

Shortest Path Analysis and Service Levels of Emergency Services in Kalady

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Abstract— Transportation System is a critical component of urban infrastructure and the lifeline of the city. The road accidents are increasing in these busiest environments of the transportation system which often leads to death. This estimated that 1.2 million people are killed in road crashes each year, and as many as 50 million are injured, occupying 30 percent to 70 percent of orthopedic beds in developing countries hospitals. Ambulance vehicles are required to respond rapidly to medical emergencies. A number of factors may affect response times, most importantly the location of emergency services stations, the number of ambulance vehicles available at each station, road conditions and traffic volumes. By considering this factor, it is important to find shortest path to the closest facility and also it is necessary to evaluate the levels of service of ambulance facilities in the area because its role play a major role in the victim's life. This paper presents the shortest route for ambulance to reach the hospital from the emergency occurring areas and also evaluate the service provided by emergency services in Kalady area.

keywords— *Geographic information system (GIS), Level of service, shortest path, network analysis*

I. INTRODUCTION

Transportation System plays an integral role in enabling the mobility that is essential to socioeconomic participation of a country. In many cases, the objective of transport infrastructure investment is to improve the accessibility of a given region by reducing travel time or increasing the potential to travel. Improvement in accessibility will increase the opportunities. Emergency services such as Ambulance, Fire Brigades, Police Vehicles requires unobstructed traffic flow. A pragmatic approach should be done in order to reduce the delay in reaching the destinations. This should be considered in all kinds of vehicle, but the priority is given to Emergency Services Vehicles. Vehicles movement at the time of emergency call have be reached to the accident spot without time lag. Emergency response is a very important aspect of healthcare services. The ambulance services play a critical role in delivery of emergency response services. It is well known that easy and timely availability of ambulances can save a lot of lives, especially in case of emergencies. To deal with such situations, emergency vehicles should be assigned with shortest path to the destination in shortest time and appropriate vehicle clearance. By the year 2025, road traffic deaths in India are expected to cross 250,000 annually [2]. Providing timely and high-quality emergency health services is a challenge, given supply-side problems, regulatory and policy issues, and lack of awareness about

emergency care in the country. The levels of service (LOS) concepts proposed enable the evaluation of an entire transit system, a single route (or run), or a segment of a specific route (or run}. In order to provide the best transportation service possible, transit planners must continuously monitor and evaluate transit system operations. In this study level of service of ambulance service is evaluated.

In Kerala, there were 336 major accident locations during the year 2016- 2018, there are 4287 fatalities, 39420 road accidents and 44108 grievous injuries [22]. Kalady in Aluva taluk is one of the major hotspot identified in this.

A. Geographic Information System

Geographic Information System (GIS) technology is one of the hottest research tools in the world recently and one of the fastest growing high technology of monitoring. It has been proven to be valid and efficient to solve real-life problems, such as responding and resolving emergency situations [17]. A geographic information system is a computerized system that is designed to capture, store, manipulate, analyze, manage, visualize, and present all types of geographical data associated with geographical locations. GIS can bring all that data together quickly and enable users to analyze and visualize information in an efficient way. It has been used in several fields such as transportation management, emergency services, gas station mapping, and healthcare planning. Geographic Information System(GIS) can be used many characters in emergency management. It is an effective tool for determining emergency vehicle response routing and solving the traffic problem.

B. Levels of service (LOS)

Levels of service (L.O.S) are mainly to evaluate the service levels of emergency service. The concept of service quality measure using LoS is first introduced in Highway Capacity Manual in 1965[5]. Quality plays an important role in the market oriented economy and the success of any transit system depends upon its quality of service. However, to improve the quality of service, it is necessary to identify the parameters to be considered important by the commuters for knowing their satisfaction levels for the present service [9]. Level of service is a quality measure which describes the operational conditions within a traffic stream, generally in terms of service provided by the road to the user. Since, the demand for transit is quite high in comparison with the supply in most of the Indian cities; quite often the level of service is not given a priority by the service providers. However, to improve the quality of service, it is necessary

to identify the parameters to be considered important by the commuters for knowing their satisfaction levels for the present service.

