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Chapter

A Narrative Review of the Measles Outbreak in North America and Globally

Adekunle Sanyaolu, Chuku Okorie, Aleksandra Marinkovic, Kareem Hamdy, Stephanie Prakash, Risha Patidar, Abu Fahad Abbasi, Priyank Desai, Abdul Jan and Jasmine Mangat

Abstract

In the early twenty-first century, measles was completely eradicated in the United States of America (USA) and almost eliminated in Canada. This was greatly due to most of the population being vaccinated against the virus. In 2018 and 2019, the USA and Canada experienced a rapidly developing measles virus outbreak due to growing debates about vaccine efficacy and side effects. Therefore, some people refused to vaccinate their children against measles, as well as many other life-threatening preventable diseases. This led to a major measles outbreak and health concern in the USA, Canada, and globally. Some countries including the Democratic Republic of the Congo (DRC) reported a significant number of cases and casualties resulting from measles, mainly due to the lack of funding for vaccines, as well as inadequate vaccination coverage in certain socio-demographic areas. People traveling from these countries can easily transmit the disease, though there has been a steep decline in cases since the travel ban due to coronavirus disease-2019 (COVID-19). The number of unvaccinated children currently in the USA and Canada has quadrupled since 2001. Over the past couple of years, most of the measles cases have been diagnosed in those who either did not receive the measles vaccine or complete the recommended doses of the vaccine. This paper reviews the measles outbreak, in recent years, among unvaccinated individuals in the USA, Canada, and globally.

Keywords: measles, child, adult, vaccination, disease outbreaks, United States of America, Canada, global, the Democratic Republic of the Congo

1. Introduction

The measles virus also referred to as rubeola from the *Paramyxoviridae* family, is considered a rapidly transmissible, vaccine-preventable disease affecting global populations. It is an enveloped non-segmented, negative-strand RNA virus that encodes six known structural proteins: N, P, M, F, H, and L; as well as two non-structural proteins V and C [1]. Virus-host transmembrane fusion requires hemagglutinin and fusion glycoproteins, while only the hemagglutinin glycoprotein is

required for host-cell attachment [1, 2]. In humans, the virus has a receptor binding preference for the CD46 protein [3]. It is possible to trace viral ancestral lines; the wild type, for example, is organized into eight clades, and twenty-two confirmed genotypes [2].

The clinical presentation may provide a relative timeline of primary exposure, as well as the progression of symptoms. The incubation period averages about eleven days until presenting with high fever, cough, coryza, and conjunctivitis. Within two to three days, koplik spots typically appear, and from three to five days a rash may appear on the hairline. Rash grouping could be identified as it spreads downwards to the trunk and limbs, along with increasing high fever. The measles virus does not only have the designation as a highly contagious human disease, but it is also often linked to the global infant, childhood, and adult morbidity and mortality, with the age group five to twenty years, having fewer complications than the elderly. Common complications include diarrhea, otitis media, pneumonia, encephalitis, seizures, and death. It is spread by air droplets and is believed to infect the respiratory tract, initially infecting alveolar macrophages and dendritic cells, spreading deep into the lungs, lymphatics, and then the rest of the body [4, 5].

With over 100,000 deaths annually and growing, the measles virus remains one of the major causes of vaccine-preventable infant death worldwide [6, 7]. With the global emphasis on the COVID-19 pandemic, the number of administered vaccinations decreased, creating the potential for a surge in measles outbreaks [8]. The objective of this paper is to provide a much-needed review and study of measles outbreaks in unvaccinated and partially vaccinated children and adults globally.

2. Methodology

An electronic literature search was performed using PubMed, Google Scholar, EBSCOhost, Mendeley, and MedLine Plus. The search was limited to peer-reviewed articles published between January 1, 2010, and September 14, 2020. An article was selected if it included keywords such as measles, partially vaccinated, unvaccinated, vaccine against measles-mumps-rubella (MMR), and disease outbreaks within North America and globally. Articles were reviewed and included based on the applicability to the topic.

