ABSTRACT

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| Title ofDissertation: | MODELING AND SIMULATION OF NOVEL MEDICAL RESPONSE SYSTEMS FOR OUT-OF-HOSPITAL CARDIAC ARREST  |
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|  | Gregory J. Lancaster Doctor of Philosophy, 2020 |
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Sudden Cardiac Arrest (SCA) is the leading cause of death in the United States, resulting in 350,000 deaths annually. SCA survival requires immediate medical treatment with a defibrillatory shock and cardiopulminary resuscitation. The fatality rate for out-of-hospital cardiac arrest is 90%, due in part to the reliance on Emergency Medical Services (EMS) to provide treatment. A substantial improvement in survival could be realized by applying early defibrillation to cardiac arrest victims. Automated External Defibrillators (AEDs) allow lay rescuers to provide early defibrillation, before the arrival of EMS. However, very few out-of-hospital cardiac arrests are currently treated with AEDs.

Novel response concepts are being explored to reduce the time to defibrillation. These concepts include mobile citizen responders dispatched by a cell phone app to nearby cardiac arrest locations, and the use of drones to deliver AEDs to a cardiac arrest scene. A small number of pilot studies of these systems are currently in progress, however, the effectiveness of these systems remains largely unknown.

This research presents a modeling and simulation approach to predict the effectiveness of various response concepts, with comparison to the existing standard of EMS response. The model uses a geospatial Monte Carlo sampling approach to simulate the random locations of a cardiac arrest within a geographical region, as well as both random and fixed origin locations of responding agents. The model predicts response time of EMS, mobile dispatched responders, or drone AED delivery, based on the distance travelled and the mode of transit, while accounting for additional system factors such as dispatch time, availability of equipment, and the reliability of the responders. Response times are translated to a likelihood of survival for each simulated case using a logistic regression model. Sensitivity analysis and response surface designed experiments were performed to characterize the important factors for response time predictions. Simulations of multiple types of systems in an example region are used to compare potential survival improvements. Finally, a cost analysis of the different systems is presented along with a decision analysis approach, which demonstrates how the method can be applied based on the needs and budgets of a municipality.