

**DEVELOPMENT OF AN OPTIMIZATION FRAMEWORK FOR THE
REALLOCATION OF AIR AMBULANCE BASE LOCATIONS IN THE UNITED
STATES**

**HOW AMBULANCE DELIVERY SYSTEMS MARGINALIZE LOW-INCOME AND
RURAL COMMUNITIES**

An Undergraduate Thesis Portfolio
Presented to the Faculty of the
School of Engineering and Applied Science
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Biomedical Engineering

By

Nishita Ardhapurkar

May 6, 2021

A SOCIOTECHNICAL SYNTHESIS

The ambulance industry is currently built on many unfair and biased systems. The technical research focuses on increasing access to air ambulances by better optimizing the locations of air ambulance bases. The current system leaves large groups of people unable to easily access air ambulances and optimizing the locations of air ambulance bases could fix this. The STS research paper focuses on ambulance dispatch systems and the subjectivity and bias involved in dispatch which could make ambulances inaccessible to many people. It investigates the creation of ambulance dispatch systems to find the main sources of bias rooted in the system. The technical and STS research both focus on making ambulances more accessible and less biased.

In the current air ambulance system, rural areas are not quickly accessible or accessible within the “Golden hour”. The “Golden hour” is a term used for denoting the hour right after a call to an ambulance is placed. Patients that reach the hospital within this hour have better outcomes. The technical project aims to re-allocate air ambulance bases so that more of the population can get care within the golden hour. In order to achieve this, an air ambulance can only fly to a 20 mile flight circle. A Greenfield approach was taken where existing locations of bases were not considered. The Maximal Covering Location Problem (MCLP) was used to optimize the bases.

Python modules, like PULP and Allagash, and CPLEX Optimization Studio were used to define and solve the problem. Virginia has 18 air ambulance bases. A 20 mile flight circle was put around the 18 bases and the locations of the bases and flight circles were optimized. The optimized bases and flight circles were able to cover major cities in Virginia, as well as rural areas. The percent of the population covered increased from 80.51% to 83.56%. This process of

optimizing the locations of air ambulance bases give an idealized solution to the problem. From here, it is easier to determine the best places to put new bases and perhaps close existing bases that are not useful.

Ambulance dispatch systems are becoming inaccessible to the population, largely due to the subjectivity and bias rooted in it. It is important to fully understand this bias in order to properly create new systems without bias. The STS research aims to use the Social Construction of Technology framework to investigate the factors that contributed to the development of ambulance dispatch systems. Mainly, government interests, the biases of technology creators, ambulance company interests and patient interests were researched. It was found that ambulance company interests had the most weight on the development of ambulance dispatch systems and patient interests were rarely considered. A variety of peer reviewed journal articles, newspaper articles, and reports on legislation, were used to answer the research question.

Ambulance companies are businesses that aim to make the most profit. They are not primarily focused on helping patients. The government has a very hands-off approach to regulating these companies and in fact, has passed legislation in the past that inadvertently makes it very difficult to pass regulation on ambulances, such as the 1978 Airline Deregulation Act. Patients are not involved in the process at all and are only considered through the little regulation the government does pass. Going forward, more regulation is needed that bring patient interests to the forefront.

There is a great need to make ambulances, and healthcare in general, more accessible to the public. The problem is not in one part of healthcare but is pervasive which makes it increasingly difficult to solve. The first step to solving this great problem is to research the ways that bias is present in the system and how to best eliminate bias and subjectivity, like how I have

done in both my technical and STS research. This problem in healthcare is solvable but requires collaboration, cooperation, and a great deal of research.

TABLE OF CONTENTS

SOCIOTECHNICAL SYNTHESIS

DEVELOPMENT OF AN OPTIMIZATION FRAMEWORK FOR THE REALLOCATION OF AIR AMBULANCE BASE LOCATIONS IN THE UNITED STATES with Ryan Finley

Technical advisor: Shannon Barker, Department of Biomedical Engineering

HOW AMBULANCE DELIVERY SYSTEMS MARGINALIZE LOW-INCOME AND RURAL COMMUNITIES

STS advisor: Catherine D. Baritaud, Department of Engineering and Society

PROSPECTUS

Technical advisor: Timothy Allen, Department of Biomedical Engineering

STS advisor: Catherine D. Baritaud, Department of Engineering and Society