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

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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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DISEASE PREVENTION IN BANGLADESH

Bangladesh, located in southern Asia, is currently classified by the World Health Organization (WHO) as a least developed country (LDC) (WHO). According to the United Nations (UN), a LDC is classified as a "low-income country confronting severe structural impediments to sustainable development" (UN, para. 1). LDCs often boast higher rates of disease than developing or developed nations because they do not have equivalent health resources to compete with more developed countries. Bangladesh is unfortunately unique because it consistently shows elevated rates of vaccine preventable diseases even when compared to other LDCs (WHO). The main reason for Bangladesh's health sector problems stems from a disconnect between the government and the needs of its citizens. This disconnect results in widespread health coverage disparity. Despite recent impressive steps in modernizing the health system and abundant access to vaccines, many Bangladeshi citizens go without healthcare due the lack of a universal healthcare system, poverty, and ability to access urban centers where hospitals are located. Additionally, poor hygiene practice and cultural beliefs about health prevent many from seeking medical attention in a western model hospital. This STS research paper will examine how Bangladeshi cultural health practice, structural violence, and a failure of communication between the citizens and the government contribute to higher rates of vaccine preventable diseases despite access to adequate health resources for an LDC using the Actor Network Theory framework.

Because of these structural and cultural barriers to proper health care, the current COVID-19 pandemic caused by the SARS-CoV-2 virus has spread rampantly throughout Dhaka, the capital. 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 (Bodrud-Doza et al, 2020, p. 2). Much as a large portion of Bangladesh has been unable to access vaccinations and proper healthcare, they have also not been able to access the appropriate testing or care resources during the COVID-19 pandemic. For this reason, the technical project seeks to create an interactive dashboard that can track the prevalence of the SARS-CoV-2 virus at a much lower cost and without requiring people to participate in clinical testing. Success of this dashboard will give government officials access to critical information about the spread of the virus in their country, allowing them to distribute resources and implement lockdowns to effectively minimize transmission of COVID-19 for the people of urban Bangladesh who have not been allowed these resources previously.

BANGLADESHI HEALTH SYSTEM FAILS TO MEET THE UNIQUE NEEDS OF ITS CITIZENS

Bangladesh hosts one of the highest rates of vaccine preventable diseases in the world even when compared to other least developed nations like Zambia and The United Republic of Tanzania (World Bank). For example, Zambia and The United Republic of Tanzania reported 0 and 1 case of Rubella (0.0% and 0.000002% respectively of the population), a vaccine preventable disease that has been all but eradicated from even underdeveloped nations, while Bangladesh reported 176 cases in 2019 (0.000108% of the population). Bangladesh had an incidence rate 54 times higher than Tanzania. Additionally, Bangladesh had an incidence rate of 0.0036% of the population infected with Measles, another common vaccine preventable disease, while Zambia and Tanzania both showed rates of contraction less than 0.00021% (WHO). These poor statistics, however, are not the result of a lack of medical resources in Bangladesh. Bangladesh has made substantial improvements to their medical facilities and

resources over the past ten years. Despite improvements, the medical system in Bangladesh is poorly structured to meet the unique needs of its citizens and the country is still far from a system of universal health care (Ahmed, 2015). Bangladesh only spends 0.69% of their gross domestic product (GDP) on health each year, which is among the lowest fractions of money spent on healthcare worldwide (Cousins, 2020). As a result, two thirds of health expenditures are paid out of pocket, which will subject the nearly 25% of citizens who live below the national poverty level to an even deeper state of destitution if they choose to seek professional medical care (Cousins, 2020, World Bank).

Furthermore, public hospitals, which are the cheapest option for citizens to get professional medical care, are ill equipped and underserved. There are not enough doctors to fulfill the full need of the country, and the doctors that do serve in public hospitals are worked beyond their capacity and paid too little. This often results in a high absenteeism of healthcare workers (WHO, 2020). Many additionally work in private hospitals where they receive better pay, however, this moonlighting often leaves their public hospital patients neglected. Private hospitals, while able to provide better care, are too expensive for a majority of citizens in Bangladesh (Cousins, 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 et al, 2020, p. 2). Even though a majority of the country relies on public medicine, a majority of the resources that Bangladesh has access to lie within private hospitals. There they are out of reach of the millions of Bangladeshis with the misfortune of residing below the poverty line (World Bank, n.d.). 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). It is incredibly common that citizens will visit unlicensed local pharmacists and healers rather than medical professionals. Many do not trust professional care or simply cannot afford it (Begum et al, 2014).

