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ORIGINAL PAPER

# Interpreting rescue vehicle patterns using geovisual analytics for spatiotemporal resource allocation

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## Abstract

This article presents a geovisual analytics approach to explore hidden travel patterns of emergency response vehicles in the city of Lahore, Pakistan. The Rescue 1122 is a department that provides emergency response services in Pakistan. These services are like the 911 working in the USA or the 999 emergency services in the UK. The Rescue 1122 emergency vehicles are categorized as fire, rescue, and ambulance services. Different categories of vehicles handle various types of requests depending upon the nature of the emergency. All vehicles are equipped with a Global Positioning System (GPS) tracker. Data obtained from these vehicles generate spatiotemporal sequences. These sequences—also known as trajectories—form the core component of moving object analysis. The aim of this study is to use visualization techniques and to assist government officials for efficient spatiotemporal allocation of the emergency vehicles. Several visualization techniques are applied in this study to get useful insight including clustering, mean time gaps in visits, hotspots, spatiotemporal aggregation and sub-setting, and caller data analysis. The results demonstrate some interesting patterns and highlight the areas that require allocation pre-planning. The findings are beneficial for effective resource planning and for understanding the complexities of a highly urbanized city of Lahore.

**Keywords** Rescue 1122 · Visual analytics · Hotspots · Resource allocation · Emergency vehicle · Geovisualization

## Introduction

Recent time has witnessed geospatial technology proliferation. Availability of smart devices equipped with GPS has enabled easy spatial data access. Similarly, the ubiquity of Web mapping systems such as OpenStreetMap (OSM)[1] and Google Maps[2] has enabled the geospatial information access to the public. The problem of spatial information overload (Tahir et al. 2014) is evident due to such advancements in geospatial technologies. In this research, our focus is on the visual analysis of the data collected from GPS trackers in emergency service vehicles. GPS tracks are spatiotemporal sequences and can be represented as trajectories. While Cook and Thomas (2005) emphasized the importance of visual analytics, geovisual analytics is an emerging research direction which highlights the spatial dimension (Andrienko et al. 2007). Furthermore, Andrienko et al. (2017) stressed the importance of visual analytics in transportation studies. We investigate rescue vehicle travel patterns as a real use case of transportation and visual analytics.

The Rescue 1122 Lahore is a government department located in the province of Punjab. The department is operational since 2004. The mission of this department is the

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[1] https://www.openstreetmap.org/
[2] https://www.google.com/maps

"development of safer communities through the establishment of an effective system for emergency preparedness, response, and prevention." Focus of the Rescue 1122 is to save lives and change minds. As per the founder of the Rescue 1122, emergency management has been long neglected in the country especially the non-existent of the pre-hospital emergency ambulance, rescue, and fire services. The general public was deprived of the basic right of emergency care in case of a disaster or an emergency. Moreover, there were very few ambulances available with Non-Government Organizations (NGOs), which lacked equipment and expert staff. For this purpose, the department was established to address the above challenges. Currently, the Rescue 1122 operates multiple vehicles in several domains including ambulances, fire, and rescue vehicles. Ambulances address medical services–related calls. Fire vehicles serve fire-related incidents, while rescue vehicles are equipped with lifesaving equipment such as cutters and diggers and are deployed in life-threatening situations.

All emergency vehicles are equipped with GPS trackers which record continuous vehicle movements. These recording data are available with tracking companies. This study is the first of its kind in Pakistan where actual trajectory data is used for emergency vehicle planning. Normally, this data is discarded after 6 months if not requested by the rescue department.

The objective of this research is to observe the behavior of emergency vehicles and to test our visual analytics methodology in the city of Lahore. Several visualization techniques are applied to emergency vehicle movements. Using the mobility data, the hotspots are identified which highlight the most active areas of the city. Furthermore, aggregates and flow maps are examined in order to get a closer insight into movement patterns and periodicity of the Rescue 1122 vehicles. This analysis leads to a better resource allocation and reallocation on the basis of historical movements and thus can optimize resources to save the lives of many individuals in emergency situations. Similarly, caller data is analyzed to observe the types of calls and to observe the caller's trend on a given day.

The remainder of the manuscript is as follows: "Related work" describes the related literature. "Methodology" outlines the methodology. "Result and discussion" discusses the results and findings, while "Conclusions" provides conclusions, recommendations, and directions to future work.

## Related work

A number of studies have already been reported using data visualization as a tool for information extraction. By adopting these techniques, visualization analysts are able to mine patterns from huge movements' datasets. A study was conducted on Milan cars, equipped with GPS trackers for a week, in order to find the patterns. As a result, multiple visualizations and interaction techniques were investigated for the exploration of massive movement datasets (Andrienko and Andrienko 2008). This study observed the vehicle movement and the paths taken in order to investigate the personal choices of routes towards the destination and possible reasoning for that choice.

In a similar study, cursor movements were recorded and then analyzed over a Web mapping application to examine the Human-Computer Interactions (HCI) with Geographical Information Systems (GIS)–based applications. In this study, 117 mouse trajectories were clustered based on the spatial closeness, while the clusters represent the tasks that were performed during the generation of trajectories (Tahir et al. 2012). The goal of this research was to examine human behavior when using online Web maps.

Likewise, McArdle et al. (2015) formulated a geovisual analytic tool based on Web for mobility data. The tool highlighted key features of mouse movement which can help the visualization analysts on patterns and trends. Web maps were displayed by virtue of a Web interface. The tool accommodates statistical graphs and plots, summarizes the movements, and supports spatial and temporal clustering. In another study, movement of 65 people for 11 months was recorded using GPS loggers (Aigner et al. 2007). Further to mouse and human movement data studies, eye and hand coordination during a search on visual displays was investigated (Cöltekin et al. 2014). The overall idea was to gain an improved understanding of user's interactions which can assist in improved user interface designs. These virtual trajectories (such as a mouse, eye, and hand) are then compared with physical world trajectories (such as vehicle movements). In most cases, the datasets from various mediums constitute data sequences which can be mapped onto real-world trajectories. These real-world trajectories are typically random and get very large when performing the computation. Some of the most critical problems when dealing with the movement data include storage and visualization of trajectories. With a rapid increase in sensors, the data are ever growing, which can be challenging to handle. Similarly, the visual clutter reduction is also challenging to handle (Bertini and Santucci 2011) Traditional methods and algorithms for processing and visualization are limited to deal with the increasing amount of data.

There can be multiple scenarios for mobility data recording including time-based recording, recording based on location change, recording based on event initiation, and composite-based recording (Andrienko and Andrienko 2013; Pelekis and Theodoridis 2014). In all cases, mobility data are analyzed to make sense out of it. Hoeber and Ul Hasan (2017) developed a tool called Visual Exploration of Movement-Event Anomalies (VEMEA). This tool essentially looks for anomalies in the data and helps analyze and visualize movement data.

