ASSESSING THE IMPACT OF COVID-19 PANDEMIC ON ROUTINE IMMUNIZATION RATES AND SERVICES IN SIERRA LEONE, 2022. MIXED METHOD STUDY

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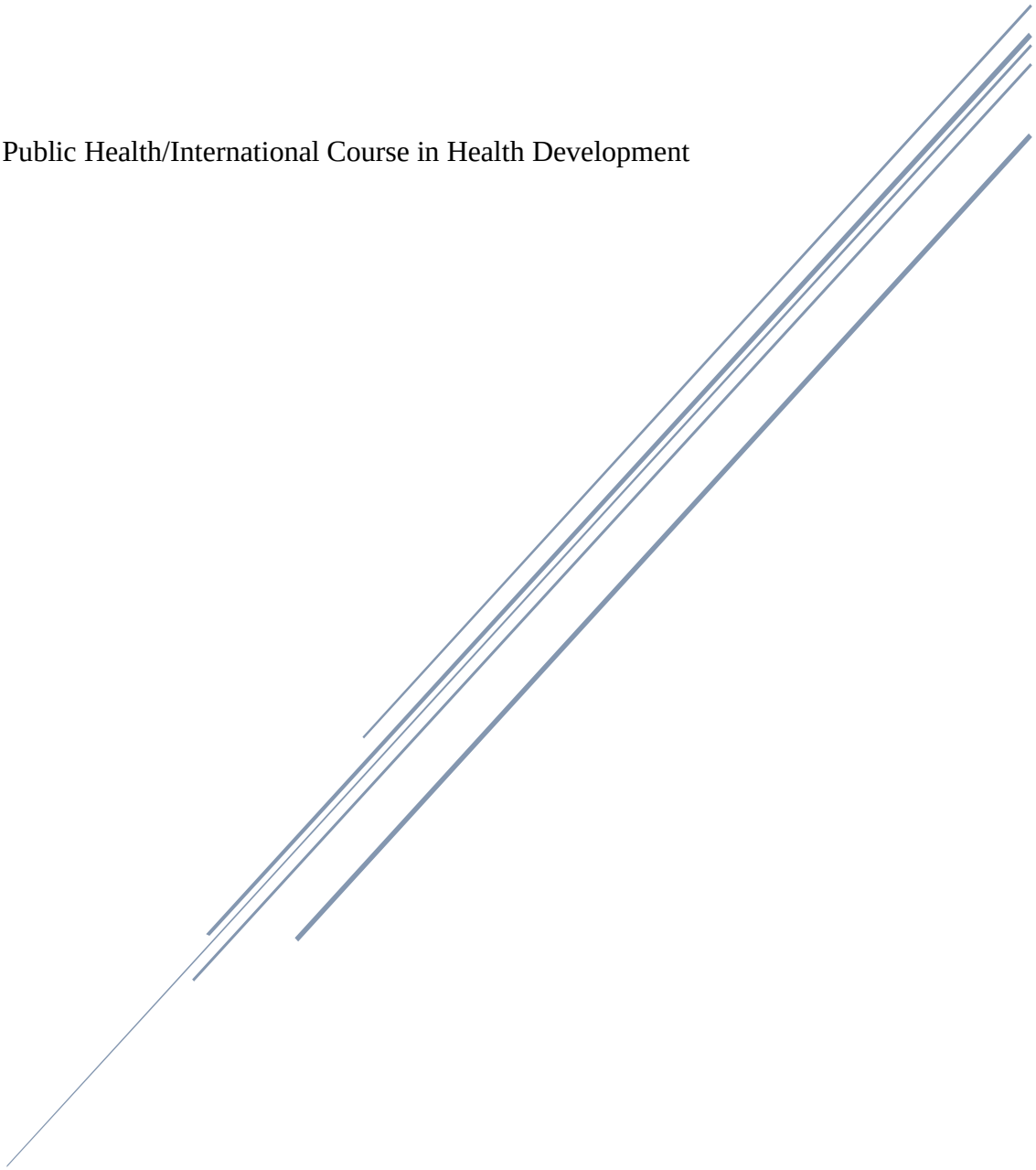
SIERRA LEONE

58th Master of Public Health/International Course in Health Development



KIT (Royal Tropical Institute);Vrije Universiteit Amsterdam (VU)

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A thesis submitted in partial fulfilment of the requirement for the degree of Master of Science in Public Health

by

UMARU SESAY

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LIST OF ABBREVIATIONS

COVID-19	Coronavirus Disease 2019
SARS-COV-2	Severe Acute Respiratory Syndrome
RI	Routine Immunization
EPI	Expanded Program on Immunization
VPD	Vaccine Preventable Disease
PHEIC	Public Health Emergency of International Concern
WHO	World Health Organization
MoHS	Ministry of Health and Sanitation
NACOVERC	National COVID-19 Emergency Response Committee
DICOVERC	District COVID-19 Emergency Response Committee
DHMT	District Health Management Team
BCG	Bacille Calmette-Guérin
OPV	Oral Polio Vaccine
nOPV	National Oral Polio Vaccine
MR 1	Measles-rubella one
MR 2	Measles-rubella two
Penta 1	Pentavalent one
Penta 3	Pentavalent three
DPT	Diphtheria Pertussis Tetanus
LLIN	Long Lasting Insecticides Treated Net
RMNCH	Reproductive Maternal and Child Health
SDG	Sustainable Development Goal
PHU	Peripheral Health Unit
PPE	Personal Protective Equipment
ANC	Antenatal Care
DHIS 2	District Health Information Software
GHSI	Global Health Security Index
CHC	Community Health Centre
CHP	Community Health Post
MCHP	Maternal and Child Health Post
HIV	Human Immune Virus
DOO	District Operation Officer

DEFINITION OF KEY TERMS

COVID-19: This is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (1).

Expanded Program on Immunization: This institution is responsible for managing and administering immunizations to children, according to a defined visit schedule (2).

Routine immunization: This is an approach used by countries to provide lifesaving vaccines to children, with the aim of preventing, controlling and eradicating vaccine-preventable diseases (2).

Childhood vaccine coverage: The coverage rate is defined as the proportion of children in the target population who received the prescribed dose of a vaccine (3)

Vaccine dropout: The dropout rate is defined as the proportion of children who received the first dose of the antigen but did not complete their doses in accordance to the immunization schedule (4).

Vaccine uptake: This is the behaviour of an individual to accept a vaccine. In a population, it is referred to as the number of people who take specific vaccines which might be different by age, sex, etc. (4).

Vaccine completion: This is the receipt of the recommended dose of specific vaccines per eligible target population. In a population, it is referred to as the proportion of persons who received a specific vaccine at a specified time and age (4).

Timeliness of vaccination: Is defined as the receipt of a vaccine at a specific date or age (5).

Partial vaccination: This is also referred to as incomplete vaccination or dropout rate. This is a proportion of a target group that receives less than the required vaccine dose in the immunization schedule or vaccine series (4).

No vaccination: The proportion of target population who did not receive any vaccine (4).

Livebirth: The child extracted alive from its mother regardless of the duration of the pregnancy(6)

Surviving Infant: Is defined as a child who survives the first year of birth.

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ABSTRACT

Introduction
The Government of Sierra Leone prioritized COVID-19 response over other health priorities. We do not know how the pandemic affected the uptake of routine immunisations (RI). To advise on future outbreak, this study aim to assess the impact of the pandemic on routine immunization rates and services in Sierra Leone among children younger than one year.

Method
District health information system RI data were compared over time regarding coverage and dropouts. Semi structured interviews with six RI stakeholders were used to contextualise the findings. .

Result
Nationally, between 2019 and 2020, the coverage rate decreased for all antigens. The dropout rate increased for pentavalent vaccines and remained unchanged for measles-rubella. Results differed among the sixteen districts., Coverage of BCG, pentavalent 1 and 3 decreased most in Falaba district; the 'Western area urban district' decreased most for measles-rubella 1 and 2. The dropout rate of measles-rubella and pentavalent antigen increased most in Kailahun and Bo district. The monthly coverage of all antigens decreased between January and April, 2020 whiles the dropout rate of pentavalent 1 and 3 increased between March and June 2020. From the semi structured interview, lockdown and difficulty in transportation were the main barriers that affected RI.

Discussion
The large proportion of children who missed out on routine vaccination particularly in Western area urban and Falaba district; are at risk of developing VPDs. The Ministry of Health, should conduct supplemental immunization activity campaign with focus on districts with low RI uptake; and revised the lockdown policy to enhance RI uptake.

Keywords: COVID-19, routine immunization, vaccines, district health information system, Sierra Leone.

Word counts; **Abstract:** 249/250; **Full texts**: 12,847

CHAPTER ONE

1.0 INTRODUCTION

I am a Public Health Superintendent, working as a Disease Surveillance Officer in the Ministry of Health and Sanitation, Sierra Leone. Growing up in Sierra Leone, I have experienced series of devastating health effects resulting from humanitarian crises: civil war, Ebola, Lassa fever, mudslides, flooding and fire outbreaks among many others. The response to these crises by the Ministry of Health and Sanitation has been a major challenge and the effect has resulted in thousands of deaths and morbidities among the population of Sierra Leone, with children and women disproportionately affected. From my experience, working with the Ministry of Health and Sanitation, I observed the key challenge, which often exacerbates the poor response activities during public health emergency in Sierra Leone. It is the lack of appropriate documented evidence to guide preparedness and response activities. Routine immunization, which is a major component of the health care system, is most affected within the health sector, during a public health emergency era, in Sierra Leone. The effect often results in a parallel outbreak, which results from a suboptimal vaccination uptake among children. Similarly, the late response to health needs, during these emergencies, often increases the vulnerability of the population resulting in poverty; gender inequality, resulting in women having the responsibility of taking care of their babies at home if they got infected; and lowering the economy of Sierra Leone, as most people often lose their jobs during these periods. Against this backdrop, I developed the intent of conducting this study, aimed at assessing the impact of COVID-19 pandemic on routine immunization rates and service in Sierra Leone. The findings of this study would guide policy makers within the Ministry of Health and Sanitation in Sierra Leone and other countries, with similar contexts in designing appropriate interventions, that will prevent the drop in routine immunization uptake in future outbreaks and other public health emergencies.

1.1 BACKGROUND

1.1.1 OVERVIEW OF COVID-19 AND RESPONSE MECHANISM IN SIERRA LEONE

The Corona Virus Disease 2019 (COVID-19), is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (1). The virus has infected 581,686,197 and resulted in 6,410,961 deaths as of the 8th August, 2022 globally (7); after it was first detected in China, December 2019 (8). The virus spreads from an infected person to a healthy person by droplets or contact with contaminated materials; transmission from an asymptomatic person is also possible (9). The virus has an incubation period between 2 to 14 days; and a basic reproduction number between 2.24 and 3.58 (10). On 30th January and 11th March 2020, the World Health Organization (WHO) declared COVID-19 as a disease of Public Health Emergency of International Concern (PHEIC) and a pandemic respectively (1). Following these declarations, the WHO recommended countries to temporarily suspend mass vaccination exercises, and to conduct a need assessment on the situation of the COVID-19 pandemic per case before implementing an outbreak response, using the mass vaccination as an approach (11). In addition, the WHO also recommended countries to endorse prevention and control measures including: physical distancing, travel restrictions among many others. The implementation of these measures have affected the operation of health care services including routine immunization (12). This has deterred the progress of the 2030 vaccination agenda, which intends to increase equitable access to vaccines in the next decade (13).

The Government of Sierra Leone activated the National Public Health Emergency Operation Centre at level 2, following the announcement of the COVID-19 pandemic as PHEIC by WHO (14). Level 2 is the response phase, where outbreak activities are coordinated and managed, by the authorities within the Ministry of Health and Sanitation in Sierra Leone. During this phase, measures including: readiness assessment using the WHO guidelines, preparedness and a response capacity training, identified temporary facilities for quarantine of travellers were conducted (14). The implementation of these measures were done through a centralized structure (Figure 1) at the national level, named National COVID-19 Emergency Response Committee (NACOVERC) and it was later replicated to the district level, called the District COVID-19 Emergency Response Committee (DICOVERC).

Despite of all these prevention measures, Sierra Leone detected its first COVID-19 case on 31st March 2020 (15). Since then, the Government of Sierra Leone endorsed several measures to curtail the spread of the infection. Despite the implementation of these measures, the COVID-19 cases continued to rise and Sierra Leone has seen three waves of the virus (Figure *2*). As of 8th August 2022, Sierra Leone has registered 7,738 COVID-19 cases and 125 deaths (CFR- 1.6%) (16). Due to the rise in the cases, the WHO reported this referred proportion of hospital utilization, including routine immunization, reduced by 19% in 2020 in Sierra Leone (17). This is because, health care workers and caregivers fear getting an infection at the health facilities and the restriction measures endorsed to curtail the transmission of the COVID-19 virus (18). Aside from the impact of the pandemic on health care, the pandemic has caused social and economic problems: people losing their jobs; struggling to feed their families. The impact also led to schools closure, forcing children to spend months out of school (19,20).

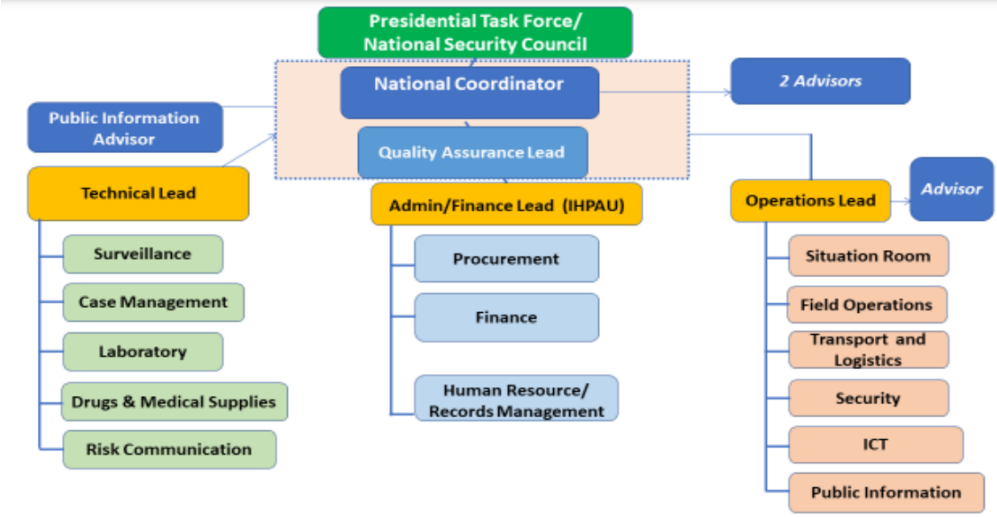


Figure 1: COVID-19 response structure in Sierra Leone as of 25 March 2020, 2020 (21)

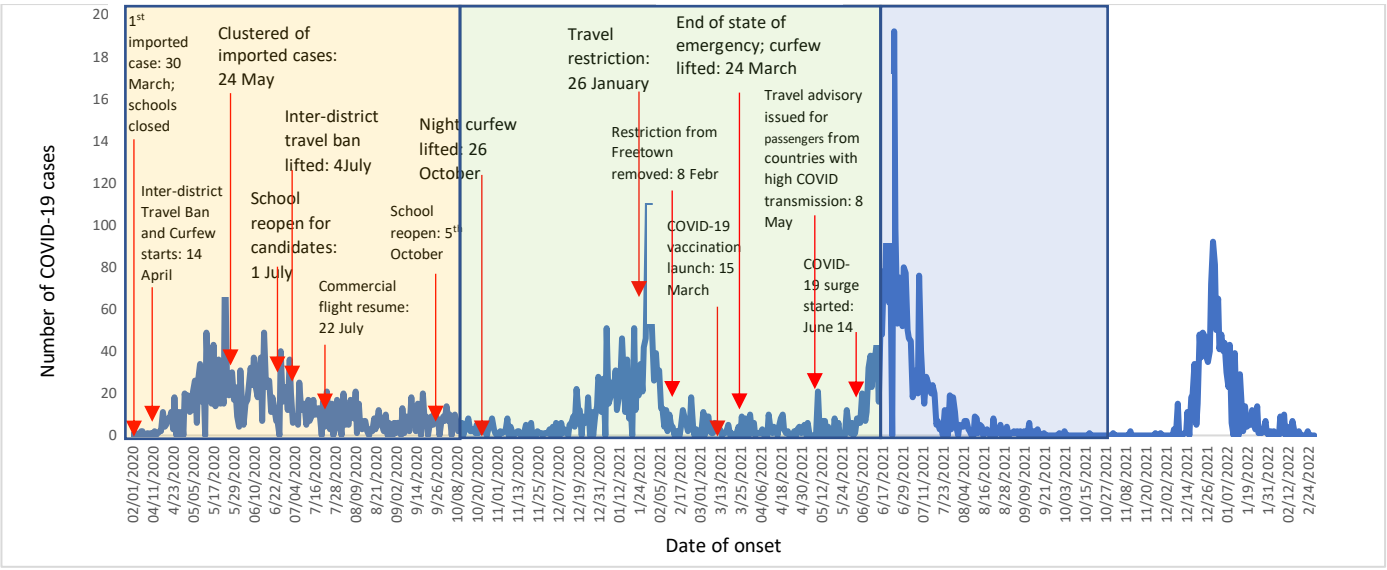
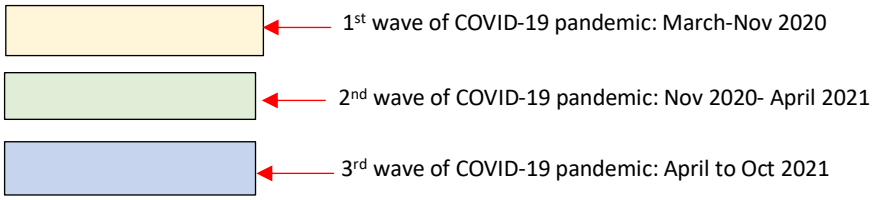


Figure 2: COVID-19 cases vs Government of Sierra Leone response timeline. Source of COVID-19 data. Our world data (22). Credit: Response timeline, Ministry of Health and Sanitation, Sierra Leone, 2022.