II. STUDY AREA

Kalady is a census town located between Angamaly and Perumbavoor, east of the Periyar river, in Ernakulam district of Kerala at 10° 09' 10" N and 10° 11' 50" N latitudes and 76° 21' 05" E and 76° 27' 31" E longitudes. Total area is 16.44 km².with a total population is 28279 and density of area is 1503 km².

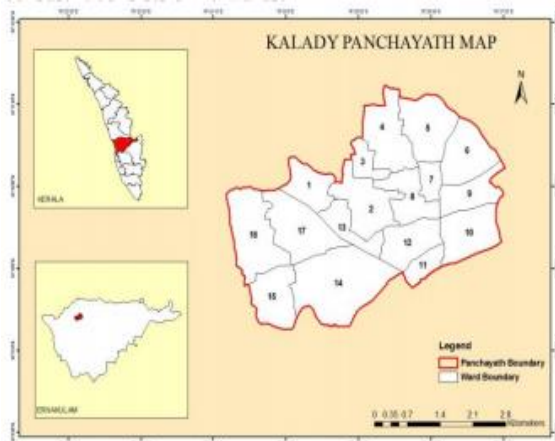


Figure I. Digital map of Kalady

III. METHODOLOGY

A. Shortest Path Analysis

Shortest path analysis is defined as finding the shortest route to the closest facility from incident locations. Arc GIS 10.2 version is used to find out the shortest path. For finding the shortest path in the Kalady Panchayat the closest facility is chosen as Little Flower hospital Angamaly. for this digital map of Kalady is prepared and road network shapefile is extracted from OpenStreetMap. Using network analyst tool set the road network layer is created.

Then from Kalady police station accident details of past three years were collected. Below charts shows the consolidate data of accident details in the year 2016, 2017, and 2018. From the chart it is clear that Kalady, Marottoor, and Marottichuvadu are the major accident-prone areas and also it is clear that most of them are grievous victims.

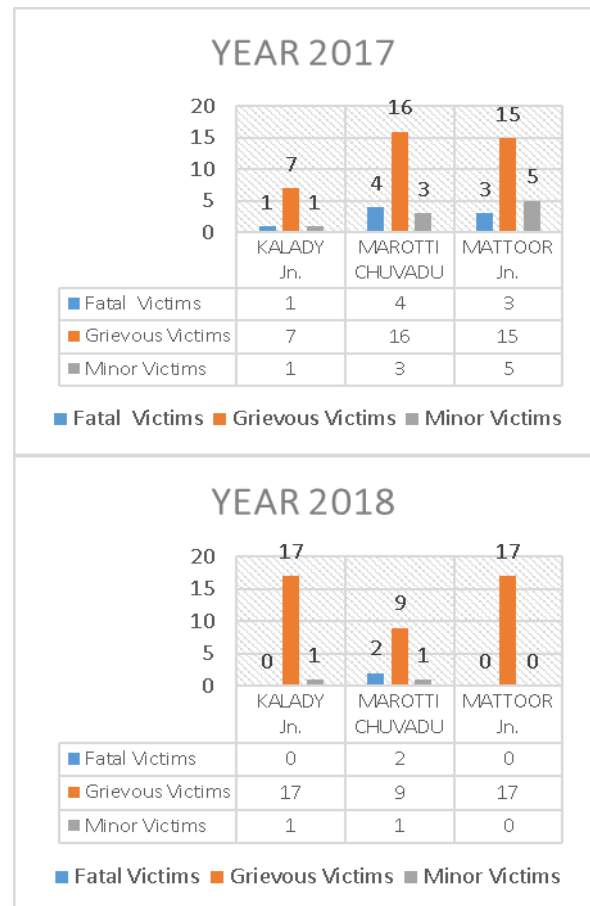
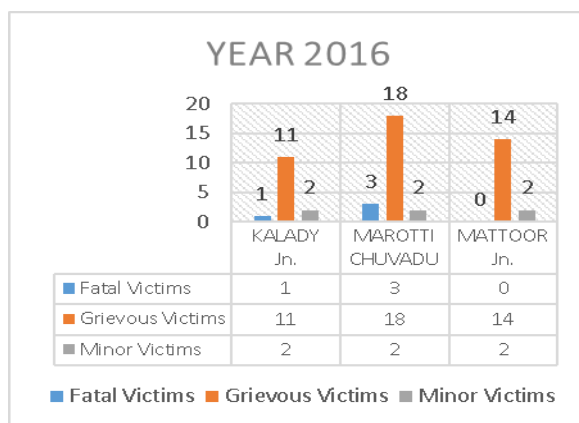


Figure II. Accident data in the year 2016, 2017, and 2018

From this data major hotspots in the area are identified and map showing the incident frequency in this hotspot are plotted using heat map using kernel density tool. Map 2,3,4 shows the hotspot frequency in the year of 2016,2017 and 2018 respectively. And also by considering some major junctions in this analysis. Then the shortest path is found out by performing network analysis extension tool bar. The best route analysis generates the best route between incident location and hospital based on less travel time.

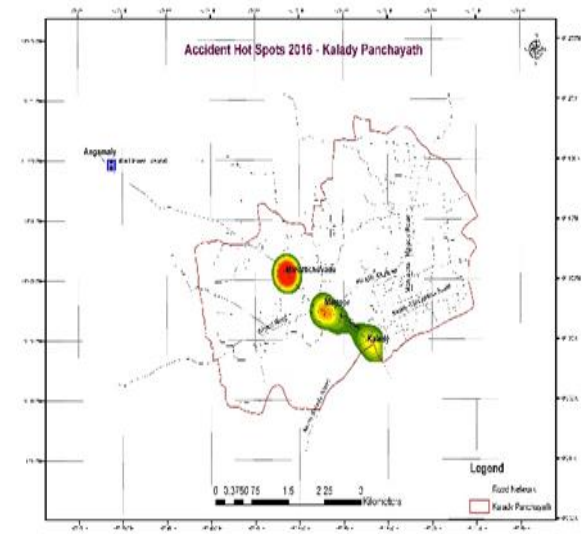


Figure III. Map showing accident frequency in the year 2016

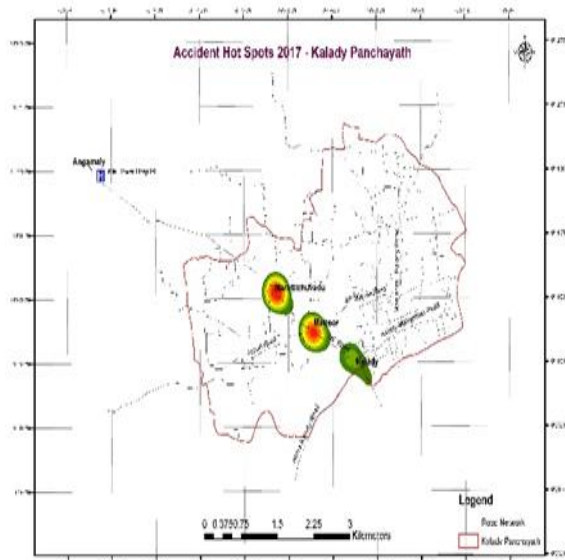


Figure IV. Map showing accident frequency in the year 2017

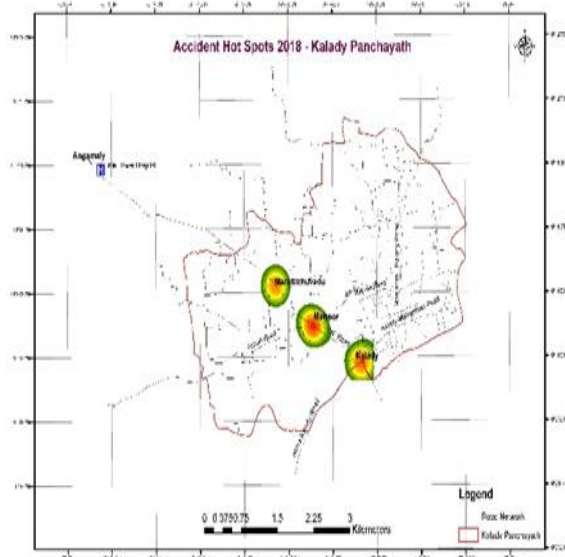


Figure V Map showing accident frequency in the year 2018
Other than the major hotspots identified, some major locations that is junctions in Kalady were also considered for this analysis and the Map 4 shows the major hotspot and identified locatons.