Among many others, CommonGIS is a tool available to interpret geographical data (Andrienko et al. 2002). The tool focuses on exploratory and interactive spatiotemporal analysis of movement datasets. Moreover, VizAnalysisTools is a specific tool which analyzes HCI data (Tahir et al. 2014). VizAnalysisTools is not as generic as CommonGIS. For the current research, CommonGIS is used for geovisual analysis of the Rescue 1122 vehicle movements. Power of CommonGIS is the connectivity it provides to existing tools such as Secondo (Güting et al. 2010). Similarly, for geospatial big data support, it can also connect to Parallel Secondo (Lu and Guting 2014).

There has been a steady progress on the movement data analysis in recent years. Simultaneously, geospatial technologies have been used extensively in emergency service planning. A study was carried out by Cinnamon et al. (2008), who used GIS as a method for strategic analysis for palliative care service. A location-based system (LBS) was proposed to understand patient's dynamics. In another study, Kar and Hodgson (2008) examined emergency situations such as hurricanes and other coastal hazards to portray a GIS-based system for emergency evacuation and shelter. This GIS-based model was implemented in 17 counties in Southern Florida. It was observed that 48% of existing shelters were located in areas which were physically unsuitable.

Tansley et al. (2015) investigated a case study for utilizing GIS as a tool in the field of emergency-related incidents. Network analysis techniques were used to observe emergency services through various routing parameters. Twenty-four-hour serving care centers were mapped using a buffer of 5, 10, and 50 km. Meanwhile, Panciera et al. (2016) examined spatial implementation and its outcomes in the domain of emergency services. Time travel in urban areas and response time were observed with respect to socio-cultural factors and geographic and economic accessibility. In all these studies, emergency vehicle analysis is being done in a traditional GIS way as opposed to moving object analysis. Similarly, Wang et al. (2017) surveyed spatiotemporal data visualization techniques with respect to emergency management. Their particular focus was on massive data processing. Due to the existence of algorithms and data processing techniques, the emergency management is getting improved within the developing and the developed world. This study presents a real use case of a developing country where efficient planning can be done using geovisual analytics.

## Methodology

The flow diagram of the methodology is shown in Fig. 1. The raw data are acquired from the Rescue 1122 department. There are a total of 44 vehicles. Out of which, 13 are fire vehicles, 27 ambulances, and 4 rescue vehicles. Total data consisted of 7 million points. The raw data are obtained in numerous files. Each data file contained spatiotemporal attributes of moving vehicles such as direction, speed, and altitude. During data pre-processing step, data cleaning is performed while multiple Python scripts are written for data pre-processing.

The first script is used to remove outliers and noise in the data. This script incorporated a boundary shapefile to omit the points created as noise outside the district boundary. A simple buffer is drawn to remove the noise. The second script is used to segregate data into different classes such as ambulances, fire, and rescue vehicles. Vehicles are segregated using the *VehicleID* field, which is relatively simpler, involving no statistics. Finally, a script is written to categorize the data based on time stamps and spatial information using town boundaries. For this purpose, a tool similar to the first one is created which accounted for the shapefiles of towns and then saved the data in separate files. Geographical coordinates (latitude and longitude), time stamps, and vehicle identifiers are extracted in order to identify each trajectory separately.

For spatial aggregation, the territory is divided into areas (town boundaries) and then, trajectories are grouped according to their start and end positions. The result is a set of aggregate moves based on areas. Similarly, the temporal segregation is done by dividing the time period into regular time intervals. The trajectories are then divided into fragments corresponding to these intervals. The fragments are then grouped according to their start and end times. The result is a set of aggregate moves based on areas and time stamps.

CommonGIS is used for analysis and presentation of information. Several maps are generated with the main intention of pattern identification in emergency vehicles as per their types. The following are some of the visual analyses which are performed in this study, while the results are discussed in the "Result and discussion" section.

- Maps with number of visits are generated for identification of hotspots through various routes in and out of the city.
- Number of moves for all types of emergency vehicles is calculated for the whole city.
- Mean time of stay is investigated as it is necessary to observe the points where the vehicles spent maximum time en route to serving an emergency.
- Mean time gaps in adjacent visits are determined to estimate the frequency of emergency calls from specific locations.
- Caller data are analyzed with vehicle movements to explore any existing relationship between them.
- Clustering and aggregation are performed to understand similar movement patterns.
- Analysis of temporal subsets of the ambulance data to cater for the temporal change in activities.

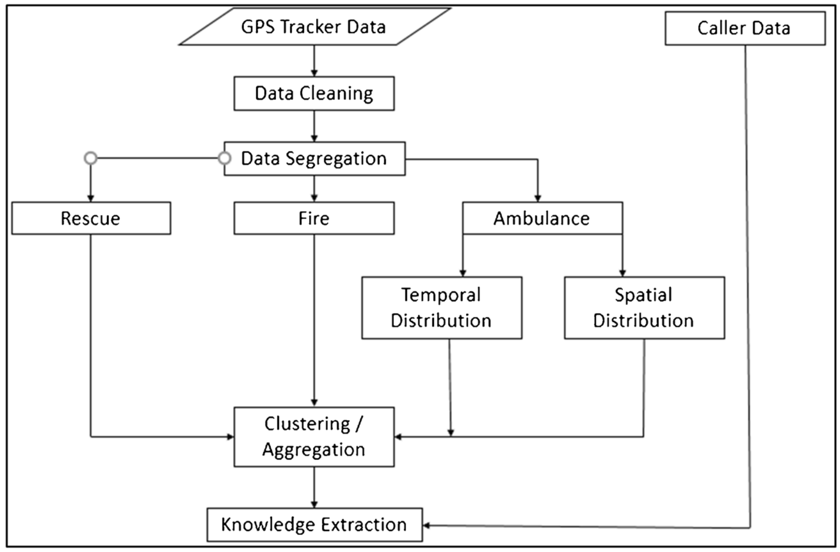


**Fig. 1** Methodology

- Analysis of spatial subsets of ambulance data on the basis of towns to notify the most and least active spatial locations in the city.

According to the Rescue 1122 officials, about 90% of the calls they receive are ambulance-related, while only 10% of emergencies are requested for rescue and fire incidents. This is the reason there are more ambulances as compared with fire or rescue vehicles. Therefore, spatial and temporal distribution analysis of rescue and fire vehicles is not reported in detail.

According to Census 2017 conducted by Pakistan Bureau of Statistics, Pakistan has an estimated population of 207 million. The city of Lahore as shown in Fig. 2 is the second most populous city of Pakistan with an estimated population of 11 million.

Lahore is the capital city of Punjab province located at 31.5497 N latitude and 74.3436 E longitude and has a total area of 1772 km$^2$. Being a huge metropolitan city of this country, it is selected as the study area for this case study (to validate the proposed methodology). The Rescue 1122 is among the most efficient emergency response services in Lahore city as compared with other cities, claiming the average response time to be 7 min. All the vehicles are also equipped with onboard GPS sensors and are regularly monitored and tracked. For the current study, the GPS tracks for all the available vehicles are collected for a duration of 10 months (August 2014 to May 2015).

Figure 2 illustrates rescue stations along with designated hospitals on the study area map. All hospitals (government and private) are not directly associated with the Rescue 1122. The government hospitals affiliated with the Rescue 1122 are Ganga Ram Hospital, Mayo Hospital, Services Hospital, General Hospital, Mian Munshi Hospital, and Jinnah Hospital.