1.1.2 GEOGRAPHY AND DEMOGRAPHY OF SIERRA LEONE

This study was conducted in the context of Sierra Leone. Located in the West coast of Africa, Sierra Leone borders with Liberia and Guinea in the South-West and in the North-East respectively. Sierra Leone has 16 districts and is divided into five regions: the Eastern region with three districts, the Southern region with four districts, the North-west region with three districts, the Northern region with four districts, and the Western region with two districts, hosting the main capital city, Freetown (Figure 3). With a population of 7.1 million people: 59% are residing in rural settings and 41% in urban setting; women account for 50.8% and men for 49.2%; the national growth rate is 3.2% per year (23). Eighteen percent of the total population are children under the age of five and 22.2 percent are women of childbearing age. The life expectancy of the population is 58.61 years (23) . The country has two main seasons: a raining season and dry season; and two seasonal movements: North-easterly Continental Tropical Wind (also known as North-east Trade Wind) and the south-westerly Maritime Tropical Winds (commonly called South-west Monsoon) determined the climate of Sierra Leone (23).

Figure 3: Map of Sierra Leone, 2019 (24).

1.1.3 STRUCTURE AND OPERATION OF HEALTH CARE SYSTEM IN SIERRA LEONE

The healthcare system in Sierra Leone is managed by the Ministry of Health and Sanitation and its operation is financed by the Government of Sierra Leone through the Ministry of Finance. The healthcare system is decentralized at the district level with each district having its owned structure called the District Health Management Team (DHMT) tasked with the responsibilities of managing the operation of the health system.

The operations of the Ministry of Health and Sanitation are separated into directorates, with the EPI program falling under the reproductive and child health directorates (Figure 4). Each of the directorates are represented across all DHMTs in the country. This is done to improve coordination and management of health events. The healthcare services in Sierra Leone are delivered through Government health institutions, faith-based institutions, private for profit and private for non-profit institutions. Traditional medicine forms part of the healthcare system in Sierra Leone. As of 2017, Sierra Leone has 10,000 health

care workers employed in the Government civil service (25). These number of health workers serving a population of 7.1 million (on average 350 patients per 1 medical doctor) make it more challenging for the health staff to deliver quality health service, in order to reduce the disease burden among the population. Also, the clinical density before the introduction of the two new district [Falaba and Karene district] in 2016 shows that, Western area urban district [hosting the capital] is disproportionately having the vast majority of the health workforce (Figure 5) in Sierra Leone. This is because the western area urban district: hosts the majority of the population, approximately 1.5 million people of the total 7.1 million people. It hosts the main administrative offices; and has basic social amenities: water, electricity and roads among many others compared to other districts, which are desired by the health workforce in Sierra Leone. Similarly, the number of health facilities (Table 1) in Sierra Leone is relatively small compared to the population of 7.1 million. The rural population is disproportionately affected by access to health services in comparison to the urban population, resulting in an increase in the disease burden that is undetected and untreated. The Maternal and Child Health Post (MCHP), manned by maternal and child health aid nurses (MCH Aid), located at village level, serve a population of less than 5000 people; Community Health Post(CHP), manned by state enrolled community health nurses (SECHN) and MCH Aid, located in smaller towns, serve a population of 5000 to 10,000; Community Health Center (CHC), manned by community health officers, SECHN, MCH Aid located at chiefdom level, serves a population of 10,000 to 20,000.

Table 1. Health Facility distribution in Sierra Leone, 2018 (23).

Category of health facility	Number in existence
Hospitals	58
CHC	231
CHP	341
MCHP	639
CLINIC	54
OTHER	5
TOTAL	1,328

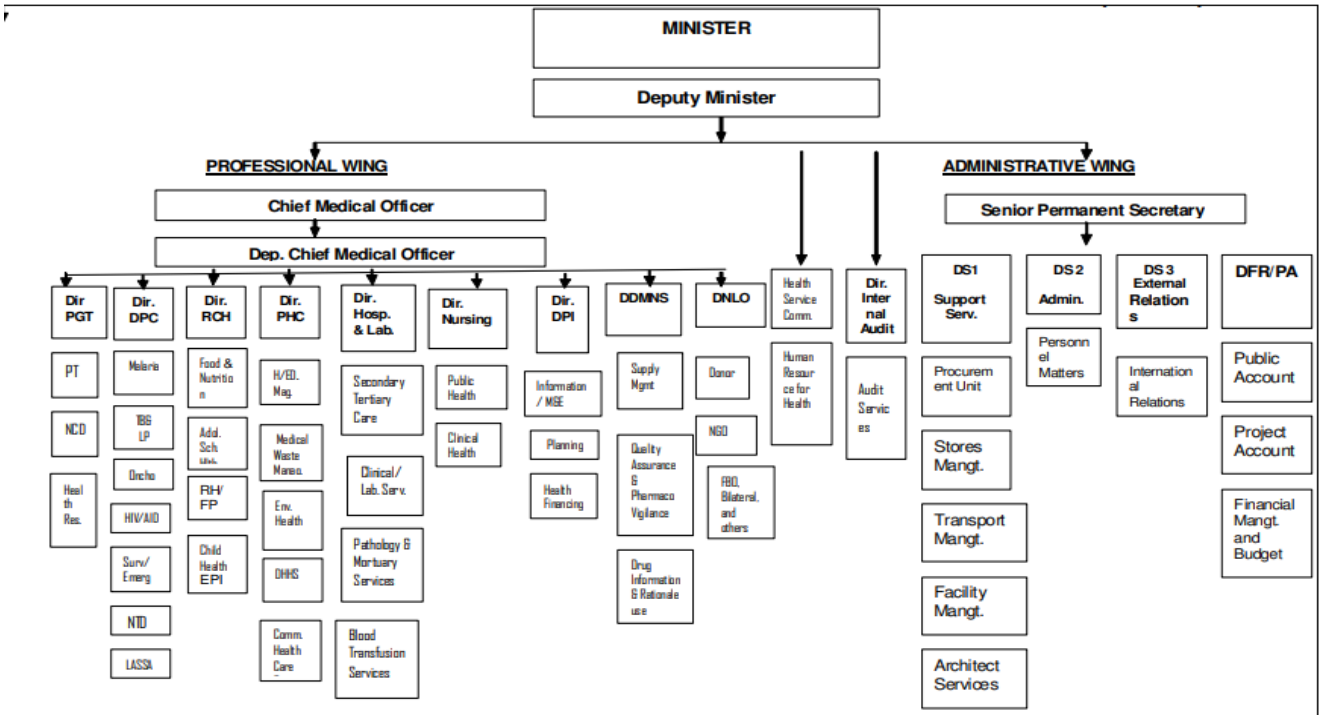


Figure 4: Organogram of the Ministry of Health and Sanitation, Sierra Leone, 2014 (26).

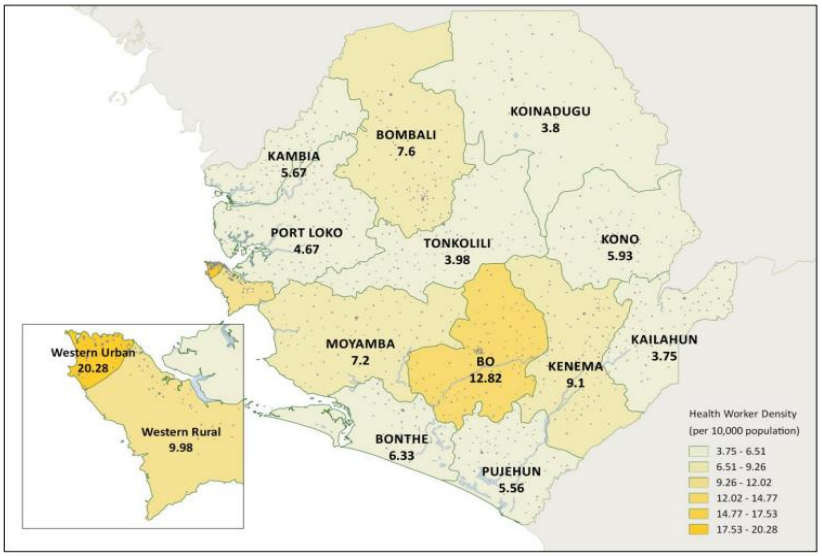


Figure 5: Clinical health workforce density per 10,000 population in Sierra Leone, 2019 (27).

1.1.4 OVERVIEW OF DISEASE BURDEN AND PUBLIC HEALTH EVENTS IN SIERRA LEONE

In 2019, malaria was the most common cause of death and disability among the population and it account for 38% hospital admission (23), followed by neonatal disorder, lower respiratory disorder, congenital disorder and diarrhoea in Sierra Leone (28). Tuberculosis which accounts for 3 new infection per every 1000 population and HIV prevalence of 1.5% are key public health problem in Sierra Leone (23). The leading risk factors contributing to these deaths and disabilities are malnutrition, air pollution, water sanitation and hygiene and high blood pressure respectively (28). Non-communicable diseases including diabetes and other cardiovascular diseases are rising overtime. In the last decades, Sierra Leone has been

affected with series of outbreaks, not limited to the Lassa fever outbreak causing hundreds of morbidities and deaths (Figure 6); a cholera outbreak causing thousands of morbidities and hundreds of deaths (Table 2); an Ebola outbreak causing hundreds of morbidities and deaths (Figure 7).

Globally, of the 195 countries in the global health security index (GHSI), Sierra Leone is ranked 116 with an overall score of 32.7 as of 2021 (29). The global health security index is the comprehensive benchmark of health security and related capacities of countries, in responding to infectious disease outbreaks. This index score shows that, Sierra Leone is performing poorly when compared to other West African countries, such as: Liberia with a 35.7 overall index score, Nigeria with a 38 overall index score (rank 86/195) and Ghana with a 34.3 index score (29). Overall, the GHSI (Table 3) shows that Sierra Leone is not well prepared to swiftly manage infectious disease outbreaks and this poses a threat to the national health security of the country, if measures are not taken to reverse the current trend.

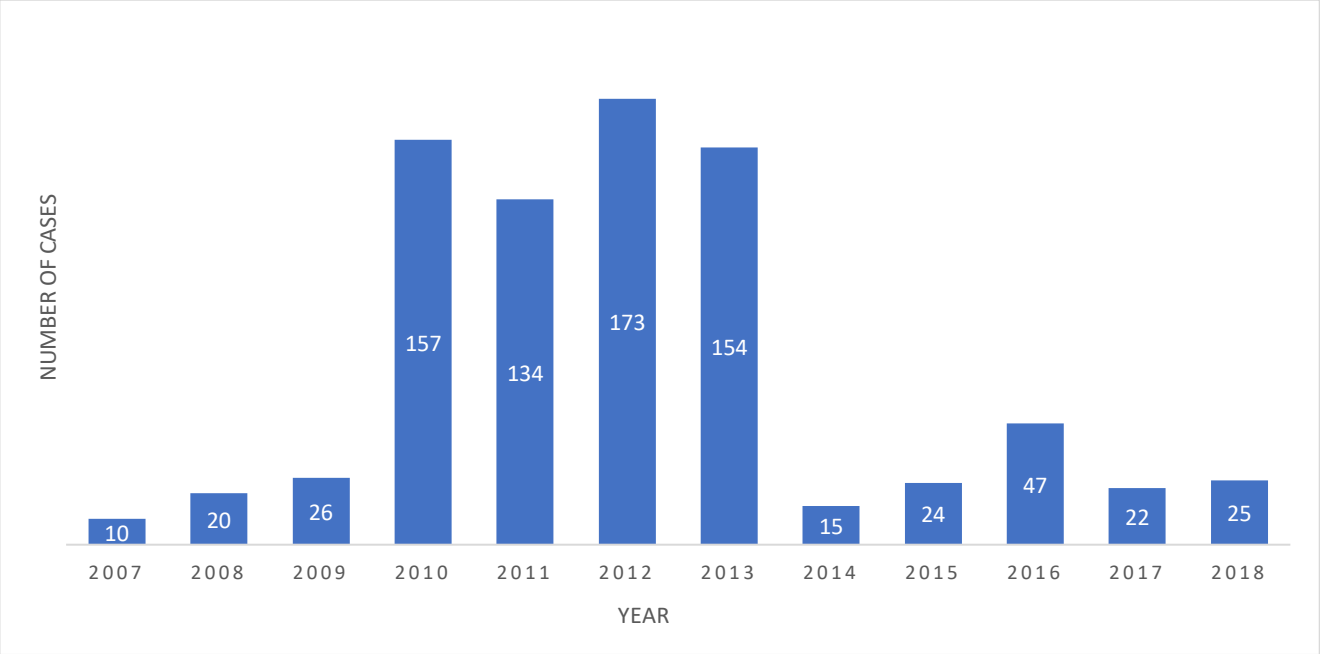


Figure 6: Lassa fever laboratory-confirmed cases in Sierra Leone, 2017-2018, 2018 (23)

Table 2: Cholera epidemics in Sierra Leone, 1998-2013, 2018 (23).

Year	Cases	Deaths	Case fatality rate	Remarks
1998	2096	57	2.7	Affected 3 districts: Freetown, Portloko, Kambia
1999	863	5	0.6	Started in September
2004	513	42	8.2	Affected Western Area, Portloko and Kambia district
2006	2560	99	3.8	Affected Western Area (rural), Kambia, Tonkolili, Portloko and Kailahun
2007	2219	84	3.79	Affected 11 out of 13 districts
2008	62	1	1.6	Affected Western Area, Portloko and Kambia
2012	22971	299	1.3	Affected 12 out of 13 districts
2013	369	2	0.54	Affected 12 out of 13 districts

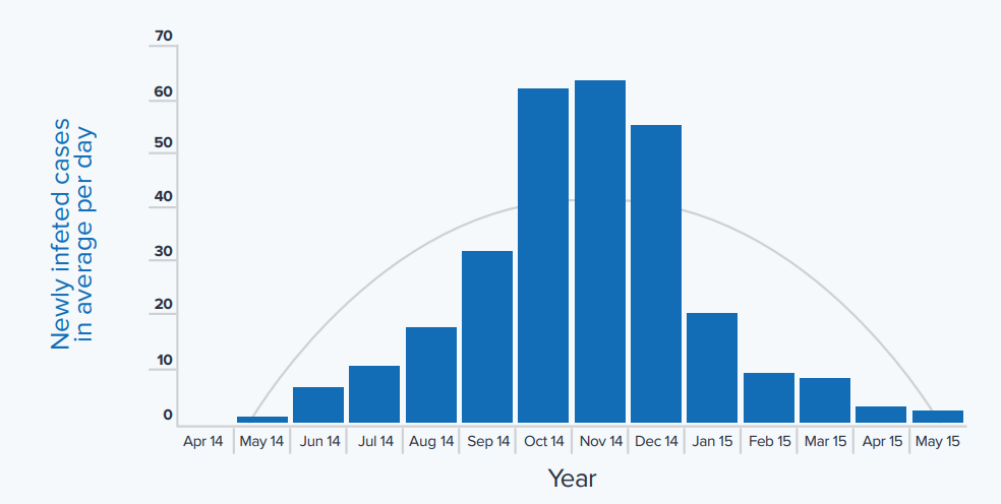


Figure 7: Ebola outbreak in Sierra Leone, 2014-2016, 2018 (23).

Table 3: Global health security indices, Sierra Leone. 2021 (29).

