Thesis Project Portfolio

Design of an Insulin Glargine Manufacturing Facility in Singapore to Target the Rise of Diabetes Cases in Asian-Pacific Countries

(Technical Report)

The Insulin Price Discrepancy in the United States and United Kingdom: An Assessment of Government Regulations and Public Opinion

(STS Research Paper)

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Executive Summary

Millions of people throughout the world are diabetic and need insulin in order to live. Insulin is a hormone produced by the pancreas to control glucose levels in the body and store this glucose for energy. People with diabetes have disfunctions with insulin release and use; thus, diabetics need insulin shots to increase insulin in the bloodstream and help the body control and store glucose. New insulin therapeutics are continuously developed to ease treatment and application of the drugs for patients, but the prices of these products remain high throughout the world. In the United States, the price of insulin continues to rise even though the drug has been produced for over 100 years. The price of insulin is also much greater in the United States than in other highly developed countries. This portfolio includes two projects which address high insulin prices. In the technical project, the capstone group designed an insulin glargine manufacturing facility in Singapore to target high insulin prices in lower income regions, and in the STS research paper, I investigated the sociotechnical issue of high insulin prices in the United States by exploring the relationship between insulin prices and government regulations in the US and UK.

The technical project was conducted over the course of a school year by a group of four chemical engineering students at the University of Virginia. In the technical report, an insulin glargine manufacturing process was designed for a plant in Singapore to reduce distribution difficulties and serve the developing nations in the surrounding area. The insulin glargine is produced via recombinant DNA technology using a strain of *Escherichia coli.* The insulin will become long acting by changing the polypeptides of the protein which will shift the isoelectric point from 5.4 to 6.7 making the molecule less soluble in physiological blood. The insulin will crystallize before dissolving in the blood stream, rendering it “slow-release.” The project targets

4% of type 2 diabetics that require insulin in the Asia-Pacific region. Thus, the process designed will produce $7.46*10^{11}$ units/year which is equivalent to 27 tonne/year (3.64 mg for 100 units). Both the upstream, protein production, and downstream, protein purification, processes were designed, and the overall recovery yield of protein is 48.96%. Thus, one batch from a 20,000L reactor will produce 35.54 kg of insulin glargine. To reach the target, 764 batches per year must be produced. In an economic analysis, the insulin was priced lower than the current market, and the process was determined to be economically viable with an internal rate of return of 242%.

The technical project proves the price of insulin can be easily reduced yet the price remains high in the United States, a highly developed country. High insulin prices can be attributed to a variety of factors including the inelasticity of the product, monopolies in the market, private insurance, patent evergreening, and pharmacy benefit managers (PBMs). These government regulations, or lack thereof, perpetuate the high insulin prices which in turn cause citizens to have a negative opinion of the pharmaceutical industry in the United States. The second project in this portfolio, the STS research paper, discusses the broader socio-technical issue of price discrepancy and public opinion, as the relationship between insulin prices and government regulations in the US and UK is investigated. Actor Network Theory is used to map out the relationships between various actors playing a role in the insulin price discrepancy. The actors include pharmaceutical giants, PBMs, pharmacies, diabetics, government, capitalism, and insurance agencies. The network among these actors creates an environment in which high insulin prices thrive, and reform needs to occur to ensure all Americans have access to life-saving medication.

The research portfolio in its entirety addresses the issue of unaffordable insulin prices in both the US and abroad. The technical report outlines a process for producing cheaper insulin to

combat high insulin prices in Asia, and the economic analysis makes evident that manufacturers have the ability to reduce the cost of insulin. The cost of manufacturing does not justify high insulin prices, so the factors causing the high insulin prices in the United States must be external to the engineering process. Further, the STS research project provides greater transparency of these external factors such as specific legislation allowing insulin prices to remain high in the United States. By conducting these two projects simultaneously, the issue of high insulin prices is explored both technically and socially. The portfolio proves reform is possible and provides more insight into the factors contributing to high insulin prices. In conjunction, the two projects in this portfolio can be used to aid in the reduction of insulin prices in the United States and abroad making the life-saving drug available to a greater percentage of the population.