EPIDEMIOLOGICAL CHARACTERISTICS, VACCINATION COVERAGE AND FACTORS ASSOCIATED WITH MEASLES INFECTION IN SIERRA LEONE FROM 2017 TO 2021; CASE BASED SURVEILLANCE DATA

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ABSTRACT

Despite the availability of safe and effective vaccines, measles outbreaks continue to occur in Sierra Leone. There is still limited information on the epidemiological pattern and vaccination coverage of measles in the country. This research aims at describing the epidemiological characteristics, vaccination coverage and identify factors associated with measles infection. We employed a cross-sectional study to analyze measles secondary data generated from 2017 to 2021. We extracted data on measles-containing vaccine (MCV) coverage and dropout. We analyzed the spatial distribution of measles cases by person, place, and time, calculated incidence, MCV coverage, and drop-out rate. Statistical analyses were performed using Epi Info 7. A multiple logistic regression model was used to calculate adjusted odds ratio (aOR) with a 95% Confidence Interval (CI) to assess factors associated with measles infection. Results showed that a total of 1,305 suspected measles cases were reported. Of the total, 1,133 were confirmed as measles cases, of which 270 (24%) were IgM positive and 863 (76%) were Epi linked or clinically confirmed. The mean age was 3.9-year 4.5 SD. Of the total confirmed measles cases, 575 (51%) were between 1 to 4 years, females accounted for 580 (51%) and 699 (62%) were not vaccinated. Non-border districts accounted for 54% (614) measles cases. The national measles incidence per 100,000 population was 203.8 in 2017 and 26.9 in 2021. The MCV1 national coverage ranged from 243,525/269,981 (90%) in 2017 to 238,505/307,022 78% in 2021, with the highest coverage in 2019, which is 266,684/284,452 (94%) and the lowest coverage in 2021 (78%). Children less than 5years old (aOR 2.28, 95% CI: 1.56 to 3.33), not vaccinated (aOR 3.42, 95% CI: 2.41 to 4.86), and border districts (aOR 0.37, 95% CI: 0.26 to 0.53) are factors associated with measles infection. We observed a high measles incidence rate in 2017. The country did not meet its national target for MCV-1 and MCV-2 in all years under study Children under five, those living in border districts, and unvaccinated individuals were more likely to contract measles. We recommend strengthening routing and supplementary immunization campaigns, prioritizing outreach services, and heightening social mobilization activities.

Keywords: Measles, Measles-Containing-Vaccine (MCV), factors of measles infection, Sierra Leone.

INTRODUCTION

Measles remains one of the leading causes of morbidity and mortality among young children. Unvaccinated children are at the highest risk of catching measles and its consequences, can be fatal. In addition, unvaccinated Pregnant women are at also at risk of been infected with the measles virus. Anyone who isn't immune (either because they haven't been vaccinated or because they have been vaccinated but haven't gained immunity) are also susceptible to measles infection (CDC-US, 2022; Mayo Clinic, 2022). According to the World Health Organization (WHO), the global measles burden in 2021 was estimated to be 140,000 cases; up from 66,000 cases in 2020. This increase was due to a number of factors, including declining vaccination rates, conflict, and population movements (Kaur, 2023).

In 2022, the global measles burden was estimated to be 240,000 cases, and the burden in 2023 is estimated to be 300,000 cases. This projected increase is due to the continued decline in vaccination rates, as well as the emergence of new and more virulent strains of the virus (Kaur, 2023; UNICEF, 2023). Most measles cases in 2021, 2022, and 2023 occur in low- and middle-income countries. This is because vaccination rates in these countries are often lower than in high-income countries (Kaur, 2023). The safe and effective measles vaccine has been recommended for use all over the world since 1974. Despite this, measles remains a major public health threat, with millions of cases reported each year (Kaur, 2023; WHO, 2023).

In 2021, there were an estimated 128,000 measles deaths and most of them were among children less than 5 years. More than 99% of measles cases and deaths occurred in low- and middle-income countries. This represents a significant increase compared to 2020 when there were an estimated 66,000 measles deaths and 9 million cases (Kaur, 2023; WHO, 2023). In 2022, there were an estimated 150,000 measles deaths globally and majority of these deaths occurred in low- and middle-income countries (Kaur, 2023).

The World Health Organization (WHO) recommends that all children receive at least two doses of the measles vaccine. The first dose should be given at 9-12 months of age, and the second dose should be given at 15-18 months of age (Kaur, 2023). Between January and March 2022, an estimated 17,500 measles cases were reported in the African continent, which was a 400% increase from the same period in 2021. In the first quarter of 2022 measles outbreaks were reported in 20 African nations, eight more than in the corresponding period in 2021(WHO, 2022). The measles vaccine is one of the most successful global public health interventions because it has significantly reduced the incidence of measles virus infection and averted millions of deaths annually, mostly in infants and young children (Moss, 2017).