3. Review of measles cases in the recent outbreaks

3.1 Measles outbreaks in the USA

The numbers of cases as illustrated in **Figure 1** are laboratory-confirmed cases as reported by the Centers for Disease Control and Prevention (CDC). The data were for cases from January 2010 to May 7, 2020; whereas the data for 2019 showed cases from December 30, 2018. The CDC noted there were 12 confirmed cases in the USA, as of August 19, 2020. The highest number of measles cases reported in the USA since 1992 was in 2019 with 1,282 confirmed cases overall from 31 states [9]. The World Health Organization (WHO) has also reported 12 cases of measles in 2020 and 1,282 in 2019 within the USA [10]. Of the 1,282 individual cases, 128 were hospitalized and 61 cases had complications such as encephalitis and pneumonia. All the identified cases were caused by the wild-type D8 and B3 of measles.

Furthermore, most cases (73 percent), were associated with the outbreak in New York State [9]. Specifically, cases reported in New York were seen among Orthodox Jewish communities in Brooklyn, Rockland, and Orange counties [11].

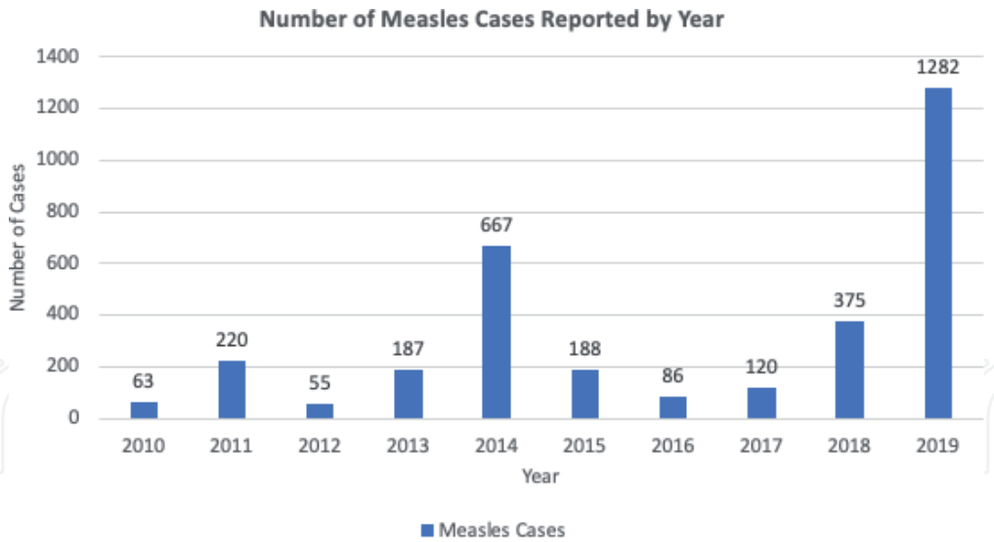

Figure 1.
The number of measles cases reported by year within the USA. Note: Data recreated and reported by the CDC, as of may 7, 2020 [9].

The neighboring state of New Jersey to date has no confirmed case of measles in 2020 but had 19 confirmed cases in 2019 [12]. Twelve of those cases were linked to the 2019 measles outbreak in Ocean County in individuals 5 to 51 years of age who were unvaccinated or had unknown vaccination status [13]. Moreover, on the West Coast during 2019, Washington State had two outbreaks of measles with a total of 86 cases. The first outbreak had 72 confirmed cases that contracted the disease between January and May 2019; whereas, the second outbreak in the state had 14 confirmed cases from May 9, 2019, through August 28, 2019, when the outbreak was declared over. This was the highest number of recorded cases seen in Washington State since 1990 [14].

Several factors contributed to the spread of measles in the USA. The most significant factor is measles infection in unvaccinated individuals, which then spread and caused outbreaks in communities throughout the USA among unvaccinated people [9]. Measles is still common globally and re-emerged in the USA when travelers who were infected with the virus brought the disease into the USA [15]. For example, in 2019, California had 73 confirmed cases, 41 of those cases were associated with six outbreaks. An outbreak is defined when there are three or more cases; hence, five of the six outbreaks were linked to patients exposed to international travelers who had measles [16].

3.2 Measles outbreaks in Canada

The number of confirmed measles cases in Canada in 2019 was 113 according to the Public Health Agency of Canada. **Figure 2** shows the measles rash onset per week from December 30, 2018, to December 28, 2019. The weeks are on the x-axis with a total of 52 weeks [17]. In contrast, there has been only one case of measles reported in Canada from December 29, 2019, until August 22, 2020 [18].

The 73 cases of measles in Canada were also genotyped and submitted to the National Microbiology Laboratory per the WHO guidelines in 2019. **Figure 3** shows the distribution of measles genotypes detected in 2019; genotype B3 (n = 20) and D8 (n = 53). Both genotypes are circulating globally [17]. The only case of measles infection in 2020 is of the genotype D8 [18].

The most significant factor for the spread of measles in Canada is when an unvaccinated visitor from an endemic area, or an unvaccinated Canadian returning

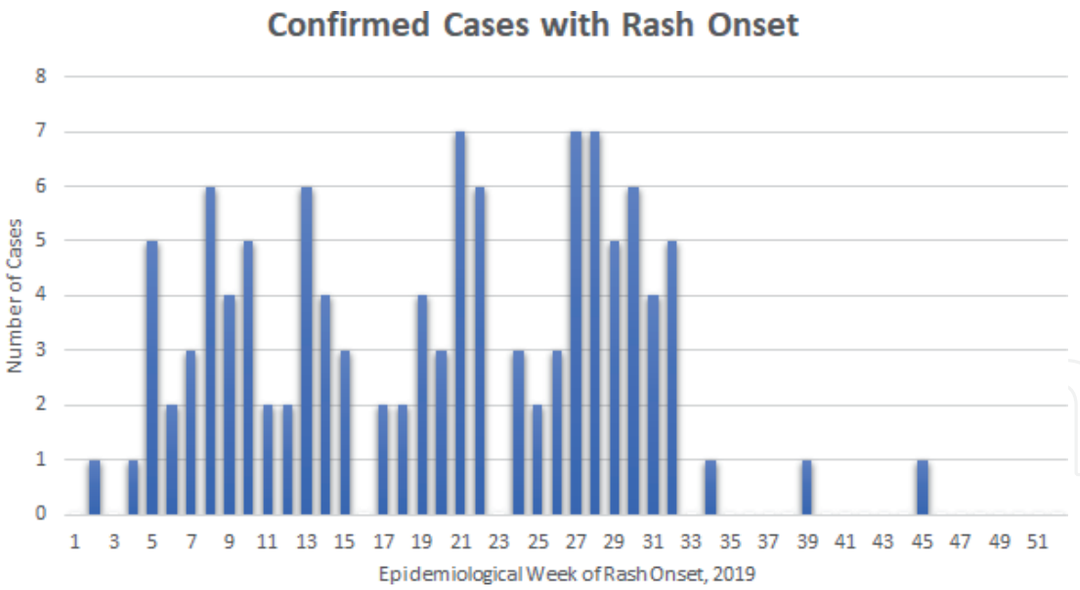

Figure 2.
The number of rash onset measles cases reported by weeks in 2019 within Canada. Note: Data recreated and reported by the Government of Canada, as of January 10, 2020 [17].

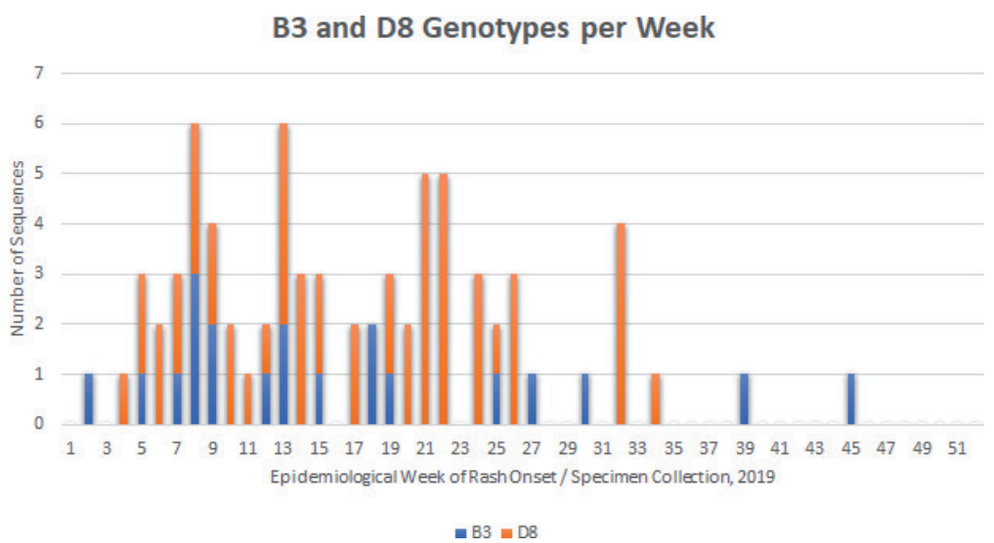

Figure 3.
The distribution of measles genotypes detected by weeks in 2019 based on rash onset in Canada. Note: Data recreated and reported by the Government of Canada, as of September 3, 2020 [17].

from such an area, imports the globally circulating measles genotype (B3, D8) into the country [19]. The stark contrast in the number of reported cases in 2020 speaks to this phenomenon. Due to an increased restriction on international travels to and from Canada, there has been a simultaneous decrease in reported cases of measles [20]. This trend is also seen in the USA where only 12 confirmed cases of measles were reported as of August 19, 2020, compared to 1,282 cases in 2019 [9].

Figure 4 shows a distribution of cases in the past in several areas according to the WHO reporting system for measles virus infection [10]. The highest confirmed years for Canada were seen in 2014, 2015, and 2019.

3.3 Measles outbreaks in the top affected countries

Although preventable, measles is a very contagious virus that is seen globally. As of September 9, 2020, the top ten countries with the highest cases of measles are as follows: DRC has 7,736 cases; Brazil follows with 6,241 cases; Nigeria is third with

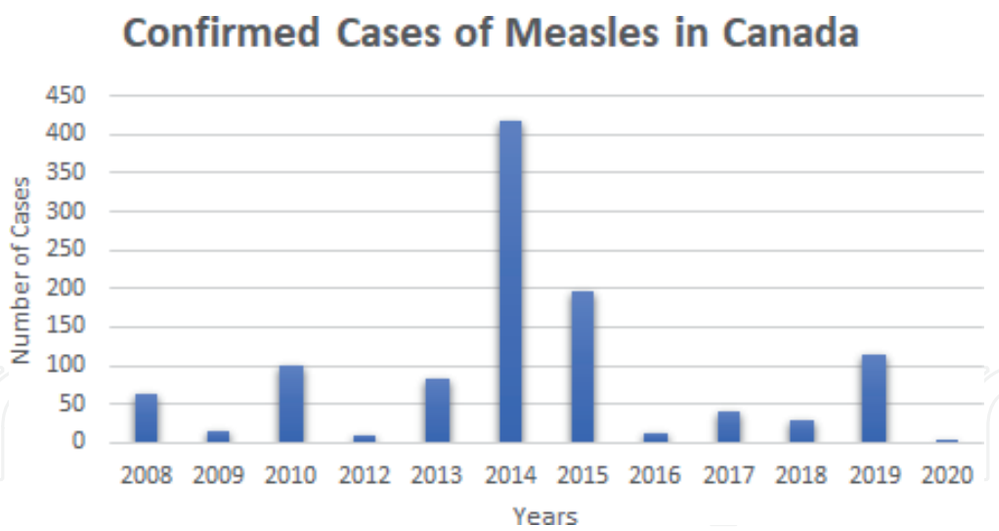

Figure 4.
Numbers of reported cases by year in Canada. Note: Data recreated and reported by WHO, as of September 9, 2020 [10].

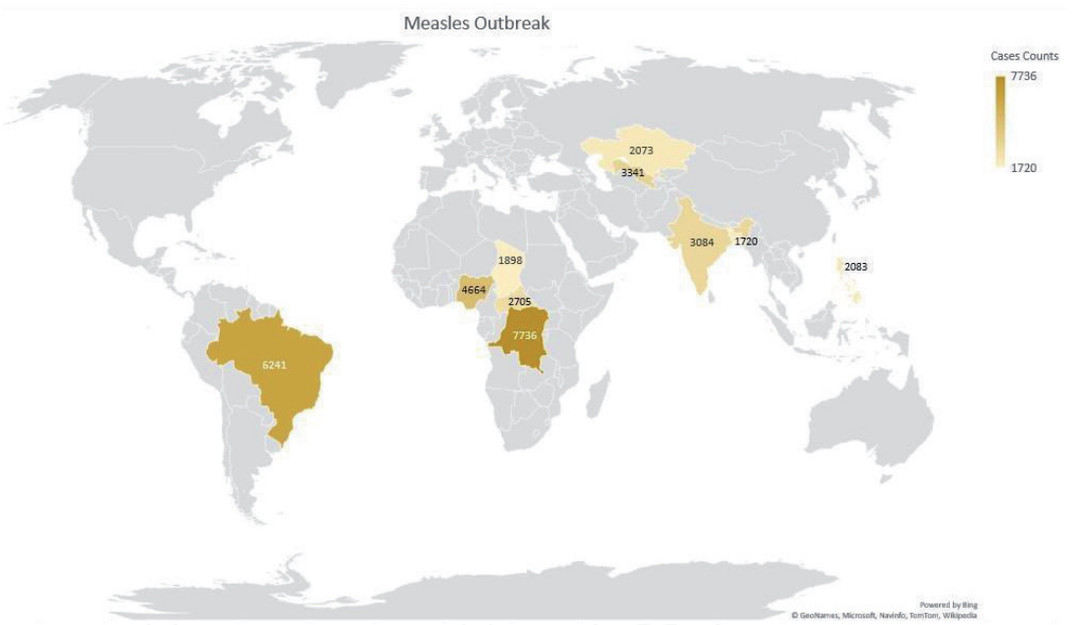

Figure 5.
Map depicting the case counts of measles in the top ten countries globally, as of September 9, 2020. Note: Data recreated and reported by the CDC [21].

4,664 cases; Uzbekistan (3,341); India (3,084); Central Africa Republic (2,705); Philippines (2,083); Kazakhstan (2,073); Chad (1,898); and lastly Bangladesh with 1,720 cases, as shown in **Figures 5** and **6** [21].

The DRC is currently the country with the highest measles cases and casualties. Prevalence is undeterred by the actions of the government and international aid agencies. This is mainly due to the lack of funding for vaccination, as well as poor vaccination coverage in certain socio-demographic areas due to weak public health system and insecurity [22]. In addition, outbreak of other epidemic prone diseases is occurring concurrently which diverted the resources needed to fight the measles outbreak [22].

In 2016, the Americas announced the eradication of measles, with imported virus resulting in isolated cases. However, at the beginning of 2018 measles was re-introduced to the Americas following a case from Venezuela that secondarily impacted Brazil [23]. Since then, Brazil has seen an increase in cases.

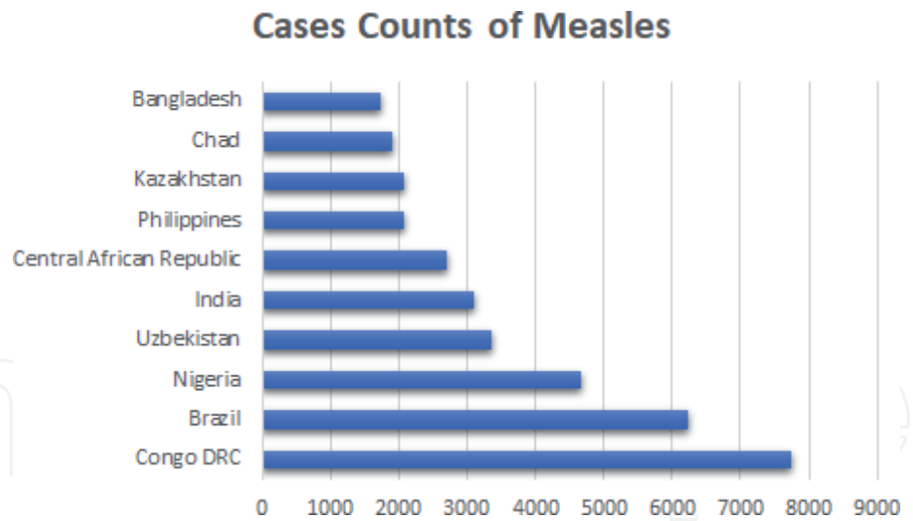

Figure 6.
Case counts of measles in the top ten affected countries globally, as of September 9, 2020. Note: Data recreated and reported by the CDC [21].

Nigeria first experienced a rise in cases beginning in 2019, which has not stopped to date. This has occurred despite the activation of the National Measles Emergency Operations Centre and the deployment of multi-disciplinary Rapid Response Teams [24]. Efforts to contain the spread of the outbreak has resulted to multiple reactive vaccination campaigns, deployment of multi-disciplinary Rapid Response Teams, intensification of surveillance activities and laboratory diagnostics as well as review of treatment protocols [24].

4. Discussion

In the year 2000, for more than twelve consecutive months, the USA did not have a single transmission of the measles virus [25]. This public health accomplishment was celebrated until recently, with measles making a comeback globally even in places where the virus had been eradicated. In 2019, the highest number of cases since 1992 was reported in the USA with 1,282 confirmed cases [9]. Outbreaks of measles can be triggered by travel into unvaccinated and/or under-vaccinated populations by infected persons. In certain parts of the USA, many areas have vaccination rates below 90 percent, and these areas experience an increase in measles transmission [26]. These outbreaks are seen mostly in densely populated areas and states, such as in New York or California. In general, the probability of contracting measles is 90 percent in those who are exposed and unvaccinated [25]. This cascade can continue to proliferate in tight-knit communities resulting in an outbreak.

In Canada, the method of measles transmission is concordant with the USA. In 2019, there were 113 confirmed measles cases in Canada. Although the number is significantly lower than in the USA, the transmission mechanism was identical; unvaccinated visitors from countries that have high measles infection rates, or unvaccinated Canadian citizens visiting those countries help to spread the disease [19]. It was also noted that outbreaks were linked to economic migrants who were from endemic areas for measles coming into Canada [15].

On a global scale, a high number of measles cases have been seen in countries where vaccination is not readily available and medical care is scarce. Most cases are seen in the DRC where over 7,000 cases have been recorded [21]. Other third-world countries with high proportions of socio-economic disparities are also in the same

situation. Without high rates of vaccination and availability of medical care, the transmission of measles along with the associated mortality will increase.

In 2019, there were more measles cases reported globally than in any year since 2006, as indicated by WHO. More than 180 countries were affected and over 500,000 confirmed cases of measles were reported. More specifically, the top three countries in terms of the number of confirmed measles cases are the DRC, Brazil, and Nigeria [21].

Once a person is exposed to measles, he/she will develop symptoms of fever, cough, coryza, and conjunctivitis. The last to appear is the rash, which can present 14 days after inoculation with the virus [9]. Once infected, there is no specific treatment for the disease and symptomatic care is the mainstay of treatment. Vitamin A has been shown to decrease the severity of measles. In a study conducted to assess the effectiveness of vitamin A, it was found that at least two doses of 200,000 IU vitamin A in children greater than 1-year old, decreased the mortality by 62 percent [27]. Since there is no treatment and infection with the disease can result in life-threatening complications, post-exposure prophylaxis is imperative when someone has an unknown immunity status. The CDC recommends that those who cannot provide evidence of immunity, either by vaccination paperwork or titers, should be offered the MMR vaccine within 72 hours of exposure or given immunoglobulin (IG) within six days of exposure. However, both should not be given together [9].

Ultimately, vaccination against the measles virus is the greatest defense against the disease. From 2000 to 2017, an estimated 21 million deaths were prevented with the measles vaccination [28]. The measles vaccine is often combined with mumps and rubella vaccines and given as a combined trivalent vaccine [29]. Millions of doses of the MMR vaccine have been given and have proven to be safe and effective with minimal adverse effects, such as mild fever or rash [30]. The vaccine should be given to children in two doses to attain maximum efficacy. The first dose of the MMR vaccine given at 12 months will result in the production of antibodies in 96 percent of the recipients, with the rest responding to the second dose, and the efficacy rate of the vaccine in preventing measles is greater than 99 percent [29].

In 2010, the World Health Assembly set three milestones for Measles Prevention that were to be achieved by 2015. The milestones were to increase coverage of measles vaccines to greater than 90 percent in children 1-year old on a national level, decrease the annual incidence of measles to less than five cases per million of the population, and to reduce the overall global mortality rate by 95 percent [28]. Even though great strides have been made, and mortality has decreased, these 2015 global milestones have not been reached [28]. Although vaccination is a clear method to prevent the spread of measles, many barriers limit mass vaccination globally.

Currently, in 2020, the rampant spread of COVID-19 has resulted in many countries placing travel restrictions and essentially halting the global travel industry. This has led to a substantial decrease in cases of measles globally. In the USA, 12 cases have been reported and one in Canada this year. In a study designed to trace the global transmission dynamics of the measles virus, it was concluded that the disease can spread not just within a given region, but also between regions that have huge distance in between them, given the massive number of travelers between those regions [31]. However, continuing restrictions as a method of control for measles is neither feasible nor reasonable.

Furthermore, specific populations and their ideology against vaccination become another barrier to the eradication of diseases such as measles. The anti-vaccination movements are fueled by claims, such as those in the 1990s suggesting that the MMR vaccine was linked to autism [26]. Even though many studies have disproved these claims, there is still strong opposition to vaccination. Also, many groups cite religious obligations as their reason for refusal of vaccination. These

groups specifically state that the rubella component of the trivalent MMR vaccine was originally derived from the cells of aborted fetuses [32]. Ultimately, these challenges need to be overcome. Public health organizations and populations against vaccination, irrespective of their reason, need to dialog for the benefit of society as a whole. By doing so, further strides can be achieved in the global fight against measles, resulting in the preservation of life and preventing complications associated with measles.

5. Conclusion

As shown in this review, the incidence of increased risk of the measles infection correlates with an increase in the proportion of unvaccinated individuals, especially in children 18 years of age and younger, those with certain religious beliefs opposing vaccinations, and those who reside in underprivileged nations. It is imperative to educate the general population on the importance of vaccination and to offer immunization to the underprivileged nations at very low or no cost, to aid in the direction of eradication of this virus. The general public's distrust of vaccines needs to be met with medically backed information that allows citizens of every nation to make better-informed decisions. In Canada and the USA, most measles cases were associated with unvaccinated individuals. In most daycares and schools, in the USA and Canada, vaccination against measles is generally required for children. It can be concluded from statistical data, that the measles vaccine has shown compelling evidence towards decreasing the prevalence of this disease. Individuals who are at higher risk such as university students, healthcare workers, and individuals who travel regularly should be vaccinated to achieve meaningful success. Ultimately, vaccines reduce disease burden by directly protecting the vaccinee and by indirectly protecting the non-immune population, and through identifying these positive impacts, the giant stride towards eradicating measles and other vaccine-preventable diseases can be replicated on a global scale.

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