EFFECT OF COVID-19 ON UPTAKE OF ROUTINE IMMUNIZATION IN GOMA, DEMOCRATIC REPUBLIC OF CONGO.

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October 2022

DECLARATION

I declare that this research thesis is my original work and has not been presented at any other University.

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DEDICATION

This thesis is dedicated to my late father, my mother, my wife, my children, and my brothers and sisters for all the efforts made.

ACKNOWLEDGEMENT

Firstly, I thank the almighty God for keeping me alive, healthy, and safe to complete my studies. secondly, I sincerely thank my supervisors Dr. Job Mapesa and Ms. Teresia Kyulu for their parental attitude and guidance that enabled me to complete my thesis work. I also, thank all lecturers of Public Health, Human Nutrition, and Dietetics and Health Systems Management departments for their generous support throughout my stay at KeMU. Thirdly, I thank my wife Anny Djumaini for her understanding, patience, and support. Fourthly, I acknowledge all other family members who contributed in one way or another to my studies in Kenya. Finally, I am grateful to my friend Daniel Kerandi and to my colleague Uchenna Jamila for providing moral support and encouragement during the good and the difficult period of this journey.

ABSTRACT

The routine immunization process continues to save millions of children's lives worldwide. The previous pandemic like Ebola impacted the health system in Africa. There was a need to investigate if COVID-19, with its restrictions and containment measures, affected the Democratic Republic of Congo health system, particularly the routine vaccination programme. The study examined the effect of the pandemic on coverage/uptake, sequence, and timing process during routine vaccination. The study was cross-sectional. The quantitative method was used to collect data from 423 children aged of 12-23 months and 27 health workers through structured interview and self-administered questionnaires, respectively, at Mabanga area in Goma city, in DRC. The Chi-square test was used to test the independence between out-of-sequence vaccination and full immunization coverage, and the chi-square test for Goodness of fit was used to test the difference between full immunization in this study and the country target. Differences in vaccine coverages, out-of-sequence, and timely and untimely vaccination were compared by using a T-test. Simple and multiple logistic regressions were used to determine the predictors of full and partial immunization coverage. Simple and multiple ordinal regressions were used to determine the predictors of attitude and perceptions of change among the health workers at a 95 % confidence interval. The full and partial immunization coverages were respectively 96.7% and 99.3%. The children whose parents were aged 18-25years and 26-33years had a high probability of being fully immunized than those whose parents were aged 34 and above years old. The likelihood for unemployed parents to fully immunized their children was 3.17 when compared to employed parents. The children whose parents possessed the vaccination cards were more likely to be fully immunized compared to their counterparts. The likelihood of full immunization was high for the children whose parents declared the immunization completion during the interview than for their counterparts. The predictors of partial immunization coverage before COVID-19 occurrence period were caretakers bracket age18-25years (OR: 0.21, P< 0.05),child sex (OR:0.45,p<0.05).During the pandemic: the likelihood of parents aged between 18-25 years old partially immunizing their children was high (OR:3.57,p<0.05) likewise the likelihood of female children(OR:2.234, P<0.05), the uptake mean of BCG, $OPV_{0,1}$, $Pentavalent_{1,}$ $Rotavirus_1$, and PCV_1 decreased from 48 to 17 doses while it increased from 17 to 81 doses for the other vaccines, and the untimely mean doses of all vaccines were high also.39.24 % was the overall out-sequence vaccination; the out-of-sequence vaccination was independent of the full immunization coverage(p >0.05). The health workers with less than 4 years of experience had more positive attitudes and perceived the change more than those with more than 4 years. The study revealed the disruption of routine immunization outcomes specifically the out-of-sequence and untimely vaccination which are essential in the prevention and control of childhood mortality, despite the high full immunization coverage.

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LIST OF ABBREVIATIONS

AAV: Anti-Amaryl Vaccine.

ANC: antenatal clinic

BCG: Bacillus of Calmette and Guerin.

COVID-19: Corona Virus Disease 2019.

CDC: Centers for Diseases Control and Prevention.

DRC: Democratic Republic of Congo.

DTP 1: The first dose of the Diphtheria, Tetanus, and Pertussis vaccine.

DTP 3: Third dose of Diphtheria, Tetanus, and Pertussis vaccine.

GAVI: Global Alliance for Vaccine and Immunization.

Hep-B: Hepatitis B Vaccine.

Hib: Haemophilus influenza type b Vaccine.

IPV: Inactivate Polio Vaccine.

MCV: Measles containing Vaccine.

MoH: Ministry of Health.

OPV: Oral Polio Vaccine.

PATH: Programme for Appropriate Technology in Health.

Penta vaccine: Diphtheria-Tetanus-Pertussis-Hepatitis B-Haemophilus influenza type B Vaccine.

PCV: Pneumococcal Conjugate Vaccine.

PHEIC: Public Health Emergency of International Concern.

OR: odds ratio

UNICEF: United Nations International Children's Emergency Fund.