Sierra Leone has adopted the global and African measles control strategies, including routine immunization for infants at nine months, supplementary immunization for children aged 9 months to 14 years, and measles surveillance with laboratory confirmation in all districts. Despite these efforts, measles outbreak

continues to occur throughout Sierra Leone. In 2016 a measles outbreak was reported, with 977 suspected cases and more than 64 of these cases were laboratory-confirmed. This outbreak occurred in multiple districts (Western Area, Bo, Koinadugu, Bombali, Kenema, and Kambia) and most of the affected individuals were age under 15 years of which 68% of them were age under 5 years. Measles is one of the immediately reportable diseases in Sierra Leone and its surveillance in most times is passive but can be easily shifted to active surveillance when there is a measles outbreak.

Currently, there is a lack of comprehensive scientific analysis regarding the epidemiological landscape of measles and vaccination coverage in Sierra Leone.

In response, this study aims at meticulously delineating the epidemiological characteristics, assess vaccination coverage, and pinpoint potential risk factors associated with measles cases. This endeavor is crucial for a thorough understanding of the disease epidemiology providing an opportunity to formulate evidence-based policies that can significantly contribute to the reduction of measles cases in Sierra Leone.

METHODS
Study design
A retrospective cross-sectional study was employed from 2017 to 2021.

Study setting
Sierra Leone, located on the west coast of Africa and bordered by Guinea and Liberia, has a diverse landscape of coastal plains, rolling hills, and inland plateaus. Covering approximately 71,740 square kilometers, the country is divided into five regions Western Area, Northern, Eastern, Southern, and North Western comprising 16 districts, eight of which border neighboring countries. Known for its rich mineral deposits, particularly in the Eastern Region. Sierra Leone also boasts significant agricultural activities across its regions, including rice, cassava, and groundnuts in the Northern Region, and cocoa, coffee, and palm oil in the Southern Region. The Western Area, which includes the capital city Freetown, is the most urbanized with an estimated population of 8,987,427 (Worldometer, 2024) and serves as the administrative, financial, and educational hub. Sierra Leone has a predominantly young population, with a large proportion under the age of 15. This demographic, coupled with the aftermath of an 11-year civil war (1991-2002) and the Ebola outbreak (2014-2016) has heavily strained the country's health infrastructure. The healthcare system faces numerous challenges, including limited facilities, a shortage of trained workers, and inadequate supplies of essential medicines. The dual burden of communicable and non-communicable diseases high maternal and infant mortality rates, and the impacts of historical conflicts highlight the urgent need for robust health interventions and surveillance systems. Despite these challenges, the country has implemented global and regional health strategies, such as routine immunizations and supplementary immunization campaigns, although outbreaks like measles continue to pose significant public health threats (Evans, Goldstein and Popova, 2015).

Description of the measles surveillance system in Sierra Leone

The measles surveillance system in Sierra Leone is integral to the national health surveillance framework, focusing on rapid detection, reporting, investigation, and response to measles cases. Community Health Workers (CHWs) and Port Health Officers use case definitions and guidelines to identify suspected cases, reporting them to health facilities and the Ministry of Health and Sanitation (MoHS). The Integrated Disease Surveillance and Response (IDSR) system supports data collection and management, utilizing electronic platforms like the District Health Information System 2 (DHIS2) through the electronic case base disease surveillance (eCDBS) are employed for real-time data entry and management, facilitating efficient data aggregation, analysis, and national-level reporting. When suspected measles cases arise, District Surveillance Officers request sample collection from laboratory technicians. These samples are sent to the Central Public Health Reference Laboratory, when results are out, they are shared within two weeks. Routine data analysis helps monitor trends and evaluate immunization programs. Rapid response teams conduct field investigations upon detecting case clusters. Surveillance data feedback is provided regularly through various channels. Sierra Leone collaborates with WHO and UNICEF, reporting measles data as per international health regulations. Control measures include targeted immunization campaigns, supplementary immunization activities (SIAs), public health interventions, and community engagement. Despite challenges like geographical barriers and resource constraints, the system's strengths are its integrated approach, community involvement, and real-time data capabilities, ensuring effective measles outbreak responses.

Measles case definition

A Suspected Measles case is defined as any person with fever and maculopapular (non-vesicular) generalized rash and cough, coryza or conjunctivitis (red eyes), or any person in whom the clinician suspects measles.

A confirmed measles case is defined as a suspected case with laboratory confirmation (positive IgM antibody in serologic test) or the use of Epidemiological link in which a suspected measles case that has not had a blood specimen taken for serologic confirmation and is linked to a laboratory confirm case by person place and time is used to confirmed cases in an outbreak. And an epidemiologically linked measles case is a suspected measles case that has not had a blood specimen taken for serologic confirmation and is linked to a laboratory confirm case by person place and time.

Data collection

Data for this study were collected through a comprehensive approach, utilizing both case-based investigation forms and the national Expanded Program on Immunization (EPI) database. The primary data source was the measles case-based surveillance system, which includes detailed investigation forms completed for each suspected measles case. These forms provided information on demographic details, clinical symptoms, vaccination status (whether individuals received the first and second doses of the measles-containing vaccine ([MCV-1 and MCV-2]), and potential sources of infection.

