Proceedings of the 2019 Winter Simulation Conference
N. Mustafee, K.-H.G. Bae, S. Lazarova-Molnar, M. Rabe, C. Szabo, P. Haas, and Y.-J. Son, eds.

ADVANCED ASSISTANCE SERVICES USING HYBRID AMBULANCE (AASHA) SYSTEM

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ABSTRACT

According to a report by the World Health Organization (WHO) in 2018, 1.35 million people die each year due to road accidents globally. Post-Accident care plays a very crucial role in reducing fatalities. In a country like India, it is becoming increasingly difficult to provide post-accident services on time with an increase in congestion. In this paper, we propose a system which decreases the post-accident response time of Emergency Medical Services (EMS) in India by adding another layer of the patient transport vehicle. The paper discusses a new system design with simulation model and algorithm. Further, when compared with the traditional system, it provides an overall time reduction of approximately 3 minutes with a 97% survival rate.

1 INTRODUCTION AND REVIEW OF LITERATURE

Emergency services play a significant role in a nation's public care system, providing response and transportation facility to millions in need every year. But, due to the increase in population, it is becoming increasingly difficult to provide reliable emergency services in populous countries like India. According to a report published in by Transport Research Wing (TRW) of Ministry of Road Transport & Highways of Government of India situated in New Delhi, the number of persons killed per 100 accidents has increased from 31.4 in 2016 to 31.8 in 2017 (Malik 2018) and (Malik 2017). It may seem to be a very negligible increase of 0.4, but when parameters are set with respect to the population of India it indicates the degrading condition of road safety.

The title of the paper, when abbreviated - forms the word ‘AASHA’. This term in Hindi means *hope* and was chosen for the reason that during any tragic incident, this system would make the situation more hopeful.

The analysis of road accidents shows high variation in the fatality risk among the states and the cities of India. 16 out of 35 states and union territories have a fatality rate higher than the Indian average which if not considered seriously, can reach to total accident deaths crossing 2,50,000 per year by 2025 in India (Singh 2017). Every week nearly 2,650 people get killed and 9,000 injured on Indian roads. And according to the report on road safety by the World Health Organization (WHO), the number of annual road fatalities are much higher at 1,50,785 as of 2016 which keeps India on the top of all other countries in terms of road traffic fatalities (WHO 2018). To add to this, statistics have shown that if the current rate is not decreased, then in the span of 2003 to 2027, there would be 100 % increment in accident fatalities (Singh 2017).

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Survival in such emergencies is majorly dependent on the time in which the victim receives the post accident care. Thus, an efficient system must provide people with the better response time. But, in a big country like India where traffic sense among people is comparatively low, it becomes difficult to provide low response time using a traditional system which can be clearly seen from the literature of (Singh 2017). The literature states that in India, despite smaller number of motor vehicles - 130 per 1000 people, compared to countries like Germany - 657 per 1000 people, Japan - 651 per 1000 people, etc., the fatality rate is highest - 8.6 when compared to these countries, which have 0.67, 0.63 fatality rate per 10,000 vehicles respectively (Singh 2017). This shows there is some serious need to understand the problem and improvise the situation. In addition, this problem keeps on increasing every year with an increase in the number of vehicles. For instance, 108 Emergency Service has given a more conducive environment for the growth of Emergency Medical Services (EMS) in India. But, it still has a lot to improve as according to an estimate, around 33 % of road accident victims didn't survive in India in 2017 (Malik 2018).

Intensive studies have been carried out in both the research areas that are particularly related to our work. Where the first area focuses on factors behind an accident and efforts to minimize their effects. The second area focuses on reducing the delay in the post-accident care the patient receives after the occurrence of an accident. A major pioneering effort in the first sector started since late 1995 by Lasse who studied the impact of different parameters on accidents; which was further carried out by (Fridstrøm et al. 1995) who developed a prediction model on the occurrence of future accidents. (Smolenskya et al. 2011) discussed the relation between sleep and accidents. (Castignani et al. 2015) developed a full-scale driver profiling system using a smart-phone, which can help in the accident prediction and (Granberg and Nguyen 2018) issued a simulation-based approach on the prediction of the next accident occurrence.