WHO: World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background Information

One of the most efficient Public Health measures is immunization. Through immunization, millions of deaths that occur due to preventable diseases are averted. For instance, according to the World Health Organization, smallpox was eradicated in 1980. In addition, vaccination improves the quality of life by offering protection, through immunization against a myriad of diseases that occur in the population. It also minimizes the chances of spreading most of the communicable diseases that have been known to afflict people in Low and Middle-Income Countries (LMICs). In the last 10 years, the number of vaccinated children has drastically increased due to the uptake of both underused and new vaccines (World Health Organization [WHO], 2020). This increased uptake of vaccines has resulted in the protection of more children from infectious diseases than ever before. Some of the vaccines including DTP1, DTP2, and DTP3 have been shown to protect against diphtheria, tetanus, and pertussis considered children's killer diseases. However, in 2019 about 20 million children did not receive DTP3, and almost half of them lived in the African region. Also, 14 million out of these 20 million haven't received even DTP1 because of a lack of access to immunization services (World Health Organization & United Nations International Children's Emergency Fund [WHO & UNICEF], 2020). Nevertheless, the Global Alliance for Vaccine and Immunization support, from 2015 to 2020, has improved slightly the coverage in some low-income countries. For instance, DTP3 coverage scaled up from 79% to 81% (WHO & UNICEF, 2020). This example clarified the unmet need for immunization to address specifically in Low incomes countries. Hence, the setting up of the programme of Immunization Agenda 2030 by stakeholders to face the challenges of immunization from 2021 to 2030 with one among the goals to make vaccination everywhere, to everyone by 2030 for sustainable development.

Low and Middle-income countries have similar challenges concerning the process of immunization. The Democratic Republic of Congo (DRC) has been implementing the Expanded Programme on Immunization (EPI) which has a total of eight antigens that are administered over nine months, the vaccines include BCG, OPV, Pentavalent vaccine, Rotavirus vaccine, IPV, PCV, MCV, AAV. The country was one among the beneficiaries of GAVI support with the following coverages respectively for 2015 and 2020: BCG (72% versus 73%), DTP3 (67%versus 63%), MCV (67% versus 57%) according to (UNICEF, 2021). This statement meant that all targeted children were not reached. In addition,2.5 million children were partially immunized and 500,000 among them were not immunized meant “zero doses ″in the country in 2017 (Ministry of Health of the Democratic Republic of Congo [MoH DRC], 2020). The un and under-vaccinated children situation in the country is mostly favouring the occurrence of major outbreaks such as measles, polio, and yellow fever in recent years. For example, in mid-2019, an outbreak of measles was declared in the country in the meantime of the ongoing tenth Ebola epidemic in the three eastern provinces of the country. WHO and UNICEF (2020) stated 863,000 cases of measles in 2019 worldwide, more than double of 360,000 cases in 2018, among them

289,450 cases reported in DRC. Besides, in 2019, 6000 deaths from Measles, which is a preventable disease, were considered a crush (Lynne, 2020). Nonetheless, the country is striving to improve immunization quality. In this way, the Emergency Plan for Revitalization of Routine Immunization was launched on 11th October 2018 with five objectives: to increase the number of sessions by 20%, to update the dashboard of key indicators of the plan monthly, to inspect immunization activities in health zones and areas monthly, to develop the operational steering committee of plan meeting weekly for the next 18 months and aim to increase of 15 % the coverage by 2020. The plan is supported by MOH DRC, GAVI, UNICEF, PATH, VILLAGE REACH, ACASUS, BILL, AND MELINDA GATE FOUNDATION (Global Alliance for Vaccines and Immunization [GAVI], 2020). In February 2020, the programme showed some encouraging results: increasing in immunization sessions by 3000 in 2019 versus 700 in 2018, 3000 health centres were monthly supervised in 2019 versus 700 in 2018, and 95% of health zones possessed functional chain cold for storage and transport of vaccines.

Routine immunization is influenced directly or indirectly by many factors. Among them were the war, the Epidemic, and the Pandemic. In this way, in December 2019, COVID-19 appeared in Wuhan town in China and became a30th January Public Health Emergency of International Concern (WHO, 2020). Thus, the African continent has been affected since February 2020. Africa Center for Disease Control and Prevention (CDC, 2020) dashboard stated for illustration 1,373,986 cases, 1,127,034 recoveries, and 33,251 deaths on 17th September 2020 in Africa, meant 82 % recovery rate and 2.4 % case fatality rate. Moreover, according to WHO regional office for Africa (2020). The number of cases in