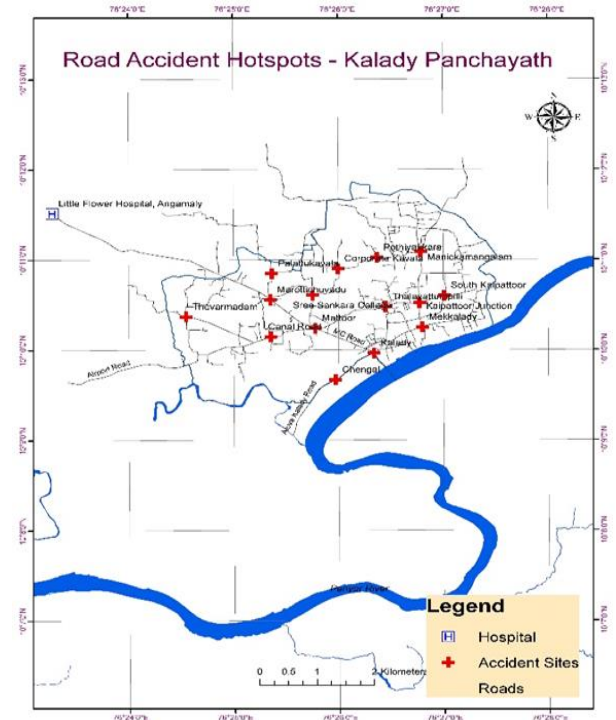


Figure VI. Map showing the major hotspot and locations identified for this analysis

B. Levels of service (LOS)

The evaluation of service quality is one of the challenging task and an important practical problem encountered by the service providers. The assessment of quality of service is required to improve the user satisfaction and thus to improve the demand for public transport services. Researchers have identified Level-of-Service (LoS) as an effective measure to understand the users' level of satisfaction for the service provided.

Data for present study were collected from 17 wards of Kalady panchayath. An extensive users questionnaire survey was carried out from 6th May to 6th June 2021. Responses were collected from users and non users in an online mode. A questionnaire was presented to the road users to understand their perception about LOS at the selected panchayat. A total of 586 responses were collected from the panchayat and that was used for LOS analysis. Table shows the questions that were asked and answering is based on rating system like the pattern Strongly Disagree, Disagree, neither agree nor disagree, Agree, Strongly Agree. And also collected the information of why the people are not using the ambulance service. The questionnaire design is a key part of any users' perception survey study. On the basis of this questions five indicators were selected. Each indicators were assigned by some weightage. To determine the overall level-of-service rating for emergency service, the number of points for each indicator is first multiplied by the weighting credits for each. Next, the resulting products are added together and that sum is then divided by the total number of weighting credits. The final answer will be a number from 1 to 5 which will correspond to a level-of-service. Hence, the present work used a five point Likert scale to collect road users' response for evaluating the importance of each variable [23]. Road users measure the importance of variables influencing LOS according to their opinion on 1 to

5 scale where '1' indicates less influencing and '5' indicates highly influencing variable

