Thesis Project Portfolio

Interrogating the Cellular Impact of Sonodynamic Therapy on Glioma Cells

(Technical Project)

The Price of Not Dying:
Evaluating Modern Healthcare Models Using a Rawlsian Approach in Pursuit of a More Equitable Solution for Disease Therapy Accessibility

(STS Project)

An Undergraduate Thesis

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Sociotechnical Synthesis

"Whenever you are asked if you can do a job, tell 'em, 'Certainly, I can!'

Then get busy and find out how to do it."

– Theodore Roosevelt

How would you feel if I told you that, at this very moment, you have contracted a terrible disease and now have less than a 6% chance of living five more years, even if I gave you the best doctors and the best treatments? Now, how would your emotions change if I told you that the best doctors and treatments can save you – but you lack the funds to afford the "best of the best?" The interplay between these two questions and their implications are what drove my research thesis over the past year. On the technical side, I attempted to optimize the use of 5-ALA-mediated sonodynamic therapy (SDT) to treat glioblastoma (GBM), an aggressive form of brain cancer with an abysmal 5.8% five-year survival rate. The treatment promises a more non-invasive and less toxic future for the treatment of cancer, and the work focused on making it more efficacious for patients with GBM. My STS (science, tech, and society) research then focused on how the United States could make new treatments more affordable for patients and reach the most patients given finite resources. This new framework for drug and therapy pricing was inspired by the U.K. healthcare system and influenced by Rawlsian concepts of justice.

The technical portion of my thesis produced a deeper understanding of the effects of SDT on GBM. SDT uses focused ultrasound (FUS) in conjunction with a sonosensitizer to kill tumor cells and shows much promise as a treatment. However, the literature sparsely covers how SDT

affects GBM on a cellular level and whether current treatment parameters are optimized for his particular brain cancer subtype. To meet this need, my technical research first produced a novel sonication platform more cost-effective to implement and requiring minimal training to operate. Its implementation means that experiments involving SDT are now more accessible to undergraduates, lessening the time commitments of collaborators. Additionally, in the exploration of parameter optimization, my capstone found a positive relationship between cell viability reduction and increased sonication power and duty cycle. My team also explored the boundaries of optimal 5-ALA dosing and incubation times. Downstream of therapy implementation, this research produced preliminary results interrogating the glioma cellular response. Primarily, my project identified a trend between sonication and increased extracellular vesicle (EV) release. EVs play important roles in cellular signaling and their modulation by focused ultrasound present an intriguing tool in the treatment of GBM.

In my STS research, I explored an important aspect of any new drug or therapy that requires vast resources to research, develop, and commercialize: namely, that it will be expensive. Better treatments are only better if they can, ultimately, be obtained by the patients they were designed for. Cost represents a significant barrier to accessibility and is an issue that must be solved to ensure that the fruits of research (such as that done in my capstone) can benefit patients. Through my STS research, I made a comparative analysis of the U.S. free market system and U.K. socialized system and their approaches to drug and therapy pricing. Neither system was perfect. The U.S. system was much costlier for patients but also produced the majority of novel biomedical innovations. On the other hand, the U.K. system was much more affordable for patients with strict price controls, yet it was criticized for stifling innovation and being feasible only because of the existence of the U.S.'s pricier system. This analysis led to the

proposal for a new system that combines the best aspects of both systems in drug and therapy pricing and economic sustainability. Importantly, I produced this new proposed system within the framework of John Rawls' *Theory of Justice*, using his concepts of the "veil of ignorance," "original position," and "just savings." In doing so, I attempted to produce an evolved system that focused on justice while promoting equitable distribution of healthcare resources to those who need them most.

All too often, research is criticized for being ignorant of the needs of the people, of remaining siloed within the "ivory tower." In this case, my technical project was focused on bringing patients a new therapy that hopes to improve upon existing treatments in efficacy and non-invasiveness, and I aimed to optimize every aspect of it. Sometimes, though, that relentless engineering also means losing sight of the patient, and the STS portion of my research helped to keep my eyes on the goal of bringing a therapy from the lab bench to the bedside. The latest drugs and therapies must make it into the hands of patients, and they must do so affordably. Using a Rawlsian approach helped to keep the focus on creating a just and equitable system that prioritizes low-income patients while preserving the economic interests of the government, industry, and academic researchers. My STS research offered a potential pathway for successfully adapting U.K. health pricing policies to the U.S. It, along with my technical research, presented a vision that, one day, better cancer treatments can successfully make it into the hands of all patients, regardless of economic background.