Additionally, we extracted data on MCV coverage and dropout rates from the national EPI database. This database includes aggregated vaccination coverage data at both national and district levels, distinguishing between border districts (those sharing borders with neighboring countries) and non-border districts. The EPI database also provided annual data on the number of children receiving MCV-1 and MCV-2, which was used to calculate coverage percentages and dropout rates over the five-year study period (2017-2021). By using both sources, we ensured a robust analysis of measles incidence, vaccination coverage, and factors associated with measles infection.

Data Management and Analysis

Data was extracted and entered using MS Excel 2016, while data cleaning was performed using Epi Info 7.2 to ensure data quality and consistency. The dataset included variables such as demographic information (age, gender), vaccination status (partially vaccinated, fully vaccinated, and not vaccinated), geographical information (border or non-border district), and measles case details (suspected and confirmed cases, laboratory confirmation status, and epidemiological links). Data cleaning was performed to check for possible duplication of records. Cumulative incidence for the five years was calculated per 100,000 population by district using district average population, while the national yearly incidence rate was calculated using each year's National Health Service Delivery projected population from the Directorate of Policy Planning and Implementation (DPPI). QGIS 3.24.0 was used to create maps to present the spatial cumulative measles incidence by place. For statistical analysis, we used univariate, bivariate, and multivariate methods with Epi Info 7.2. Bivariate analysis identified variables associated with measles infection, employing a cut-off point of $p < 0.2$ to select variables for inclusion in the multivariate analysis. The outcome variable was measles infection, with independent variables including demographic information and vaccination status. Adjusted odds ratios (aOR) with 95% confidence intervals (CI) were calculated to identify factors independently associated with measles infection. Variables with p-values < 0.05 were considered significant, providing insights into the epidemiological characteristics and vaccination coverage related to measles in Sierra Leone.

Ethical consideration

Permission to conduct this study was obtained from the Ministry of Health. No personally identifiable information was disclosed in public and participant's information was confidentiality maintained.

RESULTS

A total of 1,305 suspected measles cases were reported by the case-based surveillance system, and 1,133 were classified as confirmed measles, of which 270/1,133 (24%) were IgM positive and 863/1,133 (76%) were Epidemiological linked or clinically confirmed. The mean age was 3.9 years with a standard deviation of ±4.5. Five hundred and seventy-five (51%) of the total measles cases were between 1 to 4 years, 206/1,133 (18%) were 5 to 9 years while 28/1,133 (2%) were at age 15 years and above and females accounted for

580/1,133 (51%). A total of 614/1133 (54%) measles cases were reported from non-border districts, and 434/1133 (38%) received at least one dose of measles containing vaccine and 699/1,133 (62%) cases did not receive any dose of the vaccine.

For those vaccinated, 274/434 (63%) were aged between 1 to 4 years, 111/434 (26%) were aged between 5 to 9 years, 8/434 (2%) were 15 years and above and 17/434 (4%) were less than 9 months old. For measles cases that were not vaccinated, 301/699 (43%) were aged1 to 4 years, 131/699 (19%) were aged 5 to 9 years, 55/699 (8%) were less than 9 months old and 23/699 (3%) were aged15 years and above. (Table 1). From 2017 to 2021, the national MCV1 coverage ranged from 243,525/269,981 (90%) in 2017 to 238,505/307,022 (78%) in 2021, with the highest coverage in 2019, which was 266,684/284,452 (94%) and the lowest coverage in 2021 (78%). The National MCV2 Coverage ranges from 22% (221,302/269,981) in 2017 to 60% (183,948/307,022) in 2021, with the highest coverage in 2019 which was 73% (208,720/284,452). (Table 3).

The highest MCV dropout (76%) was observed in 2017 and the lowest MCV dropout (22%) was in 2019. (Figure 1)

The MCV-1 Coverage in Non-Border Districts was 93% in 2017, 87% in 2018, 98% in 2019, 89% in 2020, and 88% in 2021, respectively. The MCV-1 in the border districts was 85% in 2017, 83% in 2018, 88% in 2019, 83% in 2020, and 81% in 2021, respectively. The MCV dropout for non-Border was 74% in 2017, 28% in 2018, 23% in 2019, 23% in 2020, and 24% in 2021, respectively. The MCV dropout for Border districts was 71% in 2017, 23% in 2018,

21% in 2019, 21% in 2020, and 21% in 2021. (Figure 2).

At the multivariate level, cases aged 5 years and below had two times odds of measles infection in comparison to other age groups and it was statistically significant (aOR 2.3 (95% CI: 1.56 to 3.33). additionally, border districts had 0.4 odds to get measles infection in comparison to non-border districts (OR 0.4 (95% CI: 0.26 to 0.53). Cases not vaccinated with the measles vaccine had three times odds to get measles infection compared to those (aOR 3.4 (95% CI: 2.41 to 4.86) times more as compared to those who were vaccinated. (Table 2).

DISCUSSIONS

This study assessed the magnitude, vaccination status, and factors associated with measles infection in Sierra Leone. Our finding indicated that measles is still endemic in the country and a greater proportion of measles cases were reported among the age group below four years. This endemicity might be likely because of the low measles vaccination coverage, particularly among the vulnerable population. Evidence showed that community with low measles vaccination coverage is at high risk for measles outbreaks (van den Hof et al., 2001).