No	Index	Score	Rank
1	Overall score		
2	Prevention of the emergency or release of pathogens	9.0	174
3	Early detection and reporting for epidemics of potential international concern	31.4	92
4	Rapid response to and mitigation of the spread of an epidemic	84	37.3
5	Sufficient and robust health system to treat the sick and protect health workers	31	85
6	Commitments to improving national capacity, financing and adherence to norms	47.2	93
7	Overall risk environment and country vulnerability to biological threats	40.3	166

1.1.5 HEALTH CARE FINANCING IN SIERRA LEONE

The cost of accessing the healthcare system, remains high in Sierra Leone; contributing to the low utilization of health facilities (0.5 visits on average) (23). In 2019, the universal health coverage index, among the population in Sierra Leone, was 39% (30). This indicates that, the country is far behind in progress towards universal health coverage. The total general government health expenditure is 5.8% (30). This proportion is far less than the 15% target of the Abuja declaration on government budget commitment to health (31). Out of pocket expenditure, which stands at 16.7% (30), is the largest contributor to the health source of revenue generation. As a result, the proportion of the population in Sierra Leone below the poverty line, is 56% (30). This source of revenue generation makes it difficult for health services to be utilized when needed, because the vast majority of the population cannot afford to pay for healthcare. With the emergency of the COVID-19 pandemic, the poverty level of the population increased by 2.1% from 56.8% in 2018 to 58.9% in 2020; and the Western area urban district experienced the highest increase in poverty of 11.4% from 17.7% to 29.1% due to prolonged restriction measures; and the rural areas experienced a slight increase of 1.1% from 45.2% to 46.3% within the same period (19). This implies that the pandemic has severely affected every aspect of livelihood of people in Sierra Leone.

1.1.6 OVERVIEW OF THE EPI PROGRAM IN SIERRA LEONE

In 1978, Sierra Leone established the Expanded Program on Immunization (EPI) to manage routine immunization services and reduce the burden of childhood illness (26). The EPI program offers ten lifesaving mandatory vaccines, namely Measle-rubella, Bacille Calmette-Guérin (BCG), Rota, Pentavalent, and poliomyelitis [Inactivated polio vaccines(IPV), and Oral polio vaccines (OPV)], yellow fever, Hib, HepB, Streptococcus pneumonia (Table 4) (26). In addition, the program also offers other lifesaving interventions including deworming, Long Lasting Insecticide Treated Nets (LLINS), Vitamin A, and health promotion activities (26). Children younger than one year and women of child bearing age between 15 to 49 years, are the target population of the EPI program in Sierra Leone (26). Through the EPI program, routine immunization services are provided in three ways: static (done in public and private health facilities and temporary vaccination sites, where mothers and children are immunized), outreach (held sometimes by health professionals at community locations), and mobile (where a mobile team travels to communities five kilometres outside of their catchment, to provide routine immunization services).

Table 4: Immunization schedule for children 0-11 months, Sierra Leone, 2014 (26).

Age	Vaccine	Other intervention
At birth	OPV0, BCG0	EEBF, GMP
6 Weeks	Pneumo1, Rota1, OPV1, Penta1	GMP,
10 Weeks	Pneumo2, Rota2, OPV2, Penta2	GMP
14 Weeks	Pneumo3, OPV3, Penta3	GMP, LLINs
9 Months	Measles, Yellow fever	Vitamin ‘A’, GMP, etc
15 Months	Measles Second Dose	Vitamin ‘A’, GMP, etc
9-13 Years	HPV (only demonstration programme now for girls 9 years, yet to be introduced)	Other ADH interventions that are yet to be identified

CHAPTER TWO

2.1 PROBLEM STATEMENT

Routine immunization, is an approach used by countries, to provide lifesaving vaccines to children with the aim of preventing, controlling and eradicating vaccine preventable diseases (VPD) (2). Every year, approximately 2 to 3 million children are protected from death, through routine immunization worldwide (32). In the last four decades, the coverage of routine immunization, through the EPI program, increased rapidly (2). For instance, between 1980 to 2018, the coverage of diphtheria-pertussis-tetanus increased by 60% from 25% to 85%, and the coverage of the first dose of measles 1 antigen increased by 67% from 18% to 85% (33). As a result, between 2000 and 2018, measles vaccination prevented more than 23 million children from death; and between 1988 to date, the proportion of paralyzed poliovirus cases reduced by 99% among children globally (34). Despite these improvements, the World Health Organization (WHO) estimates that 29% of deaths among children, under the age of five, are attributable to VPD, primarily due to the ineffective EPI program worldwide (2). The emergence of the COVID-19 pandemic has weakened the EPI program and consequently affected the uptake of routine vaccines, with coverage rates decreasing in 90% of countries in 2020 and remaining unchanged in 30% of countries in 2019 (35). Within the same period, 23 million children did not receive any vaccines in 2020, which is 4 million more than in 2019, due to the disruption in healthcare system by the COVID-19 pandemic (36). The COVID-19 pandemic has also widened the disparities in access to routine vaccinations, with children living in low-income families, rural and urban poor environments and conflict areas, disproportionately affected (37).

In Africa, one out of every five children does not receive all basic vaccines and over 30 million are affected by VPDs (38). An estimated 58% of deaths among children under five due to VPDs globally, occurred in Africa (38). The COVID-19 pandemic has reduced the scale of reproductive, maternal and child health (RMNCH) interventions, including the supply chain of pharmaceutical products, particularly vaccines, as well as the performance of health care workers in health services delivery in the African continent (39). This is because, the Governments redirected resources in response to stop the transmission of the COVID-19 virus at the expense of RMNCH initiatives, including routine immunization (39). Similar to the Ebola outbreak, between 2014 and 2016, an estimated 127,000 to 227,000 children were predicted to be susceptible to measles infection, after 18 months of the epidemic, with 2000 to 6000 deaths in Sierra Leone, Guinea, and Liberia; due to disruptions in routine immunization services (40). A related study revealed that, routine immunization prevents 8,300 children from dying from VPDs, for every child who dies in medical facilities, after being exposed to SARS-CoV-2 in Africa (13). This exemplifies the significance of maintaining routine immunization during outbreaks, as a decline, even for a short period, can increase the risk of morbidity and mortality; it leads to secondary health issues such as a measles outbreak; and exacerbates gender inequality because of VPDs infection, which may cause women to stop working and hurt the nation's economy (41).

With an infant mortality rate of 75 per 1000 live births; under-five mortality rates of 122 per 1000 live births; and perinatal mortality rate of 32 deaths per 1000 pregnancies among women aged 20 to 39 years (24), Sierra Leone is ranked 182 of 189 countries in the human development index in 2019 (42). These high mortality rates were exacerbated by the eleven-year civil war between 1991 and 2002, and the Ebola epidemic between 2014 and 2016 (43). The effect of this civil war and the Ebola epidemic affected the operation of the healthcare system including routine immunization (43). For instance, in the Ebola epidemic era, 30% of deaths among children under five were caused by VPDs; due to disruption in the operation of routine immunization services (26).

In 2018, approximately 80% of children were vaccinated with three doses of diphtheria-pertussis-tetanus toxoid and 90% vaccinated with measles-containing vaccines (44). Even with this improvements, the

suboptimal vaccination coverage rate (Figure 8) in Sierra Leone is a major public health problem, increasing the risk of under five children developing VPDs and ultimately causing deaths (44). This suboptimal coverage is attributed to personal and vaccination-related worries of caregivers (18). Fear of vaccination adverse effects, unpleasant experiences at health facilities in the past, lack of awareness regarding VPDs, personal/religious views, complacency and the perception that there is no threat and hence no need, are examples of personal concerns (33). The vaccination-related worries include costs, illegal payment of vaccination, long lines at vaccination centres, fear of injection, fear of needles, long distance to access the vaccines, limited time to bring their children to vaccination centres and limited access to information on routine immunization coverage(33).

In 2019, the proportion of children immunized, with all basic vaccines, declined by 12% from 68% in 2013 to 56% in 2019 (24). During the same period, only 56% of children aged 12 to 23 months were immunized with mandatory antigens: three doses of pentavalent vaccine, three doses of polio, and one dose of measle-rubella vaccine (24). This indicates that the country is still a long way from achieving the Sustainable Development Goal (SDG) 3, which calls for ≥90% coverage of children aged 12 to 23 months with all basic vaccines (45).

Despite the introduction of free health care services in Sierra Leone in 2010, which provides free access to: medical consultation, medicines, and medical supplies for children under the age of five, lactating mothers, and pregnant women (46). Accessibility to routine immunization services are challenging, particularly during outbreaks including the COVID-19 pandemic. This has led to the polio outbreak caused by circulating vaccine derive polio virus type 2 (CVDPv2) between December 2020 and June 2021 (47) and the measles outbreak in Kambia district, declared in 19th October 2021 (48). These outbreaks have posed significant threats to achieving the EPI objectives of reducing measles deaths by 95% and attaining routine immunization coverage of at least 90% in Sierra Leone (26).

Similarly, key drivers of routine immunization: the supply of personal protective equipment to health workers within the immunization program, transportation of routine immunization vaccines, community support for routine immunization initiatives, and caregiver access to routine vaccination services have been affected during the pandemic (20). Anecdotal evidence suggest, the pandemic has decreased the vaccination coverage rate and increased the vaccination dropout rate, making children more susceptible to VPDs.

Currently, there is limited evidence on the impact of the COVID-19 pandemic on the routine immunization rates and services in Sierra Leone. Specifically, we do not know how the pandemic has impacted the monthly and average annual coverage rates of: BCG, measles-rubella 1 and 2, and pentavalent 1 and 3; and the dropout rate of measles-rubella 1 and 2 and pentavalent 1 and 3 at district and national level. Also, we do not know how the pandemic has affected the provision of routine immunization services influencing the decrease in coverage or increase in dropout rate. Based on this knowledge, and to advise decision making on future outbreak, this study aimed to assess the impact of COVID-19 pandemic on routine immunization rates and service in Sierra Leone.

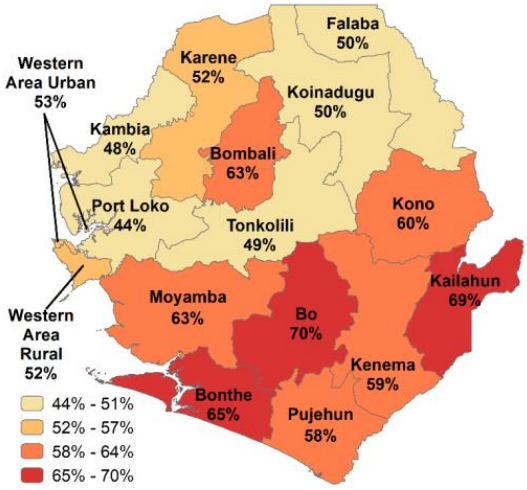


Figure 8: Vaccination coverage rate [fully immunized] among children 12-23 months old, Sierra Leone, 2019 (24).

2.2 JUSTIFICATION

Sierra Leone has experienced repeated disease outbreaks, most notably Ebola in 2014 and the current COVID-19 pandemic. The effects have increased mortality and morbidity, with children disproportionately affected due to disruption in routine immunization. To date, limited studies (8,49,50) have been conducted, in the context of Sierra Leone, aimed at assessing the impact of the COVID-19 pandemic on routine immunization rates and services. The findings of these studies, however, did not quantify the impact of the pandemic at the national level and also key drivers that sustain routine immunization uptakes, were not assessed. The selected antigens: BCG, measles-rubella and pentavalent are proxy of the other antigens including: Polio, pneumococcal, rota and yellow fever, administered at the same time (Table 4) with the same target population. Because of this, the analysis would found the same result.

Identifying the potential effect of COVID-19 pandemic on the change in coverage rates of BCG, measles-rubella 1 and 2, and pentavalent 1 and 3; as well as the dropout rate of measles-rubella 1 and 2, and pentavalent 1 and 3 at national and district level, requires evaluating the trend in coverage and dropout rate of routine immunization before the pandemic. Exploring these baseline data would enable policymakers within the Ministry of Health and Sanitation in Sierra Leone and countries, with a similar setting in gaining a more adequate understanding of the impact of the pandemic on routine immunization. This understanding of the trend in coverage and the dropout rate, before and during the pandemic, would serve as a guide for policymakers, as they design interventions and strategies to combat the impact of the pandemic and other future public health emergencies on routine immunization. Consequently, the findings from this study would also help in reducing the risk of a parallel outbreak of VPDs, boost economic growth and alleviate the double burden on a healthcare system that is already strained.

2.4 GOAL

The goal is to assess the impact of the COVID-19 pandemic on routine immunization rates and services in Sierra Leone.

2.5 SPECIFIC OBJECTIVES

1. To compare the monthly national coverage rate of BCG, measles-rubella 1 and 2; and pentavalent 1 and 3 antigen among children younger than one year; 24 months before the pandemic (March 2018 to February 2020) and 24 months during the pandemic (March 2020 to February 2022); at the national level in Sierra Leone.

2. To compare the monthly dropout rate of measles-rubella 1 and 2 and pentavalent 1 and 3 antigen among children younger than one year; 24 months before the pandemic (March 2018 to February 2020) and 24 months during the pandemic (March 2020 to February 2022) at the national level in Sierra Leone.

3. To assess the change in the annual coverage rate of BCG, measles-rubella 1 and 2, and pentavalent 1 and 3 antigen, among children younger than one year in 2019 and 2020, at the national and district level in Sierra Leone.

4. To assess the change in the annual dropout rate of measles-rubella 1 and 2, and pentavalent 1 and 3 antigen, among children younger than one year in 2019 and 2020, at the national and district level in Sierra Leone.

5. To examine the barriers imposed by the COVID-19 pandemic on the provision of routine immunization services, that could have led to the decrease in coverage or an increase in the dropout rate.

CHAPTER THREE

3.0 METHOD

This section explains the approach used by this study to obtain the study findings.

3.1 STUDY DESIGN

The study used a mixed-method design to compare the trend and assess the change in proportions of routine immunization rates in Sierra Leone, before and during the COVID-19 pandemic. To assess coverage and dropout rates, a descriptive retrospective study was conducted, using routine immunization data. For determining the monthly trend at the national level, the period covered 24 months before the pandemic (March 2018 to February 2020) and 24 months during the pandemic (March 2020 to February 2022). In addition, the study covers 2019 and 2020, with the aim of determining the difference in proportional change in BCG, measles-rubella 1 and 2, and pentavalent 1 and 3 coverage rates, as well as the dropout rate of measles-rubella 1 and 2 and pentavalent 1 and 3 at the district and national levels in Sierra Leone. To investigate the barriers imposed by the COVID-19 pandemic on routine immunization services in Sierra Leone, qualitative data was collected from one national expert and from five district operation officers within the Expanded Program on Immunization (EPI).

3.2 DATA SOURCE

The main source of data for this study was the national routine immunization data . This data is stored at the District Health Information Software 2 (DHIS2), this is open software where all health facilities report routine immunization data in Sierra Leone (51). The data is aggregated to the district level before being transferred to the DHIS2 national database. The data is anonymized (no patient information or details) and the reporting is done every month to the Monitoring Evaluation Officer attached to District Health Management Team (DHMT) at the district level, for onward submission to the DHIS2. The DHIS2 record goes back to 2012, after it was piloted between 2008 and 2009 in four districts: Bo, Kenema, Bombali and Western area urban (51), but only data generated from March 2018 to February 2022 was used for this study. This was because, before 2016, the data collection was massively interrupted by the 2014 through 2016 Ebola epidemic in the country and the quality of the data was compromised. After the Ebola outbreak, between 2017 to January 2018, this period was considered the post-Ebola recovery phase. This means that the health system was in the phase of rebuilding its major components, including the routine immunization service through health care recruitment, and drug supply among others. The researcher, therefore, considers March 2018 to be a starting period in determining the impact of the COVID-19 pandemic on routine immunization services, as the operation of the system does not experience any major breakdown from March 2018 to February 2020 before the emergence of the pandemic.

The DHIS2 data guide health professionals in monitoring the performance of health service delivery including routine immunization and reduces the fragmentation of reporting across the country (51). This is important in monitoring the proportion of children, who have acquired herd immunity from VPDs. In addition, the study also collected insights from key informant interviews from stakeholders, working within the EPI program to validate the findings and also to examine the barriers imposed by the COVID-19 pandemic in the operation of routine immunization services in Sierra Leone.

3.3 DATA COLLECTION AND ANALYSIS

3.3.1 QUANTITATIVE METHOD

This method was used to compare the monthly coverage of BCG, measles-rubella 1 and 2, and pentavalent 1 and 3; and also the monthly dropout rates of measles-rubella 1 and 2 and pentavalent 1 and 3 at the national level. Also this method was used to assess the change in the average annual coverage of BCG, measles-rubella 1 and 2, and pentavalent 1 and 3; and the average annual dropout rate of measles-rubella 1 and 2, and pentavalent 1 and 3 antigen at the national and district level, Sierra Leone.

The coverage rate is defined as the proportion of children in the target population, who received the prescribed dose of a vaccine (3). The dropout rate is defined as the proportion of children who received the first dose of the antigen but did not complete their doses in accordance to the immunization schedule (4).