Africa continued to decrease to 14% for incidence cases and 22 % for the deaths for the period from 9th September to 15th September 2020 compared to the period from the second of August to the eighth of August 2020. But it had highlighted that routine immunization might be one of the health services to be broken up by COVID-19. Hence, put the millions of children within the world at risk not only of contracting but also dying of vaccine-preventable diseases. WHO (2021) noticed a drop of ≥5% in routine immunization coverage in Azerbaijan, Bulgaria, Georgia, Kazakhstan, Kyrgyzstan, and the Republic of Moldova as an impact of COVID-19 in these European countries. Some Asian countries had documented the disruption; for instance, in Pakistan,52.5% was a drop in daily vaccination during the lockdown (Chandir et al., 2020), In Taiwan, the drop and the raise in Uptake of Pneumococcal Conjugate Vaccine 13(PCV13) were observed by comparing the year 2019 versus 2020 and 2021(Nan-chang et al., 2022). In Western Africa, Masresha et al. (2020) documented a drop of 33% in Measles vaccine uptake, due to the Ebola epidemics, in Liberia, Sierra-Leone and Guinea between 2014 and 2015. In the same way, Bimpong et al. (2021) stated a decline in vaccine uptake from 47% to 10.5% in Ghana. Abbas et al. (2020) found that routine immunization prevents more deaths than those caused by COVID-19 excess risk and clinic visits vaccination associated. Briefly, sustaining routine immunization in various contexts has paramount importance.

Subsequently, the first case of Covid-19 was declared in Kinshasa on 10th March 2020. The number increased to 10442 confirmed cases, 9840 recoveries, and 267 deaths by 17th September 2020; meaning a 94 % recovery rate and 2.6 % case fatality rate. The North-Kivu province had 291 cases, 71 recoveries, and 4 deaths translating to a 24,4 % recovery rate and a 1.4 % case fatality rate (MoH DRC, 2020). The 26 provinces of the country continued to be affected differently since the restriction measures have been lifted. Hategeka et al. (2021) found a significant reduction in non-communicable diseases and some communicable diseases visits, but the vaccination service was not affected at a significant level in public health facilities in Kinshasa during the pandemic period.

1.2 Statement of the Problem

The country's Emergency Plan for the Revitalization of Routine Immunization has been implemented and aimed to increase by 15 % the vaccine coverage by 2020, supported technically and financially by the partners, on one hand. The occurrence, in March 2020, of the COVID-19 pandemic accompanied the movement of restriction measures, and social distancing measures to contain the spreading of the pandemic, on the other hand. Maintaining population health by providing preventive, curative and rehabilitation care was paramount. However, the interaction between COVID-19 pandemic and routine immunization was unknown. the attitudes of health workers towards routine immunization during the COVID-19 period were not known in this area. The duration of the ongoing pandemic remains unpredictable. Consequently, there was a need for continuous surveillance and exploration of how the COVID-19 was impacting routine immunization in terms of uptake, sequence, and timing, to find out the associated factors and explore the health workers `attitude toward routine immunization in Mabanga area in Goma city in North-Kivu province in the Democratic Republic of Congo.

1.3 Objectives of the Study

1.3.1 Broad objective

To assess the effect of COVID-19 on the uptake of routine vaccination at the Mabanga in Goma city, in the Democratic Republic of Congo.

1.3.2 Specific Objectives

i. To identify the socio-demographic factors associated with the uptake of routine immunization before and during COVID-19 periods at Mabanga, in Goma city.
ii. To determine the vaccine coverages before and during COVID-19 periods at Mabanga, in Goma city.
iii. To compare the vaccine sequences before and during COVID-19 periods at Mabanga, in Goma city.
iv. To assess the timings of vaccination before and during COVID-19 periods at Mabanga, in Goma city.
v. To explore the attitudes of health workers towards routine immunization during the Covid-19 period at Mabanga, in Goma city.

1.4 Research Questions

i. What are the socio-demographic factors influencing the utilization of routine immunization before and during the Covid-19 periods at Mabanga in Goma city?
ii. What are the vaccine coverages regarding the COVID-19 outbreak at Mabanga in Goma city?

iii. What are the vaccine sequences before and during COVID-19 periods at Mabanga area in Goma city?

iv. What are the timings of vaccination before and during COVID-19 periods at Mabanga in Goma city?

v. What are the attitudes of health workers towards routine immunization provision during the Covid-19 period at Mabanga area in Goma city?

1.5 Justification of the Study

The vision of the World Health Organization immunization agenda 2021-2030 is through collective endeavour, countries and partners are striving for the achievement of worldwide equity in immunization. The study has drawn information on the interaction between Covid-19 and routine immunization and its associated factors. Hence, it is a useful tool or guideline for the ministry of health and other stakeholders for dealing with the immunization process in the context of the Pandemic by taking into consideration the variables such as socio-demographic factors, coverage, sequence, and timings of vaccination.

1.6 Limitations of the Study

This study has collected the socio-demographic and immunization information at the same time. Thus, the establishment of a causal relationship could be difficult between the socio-demographic characteristics and the child immunization status. Surely, we were interested in routine immunization only for the children not for the women who receive Tetanus toxoid vaccines. The variable monthly wealth index among the households wasn`t taken into account. Also, we faced the illiteracy challenge among some children's caretakers. The study used a household survey which needed the real confidence between the interviewer and the interviewee in the context of urban insecurity.

1.7 Delimitation of the Study

The study used the competent, trained, Mabanga area residents' assistants to conduct the household survey. They interviewed in Kiswahili to overcome the illiteracy problems and to establish the confidence between the interviewer and the interviewee. The survey was conducted among the Health workers who consented.

1.8 Significance of the Study

Immunization prevents illness, and disabilities, and saves the lives of children. The study`s findings have contributed to the management of routine childhood vaccination in the context of Epidemic or Pandemic by revealing the concerning factors of vaccination. It also contributed to the literature on coverage, sequencing and timings of vaccination, which is scarce in the province and the country.

1.9 Study Assumptions

The presumptions of the study are:

i. The information providing by the respondents would be honest.
ii. The children immunization data which were going to be collected from the vaccination or health facility records would be not only accessible but also reliable.

1.10. Operational Definition of the Terms

Routine immunization: activity by which children are getting vaccines from the health facility according to the expanded programme of the immunization schedule.

Caretaker: each one who looked after the child and responded to the questions during the interview despite his/her relationship with the child. The caretaker was either the biological mother or biological father, sister, brother, aunt, or uncle.

Vaccine sequences: the orders of vaccine administration as recommended by EPI from birth to nine months

Timings of vaccination: moments at which the vaccines are administered in accordance or not with the EPI.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

The description of some findings on the factors associated with child immunization, coverage, sequencing of vaccine, the timing of immunization, and an overview of some effects of COVID-19 on routine immunization.

2.2. Socio-demographic factors Associated with Childhood Immunization

The socio-demographic, economic, cultural factors and so on are associated with the utilization of routine vaccination depending upon geographical areas as demonstrated by several studies. In Kenya, on the one hand, education level of caregivers and partners, household socioeconomic status, caregiver `sage, childbirth place, prenatal visit attendance, and childbirth order had been associated with immunization uptake in Kaka mega county (Sunguti, 2016). On the other hand, Awino (2016) found mother level of education, antenatal visits, household head age, and place of delivery had significantly increased the child likelihood of immunization. Conversely, household size, order of nativity had decreased the chance of the child being immunized.

Mbengue et al. (2017) found also that at least secondary education of caregivers, 4 antenatal visits attendance, delivery at the Health facilities had been the predictors of full childhood Immunization among the Senegalese children. Also, Sarker et al. (2019)

observed that the likelihood of full immunization had been increased for the health facilities children birth than to those home birth, more than four mothers` antenatal visit attendances had increased the likelihood of full immunization for their children than those mothers with no antenatal clinic visits. In addition, children lived in the Western zone had got high likelihood of full immunization compared to those lived in the Southern zone in Senegal based on 2017 Demographic and Health Survey data.

In Nigeria, Adedire et al. (2016) found that maternal antenatal visits, mother tetanus toxoid immunization status, immunization information access, mother having good knowledge of vaccination had been the determinants of full immunization in Atakumosa-West district in Osun State. Besides, Davies et al. (2017), using the systematic review and meta-analysis, described the low level of education, poor information, vaccines not available, mother social engagements, and safety concerns of vaccines had been the negatively predicted the full immunization coverage.

In Ghana, Martin et al. (2017) observed that mothers belonging to 40-49 years, being married status, belonging to Kusaasi ethnic, belonging to the Christian religion, and child feminine sex had been the predictors of full immunization among the children aged 12-23 months, on the one hand. Eugene et al. (2020) describe that urban mothers' children had had a higher chance of immunization completion compared to rural mothers' children, a higher odds ratio for children with a secondary level of education mothers compared to those the mothers with no formal education. Moreover, they found a higher odds ratio for children` Christian mothers compared to those Traditionalists mothers based on1998, 2003,2008,2014 the Demographic and Health Survey data on the other hand in Ghana.

Nozaki et al. (2019) found that complete vaccination in Myanmar had been associated with more than four antenatal care visits, middle and high economic status, maternal tetanus vaccination, and older maternal age; also analyzed 2015 Demographic and Health survey data.

Mohamed et al. (2016) examined the Barriers to Full Immunization Coverage in Benadir Somalia and found that children having less than 5 siblings had about chance of full vaccination five times more compared to those who having 15 or more, children whose mothers had attended the clinic more than twice during the pregnancy had got the likelihood of full immunization eleven times more compared to children whose mothers had attended the clinic once during the pregnancy. Additionally, Children whose mothers received support from the husband/ partners had about 8 times to be fully immunized compared to their count parts. The children whose caregivers had negated the beliefs that “immunization is a form of family planning” had been about 3 times as likely to access full Immunization as those whose caregivers affirmed the beliefs. Additionally, the children whose families had never changed residence means migrated over the preceding one-year period had indicated about 7 times of full immunization likeliness than the children` families had migrated more than twice. The study on the factors that impede the uptake of routine vaccination was also conducted in Mogadishu city and found that younger age of caregiver, father with secondary and above education, birth order from fifth and above, married status of caregiver, being born at Health facility, cost affordability of vaccine, presence of immunization input, good knowledge of immunization input, good perception of vaccine had increased the immunization (Mohamud et al., 2020).

Mekonnen et al. (2019) conducted a study in Minjar-Shenkora in Ethiopia on immunization coverage and its associated factors and found that majors side effects preceded vaccines received by the children, staff aweless conduct, incorrect appointment date, being not married, long walking distance walking from home to health facility had been the predictors of incomplete vaccination, and they suggested to increase the number sites/clusters in the districts to address the issue of long time travel. Nour et al. (2020) stated that mother utilization of Health service, living place near the Health facility, the knowingness of immunization, mother`s level of education, household size had been the predictors of full immunization; thus, suggested that the educational activity for health should reach the less accessible regions in Ethiopia. Furthermore, Legesse and Dechasa (2015) stated that short distance walking from home to a Health facility, discussing immunization with Health extension workers, and mothers` sufficient knowledge on immunization were significantly associated with complete immunization. Moreover, literacy of parents and mother antenatal visits had been associated with full immunization in Sinana District in Ethiopia, and they suggested that the community knowingness on the usefulness of vaccines should have been upgraded and strengthened by the planned programme. Besides, Tamirat and Sisay (2019) found that a mother high level of education, number of antenatal sessions, delivery in health settings, and belonged to a family with a high wealth index was positively associated with full immunization. Conversely, living in a rural area, female being the head of the household were associated negatively with full immunization.

Doubtless, community education on the importance of immunization specifically in African rural areas is crucial because mother's knowledge and attitudes are determinants of uptake of child immunization; for example, in rural areas of Uganda. Vonasek et al. (2016) found that fear of side effects, ignorance, disinterest, laziness had been the mothers' reasons for their children missing out vaccines in rural areas. On the one hand. Kajungu et al. (2020) found that the women who had got familiarity with the usefulness of vaccine received had expressed the acceptance and the cheerful compliance for the vaccines on the other hand. Conversely, bad personal experiences with vaccination, deep misunderstanding about the usefulness of vaccines, limited knowledge had been the barriers of vaccination.

There is a need to identify the barriers factors for vaccination and to face them. The barriers to access the Health services had been elucidated as the underpinned factors for vaccine hesitancy in three settlements in Lusaka, Zambia (Pugliese-Garcia et al., 2018). In the same way, the longtime spending at the Health facility, remonstration of parents and their fear of vaccines' side effects had been negatively associated with partial vaccination in rural Nigeria (Abdulraheem et al., 2011).

There are the individual-level and community-level factors associated with immunization, for this purpose, Acharya et al. (2018) examined the determinants of immunization in the Democratic Republic of Congo at the individual -and community-level based on the 2013-2014 Demographic and Health survey, and found that four antenatal visits, Health facility delivery, post-natal care service utilization, a mother with a secondary or higher level of education, richest wealth quintile had got inferential association with complete immunization at the individual level on the one hand. Therefore, living at the area where ratio Health facility/population was high had got inferential association with the complete immunization. But the variance components model revealed that only 35% of immunization change from one community to another is explained by the factors at this level.

The childhood immunization studies in Goma city are scarce. Fortunately, Kabudi et al. (2015) found that the child sex, the lower level of mother education, the high level of father education, the bracket mothers age 31-34 years, the divorced mothers, and the married mothers had predicted the full immunization, however the negative likelihood between full immunization and number of children in the household also the child birth order.

2.3 Childhood Immunization Coverage

The immunization process aims the reduction of burden of vaccines preventable diseases through the variable "Coverage" which is an indicator of success or failure for the process. Thus, each vaccine is assessed by its coverage, but the full immunization coverage is the attainment of the service within a country i.e. the children should receive in sequence, timely, each vaccine scheduled by the national expanded programme on immunization. Nevertheless, the full immunization coverage continues to remain below the national and international target in most of the limited resources countries due to several factors.

In Senegal, on the one hand, Sarker et al. (2019) conducted the study on immunization coverage and its determinants found that 70.96 % had been the full immunization coverage and found that the vaccination uptake remains less than targeted level regardless cultural entity or part of Senegal; they recommended to emphasize on the factors associated with childhood immunization like prenatal visit, Health facility birth, fairness on Health education. In addition, they suggested that the lowest immunization coverages areas should be prioritized for vaccination. On the other hand, Mbengue et al. (2017) examined the determinants childhood immunization found that 62.8% was the full immunization coverage among the 12 to 23 months aged children in Senegal based on both vaccinated card and mother recall information. But the full immunization coverage based on vaccination card had been 37.5%. In addition, the specific coverages for BCG had been 94.7%; for third dose of oral polio vaccine had been72.7%, for third dose of Pentavalent had been 82.6%, and for first dose measles had been 94.7%. Also, underlined almost the same statement that the vaccination uptake remains below the targeted or wishful national level (superior to 80%). There were an association between the immunization coverage and Geographical location, characteristic of the mother, prenatal care, Health facility admittance; hereby they recommended to set out the complete and systematic plan of action to face the challenge of childhood immunization. In Owerri, Nigeria, 63% had been the full immunization coverage by card and mother recall, and the full immunization coverage by card only had been 47.3%.Additionaly, there was the association between the gratification post-delivery clinic visits and complete vaccination (Kelvin, 2015).Besides 73%, 93.3%,87%,and82% had been respectively the full immunization coverage, BCG coverage, OPV coverage, and Pentavalent coverage of children who attended tertiary Hospital clinic in Benin city, Nigeria (Uwaibi, 2020). Similarly, the full immunization had been 78.9%, noted a difference between urban communities (94.5%) while in rural communities (55.5%) in his study on two urban and two rural districts in Enugu state, Nigeria. Several studies have highlighted that the uptake of vaccines usually is higher in urban areas than in rural areas. curiously, in Burkina Faso, the uptake of vaccines had been higher in rural areas than in urban areas. Curiously, in Burkina-Faso, the uptake of the vaccines had been higher in rural areas than in urban areas. Moreover, they observed improvement of full immunization coverage from 72% to 79%, and from 79% to 81% respectively in 2012 and 2013 using Demographic and Health Survey data (Kagoné et al., 2017).