The "Result and discussion" section presents results in order to validate our proposed methodology which uses visual analytics on emergency vehicle movements of Lahore city.

## Result and discussion

### Geovisual analysis

Figure 3 illustrates mean time gaps between adjacent visits of the fire and rescue vehicles. Since the time duration for these data is from August 2014 to May 2015, complete data are being shown here. Together, this reveals some interesting patterns. For example, most of the rescue activities are conducted in a suburban portion in the outskirts of Lahore. Similarly, the rescue vehicles have more concentration in the southern portions of the city as compared with fire vehicles. The map of the mean time gap between adjacent visits (see Fig. 3a) combined with the visit map for fire vehicles (see Fig. 3b) revealed that the most commonly used route for attending fire incidents is usually Canal road passing through the center of the city.

Nevertheless, industrial areas are the most commonly visited areas, located at the periphery of urbanization. The two active zones for fire incidents can be clearly identified as Raiwind and Ring roads: both of which are industrial zones. If we examine the rescue vehicle movement (Fig. 3b), it is evident that more calls are generated near the congested portions of the city. Additionally, mean time gaps exhibit that more repetitive calls are generated from the outskirts and less-developed portions of the city, whereas more frequent visits are made in the city center. Likewise, rescue vehicle data are observed using mean time gaps between adjacent visits alongside a total number of visits. A combination of these two datasets shows vigorous movements in the city center, which might be since most of the hospitals are within the

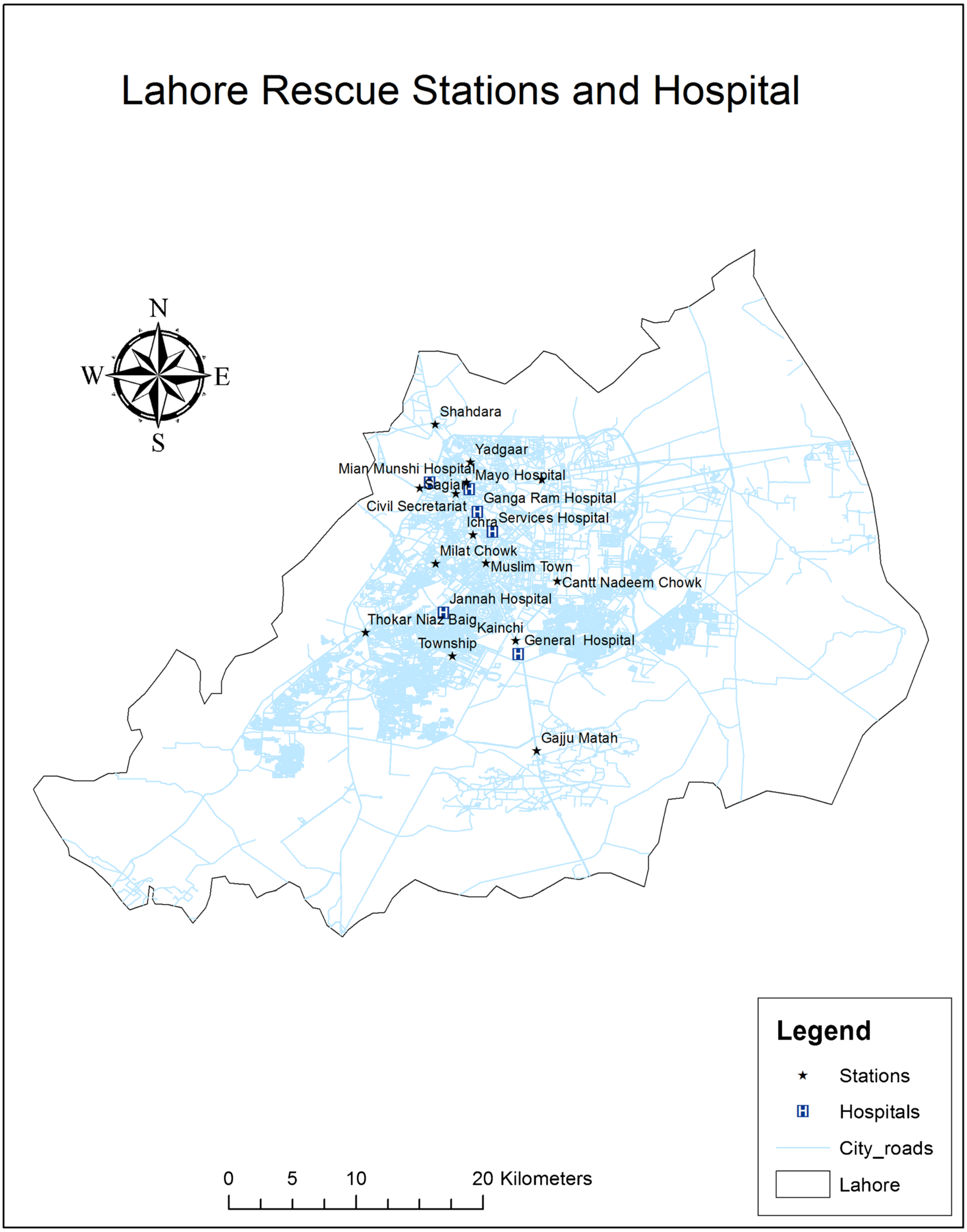


**Fig. 2** Study area

central city. The second most concentrated values can be observed on Multan road and southern portions of the city such as Kasur. With the recent developments in industrial sectors in Lahore, incidents involving fire have also been observed.

Figure 4 shows visit maps for fire vehicles. An activity can clearly be noticed such as most of the vehicles' movement is observed within the land between the hospitals and the rescue stations. On the other hand, repetitive visits are observed towards industrial zones, situated in the outskirts towards the southwestern portion of the city. The symbology used in all the maps is relative and comparative; the larger width and size of the symbol represent a higher concentration of a specific attribute and the least thickness and concentration depicts less concentration. It

