Prospectus

COVID-19 Inactivated Viral Vaccine Production Process

(Technical Topic)

Impact of Social Media on the Anti-Vaccination Movement

(STS Topic)

By

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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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Introduction

The Coronavirus Disease 2019 (Covid-19) was declared a pandemic by the World Health Organization (WHO) on March 11, 2020 (Chen et al., 2020). This disease is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), a novel human coronavirus, that has spread to almost every country in the world. To date, there have been 55.6 million cases of Covid-19 across the globe, 1.34 million of which have resulted in death (BBC, 2020). In addition to the severe death toll, the coronavirus has posed enormous economic, environmental, and social challenges to the entire human population. Business shutdowns due to the pandemic have led to the highest unemployment rate in the US since the Great Depression (Dadayan et al., 2020); many have struggled to afford housing and food, and have lost employer-sponsored health insurance. Therefore, it is paramount that a solution is made widely accessible as soon as possible. To reduce or limit many pathogenic diseases in a population, vaccines have been the solution often developed and administered. Vaccinations offer a safe method of achieving herd immunity in a population instead of direct exposure to the virus itself. The development of a safe and effective vaccine has become a global priority as nations struggle to slow disease transmission. Currently, 58 vaccine candidates are in the human trial phase of development, however, meeting the global need for billions of doses of Covid-19 vaccines is an additional challenge (Pharma News, 2020). Furthermore, according to polls by NBC and Gallup, less than half of Americans would get a vaccine if made available (Kamisar & Holzberg, 2020; O'Keefe, 2020)Without an understanding of why people are unwilling to take a Covid-19 vaccine, producing the vaccine in large scale will not alone end the pandemic due to a lack of herd immunity. In the paper below I will elaborate on the design team's plan to propose an inactivated viral vaccine production process as a technical solution to the Covid-19 epidemic. The technical solution is the design of a vaccine production process for a promising vaccine candidate from

Bharat Biotech located in India. However, creating a vaccine by itself will not end the Covid-19 pandemic because it does not address the social issue of anti-vaccination. I will also use actor network theory to provide a better understanding of how antivaccination movements have become successful due to the use of social media. To resolve the pandemic, both a technical solution and social understanding will be needed to provide the necessary health protections to people around the globe.

Technical Project

SARS-CoV-2 is a virus that has caused a global pandemic which has killed upwards of a million people worldwide and has no current widely adopted vaccine to prevent infection. Due to the severity of job and life loss due to Covid-19, many companies and world governments are focusing on creating a vaccine to help end the pandemic. Vaccines are products that are used to stimulate an immune response in the body to a specific pathogen to produce immunity against that pathogen. Viral vaccines function by presenting a virus or virus-like particles to the body for it to identify and produce antibodies against that specific virus. SARS-CoV-2 is a virus that infects the cells in the human body and uses the cells to multiply and continue to spread. Common approaches for a Covid-19 vaccine are virus like particles, mRNA, live attenuated virus, and inactivated virus vaccines. The design team will focus on an inactivated virus type of vaccine which contains a virus that has been killed but kept intact so the body can produce antibodies against it without the ability for the virus to actively infect the body (CDC, 2018). There are currently 58 vaccine candidates in human clinical trials that are using these and other types of methods but none are currently widely adopted and none are able to be manufactured on a scale for global distribution (Pharma News, 2020). Many companies in clinical trials are building out their own manufacturing process simultaneously with the anticipation of acceptance

