SEWAGE SURVEILLANCE TOOL FOR TRACKING OF SARS-CoV-2 IN URBAN BANGLADESH

ASSESSING THE STRUCTURAL AND CULTURAL REASONS FOR THE HIGH RATES OF VACCINE PREVENTABLE DISEASES IN BANGLADESH

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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 Covid-19 pandemic (caused by the Sars-CoV-2 virus) has been spreading across the world since late 2019. While no country has been left untouched by the virus, some countries have been better able to contain the spread than others. Bangladesh, a low-income nation in southern Asia, is one country that does not have the health resources to keep up with the demand caused by the virus. This problem is not new, as Bangladesh has traditionally had elevated rates of vaccine preventable diseases when compared to developed nations. Unlike countries with greater health resources, getting tested for the SARS-CoV-2 virus in Bangladesh is very difficult. There is no free testing in Bangladesh, therefore a vast majority of the population are not able to afford testing. The cheapest option for testing is through government hospitals, however, there is a long queue for testing and the wait time for results is several days. As a result, only a ratio of 1620 to 1 million people are tested (Bodrud-Doza, 2020, pg. 2). Additionally, Bangladesh has a very small number of intensive care unit (ICU) beds (1169 total) and even fewer ventilators and medical personnel compared to the number required to properly treat the large influx of patients caused by the pandemic (Bodrud-Doza, 2020, pg. 2). Medical staff are also ill equipped to protect themselves from the virus due to very limited amounts of personal protective equipment (PPE) (Bodrud-Doza, 2020). The main reason for Bangladesh's issues in the health sector stem from a weak governance structure, and inefficient allocation of public resources (WHO, 2020).

The context for this technical and STS project is the SARS-CoV-2 outbreak and the need for a more efficient and cost-effective means of tracking the spread of the virus in a country that does not have strong medical infrastructure or a means to track the spatiotemporal prevalence of the virus through a public health department. This situation is unlikely to change in the immediate future, therefore sewage surveillance and the creation of a dashboard provides the most efficient means of understanding the community spread of SARS-CoV-2 and other vaccine preventable diseases in the low resource setting of Bangladesh. For the technical project, creating an interactive mapping tool, known as a dashboard, to track the virus will help public health officials to identify trends and hotspots to prioritize their limited

resources and to shape public interventions such as lockdown, vaccine campaign, scale up testing and contact tracing to mitigate the spread of the virus (Bodrud-Doza, 2020, HealthITAnalytics, 2020).

Technical Topic: Mapping the Spatiotemporal Prevalence of Sars-CoV-2 in Dhaka, Bangladesh

The technical project aims to develop a more cost-effective solution to tracking the spatiotemporal prevalence of the virus given the lack of testing, contact tracing and spatial prevalence data in Bangladesh. Bangladesh is one of the fastest urbanizing countries in the world and Dhaka, the capital, is one of the largest cities in the world, with a population of 22 million (Roy et al., 2019, pg. 1). Since the vast majority of citizens in Bangladesh are in poverty and do not have the means to access limited testing resources and have low health seeking behaviors, a more cost-effective and unbiased indicator to tracking the spatiotemporal prevalence of the virus is required. Currently, without a way to track the virus, it is very difficult to allocate what limited resources there are to the areas that need them the most. The consequence of having no means to track the spread of viruses in Bangladesh, and thus not having a means to allocate tests, vaccines (unavailable currently for COVID-19), and other health resources, is high rates of COVID-19 and other vaccine preventable diseases. (Bodrud-Doza, 2020)

Luckily, previous research has used data from sewage to track other vaccine preventable diseases, such as poliovirus, norovirus, rotavirus, etc. (Hellmer et al, 2014). Recent studies have proven that these same techniques can be used to track the SARS-CoV-2 virus as well. Sewage data can be quite telling of the health of a particular area, providing information on infectious disease transmission dynamics within a community as opposed to clinical testing that just provides information on a single individual. When humans defecate, viral pathogens are excreted as well. When this waste enters the sewage system, it gathers with sewage from all the other humans in that particular sewage catchment area. Samples can be collected from these areas and the amount of viral pathogen in the system can be quantified using a process called reverse transcription quantitative PCR (RT-qPCR). This process amplifies the viral RNA and helps to quantitate the amount of viral pathogen in the sample. If the catchment population is known for a particular sewage sampling site, then the amount of pathogen can be used to estimate the community

spread of COVID-19 in that catchment area. (Ahmed et al, 2020, Kitajima et al, 2020). The capstone team will integrate the quantitative PCR results and clinical case data to i into a dashboard to facilitate a visual presentation of spatial and temporal trends over time, in an easily-accessible manner toin public health stakeholders in Bangladesh in real-time.