Live births and surviving infants were the target population in computing the coverage. Live birth is defined as the child alive extracted from its mother, regardless of the duration of the pregnancy (6), and a surviving infant is defined as the child who survives their first year of birth. In Sierra Leone, live births account for 4% of the total population and surviving infants account for 3.7% of the total population. These target populations were provided by the EPI program in Sierra Leone.

To compare the trend in monthly coverage rates at the national level, the study extracted the monthly total of BCG, measles-rubella 1 and 2, and pentavalent 1 and 3 antigen for 24 months [March 2018 to February 2020] before the COVID-19 pandemic and 24 months [March 2020 to February 2022] during the COVID-19 pandemic in Sierra Leone. The denominator was calculated by dividing the annual target population for each antigen by 12. The study developed an analysis plan to on how the data were to be computed and presented (Appendix 3).

The monthly coverage rate =
(monthly total number of children immunized with a specific antigen / monthly target population) * 100

To compare the trend in the monthly dropout rates at national level, the study used the total monthly data of measles-rubella 1 and 2 and pentavalent 1 and 3 used in comparing the trend in the monthly coverage rates for the same period.

The monthly dropout rate =
[(monthly total number of children immunized with the first dose of the antigen – monthly total number of children immunized with the second dose or third dose for the same antigen in a given month) / monthly total number of children immunized with the first dose] * 100

To assess the change in the average annual coverage , the study extracted the annual total number of doses administered for BCG, measles-rubella 1 and 2, and pentavalent 1 and3. The target population was obtained was provided by the EPI, Sierra Leone.

The annual coverage rate was computed as =
(annual total number of annual doses administered per specific antigen / target population per year)*100

To assess the change in the average annual dropout rates at the national and district levels, the study utilized the extracted data for measles-rubella 1 and 2, and pentavalent 1 and 3, which were used to calculate the change in the annual coverage rate for 2019 and 2020.

The average annual dropout rate was computed as =
[(Annual total number of children immunized with the first dose of the antigen - annual total number of children immunized with second or third dose at the national level) / annual total number of children immunized with the first dose of the same antigen] *100

The coverage rate of ≥90% for each antigen: BCG, measles-rubella 1 and 2, and pentavalent 1 and 3 antigen, were considered to meet the national target. And the dropout rate of ≤10% of each antigen including measles-rubella and pentavalent antigen were considered to meet the EPI targets.

After analysing the monthly coverage and dropout rates at the national level and also to assess the change in the average annual coverage and dropout rates at district and national level, the Pearson chi square test was computed to evaluate the difference in proportion in 2019 and 2020. Microsoft excel and R software version 4.2.0 were used for the analysis. The results of this study were presented in texts, tables and graphs.

Because the scale of target population and scale of doses administered was large, all differences in the chi-square test will likely be significant at the 3rd level ($p<0.001$). That was why, the study focused on discussing the size of the effect, based on the differences in coverage [%] and drop-out [%].

3.3.2 QUALITATIVE METHOD

To examine the barriers of the COVID-19 pandemic, on routine immunization services, that could have led to decrease in coverage or increase in dropout rate, 6 stakeholders including: 1 national EPI program expert and 5 district operation officers (DOO) were purposefully selected and interviewed from the EPI program in Sierra Leone.

The researcher explored the main issues (Table 12) and formulated them into interview guide (Appendix 2) in three themes: health system, community, and individual. In the health system theme, the study assessed: the impact of the pandemic on the supply of personal protective equipment; the transport system of routine immunization vaccines and outreach session during the pandemic. In the community theme, the study collected insight from stakeholders on: how the COVID-19 pandemic has affected the support or participation of the community stakeholders such as chiefs, youth leaders, and women's leader in routine immunization program; the impact of the pandemic on community mobilization or sensitization program of routine immunization activities at the community level, and how the COVID-19 pandemic has exacerbated routine immunization vaccine hesitancy (misconceptions). In the individual theme, the researcher collected insight from stakeholders on: how the pandemic has affected the movements of health workers in routine immunization program particularly in conducting outreach services; and how the pandemic has affected the movement of caregivers in seeking routine immunization services.

The researcher pretested the interview guide on one Master of Public Health student from KIT Royal Tropical Institute in the Netherland. This was done to establish the required time for the data collection and to amend the tool if needed. After pretesting the interview guide, the researcher collected insight from the selected stakeholders through an online system (phone).

The semi structured interview was conducted and lasted between 30 and 45 minutes, and the responses were recorded in a notebook and on a phone recorder. After the interview, the findings were transcribed and entered in a coding framework matrix, designed manually. The findings were summarized, based on how they were coded, and reported anonymously. The findings were triangulated with grey literature from the Ministry of Health and Sanitation and partners report, and personal observation of the researcher who works within the EPI program, and in the COVID-19 response in Sierra Leone, to give it a third point

of view. This method was primarily used to validate and conceptualized the results of the secondary data analysis, as a result, they are not presented separately.

3.4 ETHICAL CONSIDERATION

The study obtained permission from the Ministry of Health and Sanitation in Sierra Leone for the use of the DHIS2 data in a way that will not break any ethics rules. For the semi structured interview with the key informants, the study obtained a waiver request from the Ethics Review Committee of the KIT Royal Tropical Institute. To the stakeholders interviewed, the study sought their consent through an email with a consent form. The respondents were told before the interview that, they were not obliged to take part and could leave at any time if they thought it was necessary. Also, they were told that, the information would be kept confidential and it will only be accessible to the research. Furthermore, the participants were told that the data collection, processing and reporting, would not present any information that could be used to identify them. In this regards, the researcher used identification codes, during the qualitative data analysis instead of names.

CHAPTER FOUR

4.0 RESULT

This section consist of the study findings.

4.1 TREND IN MONTHLY VACCINATION COVERAGE RATE

Figure 9 to 13 illustrate the trend of the monthly coverage rate of BCG, measles-rubella 1 and 2, and pentavalent 1 and 3 antigen, 24 months before the pandemic and 24 months during the COVID-19 pandemic at national level in Sierra Leone. In each of the figures, a linear trend line was fitted for every 12 months, in order to assess the increase or decrease in the coverage rate, between each year overtime.

Monthly coverage of BCG coverage

The 12 months average between March 2018 and February 2019, March 2019 and February 2020, March 2020 and February 2021, and March 2021 and February 2022 were 85%, 80%, 85% and 90% respectively (Figure 9). Between March 2018 and February 2019, the trend in coverage slightly decrease with a conserved pattern. The lowest coverage was seen in February 2019 at 74%. Between March 2019 and February 2020, the trend continues to decrease. The lowest coverage was seen in February 2020 at 69%. Between March 2020 and February 2021, the trend in coverage rate, increased with the highest coverage in October 2020 at 78%. Between March 2021 and February 2021, the trend in coverage rate decreased with the lowest coverage in February 2022 at 50%. A decrease in coverage by 7% from January and April, 2020 was seen, after the declaration of the 12 months state of emergency in January 2020. This antigen did not meet the national target before and during the COVID-19 pandemic.

From the semi structured interview, four of the DOOs and the national expert reported that, the decrease in coverage, with a conserved pattern before the pandemic, from March 2018 and February 2019 were partly due to the Ebola outbreak effect. Between March 2020 and February 2021, the increase in trend, as reported by all of the respondents, resulted from government efforts in increasing sensitization on COVID-19, along with a routine vaccination uptake. All of the respondents, reported that the decrease in trend, between March 2021 and February 2022, were due to the introduction of COVID-19 vaccines. From the personal observation of the researcher, this decrease in trend was also due to a frequent strike action of health workers, including nurses within the EPI program. Three of DOOs reported, the low awareness among caregivers and lack of funding support for nurses to do follow up on pregnant women is the driven factor for not meeting the national target.

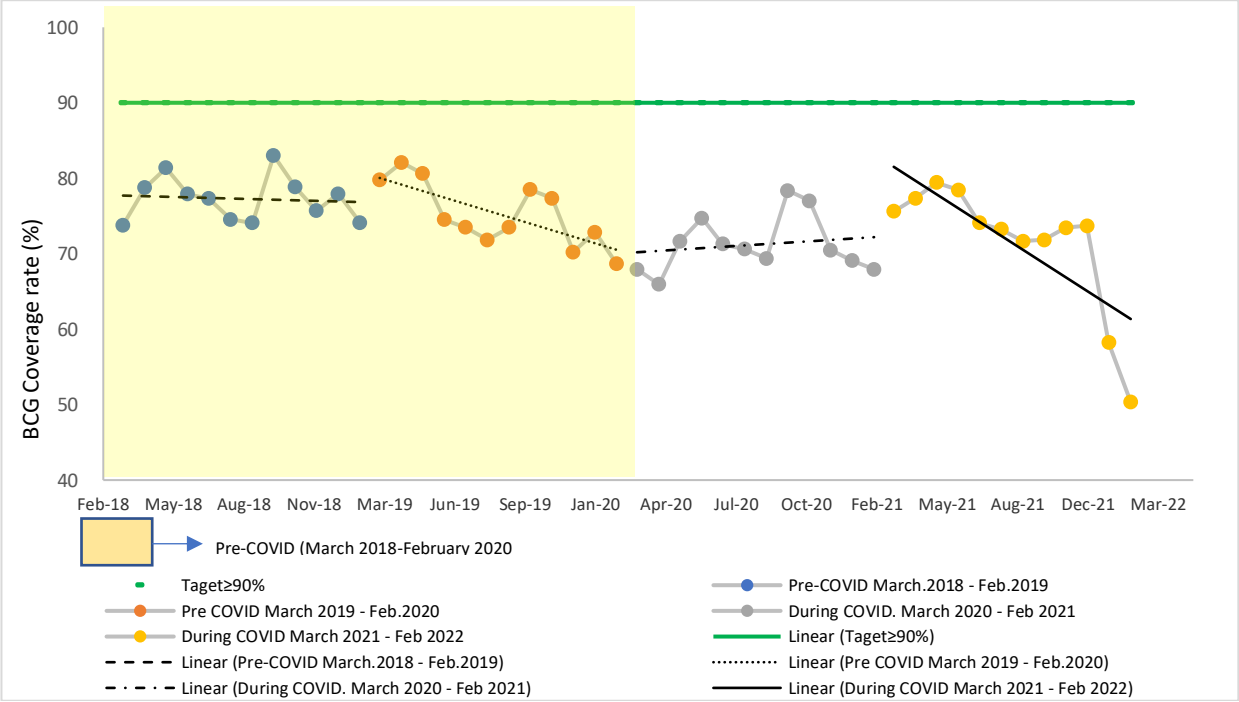


Figure 9: Trend of monthly coverage of BCG among children younger than one year, 24 months before the pandemic (March 2018-February 2020) and 24 months during the pandemic (March 2020-February 2022) at national level, Sierra Leone

Monthly coverage of Measles-Rubella 1

The 12 months average between March 2018 and February 2019, March 2019 and February 2020, March 2020 and February 2021, and March 2021 and February 2022 were 91%, 80%, 90% and 90% respectively (Figure *10*). Between March 2018 and February 2019, the coverage rate decrease in trend with a conserved pattern more pronounced (as seen in the trend line) than that of BCG (Figure *9*). The lowest coverage was in February 2019 at 77%. Between March 2019 and February 2020, the trend increase in coverage, with the highest increase in November 2019 at 94%. Between March 2020 and February 2021, the trend continues to increase with a conserved pattern. The largest increase was in October 2020 at 95%. Between March 2021 and February 2021, the trend decreased with the highest decrease in February 2022 at 80%. From January to April 2020, a decrease in coverage by 18%, was seen following the declaration of the 12 months state of emergency for COVID-19 prevention.

From the semi structured interview, similar with BCG, four of the respondents and the national expert reported, the decrease in coverage, with a conserved pattern, between March 2018 and February 2019, were partly due to the Ebola effect. All of the respondents reported that the increase in trend between March 2019 and February 2020, resulted from Government efforts in restructuring the healthcare utilization, including routine immunization after the Ebola outbreak. Between March 2020 and February 2021, similar with BCG, all of the respondents reported the increase in trend, with a conserved pattern result from the government efforts, in conducting mass sensitization of COVID-19, along with routine immunization. Also, all of the respondents, reported the decrease in trend between March 2021 and February 2022 were due to the introduction of the COVID-19 vaccines. The decreased in the 12 months average, between March 2019 and February 2020, three of the DOOs and the national expert reported to be caused by the replacement of vaccinators with technical nurses in delivering routine immunization.

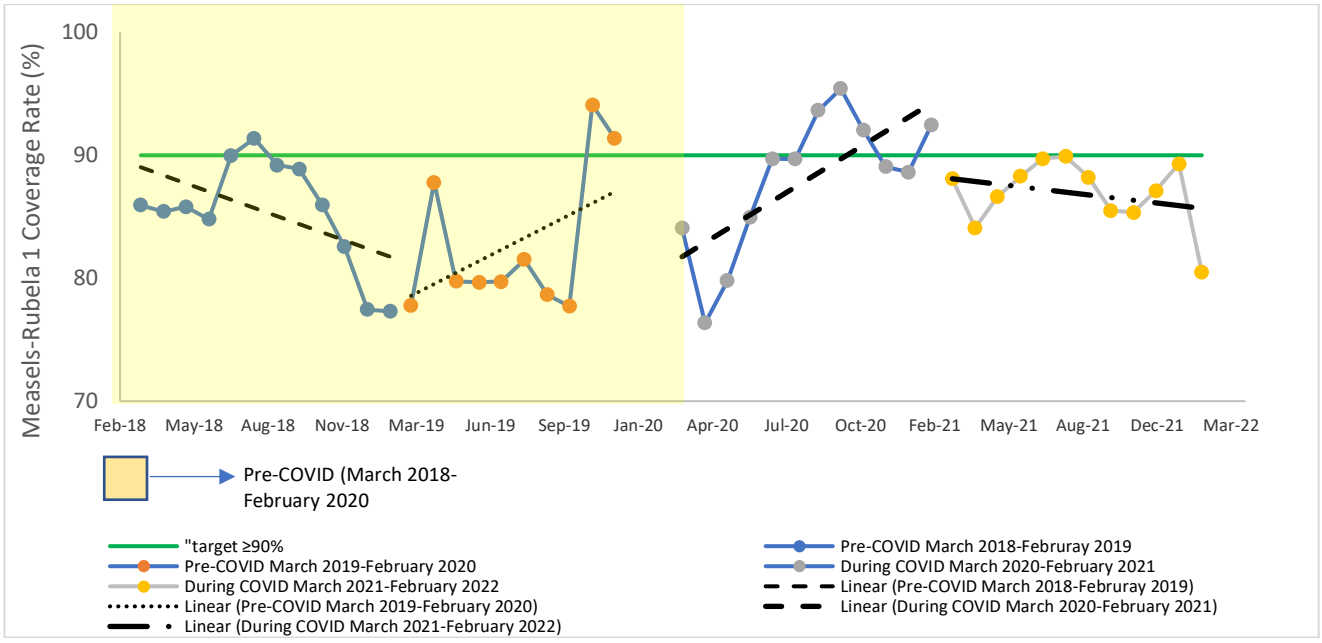


Figure 10: Trend of monthly coverage of measles-rubella 1 among children younger than one year, 24 months before the pandemic (March 2018-February 2020) and 24 months during the pandemic (March 2020-February 2022) at national level, Sierra Leone

Monthly coverage of measle-rubella 2

The 12 months average between March 2018 and February 2019, March 2019 and February 2020, March 2020 and February 2021, and March 2021 and February 2022 were 58%, 57%, 63% and 62% respectively (Figure 11). This 12 months average suggested little change in coverage before and during the pandemic and the pattern was seasonal. Between March 2018 and February 2019, the coverage shows an increase in trend, with the highest coverage in September 2018 at 70%. The increased in trend continues between March 2019 and February 2020, with the highest increased in June 2019 at 73%. The increased in trend continues between March 2020 and February 2021, with the highest coverage in October 2020 at 75%. Between March 2021 and February 2022, the trend shows a decrease in coverage with the highest decrease in March 2021 at 63%. This antigen did not meet the national target, before and during the pandemic. Overall a decrease in coverage by 14% from January to April 2020, following the declaration of the 12 months state of emergency for COVID-19 prevention.

From the semi structured interview, three of DOOs reported that this similarity in pattern, before and during the pandemic, is driven by low awareness among caregivers and lack of funding support for extensive surveillance of missed children to nurses. All of the respondents reported that the decrease in coverage, from January to April 2020, were exacerbated by the implementation of COVID-19 prevention and control measures. Similar with BCG and measles-rubella 1, the decrease between January and April, 2020 were reported by all of the respondents to be exacerbated by the pandemic.