The advancements in the post-emergency-care were made by (ReVelle et al. 1977) in which they proposed a method that helps in detecting the minimum number of facilities(Ambulances) required to satisfy the need in a range of the given response time. Recent advancements include the work of (Su and Shih 2003) who suggested a two-tier support system for ambulances in Taipei, Taiwan in which each ambulance was preassigned a network of hospitals. Ambulances need to respond to the assigned hospitals only, in order to reduce response time. (Zaldivar et al. 2011) focused on using the smart-phones as an alternative On-Board-Unit(OBU) that monitors vehicle speed, airbag triggers, etc. and in case of an accident, raises an alert to the emergency services for help. (Amin et al. 2012) also proposed a similar solution but recommended the use of GPS technology. The use of GPS facilitates a great deal in locating the accident spot, which in turn, reduces the response time. For the simulation modeling part, work of (Lubicz and Mielczarek 1987) was reviewed to understand the ways in which an Emergency medical service can be modeled. This was then further detailed with the work of (Sung and Lee 2012), from which problems that EMS usually faces were studied.

Although the above-mentioned work provides readers with a wide range of solutions, it is still not able to present a solution which can work in a scenario similar to Indian conditions. Thus, the difference between our work and other models is that the proposed solution is made keeping the Indian conditions in mind. The solution is able to work in conditions like congested environment, smaller and uneven roads; and most importantly in places where there are no stringent traffic rules. India currently has an Emergency Management and Research Institute (EMRI). It provides centralized surveillance on any of such events but still, the area where it faces problems is in reducing response time. Especially, if the patient is in a densely populated area which is full of traffic violators. The proposed solution enhances the credibility of the existing system by developing a dynamic dispatching algorithm and a hierarchical model consisting of ambulances and sub-vans, i.e. local transport vehicles like Auto rickshaws (Siddique et al. 2013). Thus, here we will be using the word sub-van as a synonym to Auto rickshaws.

In order to develop a reliable system, the correlation between casualties and response time was studied. This enables us to know how quickly does a system need to respond in order to save casualties during an emergency. As a couple of researches mentioned (Blackwell and Kaufman 2002; O'Keeffe et al. 2011), there is a high correlation between response time and casualties, when an emergency occurs. The above literature also helped in understanding the maximum response time desired in different emergencies.

The allocation of ambulances and sub-vans to the accident spots proposed is very much in the line of (Tan and Takakuwa 2016), which discusses the allocation of trucks in the open pit mines. They proposed a truck dispatching algorithm through which truck was able to collect the required quality of ore with minimum stops. Here, when a truck reaches a particular pit stop, it runs the algorithm and finds the next most optimal stop. It keeps iterating until the required amount of ore is collected, and the programming environment VBA (Visual Basic for Applications) is used to execute the algorithm. In our proposed model, the allocation of a particular ambulance to a sub-van or accident spot is done with a similar approach.

The idea of using the hybrid system has been carefully chosen after reviewing the literature (SteadieSeifi et al. 2014) on the use of Multimodal freight transportation to provide an efficient platform for transportation.

The rest of the part in the paper is divided into sections, as mentioned. Section 2 distinguishes between the proposed model and the traditional model. Further, Section 3 describes the simulation model followed by Section 4 - experiment design and Section 5 - verification of the system in which, all simulation states, their execution sequence is described. Section 6 presents the designed algorithm. Section 7 validates our model. Section 8 shows the results that are achieved during the simulation and experimentation. Section 9 describes the limitations of the model and the application. Finally, the paper is concluded in the last section 10.

2 MODEL DISTINCTION

In order to explain the two emergency response systems, the following terms are used as follows:

- *Response time*: It is the time taken by the first responder to reach the accident location after the request was placed.
- *Transport time*: It is the total time taken to make the patient reach the hospital after the request was placed.

2.1 Our Proposed Model

The system state in our model at any point of time would comprise of ambulance locations, sub-van locations, possible meeting point locations(Road Intersections), hospital locations, accident location and status of current patient. The locations of sub-vans and ambulances are initially fixed when the simulation begins. The initialization routine is invoked when a request from the patient is received. If an ambulance is able to reach the patient satisfying the traffic conditions, the traditional system is followed. Whereas, if the above conditions are not met, a sub-van would be first dispatched to the patient's location. Once the patient is picked up, it will analyze whether there is a need for a meeting point or not. The meeting point is a location where the patient is transferred from sub-van to ambulance. It comes into play if sub-van is far from the hospital. The meeting point location for sub-van and ambulance depends on the traffic conditions. Transferring of the patient from sub-van to ambulance takes place in an area with sparse traffic. Moreover, for areas with relatively less traffic, an ambulance is preferred over sub-vans. Ambulances have greater average speed compared to sub-vans, on roads with less dense traffic. The model is displayed in Figure 1. So, if a meeting point is decreasing the overall response time, sub-van would take a patient to the meeting point, i.e. a road intersection; and then an ambulance will take the patient to the hospital. If a meeting point is not possible, sub-van would take the patient directly to the hospital. Thus, the algorithm is flexible and uses sequencing of events based on the traffic conditions to minimize the total time. After the required number of iterations, the probable minimum average response and transport times are derived.

