Columbia GlobeMed HillTop 2021 Policy Challenge

Addressing the Challenges of Equitable COVID-19 Vaccine Distribution in Bangladesh, Brazil, Kenya, and South Africa

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Introduction

In November 2021, the COVID-19 pandemic has been raging for nearly two years and while it is beginning to wind down in the United States, the international toll has been undeniable: tens of millions have people have become infected with the virus and among them, millions have died. No region of the world has come out of the pandemic unscathed, and the world has fundamentally changed from pre-pandemic times.

Since the beginning of the pandemic, tremendous resources have been invested into addressing this public and global health crisis. Scientists have extensively investigated the causes of this pandemic, each new strain, possible treatments, and perhaps most importantly, the development of a vaccine to beat the virus. After the publication of thousands of articles about the biology, epidemiology, pathogenesis and mechanics of COVID-19, several vaccines of varying levels of efficacy and varying amounts of clinical trials have been developed. While countries like the U.S have been able to somewhat mitigate the spread of COVID because of vaccines, the successful control of COVID-19 depends on massive, international distribution and making sure that vaccines are made accessible to as many people as possible. However, one key obstacle to the successful implementation of the COVID-19 vaccination program is distrust of the vaccine and vaccine hesitancy that has prevailed in many communities around the world.

Case Prompt

Vaccine mistrust has existed since their invention, since people have concerns about their safety and efficacy, and there have been issues with equitable distribution. Vaccine hesitancy has become more pronounced and more important in the wake of COVID-19 since vaccination is key to preventing the spread of the disease. Now that several COVID-19 vaccines have been developed and have been made available in many countries under Emergency Authorization Use, we are now uniquely challenged with how to generate global public acceptance of these vaccines.

Imagine that the Centers for Disease Control (CDC) has allocated a budget for a one-year project that will aim to improve public perception of the vaccine and equitable, appropriate distribution of the vaccine to the public. In particular, these projects will focus on countries that have high rates of vaccine hesitancy. Each team in the policy challenge will be tasked with developing a clear plan to achieve these goals, with a well-supported and reasonable budget. The best proposals will also address vaccine hesitancy and a plan for fairly distributing vaccines throughout a country. Teams should use evidence-based practices to inform their proposed country-based vaccination program. There are several factors that affect vaccine hesitancy, such as existing political and legal environments, religion, and culture, and good distribution plans should address these issues. The winning proposals will also include an effective communication plan with strategies on how to broach sensitive issues with the public.

Each team must select one of these four countries for their proposed vaccination program: Brazil, Kenya, Bangladesh, and South Africa. Each of these countries has unique challenges that they must overcome in achieving widespread and equitable vaccine distribution. Each proposal must address some of these nation-specific difficulties.

Working with an allocated budget of $100 million USD, each team will create a proposal. After reading through each proposal, four teams (one from each country) will be selected to pitch their proposal to an esteemed judge at the close of the competition. Of these, two winning teams will be selected.

Background Information

General COVID-19 Background

What is COVID-19?

Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. Coronaviruses are a large family of viruses that usually cause mild to moderate upper-respiratory tract illnesses, like the common cold. However, three new coronaviruses have emerged from animal reservoirs over the past two decades to cause serious and widespread illness and death.

There are hundreds of coronaviruses, most of which circulate among such animals as pigs, camels, bats and cats. Sometimes those viruses jump to humans—called a spillover event—and can cause disease. Four of the seven known coronaviruses that sicken people cause only mild to moderate disease. Three can cause more serious, even fatal, disease. SARS coronavirus (SARS-CoV) emerged in November 2002 and caused severe acute respiratory syndrome (SARS). SARS quickly spread to 26 countries before being contained after about four months. More than 8,000 people fell ill from SARS and 774 died. Since 2004, there have been no reported SARS cases.

Middle East respiratory syndrome (MERS) is caused by the MERS coronavirus (MERS-CoV). Transmitted from an animal reservoir in camels, MERS was identified in September 2012 in Saudi Arabia and has since spread to 27 countries, according to the World Health Organization. Some people infected with MERS coronavirus (MERS-CoV) develop severe acute respiratory illness, including fever, cough, and shortness of breath. Since its emergence in 2012 through August 2021, WHO confirmed 2,578 MERS cases and 888 deaths.

Sars-COV-2 is the third novel coronavirus to emerge in this century. It causes coronavirus disease 2019 (COVID-19), which emerged from Wuhan, China in December 2019 and was declared a global pandemic by the World Health Organization on March 11, 2020.

Research evidence suggests that SARS-CoV and MERS-CoV originated in bats. SARS-CoV then spread from infected civets to people, while MERS-CoV spreads from infected dromedary camels to people. To date, the origin of SARS-CoV-2 which caused the COVID-19 pandemic has not been identified. The scientific evidence thus far suggests that SARS-CoV-2 likely resulted from viral evolution in nature and jumped to people or through some unidentified animal host.

The COVID-19 Pandemic

In the first three months after COVID-19 emerged, nearly 1 million people were infected and 50,000 died. By six months, the number of cases exceeded 10 million and there were more than 500,000 deaths. To date, there have been roughly 45 million cases and 727,000 deaths from COVID-19 in the United States.

Globally, as of November 3, 2021, there have been over 247 million confirmed cases of COVID-19 and over 5 million deaths. The highest rates of COVID-19 have been reported in the United States, India, Brazil, the United Kingdom, and Russia.

Every country has experienced a different mortality rate with COVID-19. According to the Johns Hopkins University mortality tracker, Mexico currently has the highest mortality rate of any country with a case-fatality ratio of around 7.6%. This is the equivalent of roughly 350 deaths per 10,000 people. Other countries with high case-fatality ratios include Egypt, Bulgaria, Romania, Russia, and Brazil. The United States trails these countries with a mortality rate of around 1.6% while countries like Singapore and Iceland have achieved some of the lowest mortality rates in the world, around 0.2%. Differences in the mortality rates of countries can be attributed to differences in the number of people tested, demographics (ex. higher mortality rates for larger elderly populations), and characteristics of healthcare systems.

Emerging Variants of COVID-19

There are multiple SARS-CoV-2 variants circulating globally. Several new variants emerged in the fall of 2020. In the United Kingdom (UK), a new (alpha) variant of SARS-CoV-2 (known as 20I/501Y.V1, VOC 202012/01, or B.1.1.7) emerged with a large number of mutations. This variant has since been detected in numerous countries around the world, including the United States (US). In January 2021, scientists from the UK reported evidence[1] that suggests the B.1.1.7 variant may be associated with an increased risk of death compared with other variants. This variant was first identified in the United States in December 2020. In Brazil, a (gamma) variant of SARS-CoV-2 (known as P.1) emerged that was first identified in four travelers from Brazil, who were tested during routine screening at Haneda airport outside Tokyo, Japan. This variant has 17 unique mutations, including three in the receptor binding domain of the spike protein. There is also a (beta) variant originating in South Africa that shares several mutations with the UK variant B.1.1.7.

The Delta variant was first identified in India and swept rapidly through that country and Great Britain before reaching the U.S., where it quickly surged. It is now the predominant SARS

CoV-2 variant, accounting for more than 99% of COVID-19 cases and leading to an overwhelming increase in hospitalizations in some states.

Delta is believed to be more than twice as contagious as previous variants, and studies have shown that it may be more likely than the original virus to put infected people in the hospital. People who are not vaccinated are most at risk, and the highest spread of cases and severe outcomes is happening in places with low vaccination rates.

How is SARS-Cov-2 Transmitted?

The principal mode by which people are infected with SARS-CoV-2 (the virus that causes COVID-19) is through exposure to respiratory fluids carrying infectious virus. People release respiratory fluids during exhalation (e.g., quiet breathing, speaking, singing, exercise, coughing, sneezing) in the form of droplets across a spectrum of sizes. These droplets carry viruses and transmit infection. While the largest droplets settle out of the air rapidly, within seconds to minutes, the smallest very fine droplets, and aerosol particles formed when these fine droplets rapidly dry, are small enough that they can remain suspended in the air for minutes to hours.

Infectious exposures to respiratory fluids carrying SARS-CoV-2 occur in three principal ways. The first method is inhalation of air carrying very small fine droplets and aerosol particles that contain infectious virus. Risk of transmission is greatest within three to six feet of an infectious source where the concentration of these very fine droplets and particles is greatest. Another mode of transmission is deposition of virus carried in exhaled droplets and particles onto exposed mucous membranes (i.e., "splashes and sprays", such as being coughed on). Risk of transmission is likewise greatest close to an infectious source where the concentration of these exhaled droplets and particles is greatest. The virus is also transmitted by touching mucous membranes with hands soiled by exhaled respiratory fluids containing virus or from touching inanimate surfaces contaminated with virus.

What are the symptoms of COVID-19?

People with COVID-19 have had a wide range of symptoms reported – ranging from mild symptoms to severe illness. Symptoms may appear 2-14 days after exposure to the virus. Anyone can have mild to severe symptoms. People with these symptoms may have COVID-19: fever or chills, cough, shortness of breath, fatigue, muscle or body aches, headache, loss of taste or smell, sore throat, congestion or runny nose, nausea and vomiting, diarrhea.

How is COVID-19 diagnosed and treated?

COVID can be tested using both viral and antibody tests. Viral tests are used to test for current infections, and two types can be used: nucleic acid amplification tests (NAATs) and antigen tests. An antibody test (also known as a serology test) might tell you if you had a past infection. Antibody tests should not be used to diagnose a current infection.

Treatment for COVID-19 is given to minimize symptoms, treat complications from existing illness, and support the immune system as the body's own immune response works to clear the infection. In October 2021, Merck released promising study results about an oral antiviral drug to treat COVID-19. Compared to placebo, the antiviral drug, called molnupiravir, significantly reduced the risk of hospitalization and death in people with mild or moderate COVID-19 who were at high risk for severe COVID. If the FDA authorizes or approves this drug, molnupiravir will be the first COVID-19 treatment that can be taken by mouth early in the course of infection to reduce disease severity.

In November 2020, the FDA granted emergency use authorization to two monoclonal antibody treatments (bamlanivimab, made by Eli Lilly; and a combination of casirivimab and imdevimab, made by Regeneron). Both treatments have been approved for non-hospitalized adults and children over age 12 with mild to moderate COVID-19 symptoms who are at risk for developing severe COVID-19 or being hospitalized for it.

There are also several drugs that doctors use for patients hospitalized with COVID-19, including Dexamethasone (a potent anti-inflammatory), Tocilizumab (a monoclonal antibody that received emergency FDA authorization), and Remdesivir, an antiviral drug that also received emergency FDA approval.

Background on COVID Vaccines

How do vaccines work against COVID-19?

Currently, there are three main types of COVID-19 vaccines that are authorized and recommended for undergoing large-scale (Phase 3) clinical trials in the United States. The Moderna and Pfizer-Biotech vaccines are both mRNA vaccines, which means they contain material from the virus that causes COVID-19 that gives our cells instructions for how to make a harmless protein that is unique to the virus. After our cells make copies of the protein, they destroy the genetic material from the vaccine. Our bodies recognize that the protein should not be there and build T-lymphocytes and B-lymphocytes that will remember how to fight the virus that causes COVID-19 if we are infected in the future. The Johnson & Johnson vaccine uses more traditional viral technology. Vector vaccines contain a modified version of a different virus than the one that causes COVID-19. Inside the shell of the modified virus, there is material from the virus that causes COVID-19. This is called a "viral vector." Once the viral vector is inside our cells, the genetic material gives cells instructions to make a protein that is unique to the virus that causes COVID-19. Using these instructions, our cells make copies of the protein. This prompts our bodies to build T-lymphocytes and B-lymphocytes that will remember how to fight that virus if we are infected in the future.

Which vaccines are in use around the world and how effective are they?

Currently, the only three vaccines authorized for use within the United States are the Pfizer-Biotech, Moderna, and Johnson & Johnson vaccines. Other coronavirus vaccines in use around the world include Oxford-AstraZeneca, Novavax, China's Sinovac, also known as CoronaVac, and Sinopharm, and Russia's Sputnik V.

Of these, Pfizer was the first to receive full Food and Drug Administration (FDA) approval for people ages 16 and older in August 2021. It was also the first COVID-19 vaccine to receive FDA Emergency Use Authorization (EUA) back in December 2020, after the company reported its vaccine was highly effective at preventing symptomatic disease. It is currently recommended for everyone aged 5 and older and consists of 2 doses, administered 21 days apart. Experts continue to learn about Pfizer's efficacy both in the laboratory and in the real world. Pfizer's initial Phase 3 clinical data presented in December showed its vaccine to have 95% efficacy. In April, the company announced the vaccine had 91.3% efficacy against COVID-19, based on measuring how well it prevented symptomatic COVID-19 infection seven days through up to six months after the second dose. It also found it to be 100% effective in preventing severe disease as defined by the CDC, and 95.3% effective in preventing severe disease as defined by the FDA. However, in August, the CDC also published studies that showed mRNA vaccine protection against infection may be waning, although the vaccines were still highly effective against hospitalization. In one CDC study, data from the state of New York showed vaccine effectiveness dropping from 91.8 to 75% against infection. There are also some challenges with distributing the Pfizer vaccine, as it needs to be stored at subzero temperature conditions. The World Health Organization (WHO) has reported over 50% vaccine wastage globally every year, in part because some points of vaccination, such as healthcare providers in poor or rural areas, may not have the resources to support cold chain requirements.

Moderna's vaccine was authorized for emergency use in the U.S. in December 2020, about a week after the Pfizer vaccine. Moderna uses the same mRNA technology as Pfizer and has similarly high efficacy at preventing symptomatic disease and consists of 2 doses, administered 28 days apart. It also needs to be stored in freezer-level temperatures. The CDC found Moderna's effectiveness against hospitalization held steady over a four-month period, unlike Pfizer. Additionally, Moderna reported that studies showed its vaccine is effective against the Beta, Delta, Eta, and Kappa variants, although it did show it to be about two times weaker against Delta than against the original virus.

The FDA granted EUA for Johnson & Johnson's vaccine in February, 70 days after Pfizer and Moderna. Unlike the mRNA vaccines, this is a carrier, or virus vector, vaccine. It can be stored in normal refrigerator temperatures, and because it requires only a single shot, it is easier to distribute and administer. It has 72% overall efficacy and 86% efficacy against moderate and severe disease in the U.S., according to analyses posted by the FDA in February. Johnson &

Johnson reported in July that its vaccine is also effective against the Delta variant, showing only a small drop in potency compared with its efficacy against the original strain of the virus.

The Oxford-AstraZeneca vaccine is currently being distributed in the United Kingdom and other countries, and it is distinguished from some of its competitors by its lower cost—it's cheaper to make per dose, and while some of the other vaccines must be stored frozen, this one can be stored in normal refrigeration for at least six months, making it easier to distribute. It also consists of 2 doses, administered four weeks apart. Similar to the Johnson & Johnson vaccine, this is a carrier vaccine. Scientists engineer a harmless adenovirus as a shell to carry genetic code on the spike proteins to the cells. Once the code is inside the cells, the cells produce a spike protein to train the body's immune system, which creates antibodies and memory cells to protect against an actual SARS-CoV-2 infection. AstraZeneca updated its data analysis of its phase 3 trials in March, showing its vaccine to be 76% effective at reducing the risk of symptomatic disease 15 days or more after receiving the two doses, and 100% against severe disease. The company also said the vaccine was 85% effective in preventing COVID-19 in people over 65.

China's Sinovac vaccine is in use in several countries, including Brazil. A large phase 3 trial in Brazil showed that two doses, administered at an interval of 14 days, had an efficacy of 51% against symptomatic SARS-CoV-2 infection, 100% against severe COVID-19, and 100% against hospitalization starting 14 days after receiving the second dose.

Currently, more than 3.93 billion people around the world have been vaccinated against COVID, comprising about 51.2% of the world population. However, less wealthy nations have limited access to vaccines. This has led to a striking divide between regions of the world. Africa has the slowest vaccination rate of any continent, with just 8.7 percent of the population receiving at least one dose of a vaccine. About 75 percent of shots that have gone into arms worldwide have been administered in high- and upper-middle-income countries. Only 0.6 percent of doses have been administered in low-income countries.

The Ethics of Vaccine Distribution

There are many vaccines available but ethical challenges about vaccine distribution are complex. Some challenges are theoretically broad, like whether to prioritize specific groups—the elderly, the disadvantaged, younger people with medical conditions that make them more vulnerable. Other ethical challenges reflect variations in social policy: what's the significance of various countries' different roll-out policies, and should some of these be challenged? Should a governmental agency at any level issue "vaccine passports," or mandate Bluetooth access to others' COVID-positive status or vaccination status? Then there are more specific ethical questions about individual behavior: what about line-jumpers and the honor system? What about vaccine hunters? What about vaccine hesitancy or outright refusers, even those who work in health care?

The Logistics of Vaccine Distribution

Cold chain capacity is a major concern of vaccine distribution, since many vaccines including both the widely-used Moderna and Pfizer vaccines need to be stored and transported at ultra-freezing temperatures. At present, the BioNTech / Pfizer vaccine is required to be kept at around -70°C and can remain stored at these temperatures for up to six months, though, once transported in unopened, dry ice packs, must reach the vaccination centre in ten days to retain their potency. Ensuring safe and effective "last mile" distribution of the vaccine in geographies where the required cold-chain infrastructure does not yet exist will be a key challenge.

Another hurdle is the concentration of production of these vaccines in Europe, the US, India and China and how they will be transported to the rest of the world. More than 90% of all COVID-19 vaccine doses are expected to be produced in those countries or regions, while Africa and Asia (excluding India and China) are expected to be the largest importers. According to the McKinsey and World Economic Forum joint scenario model, the largest exporters (Europe and India) are expected to ship approximately 1 billion doses each during the first wave in order to acquire 20% immunisation globally. However, those vaccines requiring ultra-cold chain capacity will be mostly utilised in Europe, Japan or Northern America, where the cold chain capacity difficulties mentioned above are less prevalent. Companies will need to work out logistics of how huge volumes of temperature and time sensitive cargo will be transported to countries that do not have the necessary technology or economic capacity.

The Economics of Vaccine Distribution

Once the depth and breadth of the COVID-19 pandemic was belatedly recognized, researchers across the world have moved at an unprecedented pace to advance more than 100 vaccine candidates. However, much of the infrastructure and funding needed to develop, produce, and distribute successful vaccine candidates has been pieced together reactively rather than through established emergency preparedness frameworks both nationally and globally. Delays in recognizing and responding to the threat of COVID-19, particularly in the United States, have resulted in lost lives and a battered economy. The International Monetary Fund estimates the world economy will face a $12 trillion loss in 2020-2021 because of the pandemic,1 implying a potential $500 billion gain by accelerating vaccine development by a single month.

Against a backdrop of missteps in responding to emerging infectious disease threats, the Coalition for Epidemic Preparedness Innovations (CEPI) was launched and funded by public, private, philanthropic, and civil society organizations in 2017 to accelerate development of vaccines against emerging infectious diseases and enable equitable access to vaccines during outbreaks. Other than China and the United States, CEPI is the most prominent global funder of COVID-19 vaccine efforts. Along with the vaccine alliance known as Gavi and the World Health Organization, CEPI is leading the COVAX Facility,7 which is the vaccines arm of the Access to COVID-19 Tools Accelerator, a global collaboration of almost 200 countries working to accelerate the development, production, and equitable access to COVID-19 tests, treatments, and vaccines. By supporting a diversified COVID-19 vaccine research portfolio, pooling negotiations with manufacturers, and investing in preinstalled vaccine production capacity, the COVAX Facility aims to deliver 2 billion vaccine doses by the end of 2021. Participating higher-income countries will self-finance, while lower income countries will be funded through donations to an advance market commitment for COVID-19 vaccines. Some COVAXparticipating higher-income countries are hedging their bets on having access to an effective vaccine by also contracting directly with manufacturers.

Recommended Reading

On Vaccines

Vaccine Logistics

- Fischetti, M. (2020, November 19). *The COVID Cold Chain: How a Vaccine Will Get to You*. Scientific American. https://www.scientificamerican.com/article/the-covid-cold-chain-how-a-vaccine-will-get-to-you/.
- Wallace, G., & Muntean, P. (2020, December 11). *The mind-boggling logistics of transporting one of the most important vaccines in history*. CNN. https://www.cnn.com/2020/12/11/business/vaccine-distribution-coronavirus/index.html.
- Byrne, J. (2020, November 19). *COVID-19 vaccine distribution: Gaps remain in immunization logistics and real-time tracking of vaccine storage and demand*. BioPharma-Reporter. https://www.biopharma-reporter.com/Article/2020/11/19/COVID-19-vaccine-distribution-Gaps-remain-in-immunization-logistics-and-real-time-tracking-of-vaccine-storage-and-demand.
- Michael, E. (2020, December 14). *Experts discuss logistics of COVID-19 vaccine distribution*. Healio. https://www.healio.com/news/primary-care/20201214/experts-discuss-logistics-of-covid19-vaccine-distribution.
- Saey, T. H. (2020, December 3). *The 'last mile' for COVID-19 vaccines could be the biggest challenge yet*. Science News. https://www.sciencenews.org/article/covid19-coronavirus-vaccine-last-mile-logistics-pfizer-moderna.

Economics of Vaccine Distribution

- https://academyhealth.org/sites/default/files/ah_ri_economics_of_vaccines_brief_final.pdf

- Goodnough, A., & Kaplan, S. (2020, November 14). *Missing From State Plans to Distribute the Coronavirus Vaccine: Money to Do It*. The New York Times. https://www.nytimes.com/2020/11/14/health/covid-vaccine-distribution-plans.html.
- Hafner, M., Yerushalmi, E., Fays, C., Dufresne, E., & Van Stolk, C. (2020, November 5). *Unequal Access to COVID-19 Vaccines Would Further Damage the Global Economy*. RAND Corporation. https://www.rand.org/pubs/research_briefs/RBA769-1.html.
- World Health Organization. (2020, December 3). *Global equitable access to COVID-19 vaccines estimated to generate economic benefits of at least US$ 153 billion in 2020–21, and US$ 466 billion by 2025, in 10 major economies, according to new report by the Eurasia Group*. World Health Organization. https://www.who.int/news/item/03-12-2020-global-access-to-covid-19-vaccines-estimated-to-generate-economic-benefits-of-at-least-153-billion-in-2020-21.

Vaccine Hesitancy

- MacDonald, N.E., and the SAGE Working Group on Vaccine Hesitancy. (2015). Vaccine hesitancy: Definition, scope and determinants. *Vaccine, 33*(2015), 4164-4164. http://dx.doi.org/10.1016/j.vaccine.2015.04.036.
- Jacobsen, R.M., Sauver, J.L., and Rutten, L.F. (2015). Vaccine Hesitancy. *Mayo Clinic Proc., 90*(11), 1562-1568. http://dx.doi.org/10.1016/j.mayocp.2015.09.006.
- Phadke, V.K., et. al. (2016). Association Between Vaccine Refusal and Vaccine-Preventable Disease in the United States: A Review of Measles and Pertussis. *JAMA, 315*(11), 1149-1158. http://dx.doi.org/10/1001/jama/2016.1353.
- Heidi, J.L., et. al. (2016). The State of Vaccine Confidence 2016: Global Insights Through a 67-Country Survey. *EBioMedicine, 12*(2016), 295-301. http://dx.doi.org/10.1016/j.ebiom.2016.08.042.

Country-Specific Recommended Reading

Bangladesh

- Nation Specific Challenges: **(you may choose to address in your proposal)**
  - Rohingya Refugee Crisis
  - Vaccine Adherence to Islamic Law
  - Low Education and High Poverty in Manufacturing-Based Economy
- Readings about Bangladesh:
  - Ahmed, S.M., et. al. (2015). Bangladesh Health Systems Review. *Health Systems in Transition, 5*(3), 1-214.

- Islam, M. T., Talukder, A. K., Siddiqui, M. N., & Islam, T. (2020). Tackling the Covid-19 PANDEMIC: The BANGLADESH PERSPECTIVE. *Journal of Public Health Research, 9*(4). doi:10.4081/jphr.2020.1794
    - Ali, M., & Hossain, A. (2021). What is the extent of COVID-19 Vaccine hesitancy in BANGLADESH? : A cross-sectional rapid national survey. medRxiv. doi:10.1101/2021.02.17.21251917
    - Milko, V. (2020). "Concern among Muslims over Halal Status of COVID-19 Vaccine." *PBS News Hour Weekend*, Public Broadcasting Service.
    - Ahmed, A., et al. (2018). Outbreak of Vaccine-Preventable Diseases in Muslim Majority Countries. *Journal of Infection and Public Health*, *11*(2), 153-155. https://doi.org/10.1016/j.jiph.2017.09.007.