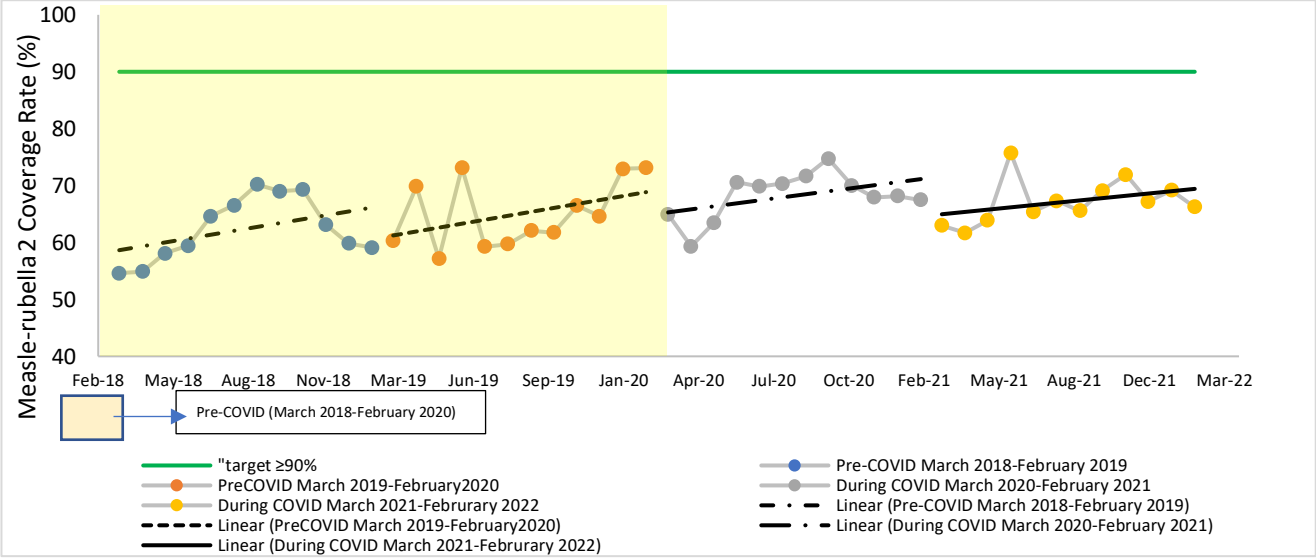


Figure 11: Trend of monthly coverage of measles-rubella 2 among children younger than one year, 24 months before the pandemic (March 2018-February 2020) and 24 months during the pandemic (March 2020-February 2022) at national level, Sierra Leone

Monthly coverage of pentavalent 1

The 12 months average between March 2018 and February 2019, March 2019 and February 2020, March 2020 and February 2021, and March 2021 and February 2022 are 98%, 82%, 99% and 99% respectively (Figure 12). Between March 2019 and February 2020, the coverage shows an increase with a conserved pattern. The highest increase was seen in January 2020 at 90%. The increase in trend continues between March 2020 and February 2021 with the highest coverage in July, October and December 2020 at 99% each. Between March 2021 and February 2020, the trend in coverage rate shows a decrease with the lowest coverage in February 2022 at 77%. The trend in coverage shows a decrease in coverage by 16% from January to April 2020 following the declaration of the 12 months state of emergency for COVID-19 prevention.

From the semi structured interview, all of the respondents reported that the decrease in coverage from January to April 2020 peaked at January, was exacerbated by the COVID-19 prevention and control measures. Similar with the BCG, the increase in coverage between March 2020 and February 2021 was reported to result from Government efforts in restructuring the health care utilization, including routine immunization after the Ebola outbreak. As well the decrease in trend between March 2021 and February 202, was due to the introduction of COVID-19 vaccines. Similar with BCG, measles-rubella 1 and 2, the decreased in coverage from January to April 2020, was reported by all of the respondent to be exacerbated by the pandemic. Similar reasons as in measles-rubella 1 (Figure *10*) were reported for the decreased in the 12 months average between March 2019 and February 2020.

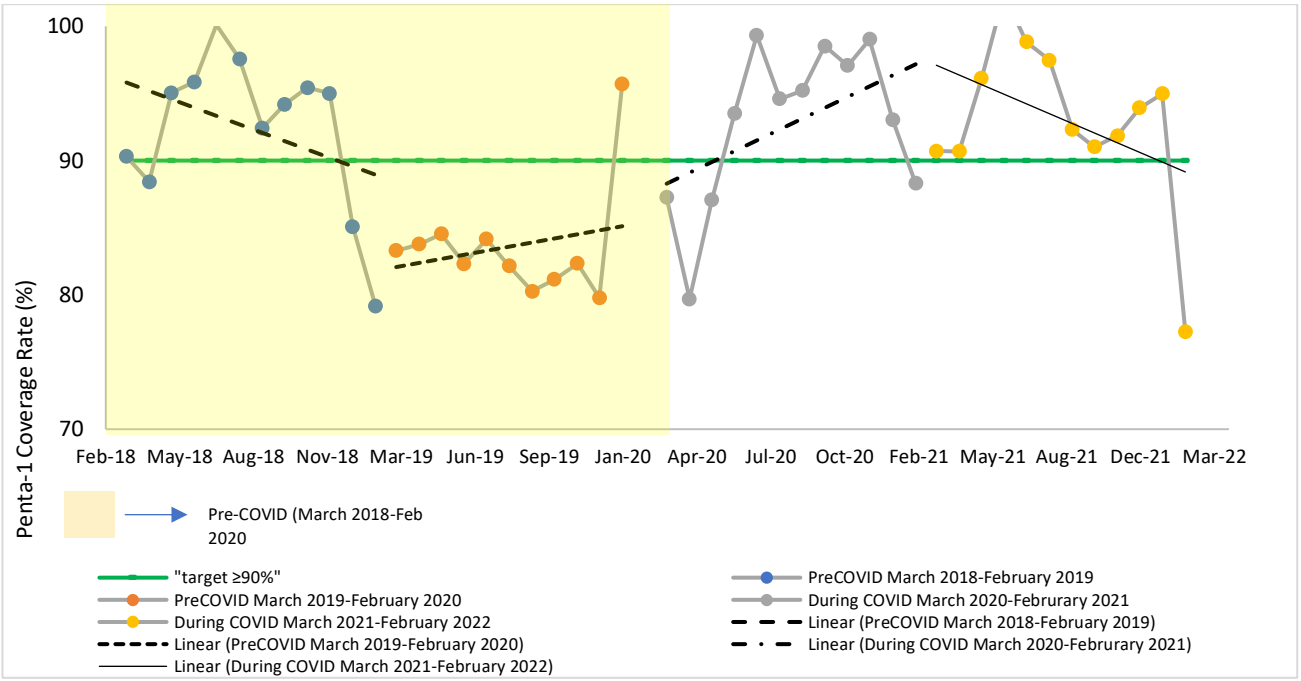


Figure 12: Trend of monthly coverage of pentavalent 1 among children younger than one year, 24 months before the pandemic (March 2018-February 2020) and 24 months during the pandemic (March 2020-February 2022) at national level, Sierra Leone

Monthly coverage in Pentavalent 3

The 12 months average between March 2018 and February 2019, March 2019 and February 2020, March 2020 and February 2021, and March 2021 and February 2022 were 87%, 82%, 92% and 88% respectively (Figure 13). Between March 2018 and February 2019, the coverage shows a slight decrease in trend with the lowest coverage in January 2019 at 80%. Between March 2019 and February 2020, the coverage rate shows an increase in trend, with the highest coverage seen in January 2020 at 93%. This increase in trend continues between March 2020 and February 2021, with the highest increase in October 2020 at 100%. Between March 2021 and February 2022, the trend shows a decline in coverage, with the lowest coverage in February 2022 at 77%. Overall a decrease in coverage by 14%, from January to April 2020, was observed following the declaration of the 12 months state of emergency.

Similar with BCG, measles-rubella 1, and pentavalent , the pattern with decrease in trend between March 2018 and February 2019, March 2019 and February 2020, March 2020 and February 2021, and March 2021 and February 2022, the reasons were the same for pentavalent 3. As well the decrease in coverage, from January to April 2020 and peaked at January, was reported to be the same.

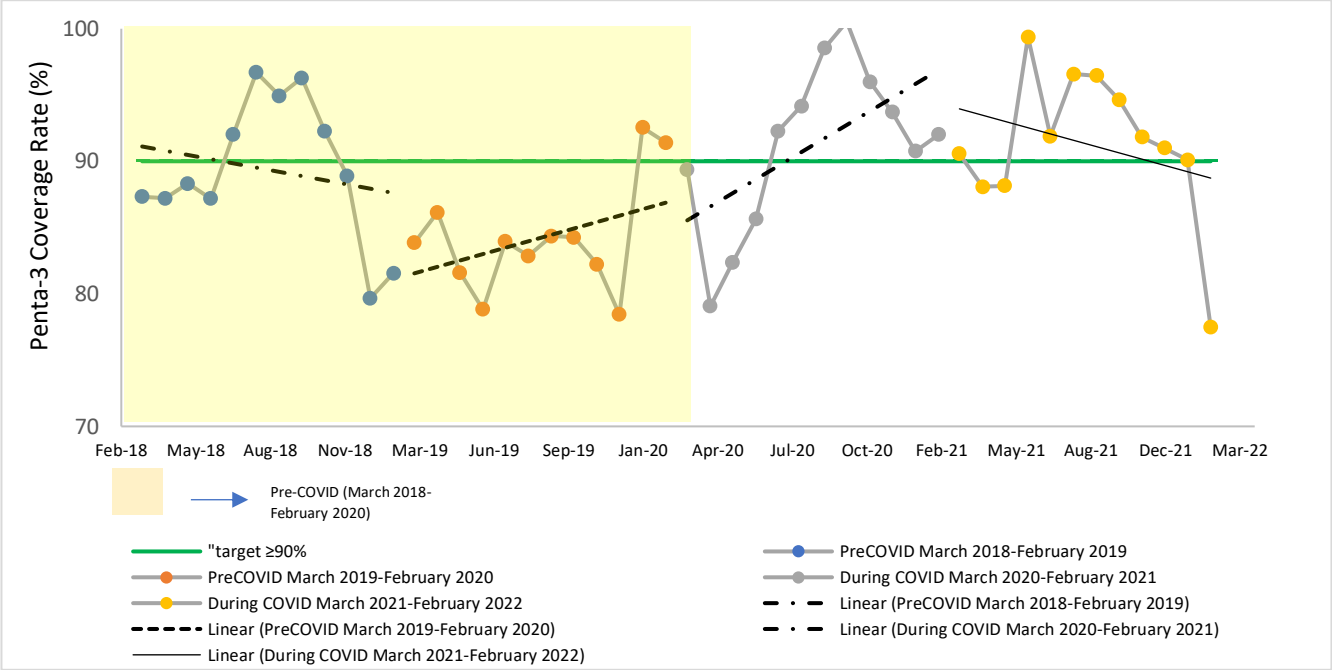


Figure 13: Trend of monthly coverage of pentavalent 3 among children younger than one, 24 months before the pandemic (March 2018-February 2020) and 24 months during the pandemic (March 2020-February 2022) at national level, Sierra Leone

4.2 TRENDS IN MONTHLY VACCINATION DROPOUT RATES

Figure 17 and 18 illustrate the trend in the monthly dropout rate of measles-rubella 1 and 2 and pentavalent 1 and 3 among children younger than one year, 24 months before the pandemic (March 2018-February 2020) and 24 months during the pandemic (March 2020 and February 2022) at national level in Sierra Leone. A linear trend was fitted in order to show the overall pattern in the dropout rate in each year.

Monthly dropout rate of measles-rubella 1 and 2

The 12 months average between March 2018 and February 2019, March 2019 and February 2020, March 2020 and February 2021, and March 2021 and February 2022 were 27%, 26%, 17% and 26% respectively (Figure 14). Like in measles-rubella 2 coverage, the pattern shown in the dropout, indicate minimal effect caused by the pandemic. This pattern it is seasonal. Between March 2018 to February 2019, the dropout rate shows a decrease in trend with the lowest rate in November 2018 at 19%. This decrease in trend continues between March 2019 to February 2020, with the lowest rate in November 2019 at 15%. On the contrary, between March 2020 and February 2021, the dropout rate shows an increase in trend with a seasonal pattern, with the lowest decrease in June 2020 at 17%. Between March 2021 and February 2022, the trend in the dropout rate shows a decrease in trend with a seasonal pattern and the lowest decrease was seen in June 2021 at 14%.

From the semi structured interview, the decrease in dropout rate, between March 2020 and February 2021, all of the respondents reported that, this decrease resulted from the government intervention, on scaling up routine immunization uptake. Two of the DOOs and the national experts reported that, the high increase in dropout rate, not meeting the national target was due to lack of funding support for nurses for defaulter tracing of missed children.

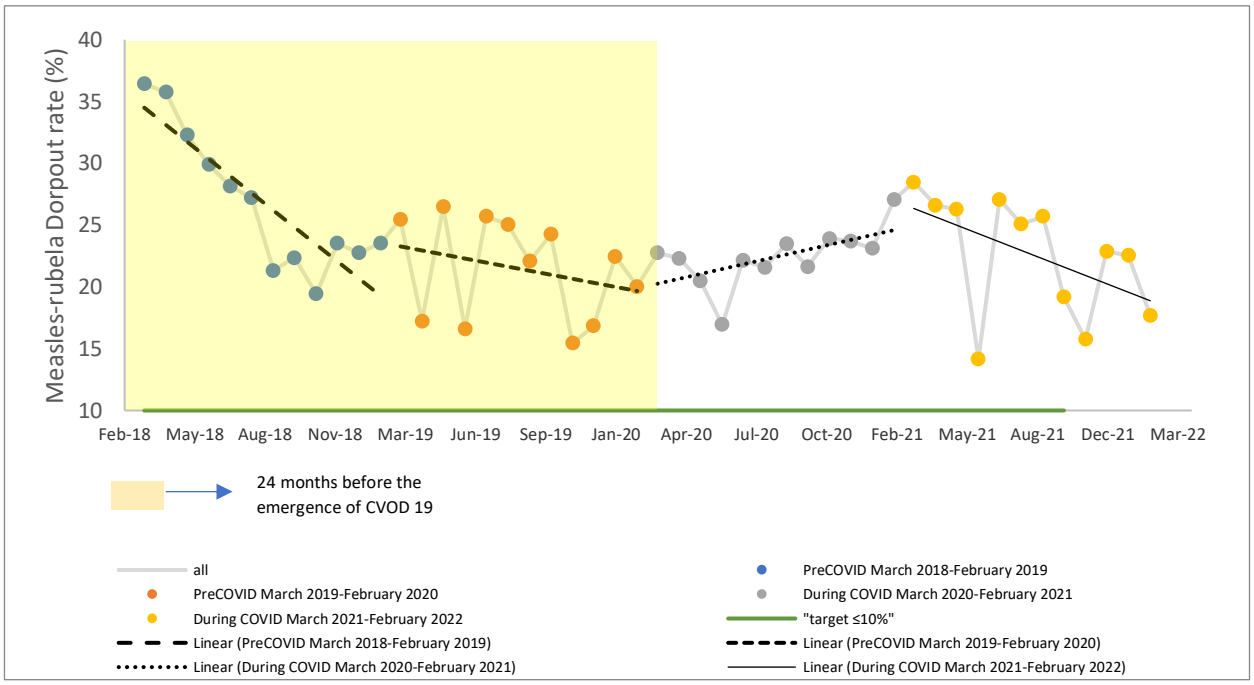


Figure 14: Trend of monthly dropout rate of measles-rubella 1 and 2 among children younger than one year, 24 months before the pandemic (March 2018-February 2020) and 24 months during the pandemic (March 2020-February 2022) at national level, Sierra Leone

Monthly dropout rate of pentavalent 1 and 3

The 12 months average between March 2018 and February 2019, March 2019 and February 2020, March 2020 and February 2021, and March 2021 and February 2022 were 8.1%, 0.3%, -3.5% and 2.9% respectively (Figure 15). Between March 2018 and February 2019, the dropout rate shows a decline in coverage with a conserved pattern. The lowest rate was seen September 2018 at 2.7%. Between March 2019 and February 2020, the trend shows an increase in dropout rate, with the highest increase seen in June 2019 at 4.2%. Between March 2020 and February 2021, in the first year of the pandemic, the dropout rate was expected to increase. However, the trend shows a decrease in dropout rate with the highest rate in February 2021 at 4.2%. Between March 2021 and February 2022, although the dropout rate shows a conserved pattern, like the other previous year. The lowest rate was seen in September 2021 at 4.5%.

From the semi structured interview, all of the respondent reported that the increase in the 12 months average, shown between March 2018 and February 2019, was due to the Ebola effect on healthcare utilization. All of the respondents reported that, caregivers are awareness on the time for routine immunization schedule dose for pentavalent relative to measles-rubella. They further said, the time interval of the schedule doses is the main factor, as Penta takes relate short interval between the 1st and 3rd dose compared with measles-rubella 1 and 2. Similar with measles-rubella 1 and 2, the pattern in pentavalent 1 and 3 is seasonal.