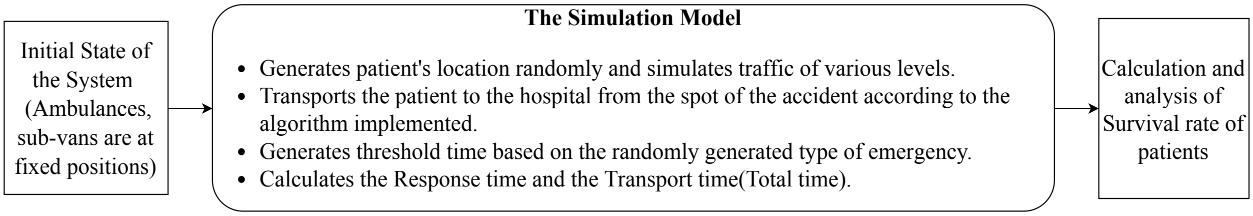

Figure 1: Our proposed model.

2.2 Traditional Model

The traditional system, at any point of time, would comprise of ambulance locations, hospital locations, accident location and status of the current patient. The locations of ambulances are fixed initially. The location of the accident is generated at random in any of the accident-prone zones. The initialization routine is invoked when a request from the patient is received. According to the present system, the nearest available ambulance is assigned as the first responder. The first responder takes the patient from the accident spot to the nearest hospital. After the required number of iterations are over, the minimum average response and transport times are derived.

2.3 The Novelty in the Proposed Model

The novelty of the proposed method is in layered transportation. In the traditional or present system, there is only one vehicle used for the entire transport of the patient. Whereas, in the proposed system, there are two different vehicles used depending on traffic density and location. Using sub-vans in dense traffic and ambulances in light traffic conditions minimizes total time.

3 SIMULATION MODEL

The simulation was performed on Ahmedabad city, one of the most populous cities in India, situated in Gujarat. It registers around 2 accidents every hour and has approximately 70 Government Ambulances and numerous other ambulances owned by private companies and NGOs. We considered 50 kilometers road network in the midst of the city for the simulation. In this network of 50 kilometers, 15 sub-van depots, 15 ambulance depots were used. A total of 10 number of hospitals in the 50 km network were considered for the simulation. A total of 57 intersections (possible meeting points) were taken into account for the experiment. The proposed discrete event simulation is based on a fixed increment time advance approach and all possible events that could occur during a cycle are as follows: call arrival(A patient request), dispatch of ambulance or sub-van to patient, arrival of emergency vehicle at the spot, assignment of a meeting point (i.e.: road intersection) if required, arrival of sub-van and ambulance at the road intersection, arrival of sub-van back to its depot, arrival of ambulance back to its depot, and arrival of ambulance or sub-van at the hospital. Occurrence of any of the above event can change the state of the system. The timeline the occurrence of events can be seen in Figure 2.

This simulation model has the following components:

- A stochastic patient location generator, which randomly assigns patients in a specified area.
- Probability distributions for the speed and length of different types of vehicles during heavy traffic hours and light traffic hours.
- Traveling model that finalizes the travel route between an origin and a destination.