Beyond quality and access to care, poverty results in a culture where hygiene practice does not comply with healthy sanitation standards. While access to drinking water is widespread, 50% consumed does not comply with safe drinking water standards (World Bank, 2016, para 3). Beyond this, piped water in cities does not reach the entire population, and there is no method of community regulation of sewage in many cities. In more rural populations, greater than 40% of latrines fail to meet the qualifications of an "improved" sanitation system (World Bank, 2016, para. 3). Lack of high-quality sanitation infrastructure contributes greatly to the spread of waterborne gastrointestinal and other preventable diseases.

Between the issues of poverty, expensive and inadequate professional medical care options, inability to access medical care from rural populations, and poor hygiene, it is clear that there is a disconnect between the needs of the citizens and the services provided by the government. The citizens and the healthcare system both fail to include each other in the network described by Actor Network Theory (Latour, 2005). This theory describes a system wherein all people, organizations, and technologies are recognized as actors in an interconnected system. Each actor in the network affects the others (Latour, 2005). By acknowledging this interaction, the actors in the network can work together to optimize their mutual

condition. Failure to acknowledge this connection can result in miscommunications, inefficiency, and misallocation of resources. In the case of Bangladesh, the government and economy, the health system, and the citizens are all involved in a network. In the current state of affairs, however, these actors are not working together efficiently. While all groups are deeply intertwined, the government and health system fail to meet the needs of their citizens and the citizens fail to comply with public health measures. This disconnect can be visualized in Figure 1. A solution is required to induce these actors to improve communication between each other so that improvements can be made to the quality of life of all actors involved.

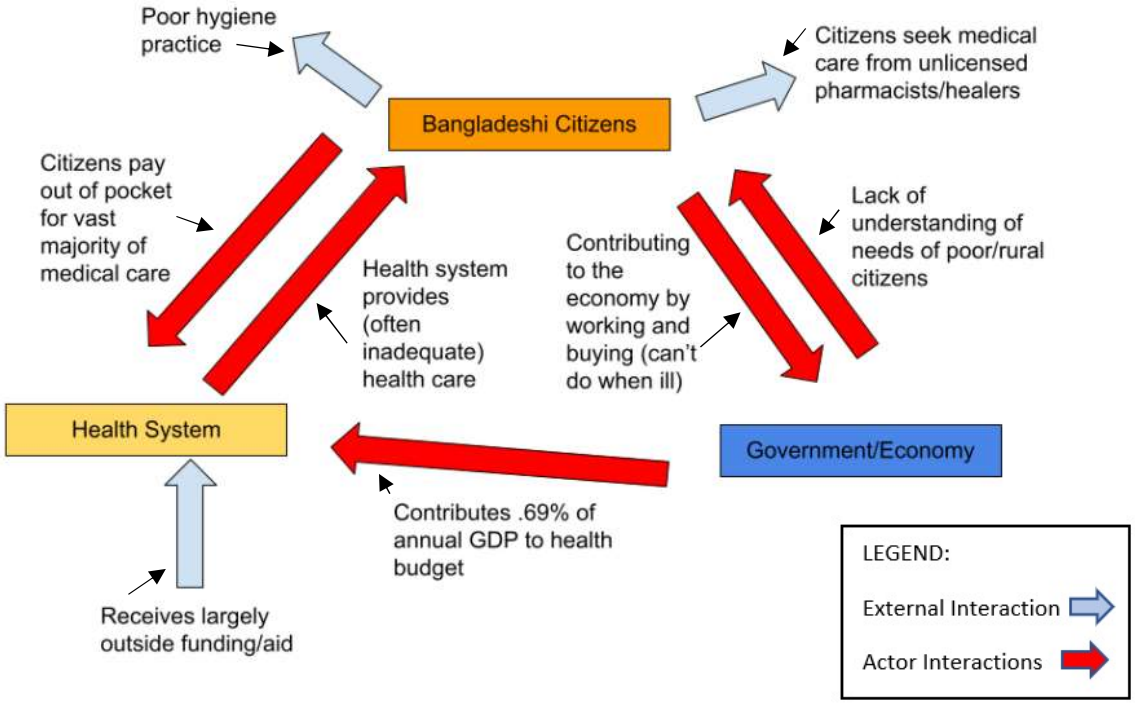

Figure 1: Actor network of Bangladesh. This figure illustrates the negative impacts that the disconnect between Bangladeshi citizens, the government, and the health system has on the actor network. Each arrow points to the actor/external force it affects and originates from the actor/external force who takes the action (Reagan, 2021).