We observed a high annual national measles incidence, particularly in 2017 and 2018. This high Measles incidence could be attributed to the high measles vaccination dropout as all districts were not able to meet the measles containing vaccination target during the study period. In our study, the highest incidence of measles was observed in 2017. This could be likely due to the fragile health system attributed to mobilization of huge resources directed towards the fight against the 2014-

2016 Ebola outbreak in the country, which weakened the response to notifiable diseases. As a result of Ebola outbreak, children experienced a gap on vaccination schedule as routine immunization decreased by 30% (The Centers for Disease Control and Prevention, 2019). A study conducted in Nigeria from 2008 to 2018 found that as routine immunization activities included strengthened, the annual incidence of measles decreased showing the importance of intensifying measles vaccination activities (Jean Baptiste et al., 2021). Also, a study conducted in Liberia post Ebola-Epidemic 2016-2017 indicated that prioritizing routine immunization services and heightening supplementary measles immunization campaigns was key to reducing measles cases among vulnerable age groups (Nagbe et al., 2019). A study conducted in sub-Saharan Africa found that areas with low vaccination coverage had more measles cases than areas with high vaccination coverage (Brownwright, Dodson and van Panhuis, 2017). This aligns with our study, which similarly found that the high incidence of measles in Sierra Leone is linked to low vaccination coverage, particularly among vulnerable populations.

For the five years under study, Sierra Leone was unable to reach its national target for measles-containing vaccine (MCV) coverage for both MCV1 and MCV2. This could be likely attributed to a high measles-containing vaccine dropout which was observed throughout the study. The country was not able to meet the recommended World Health Organization (WHO) target for dropouts which is at least 10%. This could be likely due to forgetfulness because of long time gap between the first dose and second dose of measles vaccine.

Not much difference was observed in measles-containing vaccine one, measles-containing vaccine two, and measles-containing vaccine dropout between the border and non-border districts. This could be because most districts in Sierra Leone share similar characteristics such as vaccine coverage, the status of the cold chain system, access to health care, and poor road network.

Our finding indicated that being unvaccinated was associated with measles infection. This finding is in line with a study conducted in Ethiopia where being unvaccinated was a risk factor for the measles outbreak (Tsegaye et al., 2022). Other studies have also found out that not being vaccinated is a key risk factor for measles infection. This is also in line with a study conducted in the Oromia region, Ethiopia, which also reported that children aged 1-5 years remain at high risk for contracting measles in the region while the epidemiology of laboratory confirmed measles in southern nations also found that children within the age range from one to four years were the most affected age group with measles infection (Getahun et al., 2017, pp. 2007–2014; Girmay and Dadi, 2019). In addition, a study conducted in Indonesia found that being unvaccinated was associated with the measles outbreak in the country (Sitepu et al., 2020). Our findings that children aged five and below are associated with a higher risk of measles infection are consistent with similar studies conducted globally. In Israel, the United States, and the UK, the age group of one to four years has been identified as the most at-risk for measles (Fiebelkorn et al., 2017; Keenan et al., 2017; Bassal et al., 2021) Likewise, in Ethiopia, children aged one to four years were found to

be the most affected by measles A study in Japan also reported a higher proportion of measles cases in this same age group (Inaida, Matsuno and Kobune, 2017).

These studies corroborate our findings and highlight the global trend of increased measles susceptibility among young children. The strength of our research lies in its focus on Sierra Leone, adding regional specificity to the understanding of measles epidemiology.

Limitations of this study included the possibility of missing some data as we extracted our data from the electronic case base surveillance which was introduced in the Sierra Leone health system in late 2019. In order to access 2017 and 2018 data for 2017, and 2018, we extracted the data from the paper case-based surveillance system. However, surveillance data generated during this period were crosschecked with available paper case base surveillance data for all the districts for verification of the total number of cases to check for key missing variables.

CONCLUSION

A higher proportion of measles cases were reported among children under the age of five years. Also, the country recorded a high national annual measles incidence in 2019 and 2018, and Koinadugu and Falaba were the districts with the highest cumulative incidence. The country did not reach its national target for measles MCV-1 and MCV-2 during the study period. There was a slight difference in the vaccine coverage between border and non-border districts. Not being vaccinated against measles and being under the age of five were identified as factors associated with measles infection. We recommend prioritizing outreach

service, strengthening routing, and supplementary immunization activities targeting all children in all districts of Sierra Leone. Also, to initiate health education and health promotion campaigns using different media platforms.

