Sewage Surveillance Tool for Detection of SARS-CoV-2 in Urban Bangladesh
(Technical Paper)

Obstacles and Solutions to COVID-19 Health Management in Low-income Countries: A Case Study Across Health Systems in Brazil, Bangladesh, and Tanzania
(STS Paper)

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Erin Wettstone
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Technical Project Team Members
Lauren Hughlett
Claire Reagan

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

Introduction

Since the beginning of the coronavirus disease-2019 (COVID-19) pandemic, about 465,000 cases have accumulated in Bangladesh, while Brazil has had more than 6.3 million cases, and yet Tanzania has had less than 1,000 reported cases (Center for Systems Science and Engineering (CSSE) at Johns Hopkins, 2020). The stratification of impact in each country reveals a scope of challenges that is unique to each population and presents a question of specific healthcare obstacles, especially for low-resource settings. In low- and low-middle income countries, barriers to proper healthcare has led to a detrimental number of COVID-19 deaths and severe effects on the wellbeing of people who already face severe challenges (Banik et al., 2020). The STS research portion of this paper will explore four specific areas of impact across low-resource health systems in Bangladesh, Brazil and Tanzania: unequal access to viral testing, limitations to oxygen supplies, the disruption of pediatric vaccination programs, and projections for child mortality rate goals.

Dhaka, Bangladesh is a low-middle income setting that has been severely impacted by COVID-19. Within densely populated areas of the city, lack of sanitation and proper hygiene contributes to a high transmission of infectious diseases (Bodrud-Doza et al., 2020). Moreover, the lack of testing kits and testing affordability makes it impossible to gauge the extent of the disease at the community level (Cousins, 2020). The technical research portion of this paper will cover the creation of a dashboard tool that uses qPCR data of viral loads in Dhaka's wastewater in order to assess the spatiotemporal prevalence of COVID-19 in Dhaka. Environmental surveillance methods will provide public health officials with a low-cost method of tracking COVID-19 cases in Dhaka, providing critical information for actionable public health decisions and location-specific allocation of resources.

Technical

Dhaka, Bangladesh is one of the most densely populated cities in the world, with a population of approximately 21 million people (World Population Review, 2020). In areas of high population density and where testing assays are limited or unaffordable, COVID-19 tracking methods become quickly convoluted (Bodrud-Doza et al., 2020). In order to provide a more specific and affordable analysis of COVID-19 cases in urban Bangladesh, a capstone team will design a dashboard tool that incorporates real-time sewage surveillance data along with clinical case data in several wards of Dhaka, Bangladesh. In collaboration with Lauren Hughlett and Claire Reagan, and under the advisement of Dr. Mami Taniuchi, PhD in the Division of Infectious Diseases and International Health at UVA and Dr. Isobel Blake, PhD at the Imperial College of London, the dashboard tool should help public health officials make well informed decisions about the allocation of resources and management of cases in specific areas of Dhaka, Bangladesh.

Fortunately, researchers have used sewage surveillance methods in the past to detect infectious diseases such as poliovirus, norovirus, and rotavirus (Hoque et al., 2019). Environmental detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19, has been demonstrated to detect the virus several days before clinical cases of the disease, which is critical in locating hot spots of transmission (WHO, 2020). Figure 1 shows how the process of sewage surveillance helps public health officials make well-informed decisions. Sewage samples can be collected from different catchment areas, and then the amount of viral pathogen in the system is quantified through the process of reverse transcription quantitative polymerase chain reaction (RT-qPCR). The amount of pathogen

associated with one collection site is then associated with its watershed through sewage and drainage line tracing (Ahmed et al., 2020; Kitajima et al., 2020).

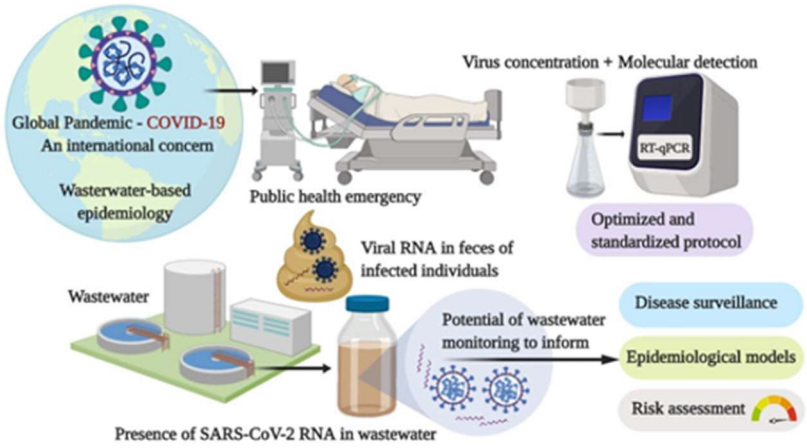

Figure 1: A summary of how wastewater can be used for disease surveillance and risk assessment of COVID-19 (Kitajima et al., 2020).

Several dashboards have been created that display the prevalence of COVID-19 cases around the world from reported health data (AccuWeather, 2020; Microsoft Bing, 2020). However, these dashboards only report the total number of cases by country for some locations like Bangladesh, which does not provide information about COVID-19 prevalence in specific cities or wards. Additionally, the Institute of Epidemiology, Disease Control and Research (IEDCR) in Bangladesh provides a nicely formatted dashboard tool that is specific to different regions, but their tracking techniques are partially incomplete due to limited testing and a lack of affordable testing options in the country (Cousins, 2020; IEDCR, 2020). In order to improve upon existing dashboard models, the primary innovation of the capstone project will incorporate visualization of sewage surveillance data. In addition to its accuracy, sewage sampling is less expensive and requires fewer health professionals for data collection, in comparison to traditional prevalence tests and contact tracing.

