An Investigation of the Societal Implications of Addiction Treatments in the US Healthcare System

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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This thesis project explores the complementary relationship between my capstone project that focuses on developing an assistive device for a novel cocaine treatment, and my STS research paper which investigates the impact of social determinants of health on cocaine use disorder in marginalized communities. Together, these topics explore the necessity for a comprehensive approach to tackling cocaine addiction in the United States.

The capstone focuses into the technical realm focusing on the design and development of an articulating arm system prototype. This device aims to assist with the precise placement of a low intensity focused ultrasound (LIFUS) during clinical trials at the University of Virginia's Center for Leading Edge Addiction Research. The articulating arm system focuses on proper and secure placement of the LIFUS ultrasound transducer flush to patients head for the duration of treatment. LIFUS is a promising, non-invasive treatment neuro modality currently being evaluated in effectiveness for treating cocaine use disorder. The capstone prioritizes the creation of an ergonomic and adaptable device to enhance treatment delivery and increase positive patient outcomes. Simultaneously, my STS research explores the social landscape surrounding cocaine addiction. Utilizing the CDC's 5 social determinants of health (educational access, social context, neighborhood environment, economic stability, and healthcare quality/access) to examine how these factors contribute to the prevalence and severity of addiction use disorder. This research penultimately evaluates the question: **to what extent do socioeconomic disadvantages exacerbate substance abuse, especially cocaine use, in marginalized communities**?

Together, these projects share a critical connection: developing a technological solution for treating cocaine use disorder cannot exist in a vacuum. The effectiveness of the LIFUS

treatment and by extension the articulating arm system, hinges on a deeper understanding of the social context in which addiction unfolds.

The capstone project centers on the ideal design of an articulating arm system specifically tailored for the precise placement of a LIFUS transducer during treatment. The specific aims include:

a. Articulation and range of motion needs to offer a wide range of motion to ensure the transducer can be positioned within a full 360 degree directionality to verify the transducer is targeting the correct region of the brain
b. Precise positioning of the transducer is paramount for successful treatment delivery. The LIFUS focuses within a millimeter precision of the dorsal anterior insula, and in order to be able to articulate that position accurately while maintaining directional control is of the utmost importance.
c. The clinical team and possible patients should feel movement to be intuitive and easy to manipulate, as well be fully portable to move between different clinical spaces.

The project leverages CAD software to create detailed 3D models of each of the important prototype designs. This model helps visualize the device's functionality and facilitates the selection of appropriate Finite Element Analysis (FEA) simulations to ensure the arm can withstand the intended loads and maintain structural integrity over time and strains of daily use. Prototyping using 3d modeling and printing allows for iterative design refinement and testing before finalization of our idealized design.

On the other hand, exploring how limited educational access, challenging social contexts marked by systemic racism and social disorganization, disadvantaged neighborhood environment, economic instability, and limited access to quality healthcare which further limits

opportunities and perpetuates addiction and use cycles. The research anticipates finding the existing healthcare treatment often falls short highlighting the need for a broader approach that addresses the social determinants alongside the medical intervention. The STS research challenged me to consider the broader social landscape and ensure the assistive device is accessible and adaptable to diverse patient needs within these communities. This combined approach emphasizes the importance of sociotechnical integration in developing effective solutions for complex societal challenges like cocaine addiction.

Overall, the Capstone project, with its focus on technical innovation, initially lacked a deeper understanding of the social context in which the technology would be applied. However, delving into the STS research paper opened my eyes to the critical role of social determinants in shaping addiction narratives and influencing treatment outcomes. The STS research challenged me to look beyond the technical aspects of the assistive device and consider the broader social landscape. It highlighted the importance of ensuring the technology is accessible and adaptable to diverse patient needs.