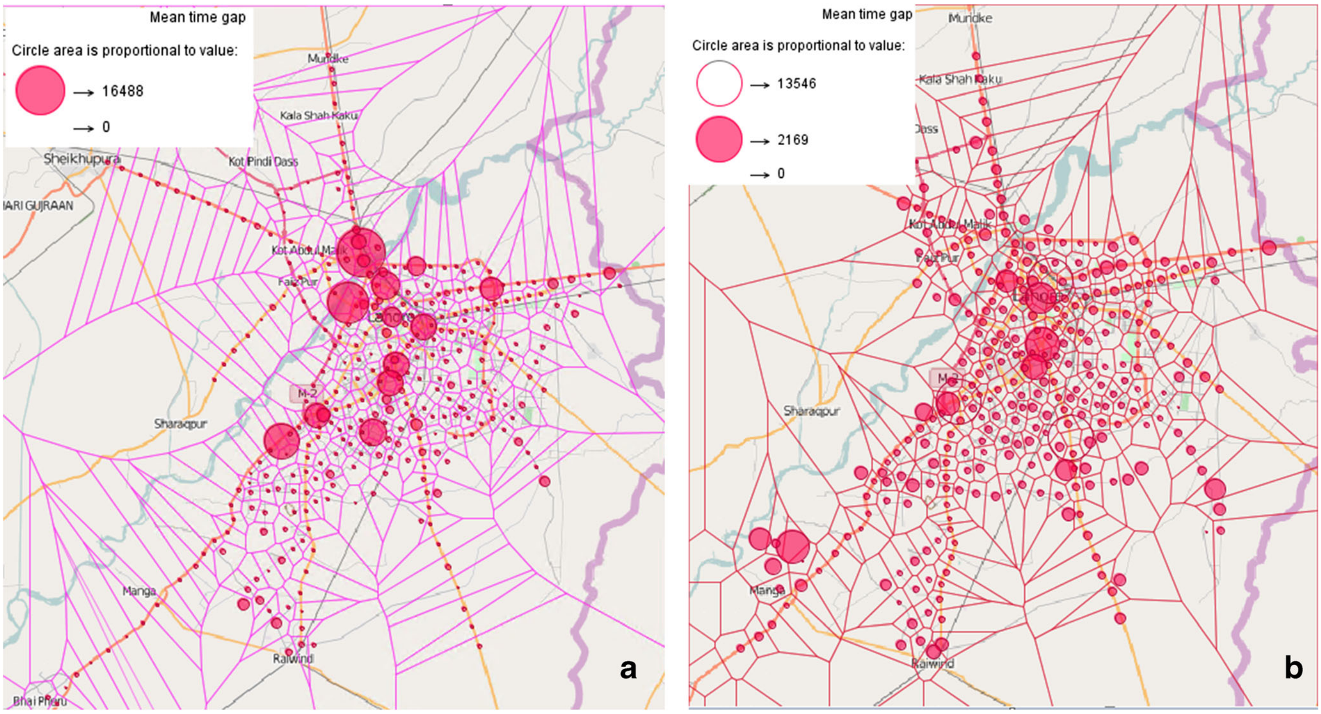


Fig. 3 **a** Mean time gap in adjacent visits of fire vehicles (August 2014 to May 2015). **b** Mean time gaps in adjacent visits of rescue vehicles (August 2014 to May 2015)

is confirmed that most of the rescue vehicles are sent in the suburban region due to the occurrence of more life-threatening incidents.

Ambulances' data are divided into two portions for the analysis. One is segregated on a monthly basis, while the other is based on spatial town boundaries.