In order to create sewage surveillance visualization, the capstone team will 1) Analyze qPCR data to assess the viral load of SARS-CoV-2 in Dhaka sewage lines and 2) Use R Shiny to create a dashboard deliverable that displays the spatiotemporal prevalence of the data. In order to qualify as successful, the final dashboard should accurately depict the collected data, be organized in a concise, effective way for public health officials, and be easily navigable to users. These metrics will be quantified by conducting a usability diagnostic. The dashboard tool should be completed by February 2021 and then improved based upon user input until May 2021.

STS Topic

As COVID-19 continues to impact millions globally, a variety of healthcare challenges have been brought to surface, especially those experienced by persons of low-income status in developing countries. These challenges are unique to each country and vary in scope and detriment, revealing inequity in various aspects of healthcare access and treatment. A considerable amount of work has been done to study these effects in Latin America (Stephens et al., 1997), as well as in urban Bangladesh (Banik et al., 2020) and rural parts of East Africa (Quaresima et al., 2020). For example, Abbas *et al.* have studied the effects of social distancing practices on childhood immunization clinics in Africa (2020) and Corburn *et al*., have revealed the impracticality of certain self-quarantine measures within urban slums (2020). Shedding light on the severity of these challenges, as well as the success of the potential solutions, is necessary to understand the societal effects of technology throughout the course of the current pandemic.

In order to analyze the relationship between healthcare technologies and medical inequities, this paper will look at the obstacles and solutions to COVID-19 health management in low-income countries. The discussion will focus on four major issues: unequal access to viral

testing, limitations to oxygen supplies, the disruption of pediatric vaccination programs, and projections for child mortality rate goals. Within each category, the role of COVID-19 will be explained, along with its effects on the overall health experienced by people groups in the countries of Bangladesh, Tanzania, and Brazil. These locations were chosen in order to gain a more global perspective and include areas of varied viral impact, income and population. A number of stakeholders affect each issue: medical personnel on the frontlines of treatment, public health officials that appropriate and establish health guidelines, researchers who drive new medical solutions and contact tracing methods, and the general population of each country which experiences the outcomes of the approaches being taken. Implicitly, world politics and socioeconomic factors also play a role in a country's ability to manage the effects of SARS-CoV-2 (Truelove et al., 2020).

Analysis of current healthcare studies in literature and statistical reports of quantitative and qualitative impact will help reveal potential connections between society and technology. Furthermore, a discussion around the historical context of prior pandemics in these countries – such as SARS and A/H1N1 – and how past solutions have prepared them to handle coronavirus cases will help frame the current state of the healthcare field. Mechanisms of techno-social analysis will best explain how the effects of COVID-19 influence health systems through strong yet latent forces of impact.

Actor network theory (ANT) will be the main STS framework employed throughout the structure of the paper. This theory was first defined by French philosopher, Bruno Latour, and describes the unspecific relationships between actors and actants in a network. Intermediaries describe the communication between actors and the translations of actor intentions to other actors. Through translations and transformations, the network becomes truly dynamic as

translation strategies such as problematization, interessement, enrolment, and mobilization of allies take form. While ANT is helpful with defining technological relationships, it easily becomes complex. A common critique is that black boxes, or placeholders that represent categories in the network that are too complex to unpack, restrain a network from being fully understood (Cressman, 2009). In fact, ANT theorists have claimed that "networks are always unreliable and can become unstable" (Tatnall & Gilding, 1999). However, it requires a complex theory to unpack complex issues, which is precisely why ANT is imperative to the analysis of the convoluted effects of COVID-19 in developing countries such as Brazil, Bangladesh, and Tanzania. One study has already employed ANT in the context of anthropandemic writing and uses ANT tools to connect the social geographies of COVID-19 (Cloke, 2020).

Methodologies

Research question: How do COVID-19 technologies affect public health components of populations in Brazil, Bangladesh and Tanzania?

In order to answer this question within the framework of Actor Network Theory (ANT), several tools will be employed to collect appropriate research sources, including documentary research methods, network analysis, policy analysis, and historical case study methodologies. Before initiating the writing process, documentary research methods will help to collect and organize literature resources into an annotated bibliography so that they will easily transition into referenced evidence. The paper will begin with a background of the socioeconomic status, current health challenges and past management of epidemic crises in each country. Here, historical case study tools will incorporate primary and secondary sources to provide an important context of healthcare in Brazil, Bangladesh, and Tanzania. Then, the paper will cover

the dynamics of different actors in the four main areas of influence: unequal access to viral testing, limitations to oxygen supplies, the disruption of pediatric vaccination programs, and projections for child mortality rate goals. The main method that will construe the elements of ANT into a formative discussion of the topic at hand is network analysis. This tool aids in describing the organization of interconnected actor networks and relationships. Finally, policy analysis will incorporate the context of past and present healthcare policies established by local and global organizations.

Conclusion

As the global pandemic persists, its impact on health systems implicitly affects health management systems around the world at different levels depending on each country's resource and environmental condition. Exploring the current solutions, remaining issues, and historical context of healthcare in Tanzania, Brazil and Bangladesh will help define relative issues and enable future solutions for those who are most impacted by the pandemic. Using STS tools and Actor Network Theory will lead to an improved understanding of these issues and how to solve them. Furthermore, the lack of affordable and accessible testing in Dhaka, Bangladesh creates barriers for public health officials to accurately track COVID-19 cases. A well-developed dashboard tool that incorporates sewage surveillance data and clinical data to different wards in Dhaka will help public health officials make actionable and well-informed decisions about where to allocate their resources. In addition to this discussion, a technical capstone deliverable will be produced for public health officials to use in Bangladesh.

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