With respect to the first point, in order to evaluate the utmost credibility and utility of the system following things were undertaken. Different accident-prone areas were determined across Ahmedabad

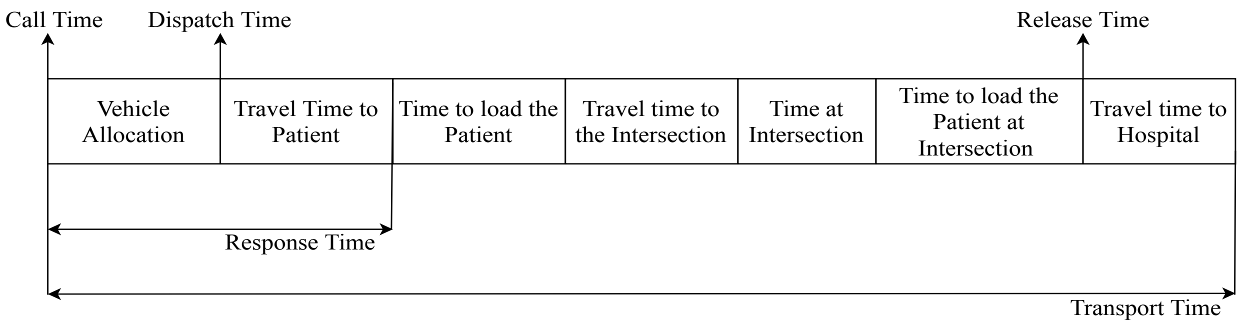

Figure 2: Time-line of events.

which had heavy traffic. Accidents were then, hypothesized at such junctions like markets, malls, offices and spiritual places in their peak and non-peak hours.

For the second point, probability distributions of speeds of vehicles during peak and non-peak hours were considered in the simulation model. These distributions helped generate the environment as real as possible for the simulation. The variations were applied in vehicle types, vehicle length, vehicle speed, vehicle acceleration, and road width.

Finally in the third point, firstly the OpenStreet GIS map identifies the actual hospital locations in the city. Our algorithm then finds the nearest hospital by examining the latitudes and longitudes of each hospital. Once finalized, it will then find different pathways to reach the destination, out of which the route which takes the patient in the shortest time possible is selected.

4 EXPERIMENT DESIGN

The experiment was conducted at two different instances of the day: (a) The time when the traffic is maximum in a day and (b) when it is minimum in a day. The selection of the time was based on the primary research done by the authors and a report on Indian road accidents by PRS Legislative Research (Mishra 2017). In Ahmedabad, the traffic density is higher in the morning between 8:30 AM and 10:30 AM and in the evening between 6:30 PM to 8:30 PM with respect to the average traffic density over the day. This duration is termed as *Peak Traffic Hours*. This is why at that time the speed of traffic is lower compared to the average speed over the day. Furthermore, during the afternoon between 1:00 PM to 4:00 PM, traffic is minimum in a day. This duration of the day is referred to as *Non-peak Traffic Hours*. So, considering the timing of the traffic variations, we simulated the model for the area spanning across 50 kilometers of the road network in the midst of the city.

This road network of 50 kilometers was then divided into subsections. Each subsection was having a road network of approximately 10 kilometers. We made the divisions such that each section contained 2 hospitals, 3 ambulances, and 3 sub-vans. For the simulation segment of the traditional system, the sub-vans were omitted. In our system, the time to transfer the patient from sub-van to ambulance was assumed to be varying randomly, with an upper bound of one minute. This time was determined after studying the existing system of 108 services provided by GVK EMRI. The number of ambulances, sub-vans, and hospitals for each subsection was determined by studying the currently running GVK EMRI 108 ambulance services. After call arrives at the call centre, the duration of the call with requester for the emergency service was also determined after consulting GVK EMRI 108 service. The road network for a subsection named Panchvati Circle is shown in Figure 3.

The traffic on the road for peak and non-peak hours was generated after studying the traffic patterns and most used vehicles in the city (Doshi et al. 2015). The location of the patient was generated on the road network based on the accident-prone zones present in the road network (Research INC 2016). For both traditional and our system, approximately 500 patient requests, for both peak and non-peak hours, were randomly invoked. For the traditional system, the experiment was conducted with 3 ambulances.

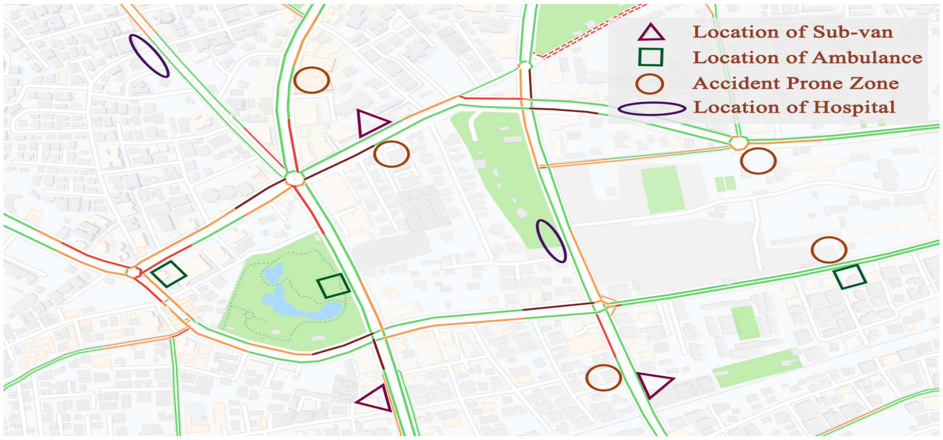

Figure 3: Panchvati circle.