LIMITED ACCESS TO SOLUTIONS FOR CITIZENS

While the government and the medical system have the technological resources to treat citizens, they do not make their services accessible to the vast majority of the population. Hospitals are underserved, overburdened, located far away from rural populations, and too costly for many citizens. Between these four factors, Bangladeshis are forced to seek unconventional medical care or avoid medical care altogether. This problem has been ongoing for as long as modern medicine has been available to the western world. Organizations like the World Bank and the World Health Organization have been investing in initiatives to aiding poverty and supporting the medical system for decades. Through these efforts, many improvements have been made, yet the problems still persist because assistance from outside organizations is largely temporary. Bangladesh still hosts one of the highest rates of contraction of vaccine preventable disease in the world and there remains a disconnect between the needs of the citizens and the services provided by the government (World Bank, n.d.). The question remains, how can the health system and the government adapt to best meet the needs of their citizens? Furthermore, why should they invest when outside organizations and NGOs seem to be doing that work already?

GREATER CULTURAL SENSITIVITY AND CHEAPER SOLUTIONS

Solving the issue of inaccessibility of healthcare and the elevated rates of vaccine preventable diseases in Bangladesh is very important for both moral and economic reasons. Without the ability to control vaccine preventable diseases, many more people will die due to these illnesses. Considering viruses such as Rubella, Measles, Tetanus and other like

diseases have been under control or completely eradicated in other parts of the world, it is inhumane to allow human beings to suffer and die because they are poor or cannot access the vaccines for other reasons. It is the ethical responsibility of any healthcare professional or government official to protect those that they serve in any way possible. The responsibility of decreasing the infection rate of vaccine preventable diseases in a way that is feasible given their resources and economic capacity is that of the government.

By implementing change to be more amenable to its citizens, the Bangladeshi government and healthcare system can improve the overall health of their country. This in and of itself is a noble goal, but economically, it is proven that a country with greater healthcare services, and thus overall health of citizens, results in a stronger economy. Not only will increasing health be ethically beneficial, but it will also improve the financial standing of the country which will allow it to grow and feed more resources back into the community and contribute more substantially to the global economy (Begum et al, 2014, p. 2).

The health of a country, and thus the successful decrease in 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 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 greater 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 correlate to Bangladesh's levels of vaccine preventable diseases.

Not all medical problems require a complicated or expensive solution. While lowering the cost of healthcare drastically, or better yet, implementing a universal healthcare system would be ideal, it is impractical for the current state of Bangladesh. A cost-effective solution for lowering the cost and accessibility of healthcare is required. One such option is sewage surveillance, which would allow the government or hospital to monitor the sewage of all the wards in Bangladesh and identify concentration of biomarkers for certain common vaccine preventable diseases (Taniuchi et al, 2017). This would allow for the healthcare system to identify where need for certain ailments is most severe and deploy healthcare professionals to that area or alert residents to the need to seek treatment.

Sewage surveillance has proven its worth when it was implemented in Bangladesh to target prevalence of the Polio virus and contributed to its elimination in the country in 2014 (Taniuchi et al, 2017). Efforts to eliminate the virus began in 1979, but vaccination campaigns became far more effective when certain areas could be targeted due to the identification of elevated biomarkers for the disease through sewage surveillance (WHO, 2019). Additionally, sewage surveillance has proven its worth as an effective early indicator of disease outbreak in studies on Norovirus and Hepatitis A infections (Hellmer et al, 2014). All three of these conditions are contracted through consuming food or water that has come into contact with infected fecal matter. Sewage surveillance can detect these viruses before they can potentially contaminate food or water sources. An early warning indicator through sewage surveillance could be used to prevent further spread and to treat those who have been affected sooner.

Beyond being an informative tool for tracking the prevalence of disease, sewage surveillance is also very inexpensive and reduces the reliance on citizens to seek out professional medical attention on their own. This type of surveillance does not require patients to come into the hospital for expensive and time-consuming testing, which eliminates the major barriers for citizens who may not otherwise seek this kind of care or be able to access it because they live in a rural area. Additionally, the tracking of disease in this manner provides the health system and government with precious information about where resource allocation is most dire (Hagedorn et al, 2020). With the ability to identify the population's needs, resources can be distributed more efficiently, saving both time and money. Being able to monitor health through sewage provides an additional link of communication between the government, healthcare system, and citizens where there was previously a disconnect.

