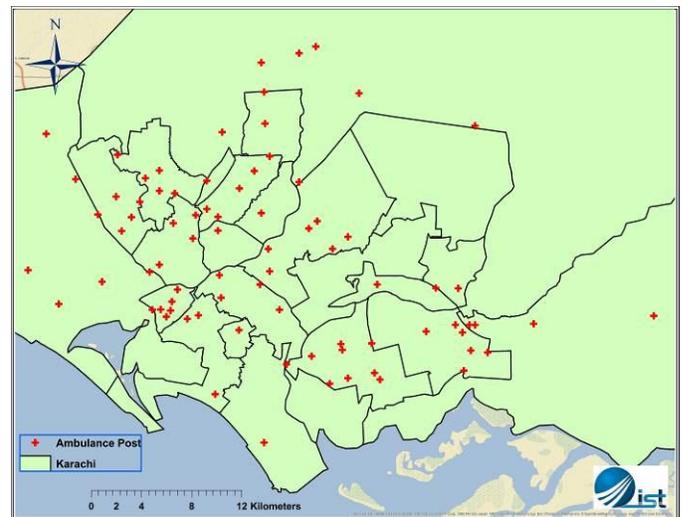


Fig.10. Distribution of ambulance posts covering almost all highly populated towns

Following are the hospitals declared by government to handle emergency cases

- Abbasi Shaheed Hospital
- Jinnah Hospital
- Civil Hospital

Other hospitals are reluctant to accept patients with trauma caused due to criminal activities (Fig. 11).

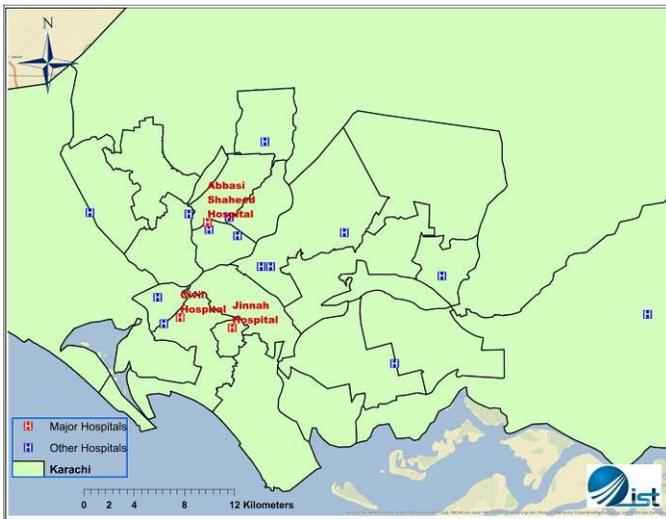


Fig.11. Three major hospitals permitted and other minor hospitals dealing with emergency cases

E. Closest Service and Shortest Route Analysis

Since data with respect to traffic flow, times of rush hours, road conditions, etc. was unavailable for this study, three major assumptions were made to analyze the road network:

- (i) There are no traffic congestions
- (ii) Road distances are the only criteria for time taken
- (iii) State of the roads is generally good.

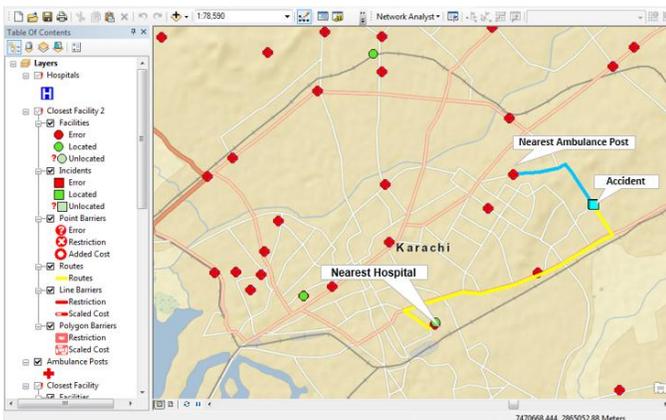


Fig.12. The closest Ambulance Post available near the incident

The shortest path was created by network analysis for finding the minimum distance path from the Ambulance post to the accident spot then from the accident spot to nearest hospital. This will help the user to minimize traveling time to facilitate a specified victim.