In Ethiopia, Etana and Deressa (2012) examined the predictors of full immunization coverage in Ambo Woreda and found that 36 % had been the complete vaccination coverage through cards and mother`s recall. The complete immunization had been 27.7% by using vaccination cards only and noted the proportion of non-vaccinated children had been 23.7%. Knowingness of vaccines schedule, mothers` access to Health care had been the predictors of full vaccination. They that concluded that the coverage of childhood vaccination continues to be low. So, the intervention focused on health education about the usefulness of vaccines, the usefulness of prenatal clinic visits, and the usefulness of health facility birth should be emphasized.

Besides, Tamirat and Sisay (2019) had found 38.3% the full immunization coverage using the demographic and Health survey, which almost confirmed that found in the Woreda district. But, Tesfaye et al. (2018) found also the full vaccination coverage at 58.4%, being born at the health facilities, antenatal visit during the pregnancy, Knowingness by the mother of vaccination schedule have been cited as predictors of full vaccination coverage in Ethiopia.

In Kenya, Isigi (2010) carried out a study on childhood full immunization in Embakasi and slums settlements in Nairobi and found 92.4% full immunization coverage in Embakasi and 70% full immunization coverage in Kibera. She noted a slight improvement in immunization coverage in Kibera that had not achieved the national target of 90%. Also, she recommended that improving the literacy level and Employment should be the target among the strategies to ameliorate the utilization of vaccine in Kibera slum. The below national target full immunization coverage of 67% in Kenya. Thus, there is a need for collaboration visions between the children's caregivers and health workers to ameliorate the full immunization coverage (Mutua et al., 2016).

In the Democratic Republic of Congo, Mwamba et al. (2017) conducted a study on the factors associated with childhood immunization among the children aged 6-11 months and found that the coverage of penta1 vaccine had been 96%, for Penta3 had been 84%. Thereby, they concluded that the coverages of immunization in 12 health zones of Kinshasa had been above to those from the official data, because of some childhood vaccinations had occurred out of their respective Health zones i.e. immunization outside the study area. Besides Acharya et al. (2018) found 45.3% the average coverage of complete childhood immunization in the country but noted variability among the 26 provinces. The North-Kivu province, with Goma capital city, headed with 70.6% and Mongala province tailed with 5.8%. The coverage of BCG vaccine had been 83%, coverage of OPV_1 had been 91 %, coverage of OPV_3 had been 65.7%, and coverage of

MCV had been 72%. They highlighted that proportion of 12 to 23 months aged children who had not immunized were 6 %.

Ashbaugh et al. (2018) stated that 70 % of children 6-59 months had been vaccinated against measles in DRC. They suggested the way of flattening measles morbidity and mortality curves by targeting and reaching the hotspot in the country. The positive change in the immunization curve over time in the country has been examined by Alfonso et al. (2019) by stating that 26% had been the full immunization coverage of children aged 12-59 months in 2007; it has increased to 44% in 2013-2014. Also, specified that the positive change in coverage is not uniform within the Country. Unfortunately, the curve had flattened in some provinces in North, South, and West provinces. They suggested that the findings would be used by the policy makers and scientifically to better immunization.

The study on immunization coverage in Goma city are scarce, but Kabudi et al. (2015) examined the proportion and predictors of unvaccinated or vaccinated partially children aged less than 60 months. 25.7% had been prevalence of under-five non-immunized children in Goma city, suggesting that the medical authorities, for ameliorating the immunization quality of fewer than 60 months aged children, should consider the barriers factors identified in this study.

Most of these researches showed the disparities in the African region, sometimes these disparities continue to persist within the countries i.e. disparities depending on different geographic areas. Thus, Casey et al. (2017) examined the state of equity in childhood immunization within Africa and found an increase in DPT3 from 52% in 2000 to 76% in

2015, and so for measles from 53% in 2000 to 74% in 2015, but with considerable differences among countries. In 2000, 36 countries had been low income with an average of DTP3 of 50%, while in 2015 had been 26 with an average coverage of 80%. For this reason, it is essential for meeting global immunization targets, to monitor and address these disparities (Casey et al., 2017).

2.4 Sequencing and Timing of Vaccines

Specific vaccine administered to the child, adolescent, or adult induces the production of specific antibodies for the prevention of specific disease. CDC (2011) stated that the type or sort of vaccine, receiver immunologic status, and receiver age determine the desirable response to a vaccine. For this reason; the vaccine should be administered to the receiver at required or recommended age for the recommended interval between the doses. Hence, the validity of the vaccine dose is considered if it is given within 4 days before the minimum interval, however, doses of any vaccine administered ≥ 5 days earlier than the minimum interval or age should be considered invalid doses and should be repeated as age-appropriate. The timing and sequencing concepts are essential in the context of multiple antigens and multiple administrations of Child Immunization specifically in low- and middle-income countries (LMICs) where the population faces the challenge of accessing health care.

A study conducted in Kenya in three slums of Nairobi city has found the coverage of full immunization 67 % by 12 months, the out-of-sequence full immunization coverage 22% (Mutua et al., 2016). Also, in Uganda, Babirye et al. (2012) examined the factors associated with vaccination delay among the 10 to 23 months aged children, using a community-based approach in Kampala and they found that non-delivery at the health facilities, high children score per woman being unmarried, and having the low income had been associated with untimely immunization.

The prospective cohort study analyzed using the Landmark approach on out–of–sequence Diphtheria-Tetanus-Pertussis (DTP) and measles vaccination and child mortality conducted in Guinea-Bissau found that the high children mortality was associated with out-of-sequence vaccination (Thysen et al., 2019). Another study carried out in Burkina Faso on delay and out-of-order vaccinations had found that 68% rate of timely vaccination. The frequency of out-of-order vaccination rate between BCG and DTP/Penta 1 was 5%; while the frequency between DTP/Penta 3 was 4%. They observed also that the proportion of out-of-sequence in early childhood was higher in the rural areas than in the urban areas (Ouédraogo et al., 2013).

The in-sequence and timely vaccination in the Democratic Republic of Congo is set out in table 2.1 below.

Table 2.1

Schedule of child vaccination in the Democratic Republic of Congo.

Contact	Time	Antigens	Disease Targeted	Administration Form
First contact	At Birth	BCG	Tuberculosis	Injectable
		OPV_0	Poliomyelitis	Oral drops
Second contact	42 days or 6 weeks	**P**$ENTA_1$	Diphtheria, Tetanus, Pertussis, Haemophilus influenza type B, Hepatitis B.	Injectable
		OPV_1	Poliomyelitis	Oral drops
		$ROTA_1$	Diarrhoea	Oral drops
		PCV_1	Pneumonia	Injectable
Third contact	70 days or 10 weeks	$PENTA_2$	Diphteria, Tetanus, Pertussis **,** Haemophilus influenza type B, Hepatitis B.	Injectable
		OPV_2	Poliomyelitis	Oral drops
		$ROTA_2$	Diarrhoea	Oral drops
		PCV_2	Pneumonia	Injectable
Fourth contact	98 days or 14 weeks	$PENTA_3$	Diphteria, Tetanus, Pertussis, Haemophilus influenza type B, Hepatitis B	Injectable
		OPV_3	Poliomyelitis	Oral drops
		$ROTA_3$	Diarrhoea	Oral drops
		PCV_3	Pneumonia	Injectable
		IPV	Poliomyelitis	Injectable
Fifth contact	274 days or 9 months	MCV	Measles	Injectable
		AAV	Yellow fever	Injectable

The Democratic Republic of Congo, one among the Low- and-Middle-Income Countries, is striving to fill the gap on childhood vaccination to face the vaccines preventable diseases. Thus, for illustration, the vaccines target in 2019 were shown the following table.

Table 2.2

The target of vaccine coverages in 2019

Vaccines	**targeted**
BCG	95%
Penta 1	95%
Penta 3	95%
OPV 1	95%
OPV 3	93 %
PCV 1	95 %
PCV 3	93 %
MV	93%
AAV	93%

2.5 Overview of some effects of COVID-19 on Childhood Immunization

COVID-19 pandemic could have surely impacted the health system components specifically in the low- and middle-income countries where most of them are weak. In this way, the child immunization could be one among the most disrupted programme due to the lockdown measures, travelling restrictions etc. The study conducted in Pakistan by Chandir et al. (2020) found a 52.5% daily decrease in the number of vaccinated children number during the COVID-19 period compared to the previous period, and the decrease for BCG vaccine was so high as almost 40.6%. Similarly, Dorward et al. (2021) stated the decrease in HIV testing of 47.6% and a weekly median decrease of patients who started the anti-retroviral treatment from 571 in the pre-COVID-19 period to 375 during the COVID-19 period in South Africa. Additionally, the study conducted in 15 African countries stated that thirteen out experienced a decrease in vaccines uptake. This decrease was large during the COVID-19 period specifically for the countries which experienced low vaccination coverages in the pre-COVID-19 period. So, they recommended the catch-up immunization activities. The disruption of child immunization service means increasing of vaccine-preventable diseases mortality specifically during the troubled period of the pandemic.