Improving the communication in this way between the government, health system, and the citizens of Bangladesh will strengthen the actor network in the country, leading to more efficient allocation of resources. This mutual benefit is represented in Figure 2 (pg. 9). Healthier citizens will be greater able to contribute to the economy, thus improving the economic wellbeing of the country. A healthier economy feeds into the government which can then assign more funding to the health system. More money for the health system in turn serves the Bangladeshi citizens. With greater information on the spatial health of its citizens and the ability to predict the outbreak of preventable diseases, the government can distribute their resources and vaccine supplies to the most critical areas.

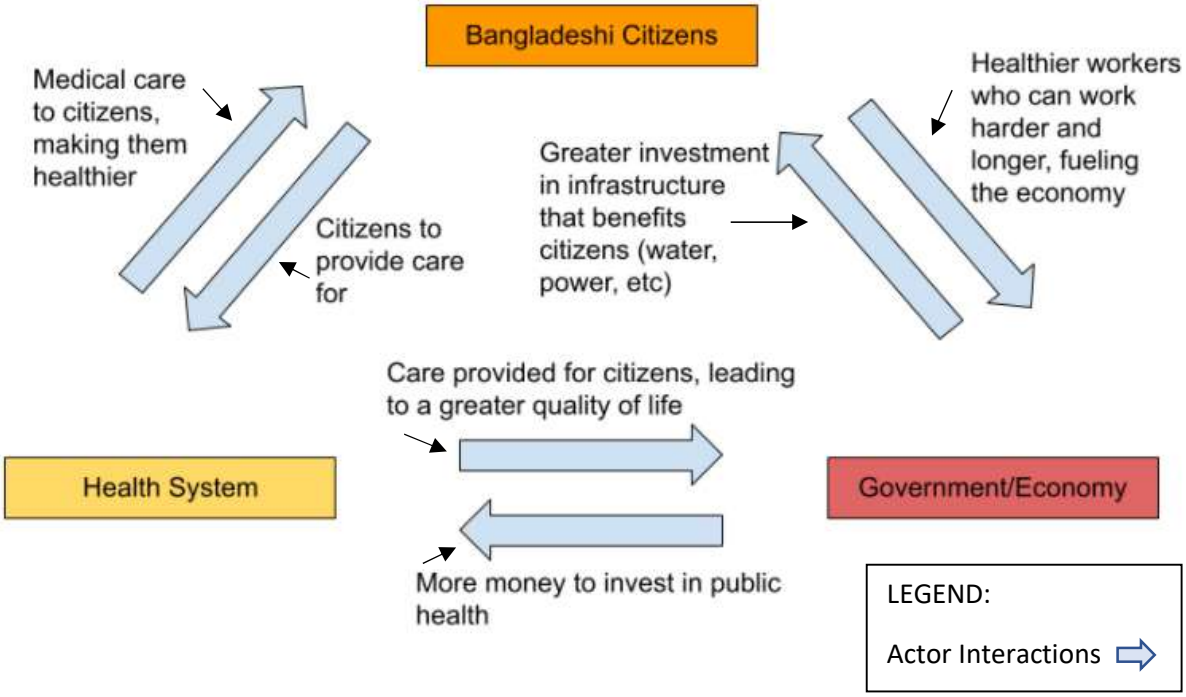

Figure 2: Cycle of benefit in Bangladeshi actor network. This figure illustrates the mutual benefit that each actor in the network will receive if more investment is made in the health sector. Each arrow points to the actor it affects and originates from the actor who takes the action (Reagan, 2021).

FUTURE WORK AND IMPROVEMENTS TO BE IMPLEMENTED

The goal of the STS portion of this research paper has been on gaining an improved understanding of the barriers to healthcare in low resource countries such as Bangladesh. 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. Moral and economic factors contribute to the rationale for fixing this problem. The government and the health system have the moral responsibility of maintaining the health and safety of their citizens. Additionally, healthier citizens correlate to a healthier

economy, so it would behoove the government in the long run to invest in this issue. Sewage surveillance is the solution to distributing healthcare to the entire country, as it provides a cost-effective solution to tracking the spatiotemporal prevalence of many kinds of preventable diseases. This then allows the government to bring healthcare to its citizens who cannot otherwise access it.

The technical portion of the undergraduate thesis project has focused 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. Data used to inform the dashboard will be sewage data collected from the sewage catchment sights of each ward of Dhaka, updated on a weekly basis. 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.

