Thesis Project Portfolio

Polymeric Synthetic Oxygen Carriers for Transfusion at the Location of Injury
(Technical Report)

Disparities in Access to Emergency Care: The Intersection of Race and Rurality
(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

In America, severe hemorrhage, or excessive blood loss, is the leading cause of death for people aged 46 and under. Unfortunately, there are several issues with the current treatment option, whole blood transfusion, including limited supply, safety concerns, and storage requirements. Therefore, the goal of the technical project is to create a safe, effective, and stable alternative for whole blood transfusions. However, blood transfusions only represent a small portion of emergency procedures. So, the STS project is aimed at uncovering the disparities in access to all emergency services across both race and rurality in the United States. It will inform the important sociotechnical considerations that must be made during the development of the synthetic blood oxygen carrier in the technical project, and, together, these projects will help improve the treatment of hemorrhagic shock for all people.

In order to combat the challenges of whole blood transfusion, the goal of the technical project is to develop a synthetic alternative to blood that has a substantial oxygen delivery capacity and increases patient survival. Perfluorocarbons are small molecules with high oxygen dissolving capabilities, but are not stable during lyophilization and while inert, may have some adverse effects *in vivo*. Thus, polymer nanoparticles were employed to encapsulate the perfluorocarbons and ensure their stability in both a dried state and in the body. Several variables in the synthesis procedure were tested to develop the smallest, yet most effective nanoparticle formulation.

First, we tested two different types of perfluorocarbons and confirmed that the PFCE dissolved oxygen capacity is significantly higher than that of PFOB while maintaining a similar size. Also, we demonstrated two effective methods for reducing the size of PFCE emulsions: microtip sonication and extrusion. Finally, we showed that both perfluorocarbon encapsulation systems are relatively stable over time as they both maintain their size and the PFCE emulsion

even maintains its oxygen delivery capacity. In the future, we would like to continue testing various synthesis parameters to decrease the size of the emulsion and extend the stability study of the PFCE emulsions beyond one month to compare against whole blood. Our ultimate goal is to test the treatments in a murine hemorrhagic shock model to assess survival times.

To inform the design of the technical project, the STS project investigates the distribution of access to emergency medical services (EMS) with the goal of making equitable healthcare products and policies. Specifically, it seeks to answer the question: How is access to prompt, quality emergency medical care distributed between racial and ethnic communities in urban versus rural United States, why do these disparities exist, and what are the outcomes of such differences? This research was motivated by the fact that rural populations face structural barriers such as fewer medical facilities while racial and ethnic minorities may experience unequal treatment due to implicit biases in healthcare. The intersection of these two factors—race and rurality—creates compounded inequities that leave certain communities disproportionately vulnerable to poor emergency healthcare outcomes.

This study examines these disparities by investigating various emergency department utilization studies as well as a case study analysis of Charlottesville, Virginia. In this study, I found that these inequities are primarily caused by issues such as the lack of adequate public transportation, financial limitations, and systemic biases within the healthcare system. The integration of predictive analytics, targeted interventions, and improved EMS staffing models could mitigate these disparities and improve the efficiency of EMS in both urban and rural settings.