Optimizing Ambulance Locations for Coverage Enhancement of Accident Sites in South Delhi

Shayesta Wajid, N. Nezamuddin*

Abstract

Our objective is to analyze the level of service of existing emergency medical services (EMS) operated by CATS in South Delhi. The fatal crash data for three years is plotted in ArcMap 10.3 and clustered to obtain demand sites. Travel time computation between ambulance location and accident clusters is done using Google Maps API. Also, change in efficiency of the system with optimization for a given number of ambulances using Double Standard model (DSM) is observed. The results indicate that the existing system can attain full coverage within 22 mins while it takes only 13 mins for the optimized system. The present system can achieve 97% double coverage with 29 ambulances within 20 mins whereas optimized system can completely cover all the accident sites with 8 ambulances.

Introduction

Road traffic crashes are the 9th leading cause of injury globally according to the Global Burden of Disease Study 2016 (Collaborators, 2017). In India, 2.9% of the deaths in 2016 occurred due to road traffic injuries and in the 10th leading cause of death in 2016 (Indian Council of Medical Research Public Health Foundation of India and Institute for Health Metrics and Evaluation, 2017). In developing countries like India, 30% of emergency patients die before they reach a hospital. Over 80% of patients would take 22 minutes for full coverage. Fitzgerald et al., (2006). This research focuses on the strategic and tactical aspect of identifying optimal ambulance locations to maximize coverage.

Methodology

1. Accident clustering: Clustering of accidents was performed with the definition of blackspots given by MoRTH using ArcMap 10.3. This resulted in 120 accident clusters of different sizes (varying between 1 to 17 accidents).
2. Demand locations and Potential sites Identification: 30 police stations, 4 fire stations and 37 other sites were identified as potential sites for locating ambulances. This leads to 100 potential sites for placing 59 ambulances.
3. Travel time computation: Travel time for the 100x120 origin (potential ambulance sites) – destination (accident clusters) matrix was computed using the Distance Matrix API of Google Maps. Historical average travel times were used to optimize ambulance locations.

Conclusions

• The results indicate that the optimized system can reach all accident sites within 14 minutes, whereas the present system would take 22 minutes for full coverage.
• For a response time of 15 minutes, the present system of 29 ambulances provides 97% coverage. If ambulances were placed optimally, the same level of coverage can be achieved using only 8 ambulances.
• The optimized system can achieve full coverage using 11 ambulances.
• The analysis demonstrates that there is significant scope for improving the existing CATS ambulance configurations to provide better service to road users.

Industrial Significance

This research could be applied at a field level by CATS or other ambulance operating agencies to optimally place their ambulances. This would not only increase the level of service of the system but would also reduce the response time taken by ambulances to reach a patient in the prevailing congestion levels.

Technology Readiness Level: This research study can be readily applied in the field of ambulance location as it involves only relocation and resizing of fleet of ambulances to gain operational efficiency.

Result

Two scenarios are considered for the analysis. The first scenario (S1) models the present system of 29 CATS ambulances operating from their current locations in South Delhi. The second scenario (S2) considers 100 potential sites to place the existing fleet of 29 ambulances to optimize the emergency service.

Single Coverage model:

Figures below show a variation in coverage percentage for S1 and S2 scenarios with different response time and numbers of ambulances.

• The existing system attains 100% single coverage for a response time of 22 mins, whereas the optimized system does the same within 14 mins.
• The maximum coverage provided by the existing fleet of 29 ambulances is 97%. Whereas, the optimized system attains 100% coverage with 11 ambulances.

Double Coverage model:

The analysis for the two scenarios considered has been done using the double standard model taking the primary coverage standard of r1 = 15 mins and secondary coverage standard of r2 = 20 mins and ε=0.95.

• The model for scenario S1 is infeasible for the above mentioned standard of EMS services.
• In the optimized system, complete coverage is attained for 95% reliability level with 16 ambulances and for the mentioned standards as shown below.

References