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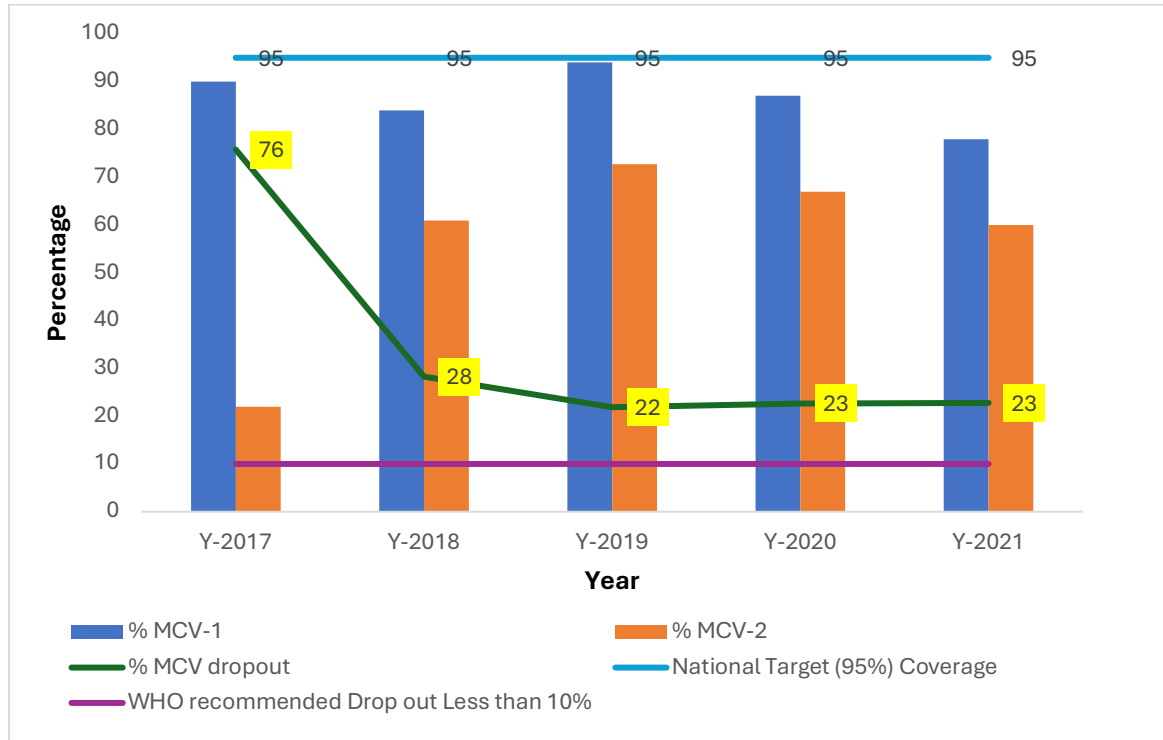
Figures and Tables

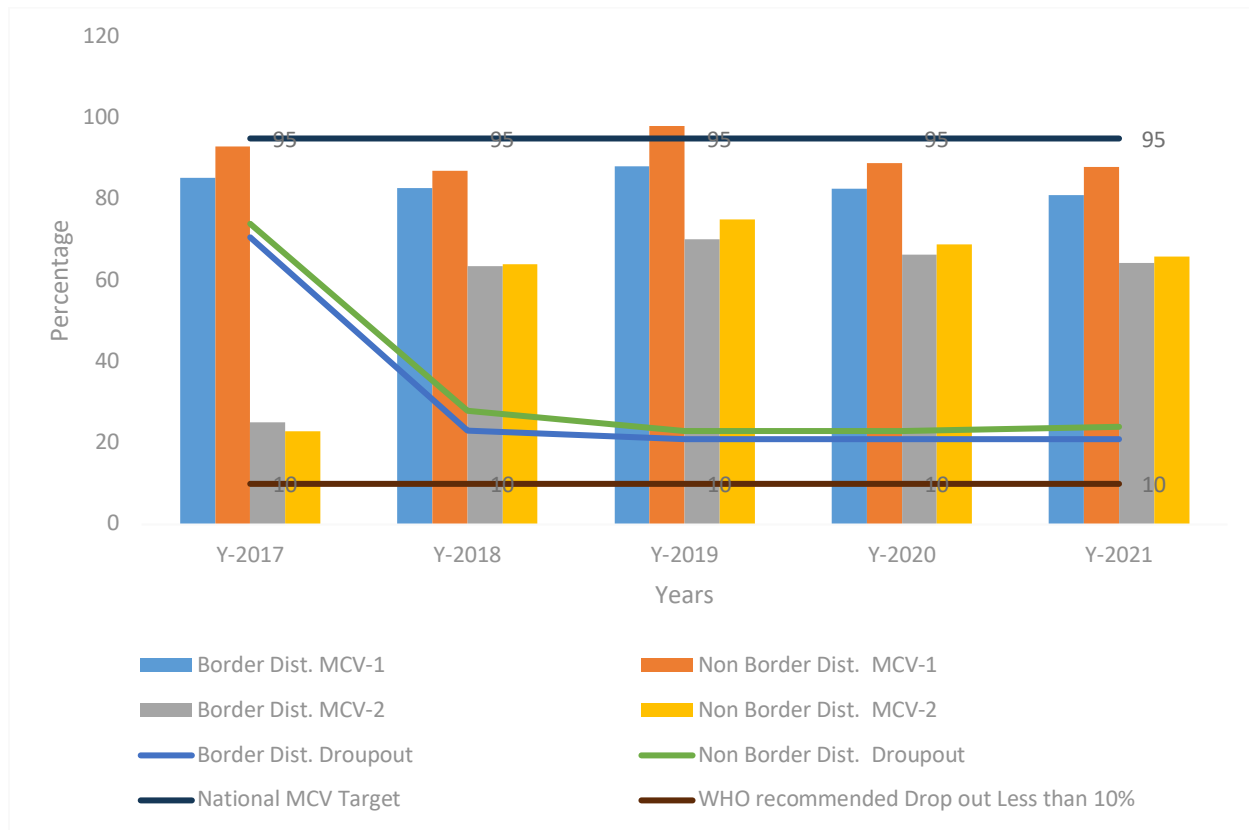**Figure 1: Yearly Percentage Measles Vaccine (MCV-1, MCV-2) and Dropout, Sierra Leone, 2017 - 2021.**

Figure 2: Yearly Percentage Measles Vaccine (MCV-1, MCV-2) Coverage and Dropout, Between Border and Non-Border Districts, Sierra Leone, 2017 - 2021
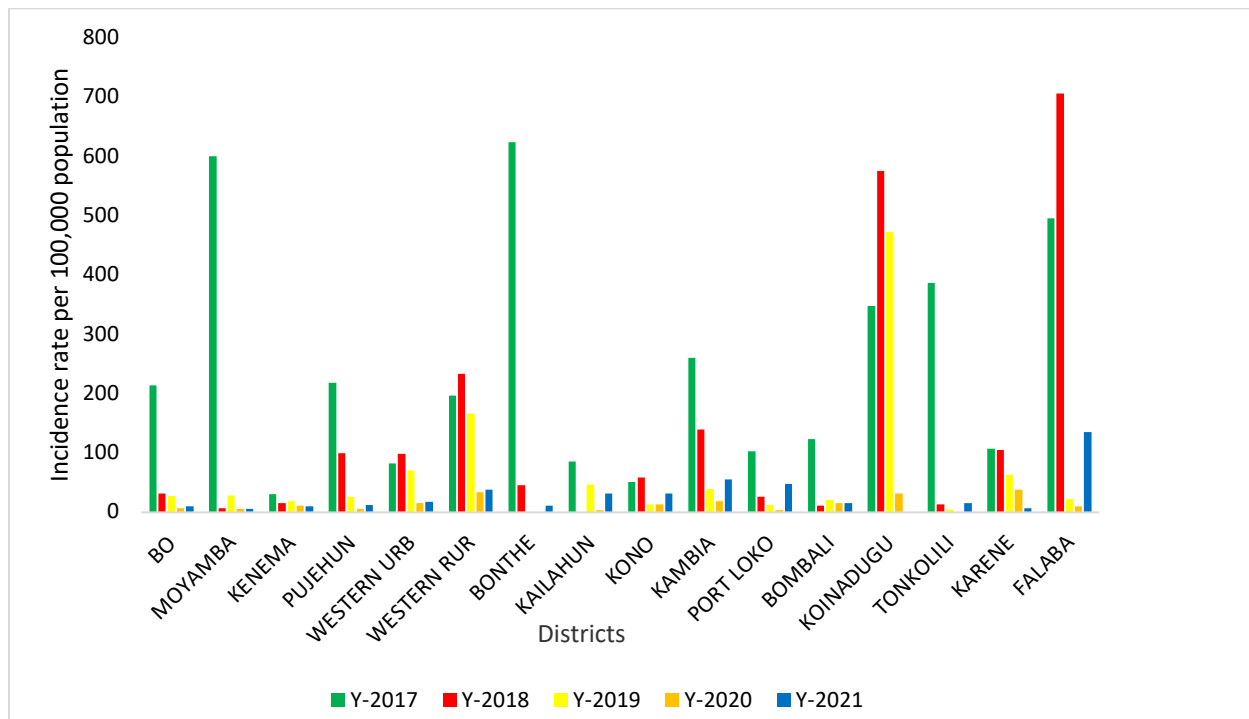
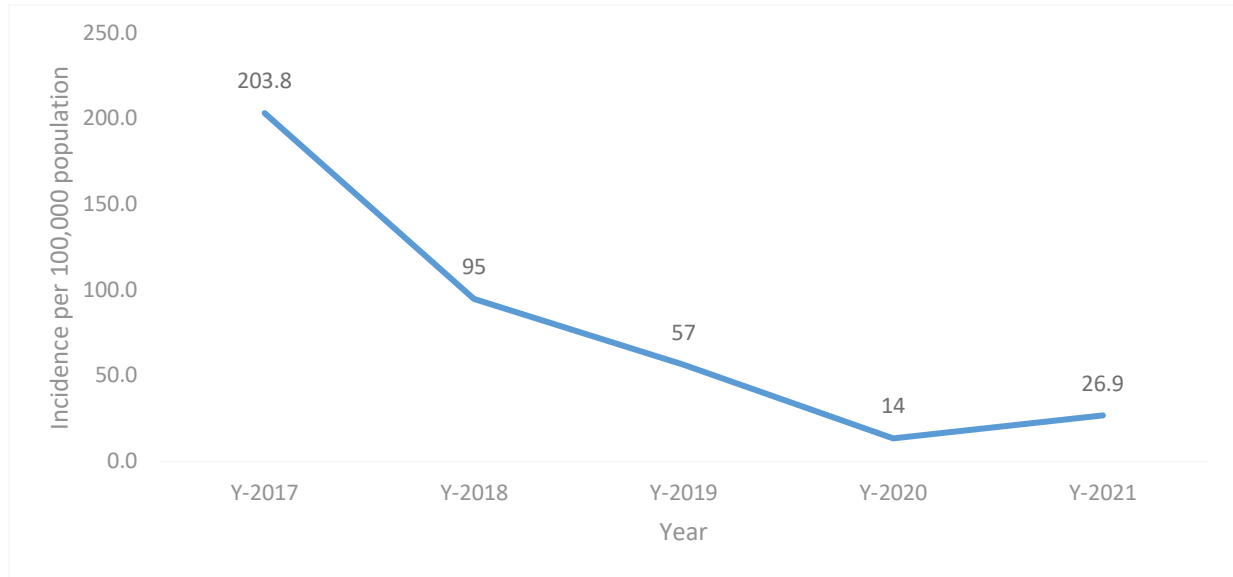**Figure 3: District Measles Incidence rate for Sierra Leone, 2017 - 2021**