Questions/ statements used in survey

1. Have you ever been transported in an ambulance as a patient or called for an ambulance for somebody else?
Yes / no
2. The reason for contacting the Ambulance Service was
Heart Diseases/Trouble in breathing/Traffic accidents/Infections/Other incidents
3. How many times did you contacted the ambulance?
Less than 2, 2-5, above 5
4. If you dial 102 the ambulance will be arrived immediately.
5. You are confident about the current service.
6. The ambulance is provided with a jump bag that carry bandages, drugs, medications and syringes.
7. Ambulance is equipped with an ECG monitor to display the heart rhythm
8. Ambulance carries sufficient oxygen cylinders
9. Ambulance service have a sphygmomanometer for checking BP
10. The seat and the bed in the ambulance are properly oriented.
11. Ambulance is provided with mechanical ventilators.
12. Extra stretchers are provided
13. Proper ramps are provided for effective movement of stretchers.
14. A cervical collar is provided for patients having a neck or head injury.
* a cervical collar is a device that used to hold the neck in correct position and reducing the risk of long-term damage.
15. Do you agree with the accurate timing of the ambulance?
16. Do you agree that the service provided by ambulance is in friendly manner?
17. Do you agree that they provide a specialized nurse inside the ambulance?
18. Do you agree that the ambulance call taker easily understands your location?
19. The ambulance call taker give advice on the phone about what to do before the ambulance arrives.
20. The ambulance was well cleaned.
21. The ambulance crew treat you with respect and dignity.
22. The ambulance crew clearly explained the care and procedures they were providing and responded to questions.
23. The ambulance ride was comfortable.
24. The ambulance arrived as you expected.
25. The ambulance crew give hospital staff all the necessary information about you.
26. Do you agree that ambulance can easily access your location if there is a need?

The questions used for this survey were grouped under 5 indicators and each indicator will be assigned by weightage on a scale of 10 based on preference. Below table 1 shows the indicators and weightage.

Table 1. Table shows the indicators and assigned weightage

Indicators	Weightage
Availability and Response time	10
Accessibilty	10
Facilities and equipments	10
Cleanliness and comfort	5
Service of crew	5

LOS can be calculated as user score of each indicator is multiplied by corresponding weightage which is divided by total weightage. User score can be obtained as average of each response score obtained from survey. The below equation (1) shows the equation for finding out overall LOS. Final answer will be a number in between 1 to 5 and LOS rating will be done in a form of grade A to D. Table below shows the calculated LOS and rating grade.

$$\text{LOS} = (\text{User score} * \text{weightage}) / \text{Total weightage} \quad (1)$$

Table 2. Table shows the calculated LOS and grade

Calculated LOS	Grade
4-5	A
3-4	B
2-3	C
1-2	D
0-1	E

IV.RESULT AND DISCUSSIONS

A.Shortest path analysis in Kalady

With the help of network analysis tool to find out shortest path between the major locations in Kalady and hospital. This will help the user to reduce the traveling time to reach a particular hospital. Map 5 shows the shortest path from incident locations to hospital that will reach have a reach time of 5 minutes. By considering emergency response time as 5 minutes. 15 major locations were considered in this analysis in that 7 of them are can be covered within this 5 minutes and others are not covered during this time.

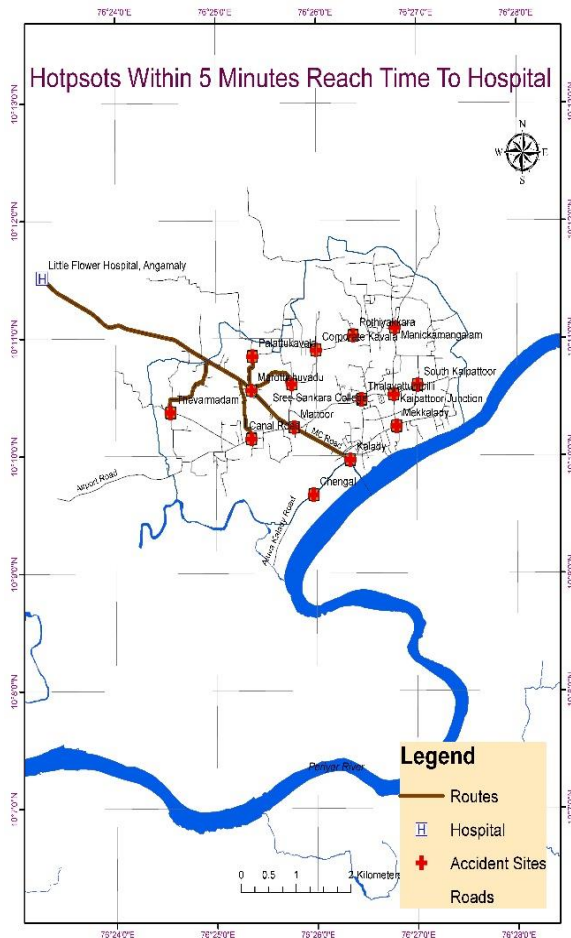


Figure VII. Map showing path reach within 5 minutes

Table 3. Tables shows the location that can be reached within 5 minutes and cannot be reached within 5 minutes