For our system, after conducting experiments with 3 ambulances and 3 sub-vans, we also executed the same simulation for different combinations of number of ambulances and number of sub-vans for the same road network. This gave us a wider spectrum of decision alternatives. Three parameters were calculated as results for observing the effectiveness of our system compared to the traditional system: Response time, Transport time and the Survival Rate. Survival rate is defined as the percentage of patients served successfully. Serving a patient successfully implies that the patient is transferred to the hospital in time less than the threshold time. Threshold time was generated according to the randomly generated type of emergency. Threshold time is the time till which the patient can be alive without being hospitalized. If the Transport time for a patient request is less than the threshold time then it is a success(I.e., the patient is saved), otherwise, it will be considered as a failure(I.e., the patient could be saved). We considered all the different types of emergencies that the current system(GVK EMRI 108) addresses and based on which the threshold time was generated.

5 VERIFICATION

The verification was performed to make sure that there are no bugs, logical faults, error and that all the states do occur when the required situation occurs. For that, numerous independent experiments were carried out and apart from that each mentioned state was explicitly checked and noted to make sure that it is working. Further, the distances obtained from OpenStreet GIS maps were crosschecked with that of Google maps, so that it can be assured that the distances are correct and in case of a difference, they do not make a significant impact. In order to make sure that the triangular distribution of speed is followed by the traffic, the arrival rate of traffic cars was noted at the end of the simulation and it was observed that they remain close to the mean of the distribution and so it was certain that the distributions are being followed. Peak and non-peak conditions were individually simulated by writing respective triangular distributions for the arrival rate of vehicles. After which, the results were noted and checked against the real values of respective distributions.

6 ALGORITHM

Let $P_1, P_2, \ldots, P_n$ be Patients' requests at different points in time, $V_1, V_2, \ldots, V_{n_v}$ be Sub-vans at different depots, $A_1, A_2, \ldots, A_{n_a}$ be Ambulances at different depots, $H_1, H_2, \ldots, H_{n_h}$ be Hospital Locations, $CS_1, CS_2, \ldots, CS_{n_{cs}}$ be Road Intersections in city. Here $n_{cs} > n_v \geq n_a > n_h$.

At any instance of time t, let P_k be the patient being served. Let the time spent on registering the emergency to the call center be $T_{CallResponse}$. Once, the patient request is received, based on the location of patient P_k

nearest available sub-van or ambulance is picked and first responder is selected from the following two cases.

1. **Case 1:** Ambulance A_k is nearer than sub-van V_k i.e., $d(A_k,P_k) < d(V_k,P_k)$ where $d(x,y)$ is the distance between x and y. In this case, Ambulance A_k goes to patient P_k in time $T_{ResponseTime}$. In the meantime, best possible hospital H_k is found on the basis of distance and traffic state. Once, the ambulance reaches the patient location, $T_{AmbLoadsPaient}$ is the time taken to load the patient into ambulance. Once loaded, ambulance A_k moves towards the select hospital H_k, time taken for the same is $T_{PatientToHos}$. Once, the ambulance reaches the hospital, total time is calculated using following formula:

$$T_{Total} = T_{CallResponse} + T_{ResponseTime} + T_{AmbLoadsPaient} + T_{PatientToHos}$$