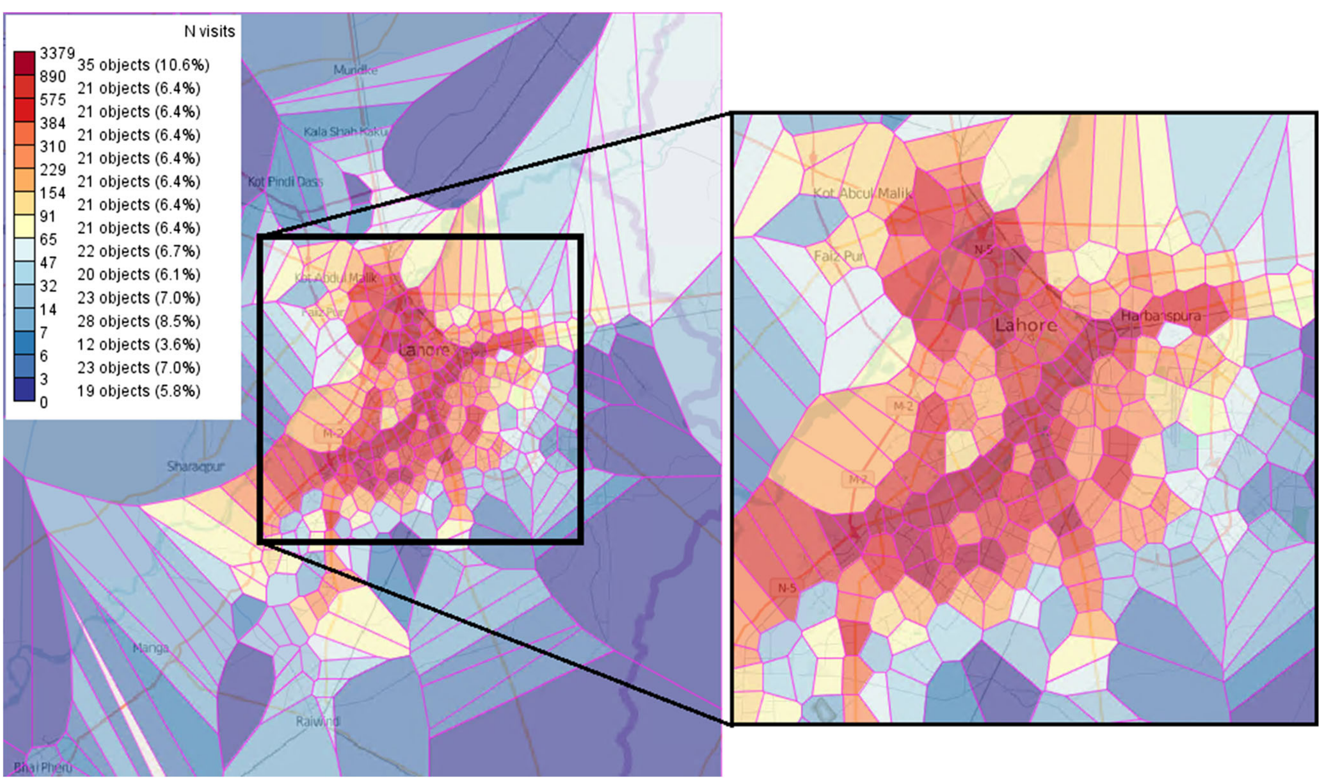


Fig. 4 Hotspots in fire vehicle visit

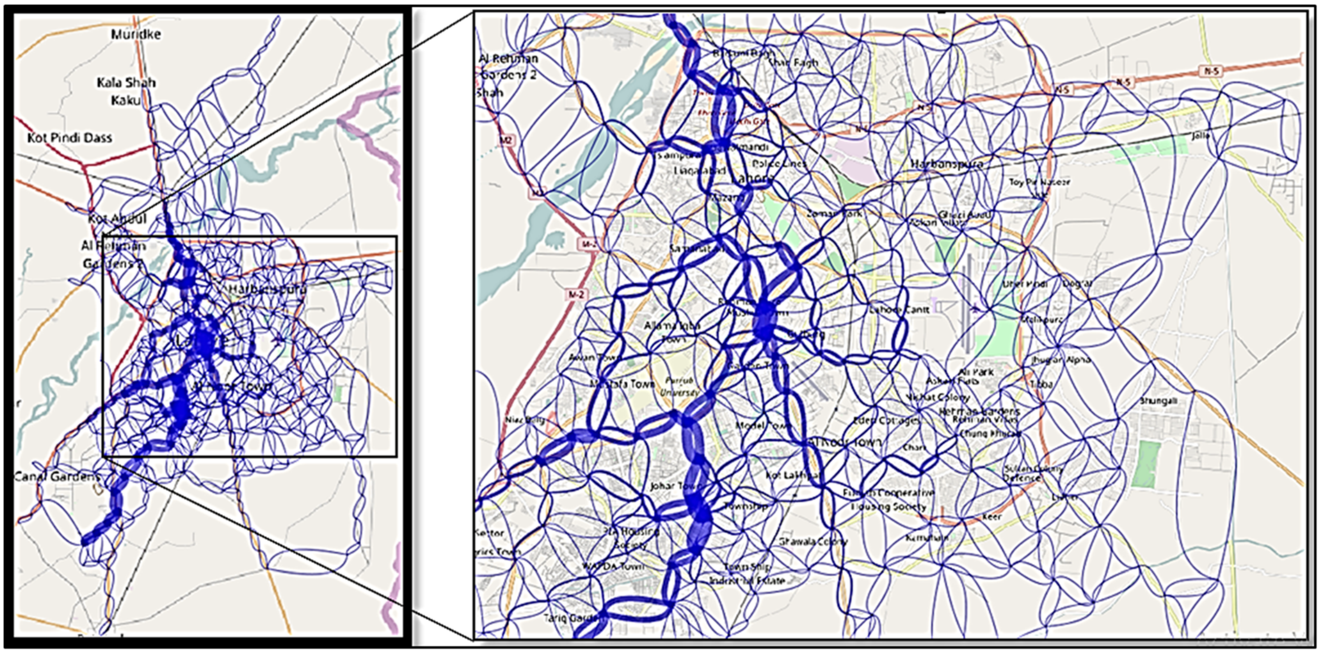


Fig. 5 Ambulance moves in September 2014

Figures 5, 6, and 7 show the temporal sub-setting (ambulance moves, average time gaps, and an average stay of the vehicles), whereas Fig. 8 represents spatial subsets (classified in several towns of Lahore).

Ambulances act as a backbone in any rescue and emergency response service. The basic purpose for an ambulance is the provision of transportation for any victim to the hospital. The Rescue 1122 ambulances squad consisted of 27 vehicles. These data are investigated spatiotemporally. In the spatial domain, GPS data are divided into towns, while in temporal distribution, GPS data are segregated on monthly basis.

Figures 5, 6, and 7 depict a complete picture when analyzed together. For testing our methodology, a detailed analysis of 1 month, i.e., September 2014, is discussed. In this month, there are more frequent activities as per the collected data, and movements are condensed towards the central portion of the city. This is also confirmed by rescue officials. However, the stay duration reveals that a