of their vaccine but the capacity will not be enough to supply vaccines to all people around the world in a short timeline. One examples to attempt to alleviate this problem in the US is the government's investment of 10 billion dollars with the goal of producing a vaccine by January 2021 called Operation Warp Speed by funding the development and manufacturing of 300 million doses of a Covid-19 vaccine that will be of low or no cost to citizens (US Health and Human Services, 2020). Even with many vaccine candidates that are worth pursuing to minimize the impact of Covid-19 and programs such as Operation Warp Speed, many facilities cannot make enough doses per batch to meet a global demand so the issue of mass production still exists. The goal of the technical project is to design a novel process for producing an inactivated virus for the Covid-19 virus at industrial scales. The design will include cell and virus propagation where we will increase the active pharmaceutical ingredient concentration using a microcarrier based bioreactor that should be adopted because it improves product yield to provide more doses. Downstream clarification and inactivation of the virus from cell debris and media will also be included so the final product is ready for filling and formulation of the final vaccine product. We plan on gathering data necessary for the design based on prior research on similar viruses and vaccines produced for other inactivated viruses. Additionally, advice from industry experts on vaccine production and downstream processing such as Professor Michael King and Professor Giorgio Carta will help inform the final process design and specifications. Final design will be compared to known mathematical and predictive models of cell growth and separations to ensure efficacy of the product. Without high capacity manufacturing of vaccine doses, even with an approved candidate, most of the population will still be at risk of contracting Covid-19.

STS Paper

Receiving a vaccine will help a single person become immune to whatever pathogen the vaccine protects against. However, not everyone is eligible to take every vaccine due to age, preexisting conditions, or other reasons but these people can still be protected through herd immunity. Herd immunity is when enough people in a population are immune to a pathogen so there are not sufficient hosts to propagate the disease (Aschwanden, 2020). To ensure there are not enough hosts to propagate a disease, there is a percentage of the population that needs to be immune. For example, measles is extremely infectious and would need a herd-immunity threshold of 92-94% for the disease to stop spreading (APIC, 2020). While these immunity thresholds are possible to be reached using vaccines, measles still persists within the population with an outbreak even happening in 2019 after it was declared eliminated in 2000 (APIC, 2020).

Getting medical information online now is much easier than it used to be. It is estimated that in 2002, 100 million Americans obtained health information from the internet as a basis of making decisions (Forkner-Dunn, 2003). Medical information that used to be only in journals are now available to everyone which has shifted power from doctors to a shared decision model between patients and doctors (Hussain et al., 2018). Even with this new access to information, diseases where there is a known effective vaccine such as for measles, mumps, and rubella there are still infections due to people choosing not to get vaccinated. In recent years there has been trends in many western countries to reject vaccines as a part of an anti-vaccination movement. The idea of being anti-vaccination is not new with records going back to the 18th century indicate that religious figures opposed the practice because it "opposed God's punishments" (Hussain et al., 2018). Additionally, movements have rejected government mandates of vaccinations as infringements on human liberties. An example of early anti-vaccination movement can be seen

as the Anti-Vaccination league of London was formed after mandatory vaccination laws for children were enacted in the mid-19th century (Hussain et al., 2018).

More recently, the fight to spread misinformation about the safety and efficacy of vaccines as a part of the antivaccination movement on social media has shown growing success. The success of antivaccination sentiment is often attributed to the ability for people to selectively spread information that brings uncertainty to the safety of vaccines. This spreading of information leads to vaccine hesitancy which is defined by the WHO as a "delay in acceptance or refusal of vaccines despite availability of vaccination services" (Burki, 2019). While the spread of misinformation is effective at influencing people, it overlooks the more important aspect of social media that enables connections between physically distanced groups and easier outreach of personal opinions. If only the content of misinformation is understood as the reason for the success of antivaccination efforts, we will not understand how the roll of social media plays in amplifying the misinformation. Using actor network theory, I will argue that the selective misinformation from public studies coupled with the ability for individuals to spread their misinformation to a wide audience on social media lead to the current success in the anti-vaccination movement. Actor network theory will allow me to analyze how antivaccination individuals are network builders that recruit human and nonhuman actors such as social media and vaccination research to obtain a heterogeneous network that has the goal of spreading misinformation about vaccines. I will analyze a case study about comments on a pediatric Facebook video post regarding vaccines to support my argument that social media is in part a cause of success for the anti-vaccination network (Hoffman et al., 2019).