2. **Case 2:** Sub-van V_k is nearer than ambulance A_k i.e.: $d(A_k,P_k) > d(V_k,P_k)$. In this case, sub-van V_k goes to patient P_k in time $T_{ResponseTime}$. In the meantime, two different locations are chosen, first being best possible hospital H_k on the basis of distance and traffic state and second being road intersection CS_k whose selection can be understood by the following example: Let A_1 be nearest to road intersection CS_1, A_2 to intersection CS_2 and similarly every ambulance would be associated with one or more intersections. Out of all this pairs, a pair is selected on following equation: $min(abs(d(P_k,CS_k) - d(CS_k,A_k)))$. I.e.: optimized intersection CS_k and ambulance A_k pair is selected which can minimize the distance between P_k to CS_k and CS_k to A_k.
After the trio P_k, CS_k and A_k are selected, another nearest hospital $H_k^{'}$ will be selected with respect to intersection CS_k on the basis of distance and traffic. The reason for selecting another hospital $H_k^{'}$ is mentioned in the following sub-cases. The reason for selecting meeting point is that if there is less traffic just a few blocks away from the accident location, it would be better for switch patient to ambulance from sub-van. And as ambulance has high powered vehicle than sub-van, it will be able to achieve higher speed than sub-van on an open road and thus will move patient faster to hospital. So even if any vehicle arrives earlier at the intersection than the other, this method of calculating the optimized intersection will reduce the waiting time. Once sub-van reaches to accident spot, it loads patient into sub-van and time taken to load the patient is $T_{SubvanLoadsPaient}$. This, again produces two sub-cases which are as follows:

   (a) **Sub-case 1:** $d(P_k,H_k) < [d(P_k,CS_k) + d(CS_k,H_k^{'})]$: Distance between patient P_k and hospital H_k is less than distance between patient P_k to intersection CS_k and intersection CS_k to hospital $H_k^{'}$. In this case, sub-van will directly take the patient to the hospital as this is the best possible way identified by the algorithm. Time taken for the same is $T_{PatientToHos}$. Once, the sub-van reaches the hospital, total time is calculated using following formula:

$$T_{Total} = T_{CallResponse} + T_{ResponseTime} + T_{SubvanLoadsPaient} + T_{PatientToHos}$$

   (b) **Sub-case 2:** $d(P_k,H_k) > [d(P_k,CS_k) + d(CS_k,H_k^{'})]$: Distance between patient P_k and hospital H_k is greater than distance between patient P_k to intersection CS_k and intersection CS_k to hospital $H_k^{'}$. In this case, sub-van V_k departs for the patient and simultaneously ambulance A_K departs towards the chosen intersection CS_k. $T_{PatientToCS}$ is the time taken by the sub-van to reach the select intersection after loading the patient from accident spot. At intersection, the patient is transferred from sub-van to ambulance in time $T_{LoadAtCS}$. Later, Ambulance takes patient to the hospital in time $T_{CSToHospital}$. Once, the sub-van reaches the hospital, total time is calculated using following formula:

$$T_{Total} = T_{CallResponse} + T_{ResponseTime} + T_{SubvanLoadsPaient} + T_{PatientToCS} + T_{LoadAtCS} + T_{CSToHospital}$$

The flow chart of the algorithm is presented in Figure 4.