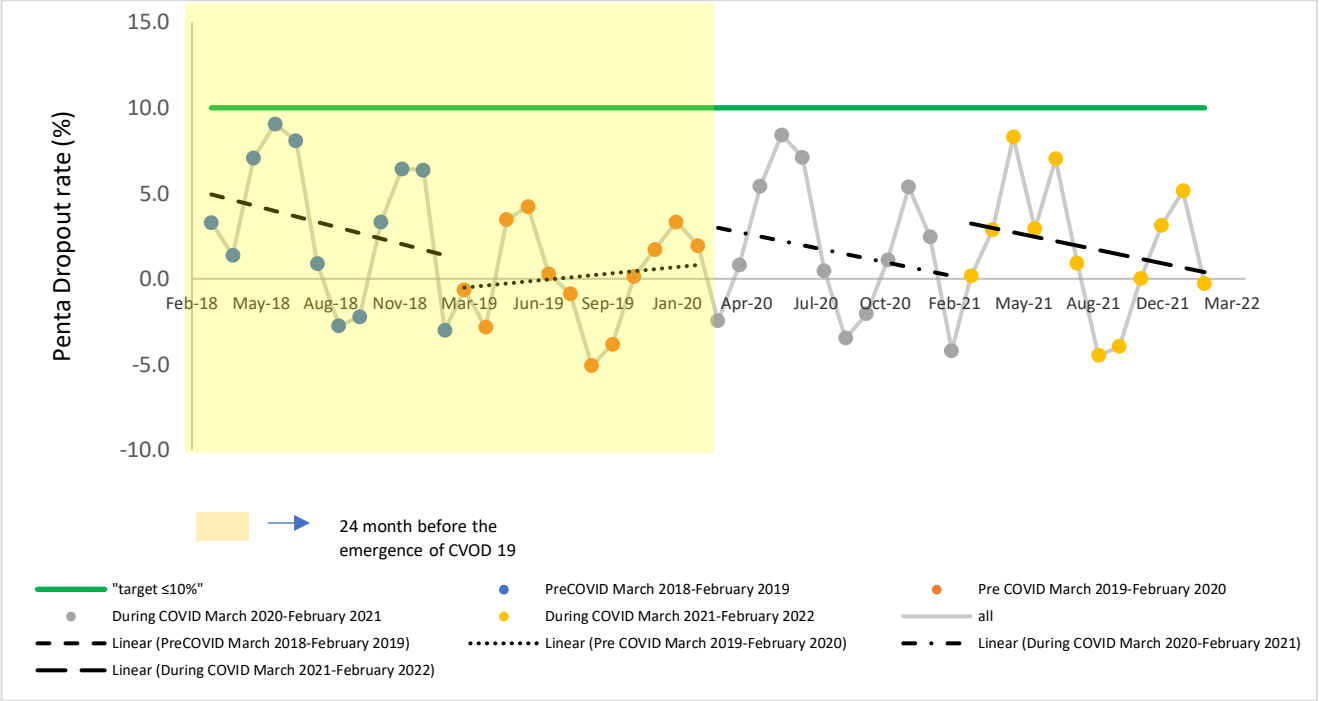


Figure 15: Trend of the monthly dropout rate of pentavalent 1 and 3 among children younger than one year, 24 months before the pandemic (Marh 2018-February 2020) and 24 months during the pandemic (March 2020-February 2022) at national level, Sierra Leone

4.3 ANNUAL VACCINATION COVERAGE RATE

Table five presents the difference in annual coverage rate of BCG, measles-rubella 1 and 2, and pentavalent 1 and 3 at national level in 2019 and 2020, Sierra Leone. Figure 14 to 16 presents the difference in annual coverage rate of BCG, measles-rubella 1 and 2, Pentavalent 1 and 3 among children younger than one year at district level in Sierra Leone.

Annual coverage at national level

Between 2019 and 2020, all the antigens show a decrease in coverage rate, with measles-rubella 1 and 2, accounting for the highest decrease, with 9.9% and 7.8% respectively (Table 5). The decrease in the number of doses administered in 2020, compared with 2019, relative to the denominator, could have resulted in a decline in the average annual coverage in all of the antigen. This pattern varies from the 12 months average coverage of 2019 and 2020 (Figure 9 , Figure 10, Figure 11 Figure 12 and Figure 13),which shows an increase in coverage. This is because, the average annual coverage starts from January and ends in December, while the 12 months average start from March and ends in February the next year.

Table 5: Average annual coverage of BCG, measles-rubella 1 and 2, pentavalent 1 and 3 among children younger than one year, 2019 and 2020, at national level, Sierra Leone

Antigen	Average annual coverage (%)		Δ%	p-Value
	2019	2020		

BCG	76.2 (240,702/316,058)	71.6 (231,866/324,013)	-4.6	<0.01***
Measle-rubella 1	93.8 (266,684/284,452)	83.9 (257,647/307,022)	-9.9	<0.01***
Measle-rubella 2	73.4 (208,720/284452)	65.6 (201,439/307,022)	-7.8	<0.01***
Pentavalent 1	96.2 (273,728/284452)	88.7 (272,223/307,022)	-7.5	<0.01***
Pentavalent 3	89.1 (273,648/307,022)	86.7 (266,248/307,022)	-2.4	<0.01***

*** = significant at p≤0.001; Pearson chi-square test of independent
Δ = Difference

Average annual coverage of BCG at district level

Between 2019 and 2020, 14 out of the 16 districts, demonstrate a decrease in coverage with Falaba district accounting for the highest decrease with 11.7% (Table 6) while Koinadugu district accounted for the highest difference with an increase in coverage of 8.5%. The decline in the total number of doses administered, compared with the target population in 2020, could have accounted for this high decrease in coverage. This pattern of decrease in coverage across districts culminates to the national level.

From the semi structured interview, four of the DOOs and the national expert reported that all districts were expected to show differences with a decrease in coverage due to the disruption in routine immunization service delivery, by the COVID-19 pandemic, which culminates in the difference with a decrease at the national level. From the personal observation of the researcher, the highest difference with an increase in average annual coverage in Koinadugu, while Falaba district accounted for the highest decrease. This was because, Koinadugu district serves as the main treatment and distribution centre for routine immunization service for Falaba district. The community people, residing in villages in Falaba district closer to Koinadugu district, often seek routine immunization service in Koinadugu and this effect became pronounced during the pandemic, as the health system in Falaba was strained to deliver efficient service delivery.

Table 6: Average annual coverage of BCG among children younger than one year at district level, Sierra Leone, 2019 and 2020

Districts	**Vaccination rates (%)**		**Δ%(2020 vs 2019)**	**p-Value**
	2019	**2020**		
Bo	91 (23309/25646)	85.5 (22490/26291)	-5.35	<0.01***
Pujehun	85.5 (13199/15440)	93.2 (14748/15829)	-7.62	<0.01***
Moyamba	104.4 (14771/14198)	96.7 (14071/14555)	-7.7	<0.01***
Bonthe	71.9 (6434/8948)	71.6 (6563/9173)	-0.3	0.84
Bombali	72.1 (13580/18849)	64.4 (12450/19323)	-7.7	<0.01***
Tonkolili	62.2 (14244/22906)	55.3 (12986/23482)	-6.9	<0.01***

Koinadugu	65.4 (5949/9092)	73.9 (6888/9321)	8.5	<0.01***
Falaba	65.2 (5965/9152)	53.5 (5017/9382)	-11.7	<0.01***
Kailahun	68.2 (16004/23458)	69.0 (16595/24048)	0.8	0.43
Kenema	79.8 (21680/27180)	72.8 (20271/27864)	-7	<0.01***
Kono	67.3 (15177/22554)	62.1 (14352/23122)	-5.2	<0.01***
Kambia	81.2 12507/15396)	70.0 (11047/15783)	-11.2	<0.01***
Karene	70.3 (8946/12725)	60.2 (7850/13048)	-10.1	<0.01***
Port Loko	84.8 (20055/23658)	82.2 (19924/24253)	-2.6	0.02
Western Area Rural	85.7 (16972/19799)	84.7 (17192/20297)	-1	0.4208
Western Area Urban	67.8 (31910/47059)	61.0 (29422/48243)	-6.8	<0.01***

*** = significant at p≤0.001
Pearson chi-square test of independent
Δ = Difference

Average annual coverage of measles-rubella 1 and 2

Between 2019 and 2020, 14 out of the 16 districts shows difference with a decrease in average annual coverage of measles-rubella 1 and 2. Western are urban district accounted for the highest difference with a decrease in coverage of 22.7% and 22.2% respectively (Table 7). Pujehun district shows difference with an increase in the average annual coverage in measles-rubella 1 with 2.1% and Kono district with an increase in measles-rubella 2 of 4%. Similar with BCG, the decline in the number of doses, administered relative of the target population in 2020, could have resulted in the decrease in coverage, as shown in the pattern. This decrease in average annual coverage across district level culminates at the national level.

Similar with the decrease in all antigen at national level and in BCG at district level, all of the respondents reported that the difference with the decrease in coverage in measles-rubella 1 and 2 were also expected to occur in all of the districts, due to disruption in routine immunization by the COVID-19 pandemic. All of the respondents reported prolonged lock down measures: Western area urban and Western area rural, difficulty in transportation, limited supply of personal protective equipment and limited health workforce: Falaba, Moyamba, Pujehun, Karene and Tonkolili district as the main barrier that decrease in coverage.

Table 7: Average annual coverage of measles-rubella 1 and 2 among children younger than one year, at district level, Sierra Leone, 2019 and 2020

Districts	**Measles-rubella 1**				**Measles-rubella 2**			
	Average annual rates (%)		**Δ%**	**p-Value**	**Average annual rates (%)**		**Δ%**	**p-Value**
	2019	**2020**			**2019**	**2020**		
Bo	103 (23682/23081)	95 (23775/24913)	-7.2	<0.01***	75 (17313/23081)	74 (18417/24913)	-1.1	0.30

Pujehun	100.6 (13972/13896)	102.70 (15403/14998)	2.1	0.20	90.70 (12604/13896)	88.95 (13341/14998)	-1.8	0.26
Moyamba	123.10 (15730/12778)	110.27 (15208/13792)	-12.8	<0.01***	110.49 (14118/12778)	100.65 (13882/13792)	-9.8	<0.01***
Bonthe	89.42 (7201/8053)	85.80 (7458/8692)	-3.6	0.07	62.50 (5033/8053)	54.91 (4773/8692)	-7.5	<0.01***
Bombali	80.52 (13659/16964)	78.08 (14297/18310)	-2.4	0.06	64.79 (10991/16964)	63.00 (11536/18310)	-1.8	0.09
Tonkolili	98.42 (20290/20615)	86.10 (19157/22251)	-12.3	<0.01***	78.70 (16225/20615)	70.98 (15794/22251)	-7.7	<0.01***
Koinadugu	92.85 (7598/8183)	87.84 (7758/8832)	-5.01	0.01	68.84 (5633/8183)	65.85 (5816/8832)	-3.0	<0.01***
Falaba	101.42 (8353/8236)	84.95 (7552/8890)	-16.5	<0.01***	76.68 (6316/8236)	67.57 (6007/8890)	-9.1	<0.01***
Kailahun	89.42 (18879/21112)	83.85 (19106/22787)	-5.6	<0.01***	86.14 (18186/21112)	71.91 (16386/22787)	-14.2	<0.01***
Kenema	97.11 (23755/24462)	85.68 (22622/26403)	-11.4	<0.01***	78.89 (19297/24462)	71.15 (18786/26403)	-7.7	<0.01***
Kono	71.08 (14429/20299)	71.66 (15700/21909)	-0.6	0.60	53.24 (10808/20299)	57.26 (12545/12909)	4.0	<0.01***
Kambia	96.33 (13348/13856)	84.36 (12617/14956)	-12.0	<0.01***	57.89 (8022/13856)	57.24 (8562/14956)	-0.7	0.57
Karene	85.43 (9784/11453)	69.64 (8609/12361)	-15.8	<0.01***	71.22 (8157/11453)	60.50 (7479/12361)	-10.7	<0.01***
Portloko	93.19 (19843/21292)	87.47 (20103/22981)	-5.7	<0.01***	71.96 (15322/21292)	72.19 (16591/22981)	0.23	<0.01***
Western Area Rural	104.57 (18634/17819)	94.41 (18157/19233)	-10.2	<0.01***	73.12 (13030/17819)	61.39 (11807/19233)	-11.7	<0.01***
Western Area Urban	88.61 (37527/42353)	65.88 (30116/45713)	-22.7	<0.01***	65.32 (27665/42353)	43.10 (19701/45713)	-22.2	<0.01***

*** = significant at p≤0.001; Pearson chi-square test of independent

Δ = Difference

Average annual coverage of Pentavalent 1 and 3

Between 2019 and 2020, 15 out of the 16 districts showed a decrease in coverage (Table 8) with Falaba districts accounting for the highest difference with a decrease in coverage in Pentavalent 1 and 3 with 19.4% and 19.2% respectively. Pujehun district showed a difference with increase in the average annual coverage in Pentavalent 1 and 3 with 2.7% each. Similar with BCG and measles-rubella 1 and 2, the decline in the number of doses, administered during the pandemic, relative to the target population, exacerbated the decrease in coverage.

Similar to the decrease in coverage, observed in BCG, and measles-rubella 1 and 3, all of the respondents reported that the disruption in routine immunization service by the pandemic as the cause. One of the DOOs and the national experts reported, the difference in increase in coverage in Pujehun district, resulted from interventions: community awareness, supportive supervision and mentorship of healthcare workers on community approach in outreach services, solely funded by partners of the district health management team. Two of the DOOs and the national expert reported, the lack of support from community

stakeholders: chiefs, mothers' club representative and youths, lockdown, social distancing, use of face mask as the main barrier that precipitated the decrease in coverage

Table 8: Average annual coverage of pentavalent 1 and 3 among children younger than oner at district level, Sierra Leone, 2019 and 2020

	Pentavalent 1				Pentavalent 3			
Districts	**Vaccination coverage rates (%)**		**% Δ**	**p-Value**	**Vaccination coverage rates (%)**		**% Δ**	**p-Value**
	2019	**2020**			**2019**	**2020**		
Bo	105.54 (24360/23081)	99.16 (24704/24913)	-6.4	<0.01***	109.19 (25202/23081)	97.95 (24401/24913)	-11.2	<0.01***
Pujehun	100.19 (13922/13896)	102.88 (15431/14998)	2.7	0.11	101.22 (14066/13896)	103.88 (15581/14998)	2.7	0.12
Moyamba	130.01 (16613/12778)	116.60 (16081/13792)	-13.4	<0.01***	124.93 (15964/12778)	112.52 (15518/13792)	-12.4	<0.01***
Bonthe	92.88 (7480/8053)	90.97 (7907/8692)	-1.9	0.36	97.09 (7819/8053)	93.42 (8120/8692)	-3.7	0.08
Bombali	82.02 (13914/16964)	77.31 (14156/18310)	-4.7	<0.01***	84.08 (14264/16964)	78.01 (14284/18310)	-6.1	<0.01***
Tonkolili	103.28 (21292/20615)	91.58 (20377/22251)	-11.7	<0.01***	100.38 (20694/20615)	86.50 (19246/22251)	-13.9	<0.01***
Koinadugu	104.14 (8522/8183)	96.84 (8553/8832)	-7.3	<0.01***	101.96 (8343/8183)	95.99 (8478/8832)	-6.0	<0.01***
Falaba	111.06 (9147/8236)	91.66 (8148/8890)	-19.4	<0.01***	110.67 (9115/8236)	91.52 (8136/8890)	-19.2	<0.01***
Kailahun	87.77 (18530/21112)	85.40 (19461/22787)	-2.4	0.05	90.44 (19094/21112)	87.25 (19883/22787)	-3.2	0.01
Kenema	96.84 (23688/24462)	85.89 (22676/26403)	-11.0	<0.01***	95.50 (23360/24462)	84.74 (22373/26403)	-10.8	<0.01***
Kono	83.16 (16880/20299)	78.29 (17152/21909)	-4.9	<0.01***	78.82 (15999/20299)	72.46 (15875/21909)	-6.4	<0.01***
Kambia	101.24 (14028/13856)	88.96 (13305/14956)	-12.3	<0.01***	102.92 (14261/13856)	86.77 (12977/14956)	-16.2	<0.01***
Karene	88.65 (10153/11453)	74.52 (9212/12361)	-14.1	<0.01***	88.97 (10190/11453)	73.69 (9109/12361)	-15.3	<0.01***
Port loko	97.34 (20726/21292)	95.38 (21919/22981)	-2.0	0.14	96.21 (20486/21292)	91.57 (21043/22981)	-4.6	<0.01***
Western Area Rural	108.10 (19263/17819)	102.98 (19806/19233)	-5.1	<0.01***	107.95 (19236/17819)	98.09 (18866/19233)	-9.9	<0.01***
Western Area Urban	83.13 (35210/42353)	72.88 (33318/45713)	-10.3	<0.01***	83.95 (35555/42353)	70.78 (32358/45713)	-13.2	<0.01***

*** = significant at p≤0.001

Pearson chi-square test of independent

Δ = Difference

4.4 ANNUAL VACCINATION DROPOUT RATE

Table 10 illustrates the difference in the annual dropouts rate of pentavalent 1 and 3 and measles-rubella 1 and 2, among children younger than one year, 2019 and 2020, at national level in Sierra Leon. Figure 19 and 20 illustrates the difference in the annual dropout rate of pentavalent 1 and 3, and measles-rubella 1 and 2 among children younger than one year, 2019 and 2020, at district level in Sierra Leone.