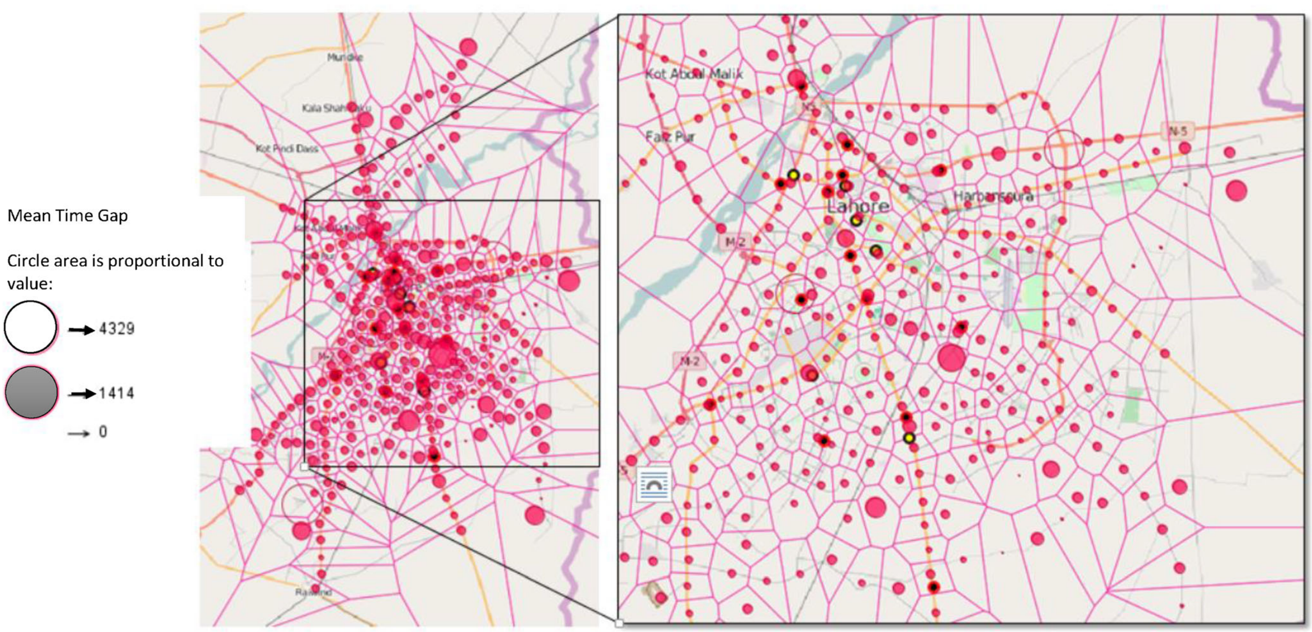


Fig. 6 Average time gaps between visits of ambulances in September 2014

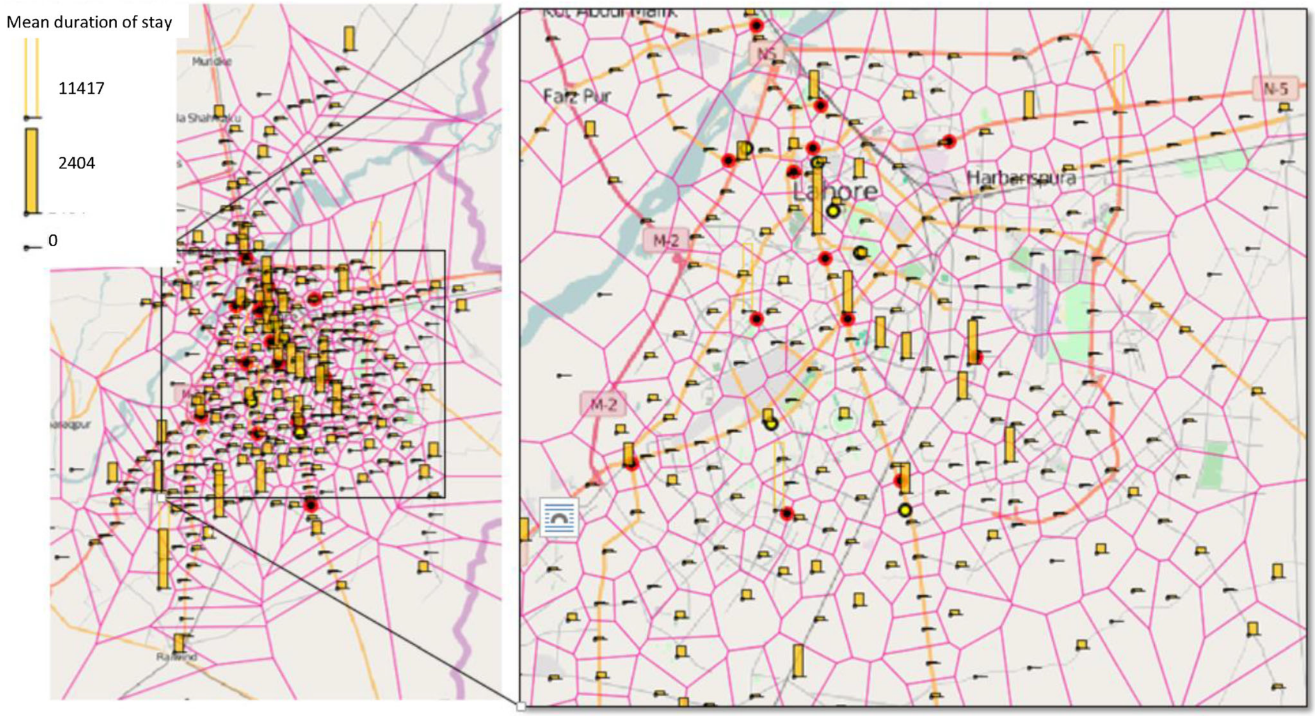


**Fig. 7** Average stay of vehicles in September 2014

much larger time span is spent in the Raiwind area and Multan road along Kala Shah Kaku. These are the industrial areas and normally heavy traffic movements are observed throughout the year. Therefore, these areas are more vulnerable and prone to incidents. Besides this, repeated visits can be seen in Wagah town area and on Grand Trunk (GT) road connecting the city to the northern portion of the country and in the vicinity of Multan road.

Ordinarily, the vehicles stay at the rescue service center. However, some considerable time has been spent in regions outside the highly populated city, which could be due to large activity in those areas. There is a possibility that some vehicles have to stay at those places to minimize response time, which is highly unlikely, as confirmed by the rescue officials through verbal communications.

The flow of traffic inside the city is evident through an in-depth examination of Figs. 5, 6, and 7. Some temporal hotspots emerge other than the rescue stations and the hospitals. This could either be due to some intense activities or undeclared rescue stations. The month of December 2014 is noticed to be the least active month of the year which can be due to minimum traffic accidents, as traffic used to be significantly low on roads in cold winter. Fog might have interfered with GPS signals, which resulted into least data production. The exact reason for this needs to be further investigated by co-relating the caller's data in the month of December.

Spatial sub-setting is done by dividing the GPS-based time stamps into non-overlapping and non-intersecting portions. This resulted in points, which are existing in a predefined boundary. For this study, town boundaries are used. This is significant in examining the exact placement of resources and also indicated the possible flow of the traffic in case of emergency. The insight into this particular factor can be the basis for improved urban planning as well as better route management.

Figure 8 shows all the towns which are analyzed in Lahore city. The results show that the most preferred routes are actually wider roads as they are less likely for blockages, such as Ferozepur road, Canal road, Multan road, and Jail road. The detailed visual analysis of 10 towns is presented as follows. The thickness of lines shows the vigor of the movement within the town boundaries; the denser the line, the more active are the portions of the town.

Aziz Bhatti town (Fig. 8a) has neither rescue stations nor any hospital. Consequently, patients are generally transported to other towns that result in a prolonged journey. Two main highways, Canal road and Zarrar Shaheed road, are connecting all the areas with maximum visits.

Despite the fact that Cantonment town (Fig. 8b) covers a vast portion of the city, there is no hospital that could be affiliated with the Rescue 1122. Only 1 rescue station is within the town and the nearest hospital is General Hospital located on the south-west. Ghazi road, Ferozepur road, and Walton road are the busiest roads. General Hospital is considered to have some of the most capable staff and thus, complex cases are referred here.