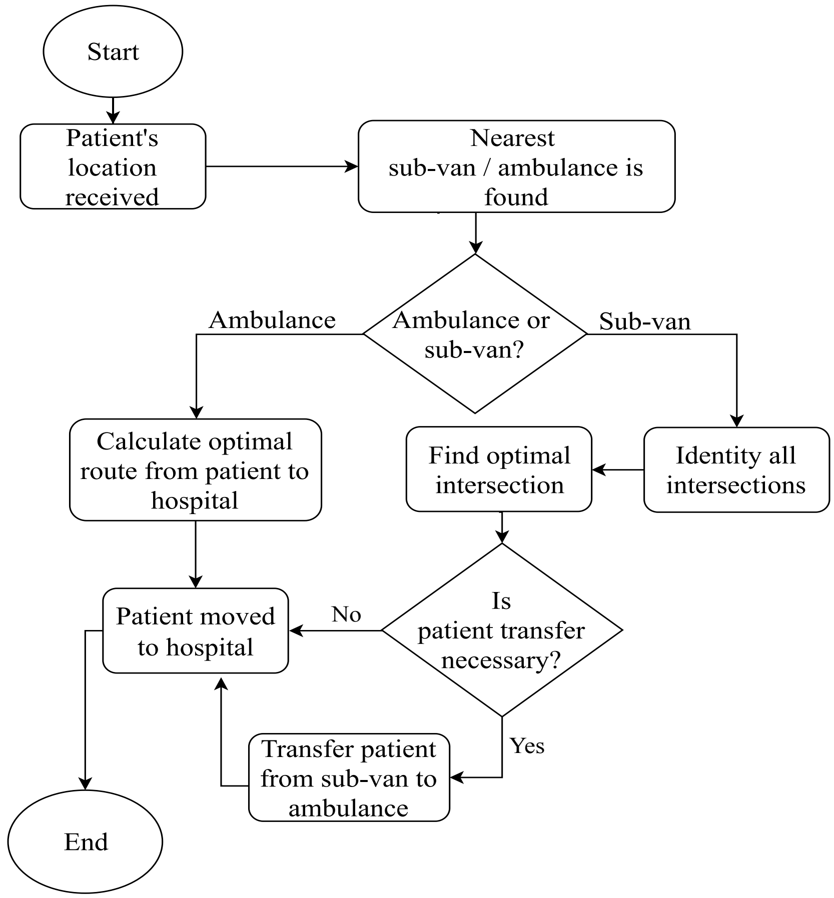

Figure 4: Flow chart of algorithm.

7 VALIDATION

Starting with the experiment length, the simulation was iterated around 500 for every possible combination, for peak and non-peak hours, for both 3 ambulances-3 sub-vans and 2 ambulances-2 sub-vans. It was iterated for 500 times for the traditional system with 3 ambulances times in order to make sure th‘at we have enough number of observations to validate the model. The number of iterations required was determined by observing standard deviation and changes in the mean of the response time and transport time at every iteration. Further, in order to determine the values of different probabilistic variables, different committee reports were examined. I.e.: For the speed and dimensions of ambulances and sub-vans, details were taken from the report titled ‘Constructional & Functional Requirements Road Ambulances’ by Automotive research association of India (Urdhwareshe 2013). Similarly, for information regarding traffic, production data was taken from the Society of Indian Automobile Manufacturers from which the range of length and speed of vehicles were derived (SIAM 2019). Once, the information was gathered, triangular distribution was used to implement the derived data in the simulation model. In order to make sure that decided distribution will correctly represent the present situation, objective evaluation of each probability distribution was done against the data of India Auto Report 2010-2025 (Taumar et al. 2019). Further, for the arrival rates and road accidents, a report by PRS Legislative Research on Indian Roads was studied from which the traffic density was adjusted for peak and non-peak hours (Mishra 2017). The final data which was used after validation was completed can be seen in Table 1.

Table 1: Parameters values.

ATTRIBUTE	PEAK	NON-PEAK
Ambulance		
Initial Speed	22 km/h	35 km/h
Preferred Speed	27 km/h	55 km/h
Normal traffic		
Vehicle Arrival Rate	triangular(125,140,160) per hour	triangular(95,130,110) per hour
Sub-van		
Initial Speed	26 km/h	30 km/h
Preferred Speed	33 km/h	45 km/h

Here, initial speed refers to the speed at which the vehicle will start and once started, it will try to maintain its speed at preferred speed. Finally, when assessed for face validity it can be seen that model is able to satisfy the stated aims when executed(i.e.: the hybrid system is able to perform better than traditional system) as seen in Table 2 below. The results are discussed in more detail in the next section.

Table 2: Efficiency comparison.

	Average Response Time		Average Total Time	
	Traditional System (Only Ambulances)	Hybrid System	Traditional System (Only Ambulance)	Hybrid System
Peak	9.10 minutes	5.30 minutes	13.39 minutes	9.83 minutes
Non-peak	7.08 minutes	4.99 minutes	10.31 minutes	9.27 minutes

8 RESULTS

In this model,different combinations of ambulances and sub-vans are considered and simulation is executed for numerous iterations. Analysis for the hybrid system for peak hours and non-peak hours is done in comparison to the traditional system. The average value is taken into consideration which can be observed below. Here, in order to find the optimal combination of ambulances and sub-vans, simulations were performed for peak hours.

Here, the best observation, as clearly seen in Table 3 is coming for the first case that is 3 ambulances and 3 sub-vans. Finally, this case is simulated for peak and non-peak hours. The results are then compared with the traditional(Only ambulance) system. The same data can be seen in Table 2. All the above data was taken from *AnyLogic*® software to MS *Excel*® where it was further analyzed in order to derive some meaningful insights into the proposed work. Figure 5 displays the difference in survival rate (percentage of lives saved) of the proposed model and traditional model.

Table 3: Efficiency comparison of different designs for peak hours.

