

Research Proposal Example 1

Out of hospital cardiac arrests (OHCAs) are a considerable health concern for societies worldwide with approximately 400 000 incidents per year in North America alone^[1]. Furthermore, the median survivability rate of OHCAs from cities around the world has been reported to be 6.4%^[2]. A critical factor for survival after an OHCA is the response time of Emergency Medical Services (EMS). For each minute that defibrillation is delayed, survivability decreases by up to 10% for the OHCA victim^[1]. However, only 60% of OHCAs are treated by EMS^[4]. Bystander response can significantly reduce the delay in time of treatment, and increase the total number of those treated through CPR and Automated External Defibrillator (AED) usage^[3]. Furthermore, studies have shown that early bystander response through the use of AEDs almost doubles the victim's chance of survival after an OHCA^[3].

While AEDs are beneficial to OHCA treatment, strategies for AED placement are not clearly defined^[5]. This is reflected by the fact there have been conflicting recommendations and guidelines for potential AED sites from both the European Resuscitation Council and American Heart Association^[6]. While current strategies for AED placement recommend placing AEDs in high risk locations, based on frequency of cardiac arrests, the challenge of determining guidelines for all the other locations and areas that are not deemed as high risk still remains^{[6][7][8][10]}. Current strategies also specifically focus on minimizing the distance from the AED to the OHCA, or similarly reducing the time it takes to treat the OHCA with a nearby AED^{[9][7][10]}. While this is a valuable metric, there has yet to be an in-depth investigation on the availability of AEDs and its effects on OHCA coverage. Current studies have been conducted in an environment where AEDs are available and accessible 24-hours a day^{[10][11]}, but in reality this is not always the case. A study by Hansen et al has shown that OHCA coverage decreased by 53.4% due to limited access to AEDs^[12]. Accessibility is a critical factor in respects to OHCA coverage that has been overlooked in previous studies.

In order to narrow this gap of the lack of rigorous AED placement strategies and consideration of AED availabilities in relation to OHCA coverage, we propose an optimization methodology, based on a validated and established optimization method for facility location, to further develop placement strategies^{[13][14]}. This methodology will include new techniques which will not only quantify the effectiveness and efficiency of current placements, but will also predict future AED placements to maximize OHCA coverage. To accomplish this, I will develop a novel model which optimizes AED placement based on geographical factors while simultaneously maximizing AED availability. This model will be the first ever to factor in both the location and availability of AEDs for optimization. The formulation of the model will be derived from the dynamic maximal covering location problem, where I will use OHCAs as the demand and AEDs as the supply, and coverage will be maximized over multiple time periods/states. The methodology will use historical cardiac arrest data, existing AED locations and availabilities, and a set of future candidate AED locations from the City of Toronto. Additionally, I will develop a novel validation algorithm using temporal Kernel Density Estimation to simulate OHCAs geographically with respect to time, to evaluate our model and further the robustness of our results.

The major goals of this project are to: 1) Develop new Operations Research tools to optimize the coverage of OHCAs based on AED placement. 2) Pilot this methodology in the City of Toronto and identify trends and analyze the impact of the optimized AED placement strategy. 3) Generalize the optimization approach to any city worldwide.

This project allows for real life applications of Operation Research methodologies in the healthcare field. This will provide a breakthrough in the development of international standards for AED placement and treatment plans for OHCAs, benefiting societies across the globe.

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