Thesis Project Portfolio

Industrial Scale Production of the R21c/Matrix-M Malaria Vaccine for Sub-Saharan Africa

(Technical Report)

An Analysis of the Failure of the World Health Organization's 70% COVID-19 Vaccination Goal in Developing African Countries Using Actor Network Theory Framework

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

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In Fulfillment of the Requirements for the Degree

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Sociotechnical Synthesis

In 2021, about 247 million people contracted malaria and 620 thousand malaria cases resulted in death (World Health Organization, 2022). Of those cases, 95% were located in Sub-Saharan Africa and 80% of the mortality cases were in children under 5 (World Health Organization, 2022). While there is currently a malaria vaccine on the market, it only has an efficacy of around 40% for preventing malaria infections. This led scientists from Oxford to develop a new, more effective malaria vaccine. Oxford's malaria vaccine uses a combination of R21 protein and an adjuvant called Matrix M to give an efficacy of 80%. The technical portion of my thesis is a design for the industrial scale production of Oxford's R21c/Matrix M malaria vaccine in a facility located in Sub-Saharan Africa. The facility will produce enough doses to fully vaccinate 68 million children under 5 annually. While my technical portion focuses on producing a vaccine for Sub-Saharan Africa, my STS research paper examines the failure to globally distribute the Covid-19 vaccine, resulting in inequitable distribution for developing African countries. Since the World Health Organization set a 70% global Covid-19 vaccination goal, my paper examines the actors that caused the goal to fail in developing African countries.

In the technical portion of my thesis, my team designed an industrial scale production plant of Oxford's R21c/Matrix M malaria vaccine intended to provide the vaccine to children under 5 in Sub-Saharan Africa. My team assumed an annual penetration rate of 70% of annual births and 20% of current children under 5 in Sub-Saharan Africa, to give a yearly target of 68 million children. At 4 doses per child, this gives an annual production of 272 million vaccines. The manufacturing process involves the fermentation of Pichia Pastorius, a genetically modified yeast, in a final working volume of 2,300 L. The yeast is genetically modified to produce R21c when exposed to methanol. Then, the solution goes through various purification steps, like homogenization, centrifugation, ultrafiltration, and multiple chromatography steps, to isolate and

purify the R21c antigen. The purified product is then filled into vials and lyophilized to distribute for administration with the Matrix M adjuvant.

My STS research explores vaccine distribution in Sub-Saharan Africa. My research focuses on the failure of the global Covid-19 vaccine network which resulted in inequitable vaccine distribution for developing African countries. I examined the World Health Organization's published guidelines for achieving 70% global vaccine coverage. I use Actor Network Theory to show how various rogue actors cause the vaccine distribution network to fail. My claim is that the World Health Organization, High Coverage Countries, and pharmaceutical companies caused the network to fail, resulting in the inequitable distribution of the Covid-19 vaccine in developing African countries. My research aims to understand the factors that impact vaccine distribution.

Working on these two projects simultaneously allowed me to better understand the many factors that influence the success or failure of a vaccine. My technical work gave me a better understanding of the vaccine production process and the various regulations that must be followed. Additionally, my STS research helped me see the other nontechnical factors that impact the ability of a vaccine to help the target population. In summary, working on my technical project and STS research paper together this past year has allowed me to fully understand the factors that impact the ability of a vaccine to reach the desired target.

Works Cited

World Health Organization. (2022). *World malaria report 2022*. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2022