Combination Type	Response Time	Total Time
3 Ambulances, 3 Sub-vans	5.30 minutes	9.83 minutes
3 Ambulances, 2 Sub-vans	6.11 minutes	12.03 minutes
2 Ambulances, 3 Sub-vans	5.99 minutes	11.32 minutes
2 Ambulances, 2 Sub-vans	6.50 minutes	13.54 minutes

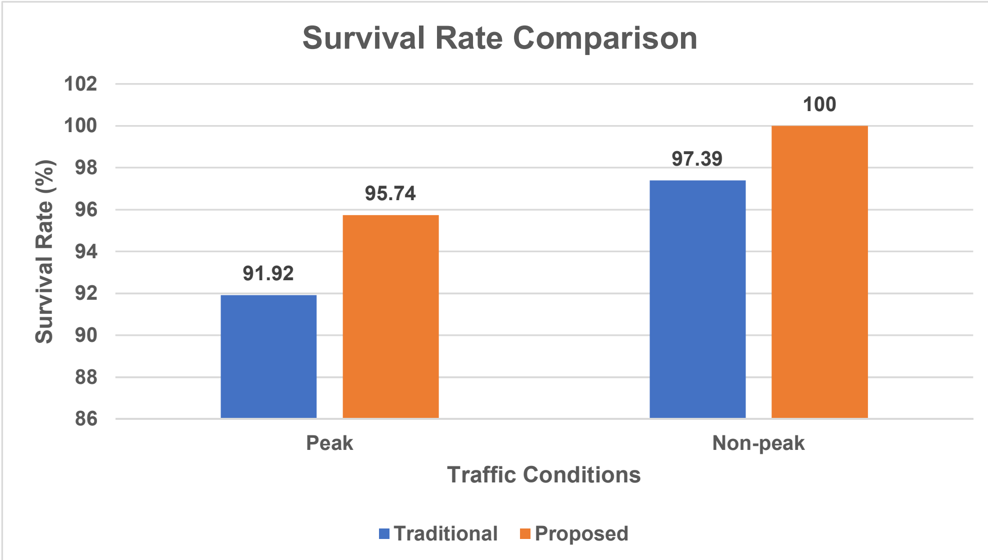

Figure 5: Survival rate comparison between the traditional and the proposed model.

9 LIMITATIONS

9.1 Simulation Design

- The proposed simulation does not consider break-down time for ambulances and sub-vans. This can impact the response time, total time, and eventually survival rate.
- Randomization of events like accident frequencies, accident spots, etc. can not be simulated with 100% accuracy. This can cause a difference in outcomes.

9.2 Application

- **Increased cost with respect to the current system**: The current system uses only ambulances whereas our system uses ambulance along with sub-vans, so overall assets and maintenance demand more cost.
- **Increased Complexity**: Adding a layer into any system, mostly, adds to the complexity. New system can become more taxing for a governing agency.
- **On the spot emergency treatment**: Ambulances are equipped to offer primary treatment for emergencies, but sub-vans are smaller vehicles and cannot carry more medical personnel and equipment to offer the same. This may result in fatalities.

If we consider the first two application limitations, we can always justify the cost and complexity by saving more lives. For the third downside, in future, advanced compact instruments can always fit in small vehicles, to offer on the spot treatment.

10 CONCLUSION

Various researches have shown that the performance of the traditional system is not at its best. At many instances, due to unpredictable traffic or for any other reason, the performance of the emergency services is obstructed. Here, we simulated one enhancement of the traditional system. Conditions for both peak time (high traffic) and non-peak time (low traffic) were created for the 50 km long road area network of Ahmedabad city. Simulating for numerous iterations for both traditional as well as a hybrid system in similar conditions with different combinations of a number of ambulances and sub-vans, trends were observed in favor of our hybrid system. Reduction in total time taken for the service of 3.56 minutes in peak hours and 1.04 minutes in non-peak hours was observed. Also, improvement in the survival rate could be significantly observed. Hence, the hybrid system that is an upgrade of the traditional system can achieve improved results in critical conditions.

ACKNOWLEDGMENT

The authors are grateful to Mr. Vikash Bihani working as a manager at Analytics Dept. in GVK Emergency Management and Research Institute, Naroda- Kathwada Road, Naroda, Ahmedabad 382 330, Gujarat, India, for providing required information and data regarding Emergency Services in Gujarat that played a vital role in our research.

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