Average annual dropout rate of measles-rubella 1 and 2 and pentavalent 1 and 3 at national level

Between 2019 and 2020, measle-rubella 1 and 2 shows no difference in dropout rate, while pentavalent 1 and 3 increased by 2.17% (Table 9). Measles-rubella 1 and 2 did not meet the national target of ≤10% in each of the years. The high dropouts rate is exacerbated by the low number of doses administered.

From the personal observation of the researcher who work in the EPI program, the lack of change in measles-rubella 1 and 2, and slight increase in pentavalent 1 and 3 demonstrates, the pandemic have limited effect in the dropout rate.

Table 9: Average annual dropout rate on measles-rubella 1 and 2, and pentavalent 1 and 3 among children younger than one year at national level, 2019 and 2020

Antigen	**Vaccination dropout rates (%)**		**Δ%**	**p-Value**
	2019	2020		
Measles-rubella 1 and 2	21.7 [(266684-208720)/266684]	21.8 [(257638-201422)/257638]	0.1	0.55
Pentavalent 1 and 3	0.03 [(273728-273648)/273728]	2.2 [(272206-266248)/272206]	2.2	<0.01***

*** = significant at p≤0.001,
Pearson chi-square test of independent
Δ = Difference

Average annual dropout rates of measles-rubella 1 and 2 at district level.

Between 2019 and 2020, of the 16 districts, we see that the districts, with prolonged lockdown measures: Western area urban and Western area rural district, and those with a relatively weakened health system: Pujehun, Bonthe, and Kailahun district, accounted for the highest difference with an increase in the average annual dropout rate (Table 10). Kailahun district accounted for the highest difference with an increase of 10.6%. This relative equal proportion of increase and decrease, in dropout rate at district level, demonstrates the lack of change at national level (Table 9).

From the semi structured interview, five of the DOOs reported that nurses within the EPI program do not get funding support, to conduct extensive default tracing of missed children. They further state that, most caregivers often moved from their usual resident, where they received the first dose, to another destination, which makes it difficult for the nurses to deliver the second dose. All of the respondents, reported the low number of measles-rubella 2 doses administered as cause for the difference with increase in dropout rate, and not the effect of the COVID-19 pandemic.

Table 10: Average annual dropout rate of measles-rubella 1 and 2, among children younger than one year, at district level in Sierra Leone, 2019 and 2020

Districts	**Vaccination dropout rates (%)**		**Δ%**	**p-Value**
	2019	**2020**		
Bo	26.9 [(23682-17313) / 23682]	22.5 [(23775-18417)/23775]	-4.4	<0.01***
Pujehun	9.8 [(13972-12604)/13972]	13.4 [(15403-13341)/15403]	3.6	<0.01***
Moyamba	10.2 [(15730-14118)/15730]	8.7 [(15208-13882)/15208]	-1.5	<0.01***
Bonthe	30.1 [(7201-5033)/7201]	36.0 [(7458-4773)7458]	5.9	<0.01***
Bombali	19.5 [(13659-10991)/13659]	19.3 [(14297-1536)/14297]	-0.2	<0.01***
Tonkolili	20.0 [(20290-16225)/20290]	17.6 [(19157-5794)/19157]	-2.5	<0.01***
Koinadugu	25.9 [(7598-5633)/7598]	25.0 [(7758-5816)/7758]	-0.8	0.37
Falaba	24.4 [(8353-6316)/8353]	20.5 [(7552-6007)/7552]	-3.9	<0.01***
Kailahun	3.7 [(18879-18186)/18879]	14.2 [(19106-6386)/19106]	10.6	<0.01***
Kenema	18.8 [(23755-19297)/23755]	17.0 [22622-18786)/22622]	-1.8	<0.01***
Kono	25.1 [(14429-10808)/14429]	20.1 [(15700-2545)/15700]	-5.0	<0.01***
Kambia	39.9 [(13348-8022)/13348]	32.1 [(12617-8561)/12617]	-7.8	<0.01***
Karene	16.6 [(9784-8157)/9784]	13.1 [(8609-7479)/8609]	-3.5	<0.01***
Port Loko	22.8 [(19843-15322)/19843]	17.5 [(20103-16591)/20103]	-5.3	<0.01***
Western Area Rural	30.1 [(18634-13030)/18634]	35.0 [(18157-11807)/18157]	4.9	<0.01***
Western Area Urban	26.3 [(37527-27665)/37527]	34.6 [(30116-19701)/30116	8.3	<0.01***

*** = significant at p≤0.001,
Pearson chi-square test of independent
Δ = Difference

Average annual dropout rate of pentavalent 1 and 3

Between 2019 and 2020, of the 16 districts, 12 districts show a slight increase in the average annual dropout rate. Similar with the average annual dropout rate in measles-rubella 1 and 2, the districts with prolonged lock down measures: Bo, Western area urban district, Western area rural district; and Kambia district with the major crossing point (Gbalamuya point of entry) accounted for the highest difference with increased in dropout rate (Table 11).

From the semi structured interview, all of the five DOOs reported the same reasons, as in measles-rubella average annual dropout rate, to be the cause of the relatively low change.

Table 11: Average annual dropout rates of pentavalent 1 and 3 among children younger than one year, at district level, Sierra Leone, 2019 and 2020

Districts	**Vaccination dropout rates (%)**		**Δ%**	**p-Value**
	2019	**2020**		
Bo	-3.5 [(24360-25202)/24360]	1.2 [(24704-24401)/24704]	4.7	<0.01***
Pujehun	-1.0 [(13922-14066)/13922]	-1.0 [(15431-15581)/15431]	0.1	<0.01***
Moyamba	3.9 [(16613-15964)/16613]	3.5 [(16081-15518)/16081]	-0.4	0.07
Bonthe	-4.5 [(7480-7819)/7480]	-2.7 [(7907-8120)/7907]	1.8	<0.01***
Bombali	-2.5 [(13914-14264)/13914]	-0.9 [(14156-14284)/14156]	1.6	<0.01***
Tonkolili	2.8 [(21292-20694)/21292]	5.6 [(20377-19246)/20377]	2.7	<0.01***
Koinadugu	2.1 [(8522-8343)/8522]	0.9 [(8553-8478)/8553]	-1.2	<0.01***
Falaba	0.3 [(9147-9115)/9147]	0.1 [(8148-8136)/8148]	-0.2	0.01***
Kailahun	-3.0 [(18530-19094)/18530]	-2.2 [(19461-19883)/19462]	0.9	<0.01***
Kenema	1.4 [(23688-23360)/23688]	1.3 [(22676-22373)/22676]	-0.1	<0.01***
Kono	5.2 [(16880-15999)/16880]	7.4 [(17152-15875)/17152]	2.2	<0.01***
Kambia	-1.7 [(14028-14261)/14028]	2.5 [(13305-12977)/13305]	4.1	<0.01***
Karene	-0.4 [(10153-10190)/10153]	1.1 [(9212-9109)/9212]	1.5	<0.01***
Port Loko	1.2 [(20726-20486)/20726]	4.0 [(21919-21043)/21919	2.8	<0.01***
Western Area Rural	0.1 [(19263-19236)/19263]	4.7 [(19806-18866)/19806]	4.6	<0.01***
Western Area Urban	-1.0 [(35210-35555)/35210]	2.9 [(33318-32358)/33318]	3.9	<0.01***

*** = significant at p≤0.001,
Pearson chi-square test of independent
Δ = Difference

CHAPTER FIVE

5.1 DISCUSSION

The aim of this study was to assess the impact of COVID-19 pandemic on routine immunization rates and services in Sierra Leone. Specifically, the study assessed the monthly and annual coverage rate of BCG, measles-rubella 1 and 2 and pentavalent 1 and 3. And the monthly and annual dropout rate of measles-rubella 1 and 2 and pentavalent 1 and 3. Furthermore, the study examined the barriers imposed by the pandemic on routine immunization services that led to the decrease in coverage or increase in dropout rate.

Between March 2018 and February 2019, this study found that, the trend in monthly coverage rate decreased in BCG, measles-rubella 1, and pentavalent 1 and 3 (Figure 9, Figure 10, Figure 12, and Figure 13). This study suggested that this decrease in trend in monthly coverage was partly due to the Ebola outbreak effect. This was due to the fact that, an estimated 6.85% of the total health care workers in Sierra Leone died during the Ebola outbreak response, between 2014 and 2016, leaving the health workforce understaffed, to provide efficient service delivery, including routine immunization (52). In other words, the decrease in trend could also result from caregivers negative experiences due to the devastating Ebola outbreak, which caused an estimated 8,704 confirmed cases and 3,589 deaths (CFR: 41.2%) in Sierra Leone (52). Between March 2019 and February 2020, this study found the trend in monthly coverage increased while the monthly dropout rate decreased in all of the antigen under study (Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, Figure 14 and Figure 15). This increase in trend, of the monthly coverage and decrease of monthly dropout rate, could likely result from the Government of Sierra Leone efforts, in rebuilding the healthcare system. Through health workers recruitment and training, community engagement through psychosocial intervention and social mobilization, and standardizing data reporting, among others. (53). These findings were similar with a descriptive cross sectional study, using routine immunization data in Liberia, where the authors reported an increase in coverage before the Ebola outbreak, decrease during the outbreak and increase after the outbreak (54). The authors concluded, the deaths of health workers which left the health workforce understaff, deterred the progress in routine immunization coverage in the post Ebola era (54).

This study discovered a more pronounced decrease in the coverage of the 12 months average, between March 2019 and February 2020, in BCG, Measles-rubella 1, pentavalent 1, and 3 vaccinations (Figure 9, Figure 10, Figure 12, and Figure 13) relative to the other periods. Through semi-structured interviews, this study discovered that the decline was caused by the cessation by partners (UNICEF) of financial incentives offered through the Ministry of Health and Sanitation to nurses to provide weekly outreach service. Due to this, nurses lacked the motivation to execute their primary duties. On the other hand, this study discovered, through semi-structured interviews that, this decline could also result from the replacement of vaccinators with technical nurses, specifically maternal and child health aid (MCH Aid) nurses. This study determined that this choice was made at a time when there was a very small number of technical nurses to provide efficient service delivery within the immunization program, which could have led to the decline in coverage.

Also, as discovered by this study, the decline in the monthly coverage rate, from January to April 2020, after the declaration of the 12 months state of emergency in all of the antigens (Figure 9, Figure 10, Figure 11, Figure 12, and Figure 13). This study suggested that, like in many low-middle income countries, the implementation of the COVID-19 prevention and control measures, starting with the 12 months state of emergency, declared in January 2020, coupled with the lockdown [stay at home], exacerbated the already existing factor that limits the utilization of routine vaccines including: cost, personal and religious beliefs, long distance to access health services among many others (33). This was because, during this period, two successive lockdown measures were instituted: between 3rd to 5th April and between 8th to 11th April 2020 (55). This could have likely led to the decline in the monthly coverage rates in all of the antigens under

study. This findings was similar with a cross sectional study, conducted on the Impact of the Ebola outbreak on routine immunization in the Western area, Freetown – a field survey from an Ebola epidemic area (56). The authors concluded the coverage for measles and pentavalent antigen further decreased during the outbreak due to disruption in routine immunization even though it was low prior to the outbreak, (56).

Between March 2020 and February 2021, as discovered by this study, with an increase in monthly coverage rates in all of the antigens and the decrease in monthly dropout rate in pentavalent antigen 1 and 3 with conserved pattern as shown in BCG, measles-rubella 1 and 2, pentavalent 1 and 3 and the monthly dropout rate of pentavalent 1 and 2 (Figure 9, Figure 10, Figure 11, Figure 13, and Figure 15). This study found through the semi structured interviewed that, the implementation of mass sensitization on COVID-19, community engagement meetings, could have likely resulted in the increase in monthly coverage rates in all of the antigens and the decrease in measles-rubella dropout rate as shown in the conserved pattern. Like in other places across the world, these factors contributed immensely to the uptake of routine immunization service utilization. This could have been the likely cause of the increase in trend of coverage.

Also, as discovered by this study, with a trend showing a decrease in the monthly coverage of BCG, measles-rubella 1, pentavalent and 3, between March 2021 and February 2022 (Figure 9, Figure 10, Figure 12 and Figure 13). This study found that, this decrease in coverage could have likely result from the introduction of the COVID-19 vaccine. With an illiteracy level of over 80% (57), the introduction of the COVID-19 vaccines precipitated diverse negative views, which aggravated panic among caregivers in seeking routine immunization, in Sierra Leone. This was because, the majority of the population perceived the introduction of the vaccines as a population control strategy by the government of Sierra Leone. This could have likely led to the decreased in the trend of the coverage. In other words, the study also discovered through the semi structured interview that, the frequent strike action among health workers could have likely contributed to the decrease in trend. This study suggested that, this strike action triggered health workers including nurses within the EPI program to halt service provision in protest of their monthly incentive for their participation in the COVID-19 response. This could have likely resulted in the decrease in coverage.

As confirmed by this study, between 24 months before and during the pandemic, the coverage rate of BCG, [which is given at birth expected to be administered at the health facilities] and measles-rubella 2 not meeting the national target of $\geq$90% (Figure 9 and Figure 11) and measles rubella 1 and 2 dropout rate not meeting the national target of $\leq$10% (Figure 14). The Government of Sierra Leone introduced the free health care initiative in 2010, aimed to ameliorate the barriers such as costs that deterred health service utilization among pregnant women (46). This study suggested that the low monthly coverage rates in BCG, indicates that the policy is not achieving its intended purpose as the suboptimal vaccination coverage in BCG, could likely be due to a low institutional delivery. In addition, the semi-structured interview revealed that, the suboptimal monthly coverage of measles rubella 2 could have likely result from the limited understanding of caregivers regarding the significance of routine immunization uptake. This study suggested that, because the uptake of measles-rubella 2 was suboptimal, it consequently affected the dropout rate of measles-rubella 1 and 2 not meeting the national target. To amend this suboptimal monthly coverage rate, the study suggested that health care workers have to intensify surveillance in following up of pregnant women, during the antenatal care (ANC) and ensure they are delivered at the health facility, as well as to follow up on missed children in the routine vaccination schedule doses (45). This finding was similar with a study conducted by Dr. Danilo Buonsenso and colleagues, on child health care and immunization in Sub-Saharan Africa, during the COVID-19 pandemic, in the context of Sierra Leone (8); where the authors revealed that, home delivery was the main cause attributed to the low coverage of BCG, because community members were afraid of contracting the COVID-19 infection if they delivered in the health facility (8).

Between 2019 and 2020, as discovered by this study, with a decline in the average annual coverage in all of the antigens and the increase in annual dropout rate of pentavalent 1 and 3 with measles-rubella 1 and 2 annual dropout rate, remaining unchanged at national level (Table 5 and Table 9). This study suggested that, this could likely due to the decrease in the number of doses administered in 2020, compared with 2019. This resulted from fear of a COVID-19 infection among caregivers and the competing activities among health workers, as they prioritized COVID-19 activities at the expense of routine immunization. In addition, this study discovered that, the Western area urban district is having the highest difference with decline in the average annual coverage rate of measle-rubella 1 and measle-rubella 2 at district level (Table 7). Also, this study found that, Western area urban district, which host the capital city, Freetown had easy access to routine vaccine distribution, compared to other districts. However, this district was the first to register a COVID-19 case in Sierra Leone and as a result, it experienced the longest lockdown measures, coupled with the ban on the movement of internal transportation, as compared to any other district in Sierra Leone. This could have likely resulted in the difference with highest decreased in coverage in measles-rubella 1 and 2. This finding was consistent with a study conducted on COVID-19 and childhood immunization in Africa: Leveraging systems thinking and implementation science to improve the immunization system performance by Dr. Abdu A. Adamu and colleagues(10), where the authors reported lockdown measures as a barrier in accessing vaccines during the pandemic.