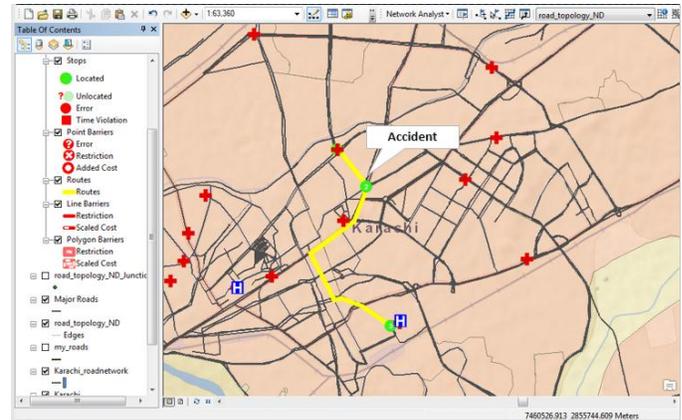


Fig.13. shows the shortest route from ambulance post to accident spot and from accident spot to nearest hospital

F. Edhi Ambulance Coverage

Ambulance posts are deputed as per the concentration of incidents in certain areas. Standard time for picking the patient is 6 minute for emergency and 10 minutes for other cases whereas ambulances take 6 to 10 extra minutes because of road condition and congestion.

The Service coverage was computed by a benchmark speed of 60km/h for the ambulances. Service coverage was computed for 6 minute, 8 minute and 10 minute response times to highlight the potential coverage of Edhi Ambulance service (Fig. 14).

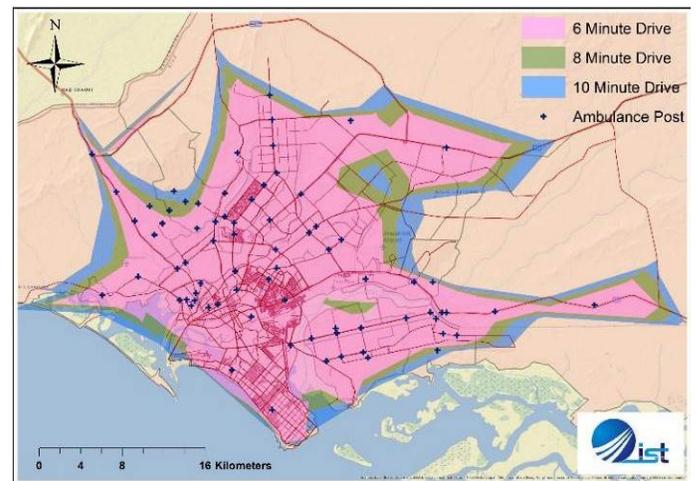


Fig.14. Service area of Edhi ambulance in Karachi city on 6 in, 8 min and 10 min drive

It was observed that even under ideal assumptive circumstances of zero traffic and excellent road conditions, there are areas which have a history of incidents and yet the emergency responders could not have reached them in a maximum of 10-minute drive (Fig. 15). Therefore, the ambulance posts must be relocated so that those areas may also fall under coverage within a reasonable response time.

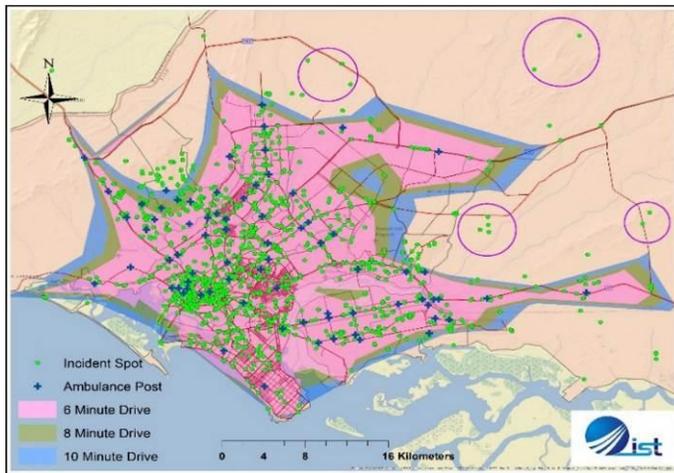


Fig.15. Under coverage and coverage accident spots

VI. CONCLUSION

The time required to pick up the patient is a crucial component of overall response mechanism for emergency management. The government should encourage and promote private hospitals to facilitate the emergency cases so that commuting times may be shortened. Facility of paramedics is yet another factor for pre-hospital medication and recovery. There is an urgent need of creation of designated Emergency Evacuation and Ambulance lane on the roads of Karachi. The results can be used to analyze the shortest path, Closest Facility and easy passage to concerned spot. Gadap, Hub, and outskirts of the city is prone to gunshots and torture cases. Lyari, Landhi and Orangi town need serious attention by government and law enforcement agencies to ensure peace and establishment of Emergency evacuation routes and proper Medicare.

VII. FUTURE WORK

Authors are looking forward to enhancing the scope of this study by analyzing trends of various incidents over time. Comparison with other EMS i.e. CHIPPA, AMAN Foundation, etc. Furthermore, proposing dynamic routes in real time and development of Web based GIS Application for EMS Functionality and Analysis is also foreseen.

VIII. ACKNOWLEDGEMENT

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