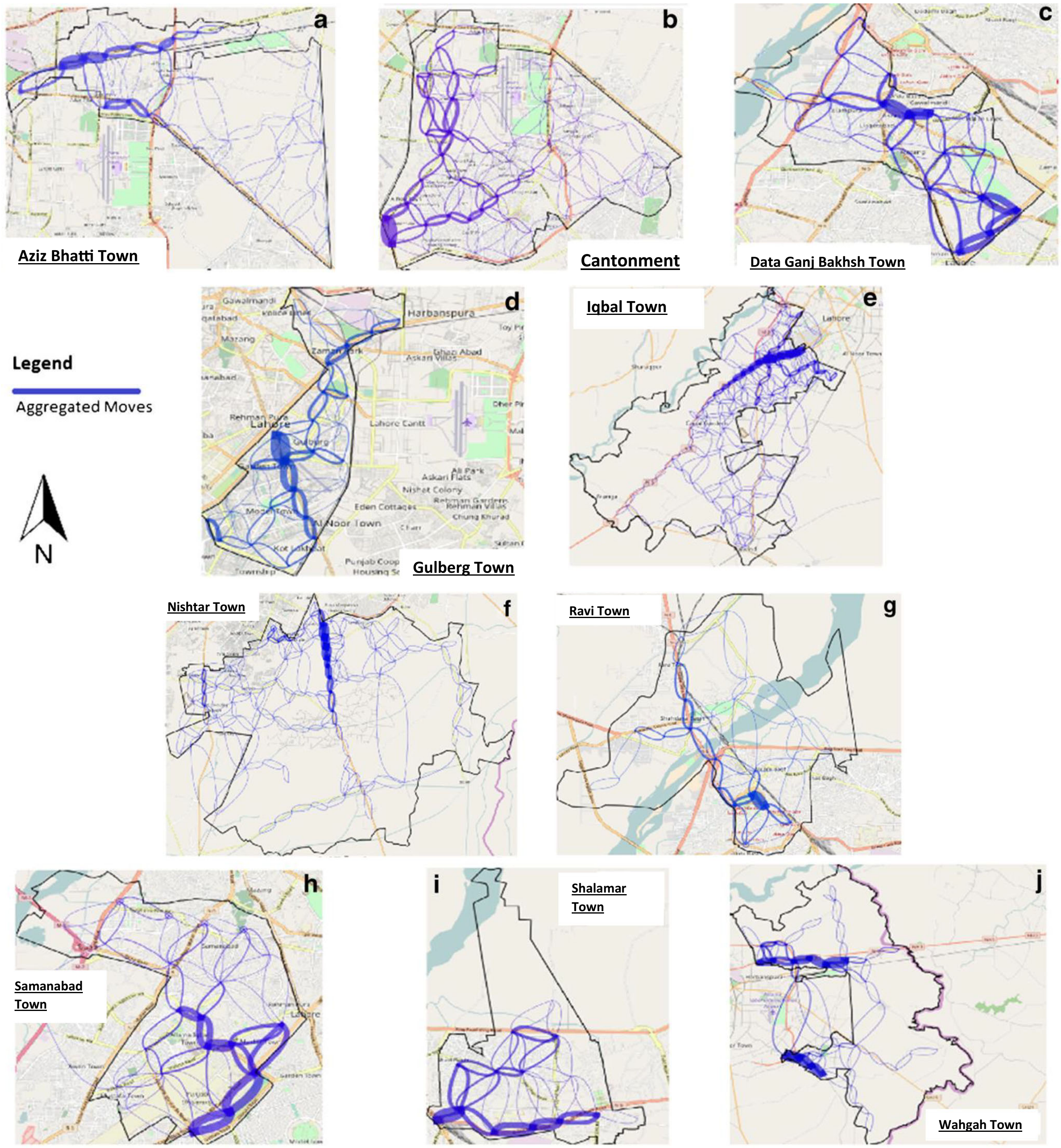


**Fig. 8** Towns in Lahore

Data Ganj Bakhsh town (Fig. 8c) is the most densely populated area of the city having 3 rescue stations and 4 hospitals. The most vigorous ambulance traffic is clustered around these hospitals and rescue stations. Nevertheless, the most active road is Canal road connecting the Ravi River. Data Ganj Bakhsh town encompasses mainstream business and trade as well.

Gulberg town (Fig. 8d) is the core metropolitan region of the city. It has neither a rescue station nor any associated hospitals. However, just outside the boundary, there are 4 rescue stations and 4 hospitals. The active routes are Canal road and Ferozepur road, while other regions are relatively less rush areas.

Iqbal town (Fig. 8e) is one of the towns which are densely populated. Being on the southwestern portion of the city, this town has a lot of empty regions, and the most population is concentrated in the eastern portion of the town itself. The busiest routes are Multan road and Raiwind road. These routes are primarily used for trade purposes. As a result, traffic incidents are more frequently observed in this region. Iqbal town has only two rescue stations located towards the north. This town mostly consists of agricultural land, gradually transforming into urban areas due to lack of planning. One rescue station is located towards the center of the town while another rescue station is at the outskirts of the city near Jinnah Hospital. The Ring road also bisects the town on the eastern portion; therefore, moderate movements are observed.

Nishtar town (Fig. 8f) is situated on the southeastern portion of the city. This is one of the newly developed localities in the city. Generally, not much concentration of traffic is observed in this town besides the Canal road. This town has agricultural land in the southern region. This town has one rescue station at Thokar Niaz Baig chowk and Jinnah Hospital in proximity.

Ravi town (Fig. 8g) is located on the northwestern portion of the city. This is also one of the densely populated towns. As the ancient walled city is included in this town, most of the areas are valuable for industries and businesses. This town has 3 rescue stations but no affiliated hospital. Therefore, all the victims have to be taken to nearby towns resulting in longer travel times for ambulances.

Samanabad town (Fig. 8h) is also one of the congested and populated areas which lie in the western portion of the city. There are only 1 hospital and 3 rescue stations. The roads that carry the maximum load in terms of rescue vehicle movement are Wahdat and Canal roads. Most reported incidents in this town are road traffic accidents.

Shalamar town (Fig. 8i) presents itself as a relatively quiet area in terms of rescue activities. Nevertheless, areas along old GT road show slightly higher activities. Only 1 rescue station lies in this town and no affiliated hospitals are reported, making it even harder for the rescue services to timely respond to victims.

Wahgah town (Fig. 8j) located at the eastern belt of the city has a long border with the neighboring country, India. This town has undergone massive development over the last two decades. It was renowned for agricultural activities and scenic beauty, but now this is getting more urbanized. There are no rescue stations nor any affiliated hospital in the vicinity. Hence, it would take more time to carry a victim to any hospital. Extensive activities are observed on the Canal road, a major road bisecting Lahore city into two sections. The Canal road is a highly active zone due to the presence of recreational parks along the road.

The discussion above presents useful insights into various towns of Lahore. The presence of existing rescue stations and hospitals is an indication of planning efficient resource allocations. In the following, callers' data is being analyzed which can be related to movements of the rescue vehicles.

## Caller data analysis

Figure 9 illustrates the frequency of the calls received in October 2014. The x-axis shows the days, while the y-axis shows the number of calls. This can be clearly observed that a high frequency of calls is received on daily basis. For example, the overall pattern of calls is uniform, i.e., 2000 to 3500 calls every day. A significant trend can also be noticed monthly; for example, there are more calls at the start of the month, whereas there is a gradual decline towards the end of the month.

Similarly, Fig. 10 illustrates the types of calls. On the x-axis, dates are shown, while on the y-axis, the total number of calls is shown. Each color represents the specific nature of the call. For instance, there are abusive calls, distorted calls, emergency calls, gossip calls, missed calls, etc. This graph displays almost 5 months of data. These data are not very useful as there are a lot of unnecessary calls. A filter is applied to get rid of unnecessary data. Once the filter is applied, only emergency calls are