Locations that can be reached within 5 minutes	Locations that cannot be reached within 5 minutes
Marottichuvadu	Thalayattumpilli
Kalady	Cooperate kavala
Canal road	Chengal
Mattoor	South Kaipattoor
Thevarmadam	Kaipattoor junction
Palattukavala	Mekkalady
Sree Sankara college	Manickamangalam
	Pothiyakkara

B.Levels of service of ambulance facility in Kalady

From the 586 responses, it was found that those who answered were 50.9% are female and 49.1% males, most of the responses were done by the people who are in age group of 18 to 45 about 60.8% and remaining responses from age group of below 18, above 60 and in between 46 to 60. From the survey it is observed that 56% of people were not using this service because 45.4% of people using private vehicles, 48.6% peoples are not having such emergency cases, 11.6% peoples are responded that ambulance arrival time is less and 24.7% were not confident about current services. The average user score of the questions that influence the indicators are given as overall user score for each indicator

and below table 4 shows the user score for each indicators from survey.

Table 4. Table shows the users score from survey

Indicators	Questions	Users score
Accessibility	1. Do you agree that the ambulance call taker easily understands your location? 2. Do you agree that ambulance can easily access your location if there is a need. 3. Are you confident about the current service.	4
Facility and equipment's	1. The ambulance is provided with a jump bag that carry bandages, drugs, medications and syringes. 2. Ambulance is equipped with an ECG monitor to display the heart rhythm 3. Ambulance carries sufficient oxygen cylinders 4. Ambulance service have a sphygmomanometer for checking BP 5. Ambulance is provided with mechanical ventilators. 6. Extra stretchers are provided 7. Proper ramps are provided for effective movement of stretchers. 8. A cervical collar is provided for patients having a neck or head injury. * a cervical collar is a device that used to hold the neck in correct position and reducing the risk of long-term damage.	3.55
Availability and Response time	1. The ambulance arrived as you expected. 2. Do you agree with the accurate timing of the ambulance? 3. If you dial 102 the ambulance will be arrived immediately	4.05
Service of crew	1. The ambulance crew treat you with respect and dignity. 2. The ambulance crew clearly explained the care and procedures they were providing and responded to questions. 3. The ambulance crew give hospital staff all the necessary information about you. 4. Do you agree that the service provided by ambulance is in friendly manner? 5. Do you agree that they provide a specialized nurse inside the ambulance? 6. The ambulance call taker give advice on the phone about what to do before the ambulance arrives.	3.9
Cleanliness and comfort	1. The ambulance was well cleaned. 2. The ambulance ride was comfortable. 3. The seat and the bed in the ambulance are properly oriented.	4.12

Using equation(1) LOS can be calculated as follows

$$\text{LOS} = \frac{\{(4 \times 10) + (3.55 \times 10) + (4.05 \times 10) + (3.9 \times 5) + (4.12 \times 5)\}}{40} = 3.9$$

From the table 3 it is clear that 3.9 lies in between LOS grade of B.

V.CONCLUSION

The present study identified shortest routes to the closest facility and evaluated service offered from emergency service in Kalady area. From this analysis it was found out that only hospital that can accessible if any major incident was happened there is Little flower hospital Angamaly which can be considered as a drawback in the area. By finding shortest path, it was concluded that from selected locations only 7 locations were able to access the closest facility within response time. So it is necessary to have a specialized hospital in this area.

By evaluating levels of service, it was found out that the area is having LOS grade of B which indicates the service is good and the users are satisfied with the present service system. It was concluded that most of the peoples were using private vehicles instead of ambulance for some reasons including accessibility to their location or response time is high. Also the user survey suggests that the ambulance requires a specialized nurse and also the facilities in the local health centre need to be improved so that any casualties can be directly brought there within the panchayath.

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