Using sewage, as opposed to traditional random prevalence testing and contact tracing, is far cheaper and requires fewer health professionals to collect the data. Once the data is collected, it can be put into a dashboard that will give public health officials a visual tool for tracking the spatiotemporal prevalence of the SARS-CoV-2 virus in their community. With this knowledge, the public health officials can visualize which regions are having higher instances of the virus and can allocate more of their testing resources to those areas or observe the impact of mitigation plans such as lockdowns.

Many communities, ranging from full countries to college campuses, have successfully been using sewage surveillance to track the SARS-CoV-2 virus. A study in the Netherlands determined that there was a strong correlation between the amount of viral RNA detected by the RT-qPCR and the reported COVID-19 case prevalence. To determine this, the researchers gathered sewage data from five cities, quantified the amount of virus present over the course of several weeks and determined that it was possible to predict outbreaks of COVID-19 cases days before they happened. From these conclusions, the Dutch were able to come up with a model for how to best contain the spread of the virus based on this data (Figure 1) (Medema et al, 2020). This same method has been used on US college campuses to detect the virus in sewage so that preventative measures can be put in place. Sewage data is collected from dorms, and, similar to how the Dutch study handled spikes in prevalence, lockdowns are enforced and scaled up testing measures are enacted if the concentration of viral

COVID Response Based on Viral Load in Sewage

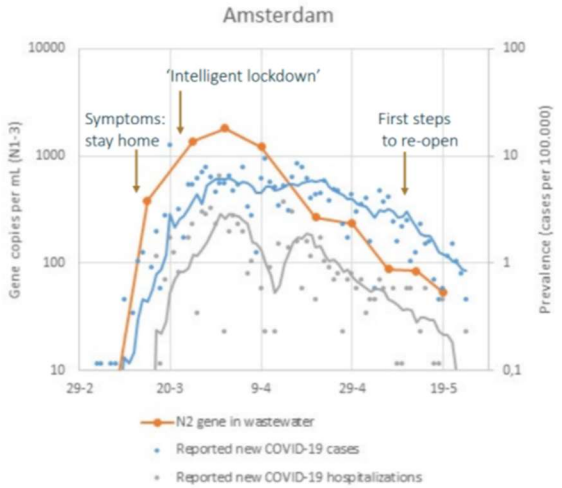

Figure 1: This graph shows how the gene copies of the SARS-CoV-2 virus corresponds to the prevalence of the virus for a particular area, as well as the public health reaction, as it relates to case prevalence and sewage prevalence, to best prevent the outbreak.

pathogens reaches a particular threshold(HealthITAnalytics, 2020). These methods have proven to be very effective at being able to track outbreaks, giving public health officials a lead time of several days to come up with a targeted intervention or mitigation strategy.

This information is particularly pertinent for Bangladesh to have, as they do not have a strong medical infrastructure and cannot properly track and contain the SARS-CoV-2 virus with the resources that they currently have. By creating a dashboard that can visually represent the spatiotemporal prevalence of the virus in Dhaka, public health officials will be able to predict outbreaks, focus their testing resources in those areas and implement restrictions to keep the community safe, and eventually examine the effectiveness of their mitigation strategy by monitoring viral load after the lockdown measures have been enacted. The largest challenge in creating this dashboard is creating an interactive mapping system, using existing data, that will be easy to use for public health officials in Bangladesh (Hagedorn, 2020, Kitajima, 2020).

STS Topic: Assessing How the Weak Medical Infrastructure in Bangladesh Contributes to Higher Rates of Contraction of Vaccine Preventable Diseases

The STS topic of this project aims to attain a greater understanding of the structural reasons why Bangladesh suffers from higher rates of vaccine preventable diseases developed nations. Health is a fundamental requirement for daily life, and studies have shown that economic and social development of a country are dependent on the health of the country's citizens and workers. Bangladesh is among the most underdeveloped nations in the world. The per capita income of the country is 1464 US dollars (World Bank, 2020). Bangladesh, like many developing nations, suffers from a dire need of many kinds of resources, but perhaps the most pressing of these needs is that of healthcare (Begum et al, 2014). In particular, Bangladesh suffers from an overly centralized health system, a weak governance structure, a lack of strong management, inefficient allocation of public resources, a failure to regulate the private sector, and high turnover and absenteeism of health workers (WHO, 2020).