Within the same period (2019 and 2020), the difference with a decrease in the average annual coverage rate of BCG, pentavalent 1 and 3 antigen was also expected to be the highest in the Western area urban district, because of the prolonged restriction measures. The study found that the difference with the decrease in the average annual coverage of BCG, pentavalent 1 and Pentavalent 3 antigen was the highest in Falaba district (Table 6 and Table 8). Falaba district, borders with Guinea in the northern region of Sierra Leone, was one of the two new districts added in 2016 to Sierra Leone. As discovered by this study, with districts having many hard to reach areas and a weakened health system, disproportionately affected by the transportation and access to personal protective equipment during the pandemic. The finding from the semi structured interview suggested that this district was a notable example and it could be the likely reason which contributed to the low coverage rate, as children had difficulty in accessing routine vaccines during the pandemic. This finding was consistent with a study conducted by Dr. Anja Susa and colleagues (58), on the impact of the COVID-19 pandemic on routine vaccination services and maternal and infants immunizations. The authors concluded that, the delay in transportation as the main barrier imposed by the COVID-19 pandemic, which made access to vaccines difficult.

Despite the impact of the COVID-19 pandemic, which resulted in lower coverage and dropout rates in all of the antigen across every district in Sierra Leone, between 2019 and 2020. In Pujehun district, the average annual coverage rate for measles-rubella 1 and pentavalent 1 and 3 antigens increased while the annual dropout rate for pentavalent 1 and 3 remained unchanged (Table 9 and Table 10). Pujehun district, borders with Liberia and is located in the Southern region of Sierra Leone, is one of the most deprived districts in Sierra Leone, with lack of basic essential amenities and their healthcare system is strained, compared to the rest of the other districts. Even though this district had less coronavirus cases, compared to the rest of the country (59), this finding was new, suggesting that with appropriate strategies and interventions, routine immunization can be sustained in districts with a relatively weakened health system. Through the semi structured interview, this study found that, this district involved chiefdom stakeholders in micro planning and sensitization of vaccine related activities at chiefdom level; solicited fund from implementing partners for outreach session for defaulter tracing and missed children; and intensified monitoring and supervision activities. This could have likely led to the increase in coverage. For the government of Sierra Leone and countries with similar context to maintain a routine immunization coverage rate during epidemics or other public health emergencies, the lessons learnt in this district will be essential to copy and implement. This finding is different from a community based cross sectional study, conducted in assessing the impact of COVID-19, on vaccination coverage among children aged 15

to 23 months, at Dessie town, North East Ethiopia, 2020 (60). The authors concluded that the vaccination coverage rate declined during the pandemic and it was due to the absence of poor awareness raising strategies by the authorities on the uptake of routine vaccines, to counter false information on the utilization of routine vaccines (60).

5.2 STRENGTHS AND IMPLICATION OF THE STUDY

1. This study provides detailed insights on the uptake of routine immunizations and the provision of services, 24 months prior to and 24 months during the pandemic, which is adequate to explore changes during the pandemic at national and district level.

2. This study was adequate to explore changes during the pandemic on routine immunization coverage and dropout rates, using data representative of every health facility in Sierra Leone. As a result, the exploration of the effects of Covid on routine immunization service, should explore data using both annual and monthly rates (patterns) and at national and lower administrative division levels. This provide a view of the different levels where effects can be seen in Sierra Leone

3. This research adheres to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) recommendations (61). Thus, this study provides insights on public health events with an exploratory analysis on routine immunization rate before and during the COVID-19 pandemic, with extensive analysis on the interventions that were done and it implications to routine medical practice and public health.

5.3 LIMITATIONS OF THE STUDY

1. The routine immunization data is not separately reported for boys/girls and thus the study could not look at gender differences and socio-economic status of the children. Because of this, the study could not determine whether children were disadvantaged in the access of routine vaccines due to their gender or economic situation.

2. It was impossible for the study to establish whether the target population used, to compute the coverage rates, changed during the pandemic. As a result, this might have impacted the study findings, possibly resulting in overestimation or under estimation in some coverage rate or dropout rates.

3. This study did not quantify and compare the effects of different containment measures on routine immunization rates. This is important for policy makers to be adequately informed on assessing the impact of the different containment measures and their effect on routine immunization

4. This study did not analyse the changes in rates, due to changes in diagnoses in the corresponding VPDs. This is a guide for policy makers in devising appropriate interventions with an insight on the categories of people most affected and which district to be prioritized in the implementation.

5. The purposeful sampling of DOOs from the five regional head quarter districts and the national expert, might not represent the views of the other DOOs in other districts, or other categories of health workers and caregivers. This might introduce bias in the qualitative insights, gathered to validate the quantitative findings. Similarly, the retrospective data collection might have introduced recall bias in the study results.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

During outbreaks or other public health emergencies, the disruptions of routine immunization increases the risk of children developing VPDs.

1. Regarding the monthly coverage and dropout rate at national level before and during the pandemic, this study shows:

- The impact of the prolonged Ebola outbreak, negatively affected routine immunization uptake and service delivery, between March 2018 and February 2019.

- The replacement of vaccinators at a period when there were low number of technical nurses; and the halt in funding support for outreach services, affected efficient routine immunization service delivery, between March 2019 and February 2020 relative to the other periods.

- The Governments efforts in intensifying awareness raising on COVID-19 pandemic as well sensitization on the benefit of routine immunization, improved routine immunization uptake, between March 2020 and February 2021.

- The introduction of COVID-19 vaccines and the frequent strike action of nurses within the EPI, deterred progress in routine immunization uptake and service delivery, between March 2021 and February 2022.

- The pandemic had minimal effect on the coverage of BCG and measles-rubella 2 coverage; as the suboptimal coverage of not meeting the national target exist even before the pandemic.

2. Regarding the average annual coverage and dropout rate at district and national level, between 2019 and 2020, this shows that:

- The decreased in the number of doses administered relative to the target population, led to the decreased in coverage and the increase in dropout rate in some key districts which culminated at the national level.

- The high proportion of children who missed out on routine vaccination particularly Western area urban and Falaba district; are at higher risk of developing VPDs.

- Some districts like Pujehun did far better than others and adapted useful strategies in sustaining routine immunization.

3. Regarding the barriers imposed by the covid-19 pandemic this study found that

- There is a lack of funding for nurses to follow up BCG and measles-rubella 2 missed vaccines.

- The advise to stay at home had an important negative effect on RI uptake.

- Partners were not sufficiently aware of the needs in the EPI programme.
- Data is lacking on who is most affected, why they are most affected and how this can best be addressed.
- It is unclear to date what the health impact of the drop in immunizations has been in Sierra Leone.
- The difficulty in transportation and competing activities of the health workforce affected RI service delivery and uptake

6.2 RECOMMENDATIONS

The Government of Sierra Leone through the Ministry of Health and Sanitation:

1) Should revise the prevention and control measures, imposed during future outbreaks or other public health emergencies specifically lockdown, (stay a home) in order to enhance routine immunization uptake. This process should include: technical experts: international and local non-governmental organization representatives, parliamentarians, civil society, paramount chief, district medical officers, representative of police and military. Representative of the office of national security, public health researchers representing the two main universities in Sierra Leone, representative from aligned ministries: trade, agriculture, environment, and communication; representative from independent media commission, should also be included. The revised measures should be shared with all DHMTs for implementations. Also, the revised measures should be shared with paramount chiefs at chiefdom level for it implementation.

2) Should increase public awareness and provide funding to support maternal and child health nurses in conducting extensive follow-up on missing children and pregnant women. In this way, they would increase BCG and measles-rubella 2 coverage. The DHMTs, specifically the district social mobilization coordinator, should be tasked with coordinating activities and ensuring that technical experts within the DHMTs, including DOOs, are on the radio at least once a month to raise awareness about the importance of routine vaccinations, such as BCG and measles-rubella 2. Stakeholders including: community health workers, traditional birth attendants, mothers club representatives, youth representatives, and chiefs should be tasked with disseminating the information at the village level.

3) Should conduct supplemental immunization activities (SIA) with focused on districts with prolonged lockdown measures including Western area urban district and those with weakened health system including Falaba district. This is to reduce the risk of potential outbreak due to VPDs. The nurses working in this district should be given the responsibility to recruit the community health workers in their catchment areas to deliver the vaccines. The DHMTs together with the chiefdom supervisors, should be tasked with the responsibility of supervising the health workers during the SIA, to ensure eligible children are provided with the vaccines.

4) Should replicate the successes and adapt to local circumstances of the strategies used in preventing the drop in coverage rates of the routine immunization rate: measles-rubella 1, pentavalent 1 and 3 antigen, in Pujehun district in future outbreaks and other public health emergencies. Through this, a two days stakeholder meeting should be held with the Emergency operation committee members in Sierra Leone. The district medical officer and the DOO in Pujehun DHMT should be invited to give a wholistic presentation on the strategies used during the pandemic.

Public health researchers and epidemiologists are advised

5) To conduct a cross sectional study in order to explore the variations in the uptake of routine immunization services for boys/girls before and during the pandemic. Disaggregated not only by district but also by gender, socioeconomic status and other variable that may assist, policy makers on strategies to increase access to routine immunization service during outbreaks targeting the most vulnerable populations.

6) To conduct an explorative qualitative study to explored the perspective of caregivers, community stakeholders and health care workers on the impact of COVID-19 pandemic on routine immunization services in Sierra Leone. Through this study a balance and more comprehensive findings will be obtained, which will inform and guide stakeholders devising appropriate interventions.

7) To conduct a cross sectional studies analysing the effect of the pandemic on the diagnosis of VPDs. This study will give insight to policy makers on prioritizing interventions of VPDs during outbreaks in Sierra Leone. Through this study, the researcher will opt to used hospital data (registers and patient chart) to assess the diagnosis of VPDs before and during the pandemic. Also, the researcher will opt to use the weekly integrated disease surveillance and response data on the diagnosis of VPD. For instance: measles, polio, and neonatal tetanus available in the DHIS2.

8) To conduct a retrospective study comparing routine immunization rates during different containment measures in different districts. Insights from this study will guide policy makers in devising interventions. Through this study, the researchers will use the routine immunization data available in the DHIS2 and compute the coverage and dropout rate over the various containment period. For example, the researcher will consider assessing the coverage rate and dropout within the first 2 lockdown periods that were imposed to get an insights.

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APPENDIX 2: SEMI-STRUCTURED INTERVIEW QUESTIONS

1. Health system-related factors

a. How has the COVID-19 pandemic influenced the supply of personal protective equipment to health workers? and its usage led to the increase or decrease of routine immunization uptake?
b. How has the COVID-19 pandemic influenced the supply of routine immunization reporting tools (e.g. registers, cards, tally sheets, etc.) led to the increase or decrease of routine immunization uptake?
c. How has the COVID-19 pandemic influenced the transport of routine vaccines, led to the increase or decrease of routine immunization uptake?

2) Community factors

a. How has the pandemic affected the support received from the community for example; community stakeholders' involvement led to increase or decrease of routine immunization uptake?
b. How has the COVID-19 pandemic influenced the sensitization program/ community mobilization conducted by health workers to enhance the uptake of vaccines among caregivers, leading to increase or decrease of routine immunization uptake?
c. How do you perceive the issue of vaccine hesitancy amidst the COVID-19 pandemic in the routine immunization program (Misconceptions)

C) Individual factors

a. How has the COVID-19 pandemic influenced the movement of health workers to deliver routine immunization services, for example conducting outreach services
b. How has the pandemic affected the movement of care givers in seeking routine immunization services
c. How has the pandemic influenced the concern raised by the relatives of health workers working in the immunization program amidst COVID-19

4. Insights on the coverage rate of measle-rubella vaccine and pentavalent vaccine from the secondary data analysis. Whether there is a difference in the proportion of the uptake of routine MR and Pentavalent vaccine in 2019 and 2020. Why?

6. Insights on the drop-out rate of measle-rubella vaccine and the pentavalent vaccine from the secondary data analysis. Whether there is a difference in the proportion of children who did not complete their routine MR and Pentavalent vaccine uptake in 2019 and 2020. Why?

APPENDIX 3: DATA ANALYSIS PLAN; DUMMY TABLE

Annual coverage rate of BCG, measles-rubella 1 and 2, and pentavalent 1 and 3 antigen among children younger than one year, 2019 and 2020, at national level in Sierra Leone

Antigen	**Vaccination coverage rates (%) (Total number of doses / Target population) X 100**		**Δ% (2020 – 2019)**	p-Value
	2019	**2020**		
BCG				
Measle-rubella 1				
Measle-rubella 2				
Pentavalent 1				
Pentavalent 3				

*** = significant at p≤0.01

Δ= Difference

Difference in annual coverage of BCG among children younger than one year, in 2019 and 2020, at district level in Sierra Leone.

Districts	**Vaccination rates (%) (MR1 / Target population) X 100**		**Δ% (2020 vs 2019)**	**p-Value**
	2019	**2020**		
Bo				
Pujehun				
Moyamba				
Bonthe				
Bombali				
Tonkolili				
Koinadugu				
Falaba				
Kailahun				
Kenema				
Kono				
Kambia				
Karene				
Port Loko				
Western Area Rural				
Western Area Urban				

*** = significant at p≤0.001

Δ= Difference

Difference in annual coverage of measles-rubella 1 and measles-rubella 2 antigen among children younger than one year in 2019 and 2020 at district level in Sierra Leone.

Districts	Measles-rubella 1				Measles-rubella 2			
	Vaccination rates		Δ% (2020 vs 2019)	p-Value	Vaccination rates		Δ% (2020 vs 2019)	p-Value
	2019	2020			2019	2020		
Bo								
Pujehun								
Moyamba								
Bonthe								
Bombali								
Tonkolili								
Koinadugu								
Falaba								
Kailahun								
Kenema								
Kono								
Kambia								
Karene								
Port Loko								
Western Area Rural								
Western Area Urban								

MR1 = measles-rubella 1
MR2 = measles-rubella 2
*** = significant at p≤0.001
Δ= Difference

Difference in annual coverage of pentavalent 1 and 3 antigen among children younger than one year in 2019 and 2020 at district level in Sierra Leone.

Districts	Pentavalent 1				Pentavalent 3			
	Vaccination coverage rates (%)		% Δ (2020 vs 2019)	pValue	Vaccination coverage rates (%)		% Δ (2020 vs 2019)	pValue
	2019	2020			2019	2020		
Bo								
Pujehun								
Moyamba								
Bonthe								
Bombali								
Tonkolili								
Koinadugu								
Falaba								

Kailahun								
Kenema								
Kono								
Kambia								
Karene								
Port Loko								
Western Area Rural								
Western Area Urban								

Penta1 = Pentavalent 1
Penta 3 = Pentavalent 3
*** = significant at p≤0.001
Δ= Difference

Difference in annual dropout rate in measles-rubella1 and 2 antigen among children younger than one year, 2019 and 2020 at the district level in Sierra Leone.

Districts	**Vaccination dropout rates (%)**		**Δ%** **(2020 vs 2019)**	**p-Value**
	2019	**2020**		
Bo				
Pujehun				
Moyamba				
Bonthe				
Bombali				
Tonkolili				
Koinadugu				
Falaba				
Kailahun				
Kenema				
Kono				
Kambia				
Karene				
Port Loko				
Western Area Rural				
Western Area Urban				

MR1 = measle-rubella 1
MR2 = measle-rubella 2
*** = significant at p≤0.001
Δ= Difference

Difference in annual dropout rate in Pentavalent antigen among children younger than one year, 2019 and 2020, at the district level Sierra Leone

Districts	Vaccination dropout rates (%)		Δ% (2020 vs 2019)	p-Value
	2019	2020		
Bo				
Pujehun				
Moyamba				
Bonthe				
Bombali				
Tonkolili				
Koinadugu				
Falaba				
Kailahun				
Kenema				
Kono				
Kambia				
Karene				
Port Loko				
Western Area Rural				
Western Area Urban				

Penta 1 = Pentavalent 1 antigen
Penta 3 = Pentavalent 3 antigen
*** = significant at $p \leq 0.001$
Δ= Difference

APPENDIX 4: RESEARCH TABLE

Objective: To assess the coverage rate of BCG, measles-rubella 1 and 2, and pentavalent 1 and 3; and the dropout rate of measles-rubella 1 and 2 and pentavalent 1 and 3 antigen among children younger than one year before and during the COVID-19 pandemic; and also examine the impact of the pandemic on the provision of routine immunization services within the EPI program in Sierra Leone.

Table 12: Research table

To examine the barriers imposed by the COVID-19 pandemic on the provision of routine immunization services that could have led to the decrease in coverage rate or increase in dropout rate.	Themes	Issues	Method	Respondents
To examine the major barriers imposed by the COVID-19 pandemic and its effects on the operation of routine immunization services	Health system	• Supply of personal protective equipment such as gloves, hand sanitizers, and face mask • Transportation of routine vaccines during the pandemic • Outreach session during the pandemic	Semi structured interview Personal observation of the researcher	DOOs and national expert within the EPI program
	Community	• Community participation in support of sustaining routine immunization • Community mobilization or sensitization program of routine immunization activities • Misconception that led to hesitancy (misconceptions).		
	Individual	•Knowledge of health care workers in carrying out routine immunization during the pandemic •Knowledge of care givers in seeking routine immunization service •Accessibility of routine immunization service by caregivers		