Conclusion

The technical project will propose a novel production process for a Covid-19 inactivated virus vaccine. The process will include cell and virus propagation from storage banks and downstream inactivation and purification of the product until the virus bulk is ready for vaccine formulation. The technical project will result in a product that will help provide immunity against the Covid-19 virus. The STS paper will use actor network theory to help illustrate how anti-vaccination individual's use of social media in addition to the use of misinformation creates uncertainty around vaccines which lead to their network's success. With the knowledge from both works, greater understanding of how vaccine misinformation is spread and increased availability of a Covid-19 vaccine will be possible which will increasing the populations percentage for herd immunity against Covid-19 with the goal to end the global pandemic.

Word Count: *1742*

References

APIC. (2020). Herd immunity. *Association for Professionals in Infection Control and Epidemiology*. https://apic.org/monthly_alerts/herd-immunity/

Aschwanden, C. (2020). The false promise of herd immunity for COVID-19. *Nature*, *587*(7832), 26–28. https://doi.org/10.1038/d41586-020-02948-4

BBC. (2020, November 18). Covid-19 pandemic: Tracking the global coronavirus outbreak. *BBC News*. https://www.bbc.com/news/world-51235105

Burki, T. (2019). Vaccine misinformation and social media. *The Lancet Digital Health*, *1*(6), e258–e259. https://doi.org/10.1016/S2589-7500(19)30136-0

CDC. (2018, May 16). *Immunization Basics & Vaccines and Immunizations*. https://www.cdc.gov/vaccines/vac-gen/imz-basics.htm

Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., Qiu, Y., Wang, J., Liu, Y., Wei, Y., Xia, J., Yu, T., Zhang, X., & Zhang, L. (2020). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: A descriptive study. *The Lancet*, *395*(10223), 507–513. https://doi.org/10.1016/S0140-6736(20)30211-7

Cressman, D. (2009). *A Brief Overview of Actor-Network Theory: Punctualization, Heterogeneous Engineering & Translation*. https://summit.sfu.ca/item/13593

Dadayan, L., Charleston, D., Boddupalli, A., & Rueben, K. (2020, May 27). *Monitoring State Unemployment Insurance Claims during the COVID-19 Pandemic*. Urban Institute. https://www.urban.org/features/monitoring-state-unemployment-insurance-claims-during-covid-19-pandemic

Forkner-Dunn, J. (2003). Internet-based Patient Self-care: The Next Generation of Health Care Delivery. *Journal of Medical Internet Research*, *5*(2). https://doi.org/10.2196/jmir.5.2.e8

Hoffman, B., Felter, E., Chu, K.-H., & Shensa, A. (2019). It's not all about autism: The emerging landscape of anti-vaccination sentiment on Facebook. *Vaccine*, *37*(16), 2216–2223. https://doi.org/10.1016/j.vaccine.2019.03.003

Hussain, A., Ali, S., Ahmed, M., & Hussain, S. (2018). The Anti-vaccination Movement: A Regression in Modern Medicine. *Cureus*, *10*(7). https://doi.org/10.7759/cureus.2919

Kamisar, B., & Holzberg, M. (2020, August 18). *Poll: Less than half of Americans say they'll get a coronavirus vaccine*. NBC News. https://www.nbcnews.com/politics/2020-election/poll-less-half-americans-say-they-ll-get-coronavirus-vaccine-n1236971

O'Keefe, S. (2020, August 7). *One in Three Americans Would Not Get COVID-19 Vaccine*. Gallup.Com. https://news.gallup.com/poll/317018/one-three-americans-not-covid-vaccine.aspx

Pharma News. (2020, November 16). *How to use the dashboard: | Global Health Pharma News*. https://pharmanews.linksbridge.com/Covid-19

US Health and Human Services. (2020, August 12). *Fact Sheet: Explaining Operation Warp Speed*. HHS.Gov. https://www.hhs.gov/coronavirus/explaining-operation-warp-speed/index.html