This dashboard will represent the first time that the Bangladeshi government has decided to rely on the use of sewage surveillance on a large scale to monitor the progression of a disease. As the government comes to rely on this new resource provided by my capstone group, it will be important to monitor its impact on the distribution of the COVID-19 vaccine and managing outbreaks. This tool can act as a further model of the effectiveness of disease monitoring via sewage surveillance. Future studies may involve reviewing the success of this project and critiquing its benefits and weaknesses. As this type of monitoring becomes more common, constant evaluation of its successes and failures will have to be made as well as adjustments to account for any shortcomings that may be discovered.

WORKS CITED

Ahmed, SM., Alam, BB., Anwar, I., Begum, T., Huque, R., Khan, JAM. (2015) Bangladesh Health System Review. *Manila: World Health Organization, Regional Office for the Western Pacific*, 5(3).

Begum, F., Alam, S., & Hossain, A. (2014). Funds for treatment of hospitalized patients: evidence from Bangladesh. *Journal of Health, Population, and Nutrition*, *32*(3), 465–470.

Bodrud-Doza, Md., Shammi, M., Bahlman, L., Islam, A. R. Md. T., & Rahman, Md. M. (2020). Psychosocial and socio-economic crisis in Bangladesh due to COVID-19 pandemic: a perception-based assessment. *Frontiers in Public Health*, *8*. https://doi.org/10.3389/fpubh.2020.00341

Cousins, S. (2020, August 29) Bangladesh's COVID-19 testing criticised. *The Lancet, 396(10251)*. P591. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31819-5/fulltext

Hagedorn, B. L., Gauld, J., Feasey, N., & Hu, H. (2020). Cost-effectiveness of using environmental surveillance to target the roll-out typhoid conjugate vaccine. *Vaccine*, *38*(7), 1661–1670. https://doi.org/10.1016/j.vaccine.2019.12.061

Hellmér, M., Paxéus, N., Magnius, L., Enache, L., Arnholm, B., ... Norder, H. (2014). Detection of pathogenic viruses in sewage provided early warnings of Hepatitis A virus and Norovirus outbreaks. *Applied and Environmental Microbiology*, *80*(21), 6771–6781. https://doi.org/10.1128/AEM.01981-14

Latour, B. (2005). Reassembling the Social. *Oxford, UK: OUP Oxford*.

Reagan, C. (2021). *Actor network of Bangladesh.* [Figure 1]. *STS Research Paper: Assessing the structural and cultural reasons for the high rates of vaccine preventable diseases in*

Bangladesh (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA

Reagan, C. (2021). *Cycle of benefit in Bangladeshi actor network.* [Figure 2]. *STS Research Paper: Assessing the structural and cultural reasons for the high rates of vaccine preventable diseases in Bangladesh* (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA

Taniuchi, M., Famulare, M., Zaman, K., Uddin, M. J., Upfill-Brown, … Petri, W. A. (2017). Community transmission of type 2 poliovirus after cessation of trivalent oral polio vaccine in Bangladesh: An open-label cluster-randomised trial and modelling study. *The Lancet. Infectious Diseases*, *17*(10), 1069–1079. https://doi.org/10.1016/S1473-3099(17)30358-4

United Nations (n.d.). *Least developed countries (LDCs)*. Retrieved March 24, 2021, https://www.un.org/development/desa/dpad/least-developed-country-category.html

World Health Organization (October 28, 2019). *World polio day: Bangladesh continues efforts to sustain the polio-free status.* Retrieved March 16, 2021, https://www.who.int/bangladesh/news/detail/28-10-2019-world-polio-day-bangladesh-continues-efforts-to-sustain-the-polio-free-status#:~:text=In%202014%2C%20Bangladesh%20was%20declared,a%20major%20public%20health%20milestone.

World Health Organization (n.d.). *WHO | Bangladesh*. Retrieved October 9, 2020, from https://www.who.int/workforcealliance/countries/bgd/en/

World Bank (n.d.). *Bangladesh Country Profile.* Retrieved February 25, 2021, http://www.searo.who.int/entity/asia_pacific_observatory/publications/hits/hit_bangladesh/en/

World Health Organization (n.d.). *WHO vaccine preventable diseases: monitoring system. 2020 global summary*. Retrieved March 23, 2021, https://apps.who.int/immunization_monitoring/globalsummary/countries?countrycriteria%5Bcountry%5D%5B%5D=BGD

World Bank (October 8, 2016). *Bangladesh: improving water supply and sanitation.* Retrieved March 17, 2021, https://www.worldbank.org/en/results/2016/10/07/bangladesh-improving-water-supply-and-sanitation#:~:text=Bangladesh%20has%20made%20significant%20progress,at%20only%201.1%20percent%20annually.