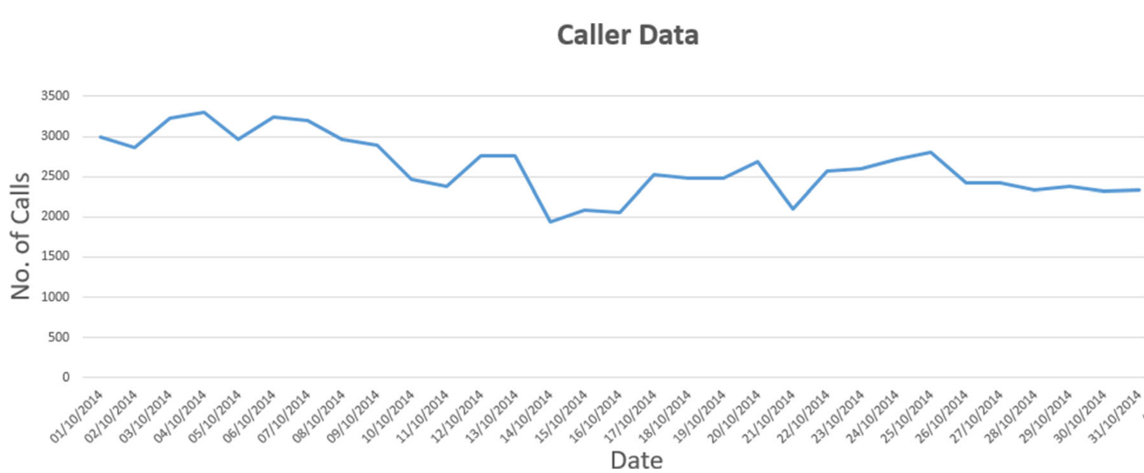


**Fig. 9** Calls received in the month of October 2014

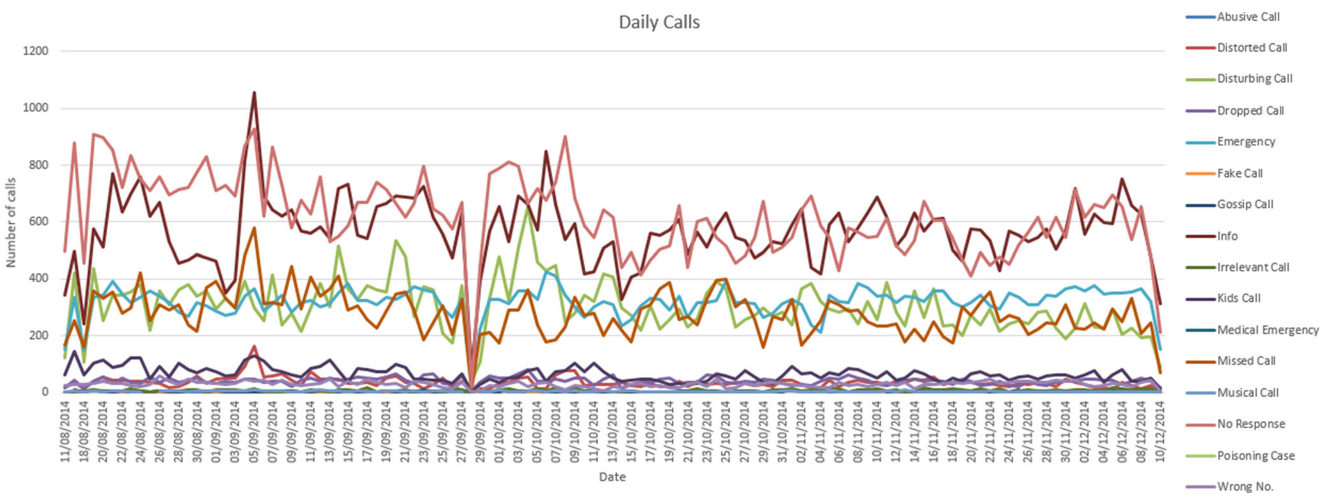


**Fig. 10** Calls received in 5 months (from 11 August 2014 to 10 December 2014)

shown for analysis purposes (as shown in Fig. 11), including fire, injury, and medical emergencies and road traffic accidents. Majority of calls received are road traffic accidents, while medical emergencies are the second highest. The x-axis shows the hours on a particular day, while the y-axis shows the total number of calls. Most types of emergencies are observed during the mid-day and then gradually decrease as the day ends. This analysis is indicative of call classification and the exact situation during a specific hour of the day.

## Conclusions

The current study presented geovisualization approaches for rescue vehicles' movements in Lahore city. Various data processing and analysis methods performed are found to be effective. The travel patterns of rescue vehicles reveal the need for resource reallocation for maximizing the efficiency and minimizing the response time. For example, hotspots are identified along the routes, especially movements in and out of the city. Number of moves, mean stay time, and mean time gaps are visualized for all types of vehicles, demonstrating an interesting behavior. Correspondingly spatial and temporal clustering is performed to find alike groups. Furthermore, spatial and temporal sub-setting is performed. In the end, caller data are explored to observe the type of calls received, and analysis on a specific date is performed. These statistics revealed further insights into caller behaviors. Visualization techniques along statistical analysis can facilitate the rescue officials for planning purpose.

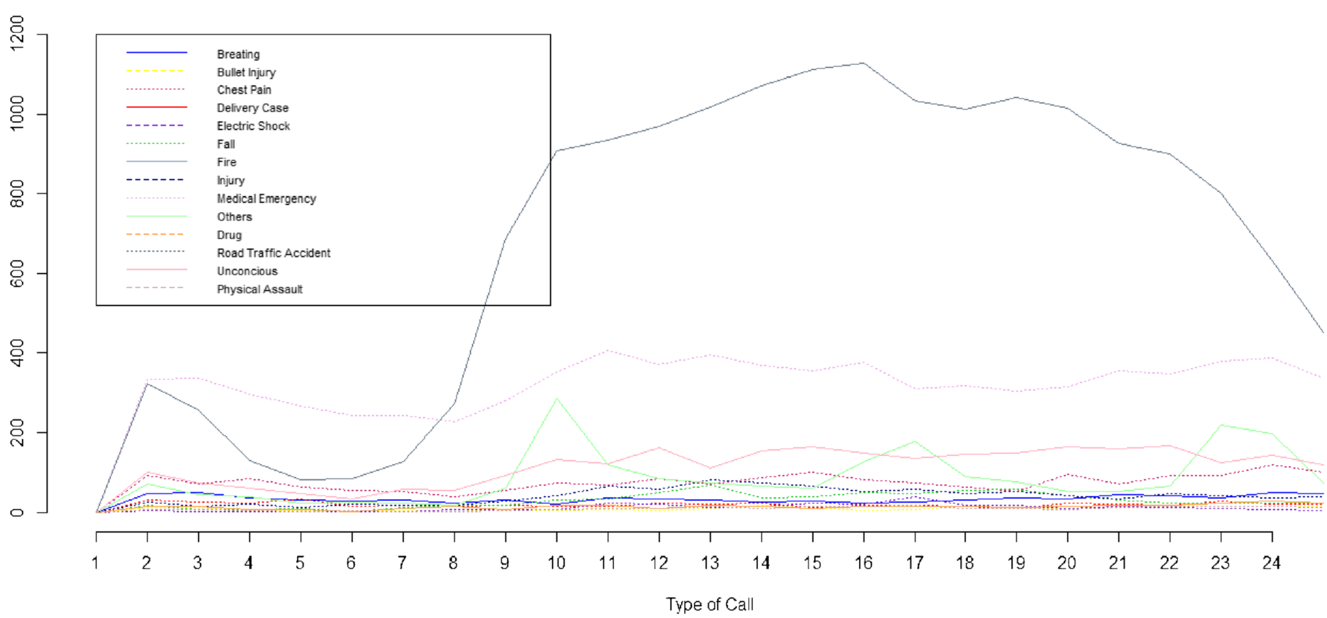


**Fig. 11** Type of emergency calls

In some cases, map visualizations can be further improved by including areas on finer map views. For example, town map boundaries can be added and individual towns can be analyzed and compared on large-scale maps. An effective visualization is to provide an overlay of time stamps of aggregated vehicle movements on a particular hour of the day. It is also recommended to perform a comparison between trajectory-oriented view and traffic-oriented view which will provide further intuition on travel patterns. These are left for future work.

Individual towns in Lahore are analyzed based on existing available resources. In particular, fire incidents are noticed mostly in industrial areas, especially on Multan road. The rescue incidents are recorded mostly in the periphery of the congested locations. While analyzing ambulance data temporally, the busiest month is found to be September, and minimum activities are observed in December. Low activity during December can be due to fog or minimum calls were generated. Furthermore, there are various patterns in caller's behavior such as during a month or on a specific date.

One of the interesting facts is to observe and correlate the individual caller data and the spatiotemporal movement of the rescue vehicles. By doing so, the type of caller and the route vehicles took in order to serve that emergency can be investigated. This is also left for future work. It will also be interesting to run the above analytics on geospatial big data platforms such as Parallel Secondo (Lu and Guting 2014). In the next phase, we will scale up our research by including other cities where the Rescue 1122 is working efficiently. We also plan to investigate the Rescue 1122 motorbikes which are recently launched by the government. This will be useful to compare both rescue vehicles and bikes to analyze the movement behaviors while serving different types of emergencies.

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