Development and Testing of an Algorithm for Efficient Resource Positioning in Pre-hospital Emergency Care
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Abstract: Response times for pre-hospital emergency care may be improved with the use of algorithms that analyzes historical patterns in incident location and suggests optimal places for pre-positioning of emergency response units. We will develop such an algorithm based on cluster analysis and test whether it leads to significant improvement in mileage when compared to actual historical data of dispatching based on fixed stations.

Introduction: Emergency Medical Services (EMS) agencies continuously strive to achieve optimal response times for critical events. System Status Management (SSM) algorithms analyze historical patterns of incidents over time and geographical area and recommend places where the ambulances could be pre-positioned to respond to events more efficiently. These algorithms have been used for about twenty years, although there is very minimal research supporting their superior efficiency over the standard response strategy based on fixed stations.

Methodology: Historical event information for one year will be obtained from EMS agencies that collect it electronically. We will divide the data into two subsets: one subset will be used to develop the algorithm, and the other to test it. Incident location for each event in the training subset will be plotted on a geographical information system. These events will be grouped into clusters using K-median analysis, the number of clusters depending on the number of EMS units in service. The algorithm will suggest an optimal point for pre-location of the units near the cluster centers (centroids), allowing the units to be optimally placed to respond to events in their respective cluster.

This algorithm will then be tested using a simulation on the test sub-set of the data. For each incident, the unit in its cluster center will be ‘dispatched’, and mileage from the starting point to the incident location will be noted. The simulation will keep the unit ‘busy’ for the time period typical for that incident type and distance. If another call originates in the same cluster while the unit is ‘busy’, the next nearest unit will be ‘dispatched’. The average mileage for the simulation will be compared to the actual average mileage recorded for the run using paired-sample t-test. If we have enough data, we will also perform a sub-analysis for cardiac, trauma and stroke events, where improving the efficiency of response would provide particular benefit.

Limitations: The underlying assumption of SSM algorithms is that trends in historical data can predict future incident location. This might not be true for a population with rapidly changing characteristics and in case of mass casualty incidents or disasters. Other drawbacks of SSM have been reported, including increased wear-and-tear of EMS units and increased incidence of back pain in the personnel. We are not considering factors, such as traffic conditions, that might affect the assumptions in the simulation. Our study focuses on mileage as an outcome, which would be difficult to convert to response times, the current standard for measuring efficiency of response. We are assuming that, other factors being constant, a decrease in mileage would translate to a decrease in response time. However, even if this study shows a statistically significant improvement in mileage, and thus response time, it is uncertain whether it would be large enough to make a difference in clinical outcome for the patients.

Conclusion: If the study shows that average mileage for the simulation of the algorithm is significantly lower than the actual average mileage, we can conclude that the use of the algorithm may improve the efficiency of dispatching. This has the potential to improve outcome for patients by providing early access to specialized care.

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References: