

## PROSPECTUS

In 2016, the region of the Americas became the first to eliminate measles after decades of immunization campaigns and disease control efforts (PAHO, 2020). Yet, the region saw a great resurgence of cases shortly thereafter. The Venezuelan crisis set up the perfect environment for the resurgence of infectious disease: faltering availability of vaccinations, limited food and medical supplies, and a health system in complete disarray allows infectious disease to spread rapidly and indiscriminately. Beginning in 2017, measles cases burgeoned in Venezuela with 727 reported cases according to the World Health Organization (WHO). Then, 5,667 were reported by the WHO in 2018. The mass exodus of Venezuelans seeking economic relief allowed the disease to spread across borders. Measles virus of identical lineage returned to other countries in the region, notably in both Colombia and Brazil - two of Venezuela's closest neighbors (PAHO/WHO, 2018).

While measles virus was at one time a common childhood illness – almost a rite of passage – its effects are much larger and more impactful than the mere symptoms of disease. Its transmissibility is nearly unmatched by any other communicable disease. With an  $R_0$  (or number of secondary cases resulting from a single case) of 12-18, vulnerable populations have little chance of avoiding infection even following brief contact with an infected individual or their lingering viral respiratory particles (Laksono et al., 2016). A number of complications can arise in conjunction with the typical rash, fever, and respiratory symptoms. These include respiratory infections, like pneumonia, or in extreme cases, central nervous system infections like encephalitis (Laksono et al., 2016). Recovery from measles provides lifelong immunity to the virus, but also drastically impairs the immune system for years following recovery. This lasting immunosuppression has been termed “immune amnesia”; the measles virus weakens the magnitude of antibody binding signals and reduces antibody diversity, essentially destroying

built up immunity to various pathogens (Mina et al., 2019). This indicates that measles vaccine drastically improves childhood mortality rates by providing a degree of herd immunity to other, non-measles infections (Mina et al., 2015). In the pre-vaccine era, it is estimated that the measles virus could have been associated with up to 50% of all childhood infectious disease deaths due to this immune system destruction (Mina et al., 2019). The World Health Organization reported that between 2000 and 2017, measles virus vaccinations prevented over 21 million deaths – this statistic does not account for deaths resulting from immunosuppression (Mina et al., 2019). The actual figures are likely much higher.

The measles outbreak in Venezuela was brought back under control by the Pan American Health Organization in 2019, and case numbers have since subsided in surrounding countries (PAHO, 2020). However brief, this period of resurgence of measles highlights some major weaknesses that exist in cross-border disease control methods. The breakdown of vaccination coverage in Venezuela was able to wreak havoc across the region – determination of the factors allowing this to occur, as well as factors that were helpful in prevention, will be vital in informing actions that can be taken to avoid recurrence of this in the future.

An interesting paradox exists within this period of measles resurgence: Colombia, located along Venezuela's western border, receives far more Venezuelan migrants than does Brazil, located along Venezuela's southern border. These two bordering countries both saw a resurgence of measles in 2018, but Brazil's outbreaks occurred to a much greater extent. The WHO reported 208 measles cases in Colombia in 2018, while 10,330 were reported for Brazil. This enigmatic scenario is cause for further study. What factors allowed for the better control of measles outbreaks in Colombia compared to Brazil? Once these factors are determined, how can they be implemented in Brazil to improve disease control measures and prevent subsequent outbreaks?

There are various points of investigation when determining factors relevant to measles control in Colombia and Brazil in the face of large-scale Venezuelan migration. The most apparent avenue of analysis is vaccination coverage in each country. Herd immunity is of great importance to infectious disease control, and a 95% vaccination coverage rate is the standard for sufficient population protection from measles virus. Vaccination coverage is dependent upon a multitude of factors, including accessibility of vaccinations, willingness to vaccinate, and capabilities of health care centers (Phillips et al., 2017). In-depth analysis of the breadth of each country's vaccination programs, anti-vaccination movements, and health care infrastructure could reveal inconsistencies contributing to the differing impacts of mass migration on measles control.