Figure 4: Yearly Incidence Rate of Measles Cases, Sierra Leone, 2017 - 2021
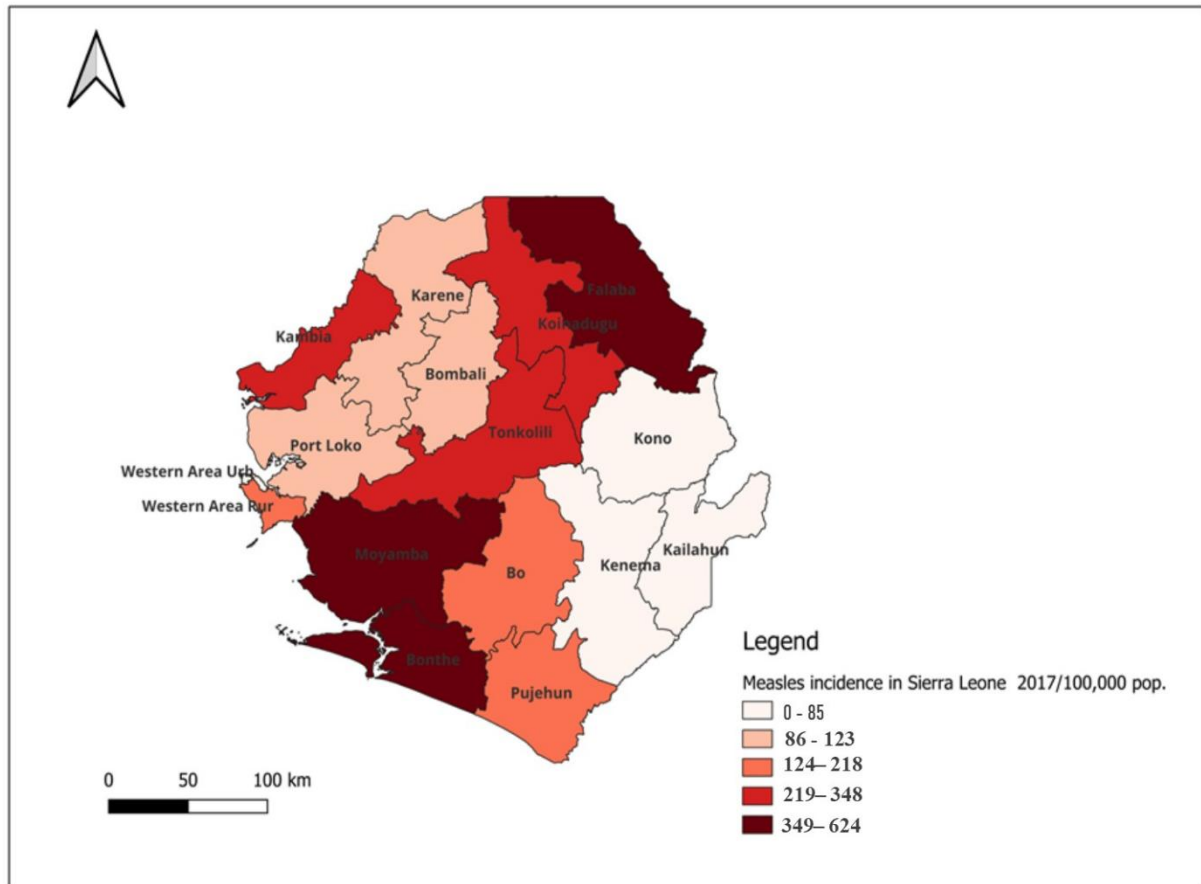
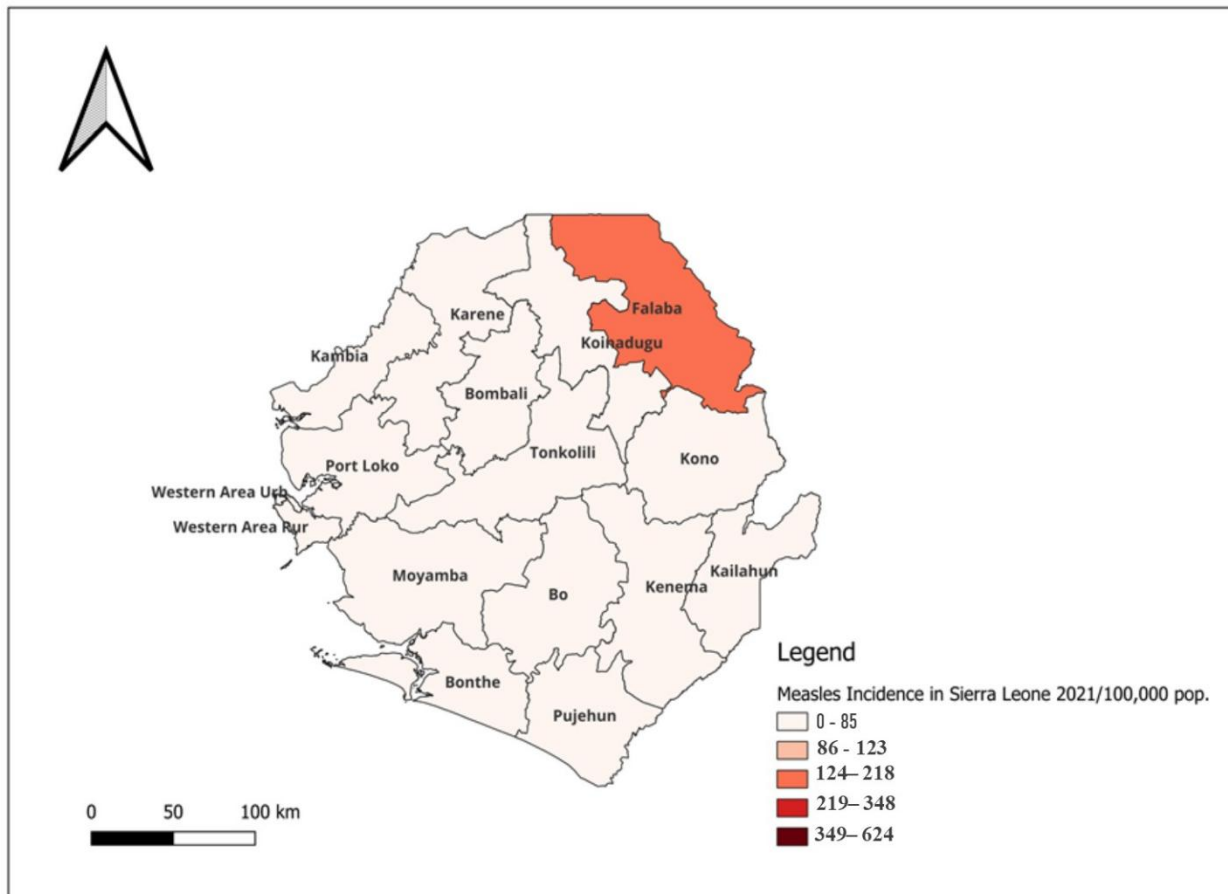**Figure 5: Incidence Rate of Measles by Districts in Sierra Leone, 2017**

Figure 6: Incidence Rate of Measles by Districts in Sierra Leone, 2021

Table 1: Vaccinated and Not Vaccinated Measles Cases by Age Category, Sierra Leone, 2017 - 2021.

	Vaccinated		Not Vaccinated	
Age Category	**Frequency**	**Percent**	**Frequency**	**Percent**
Less than 9 months	17	4	55	8
9-11 months	3	1	164	23
1-4 years	274	63	301	43
5-9 years	111	26	131	19
10-14 years	21	5	26	4
15 and above	8	2	23	3
TOTAL	**434**	**100**	**699**	**100**

Table 2: Bivariate and Multivariate Analysis on Factors Predisposing to Measles, Sierra Leone, 2017 – 2021.

Independent variables	Outcome		cOR	aOR	95% C.I	p-value
	Measles	**Non-Measles**				
Age						
Age 5 and below	970	115	**2.95**	**2.28**	**1.56 - 3.33**	**<0.001**

Above Age 5	163	57			Ref.	
Gender						
Female	580	79	1.23	1.29	0.92 - 1. 81	0.1364
Male	553	93			Ref	
Location						
Border Districts	519	122	**0.35**	**0.37**	**0.26-0.53**	**<0.001**
Non-border Districts	614	50			Ref	
Vaccination status						
Non- vaccinated	699	55	**3.43**	**3.42**	**2.41 - 4.86**	**<0.002**
Vaccinated	434	117			Ref	

Table 3: Yearly MCV1 and MCV2 Coverage

Year	MCV-1			MCV-2		
	Total Vaccinated	Target	Percentage Coverage (%)	Total Vaccinated	Target	Percentage Coverage (%)

2017	243,525	269,981	90	221,302	269,981	22
2018	233,676	277,243	84	170,028	277,243	61
2019	266,684	284,452	94	208,720	284,452	73
2020	253,046	291,611	87	196,780	291,611	67
2021	238,505	307,022	78	183,949	307,022	60