Bangladesh is divided into two medical spheres: the public and the private. Private practice in Bangladesh accounts for approximately 58% of the medical personnel of the country. Additionally, 737 of the country's 1,169 ICU beds are in the private sector, while only 432 reside in public hospitals (Bodrud-Doza, 2020, pg. 2). A majority of Bangladesh's population lives below the poverty line. When it comes time for one of these individuals to seek medical care they have four options: attempt to get one of the very limited spots in a public hospital, go into debt and pay for a spot in a private hospital, go to a local pharmacist for medicine without seeking professional medical advice, or ignore the medical issue and do not seek medical attention (Begum et al, 2014). Private medicine is something only truly accessible by the upper class. This leaves more than half of the residents of Bangladesh without means of accessing proper care. As well as causing limited access to health resources for a vast majority of citizens in Bangladesh, poverty in Bangladesh also greatly contributes to poor sanitation and hygiene practice. This contrasts the comparatively greater net income per capita and resultant improved hygiene practice of developing nations. The combination of inadequate access to proper means of sanitation as well as limited access to affordable and professional medical care and testing services contribute to higher rates of transmission of vaccine preventable diseases despite availability of preventative treatments within the country.

Through this analysis, it can be concluded that the reason for high rates of vaccine preventable diseases in Bangladesh is due to a combination of limited health resources in the medical system, rampant poverty, and poor sanitation and hygiene practice. These factors are actors in the network of why prevention of disease in Bangladesh are not as strong as in high resource countries. This is very similar to the transportation system, Aramis, described in Who Killed Aramis?, written by Latour. In Latour's writing, the well designed, novel transportation system was scrapped due to various political and resource scarcity issues. Latour argues that if Aramis was treated, as it should be, as an equal to the human actors in the network, then it would have been built properly instead of thrown out. By this logic, Latour would likely also argue that the lack of resource availability in the health system, poverty, and poor sanitation

and hygiene practice should all be considered actors in the network of reasons why there are higher rates of vaccine preventable diseases in Bangladesh (Latour, 1996, preface, prologue, epilogue).

The health of a country, and thus the successful improvement of the transmission of vaccine preventable diseases, is an indicator of the economic stability of a country. Therefore, the health system and poverty are more than just that. They are also actors that determine the health of a community and thus the strength of the economy that is fueled by those workers (Begum et al, 2014). Though there are some factors at play in this scenario that are somewhat uncontrollable restrictions (funding, finances, etc), these barriers would be greatly reduced by investing more resources in developing solutions that aid giving more people access to the health system (WHO, 2020). Improving access to affordable health care and providing easy to use, cheap solutions to improving hygiene would not only decrease the rate of vaccine preventable diseases, but it would also improve the economy, making it easier to invest resources in all aspects of Bangladeshi life. Therefore, it is actors associated with easy, financially-feasible access to proper healthcare and sanitation that contributes to Bangladesh's elevated levels of vaccine preventable diseases.

Conclusion:

The technical portion of my undergraduate thesis project will focus on creating an interactive mapping tool, known as a dashboard, that will provide public health officials of Dhaka, Bangladesh with a visual aid to track the spatiotemporal prevalence of the SARSs-CoV-2 virus in communities where no such data exists. If successful, public health officials can use this information to shape public health interventions to mitigate outbreaks and hotspots, focus their testing resources in those areas, and implement restrictions such as a lockdown to keep the citizens of the community as healthy as possible during this pandemic. The STS portion of my thesis will focus on gaining an improved understanding of the barriers to healthcare in low resource countries, such as Bangladesh. By providing data where it does not already exist my team and I will be directly impacting global health measures to deal with the SARS-

CoV-2 pandemic. This experience will challenge me as an engineer and develop my problem-solving skills in a low resource setting, which is a crucial lesson in world where so many people go without access to proper healthcare and sanitation.

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