Continuing on, the degree of heterogeneity of populations could serve as an additional explanation for the discrepancies that exist. Maximal dispersal of unvaccinated individuals within a vaccination population has been found to deter the spread of measles, rather than favoring it (Bosetti et al., 2020). The existence of heterogeneous populations of vaccinated and unvaccinated individuals increases the likelihood that infectious contacts occur between immune and nonimmune individuals, indicating that pockets of under-immunized populations are particularly threatening to disease control efforts. These pockets could come into existence as a result of many different mechanisms, including low vaccine access, vaccine hesitancy and segregation of unvaccinated migrants into separate communities. Each of these phenomena could bolster disease spread and the magnitude of outbreaks (Bosetti et al., 2020). It is for this reason that heterogeneity of vaccination coverage, as well as the population integration of Venezuelan migrants in Colombia compared to Brazil, are important points of investigation.

Lastly, governmental policies relating to migrant health and their access to care could serve as an additional explanation for differing outcomes. A myriad of methods exist through which governments can prevent measles outbreaks in response to a large influx of under-immunized or infectious migrants. These include protocols for identification and isolation of contagious individuals, maintaining laboratories capable of confirming measles cases, and timely vaccination of susceptible individuals (Gastañaduy et al., 2018). Comparison of migration policies in Colombia and Brazil in response to the Venezuelan crisis could highlight explanations for their successes and failures, as well as serve as possible explanations for discrepancies in the aforementioned factors.

I have selected Colombia and Brazil as cases of comparison for a variety of reasons. First is their similar geographic proximity to Venezuela. Both are bordering countries, which makes comparison justifiable in that all Venezuelan migrants enter directly: there are no additional borders to cross in route from Venezuela to Colombia or Brazil. Moreover, both receive a significant number of Venezuelan migrants and have faced significant public health concerns as a result. As Venezuelans flee in search of economic, social, and political stability, they often arrive in Colombia and Brazil in poor health and carrying a variety of communicable diseases.

What makes Colombia and Brazil an interesting selection for comparison is their differing outcomes as a result of this influx of Venezuelan migrants. Because they are in similar situations, it could be logically expected that the number of measles cases in each country would be proportional to the number of Venezuelan migrants in each country. The fact that this assumption does not hold true in the case of Colombia and Brazil points to the likelihood that there are underlying factors contributing to each country's disease control capabilities. Isolation

and identification of these factors would contribute greatly to the discussion of cross-border disease control and public health.

I hypothesize that a combination of the previously mentioned factors resulted in the differing outcomes of Colombia and Brazil. I predict that Brazil's vaccination coverage rates are lower and less heterogeneous, owing to their notorious socioeconomic inequalities. I also hypothesize that Venezuelans tend to integrate into Colombian society more so than into Brazilian society, possibly because of more shared cultural similarities. Lastly, I hypothesize that Colombia's response to the Venezuelan crisis was much more rapid and effective than that of Brazil.

In order to cover the factors leading to differing measles control capabilities in Colombia and Brazil, I will use both qualitative and quantitative methods of analysis. First, I will analyze the presence of vaccine hesitancy and anti-vaccination movements with the purpose of determining parents' reasons for refusing vaccination. Next, I will examine the disease and vaccination surveillance capabilities of each country, which will give insight into their respective vaccination coverage and disease outbreaks. Lastly, I will analyze the governmental policies relating to migrant health in each country, specifically looking at each government's response to the Venezuelan crisis. For example, I will look for answers to questions relating to the identification and quarantine of infectious persons, the presence of laboratories capable of confirming cases of infectious diseases, procedures for health screenings, proof of vaccination, and provision of vaccination to those who are under immunized.

In terms of quantitative analysis, I will use cross tabulations to analyze the relationship between many variables which could have an impact on the measles outbreaks in each country. I will use LAPOP survey data to investigate the perceptions of Brazilian and Colombian residents

with regard to Venezuelan migration, public health capabilities, and health policy. In addition, I will use a form of linear regression in order to predict how relevant vaccine coverage and the number of Venezuelan migrants are to measles outbreaks. For this analysis, I will use multiple Latin American countries to strengthen the results and relationships established.

This study is primarily limited by the reliability and availability of epidemiological data. While a myriad of data exists on measles, all people who get the disease don't always see a medical professional. Additionally, misdiagnosis may occur, along with inabilities to confirm measles cases due to lacking laboratory testing. Additionally, there are limitations pertaining to the extent to which causality and correlation can be determined using these statistical methods.

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