Brazil

- Nation Specific Challenges:
    - Health Inequity within Urban Centers and across Regions within the Country (i.e., Rio age gap across city and Northeast vs. Southeast country health outcomes)
    - Misinformation Campaigns
- Readings about Brazil
    - Machado, C.V., and Silva, G.A. (2018). Political struggles for a universal health system in Brazil: successes and limits in the reduction of inequalities. *Globalization and Health, 15*(1), 77. https://doi.org/10.1186/s12992-019-0523-5.
    - Szcwarcwald, C.L., et. al. (2011). Health Inequalities in Rio de Janeiro, Brazil: Lower Healthy Life Expectancy in Socioeconomically Disadvantaged Areas. *Am J Public Health, 101*(3), 517-523. http://10.2105/AJPH.2010.195453.
    - The World Bank. (n.d.). Brazil Overview. Retrieved February 1, 2021, from https://www.worldbank.org/en/country/brazil/overview.
    - Galhardi, C.P., et. al. (2020). Fact or Fake? An analysis of disinformation regarding the Covid-19 pandemic in Brazil. *Cien Saude Colet, 25*(2), 4201-4210. https://doi.org/10.1590/1413-812320202510.2.28922020.
    - Biancovilli, P., and Jurberg, C. (2020). When governments spread lies, the fight is against two viruses: A study on the novel coronavirus pandemic in Brazil. medRxiv. https://doi.org/10.1101/2020.10.20.20215962.

South Africa

- **Nation specific challenges:**
    - Weak vaccine administration infrastructure

- Other pressing health crises (HIV, tuberculosis) and overburdened healthcare system
- Civil unrest (looting and protests following imprisonment of former president)

- **Readings on South Africa:**
    - https://www.one.org/international/blog/covid19-vaccine-rollout-south-africa/
    - https://www.afro.who.int/news/risks-and-challenges-africas-covid-19-vaccine-rollout
    - https://www.hrw.org/news/2021/02/03/ensuring-equitable-covid-19-vaccine-distribution-south-africa
    - Machingaidze, S., Wiysonge, C.S. Understanding COVID-19 vaccine hesitancy. *Nat Med* 27, 1338–1339 (2021). https://doi.org/10.1038/s41591-021-01459-7
    - Patrick Lydon, Ticky Raubenheimer, Michelle Arnot-Krüger, Michel Zaffran,
    - Outsourcing vaccine logistics to the private sector: The evidence and lessons learned from the Western Cape Province in South-Africa, Vaccine,
    - Volume 33, Issue 29, 2015, Pages 3429-3434.

Kenya

- **Nation Specific Challenges:**
    - Reliance on COVAX to receive vaccines
    - Widespread economic inequality
    - Limited organization of vaccine distribution process
- **Readings on Kenya**
    - https://www.washingtonpost.com/world/2021/04/03/kenya-vaccine-inequality/
    - https://phr.org/our-work/resources/covid-19-vaccine-access-in-kenya-illustrates-dire-global-inequity/
    - https://gh.bmj.com/content/bmjgh/5/8/e003042.full.pdf
    - https://web.p.ebscohost.com/ehost/pdfviewer/pdfviewer?vid=0&sid=37e8f958-8cb6-453d-a332-19b28e1441ad%40redis
    - Mercy Mvundura, Kristina Lorenson, Amos Chweya, Rosemary Kigadye, Kathryn Bartholomew, Mohammed Makame, T. Patrick Lennon, Steven Mwangi, Lydia Kirika, Peter Kamau, Abner Otieno, Peninah Murunga, Tom Omurwa, Lyimo Dafrossa, Debra Kristensen, Estimating the costs of the vaccine supply chain and service delivery for selected districts in Kenya and Tanzania, Vaccine, Volume 33, Issue 23, 2015.

The readings and nation-specific challenges above are meant to serve as an introduction into the topic and a starting point for your proposals. You may choose to address other points in our proposal if you wish, and use any resources that may further inform your work.