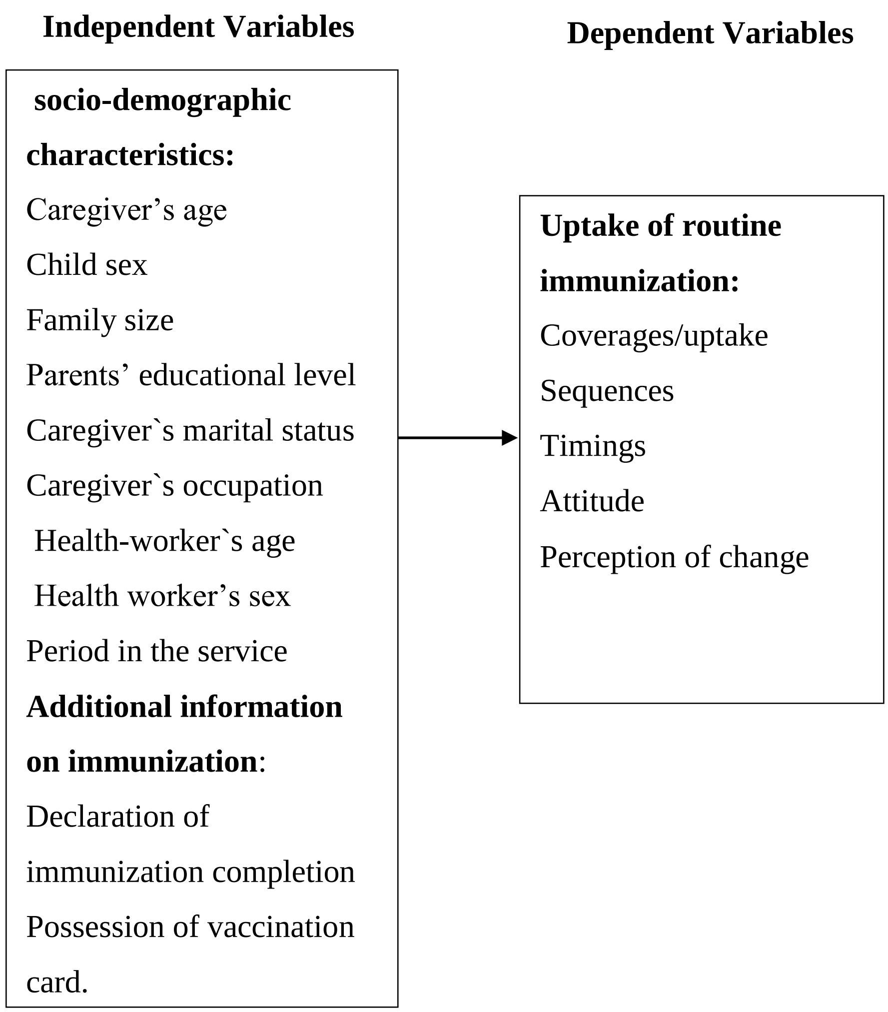
In this way, Abbas et al. (2020) stated that routine immunization prevents more deaths than those due to excess risk of COVID-19 and clinic visit of vaccination, and so, urged for the sustainability of routine immunization in Africa during the COVID-19 period. Besides, WHO has urged the countries to carry out the benefit-risk evaluation to guide the decision-making. COVID-19 is impacting not only routine immunization but also supplementary immunization activities. The study conducted on July 202O in Kenya on supplementary immunization activities for preventing Measles outbreak during COVID-19 predicted the decrease of 100% of measles vaccination coverage once the physical distancing measures were lifted (Mburu et al., 2020). In Democratic Republic of Congo, the immunization campaigns against measles Planned in March 2020 aimed to reach 1.3 million unvaccinated children were suspended. Whereas the outbreak of measles declared in mid-2019 decimated more than 6000 Thousand lives, most of them were under-five year children. The efforts to eradicate the measles in the country have been derailed by

Covid-19. COVID-19 has threatened the similar campaigns against the old scourges like tetanus, diphtheria, meningitis, Polio, yellow fever, and typhoid in Low- and Middle-Income Countries, and highlighted that more than13 millions of children have not been vaccinated due to suspension of planned immunization campaigns in 25 countries (Lynne, 2020).

COVID-19 is impacting also health workers, the case fatality rate among them is increasing endangers the provision of vaccines to the children. Undark report stated that in Poor Nations, a New Disease Stalls Efforts to Fight Old ones said the protection of health workers should be taken in account in the low-income countries to prevent shortage problem in the future (Lynne, 2020).

Figure 2.1

Conceptual Framework



CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Introduction

To achieve our objectives, need the establishment of procedures or methodology. Thus, the chapter describes the design of the study, study area, population targeted, sampling procedure, inclusion and exclusion criteria, validity and reliability, data method of data collection and tools, operational definition of variables, data analysis and presentation, and ethical issues.

3.2. Study Design

The study was an observational study according to the nature of the investigation, cross-sectional, and prospective-retrospective according respectively to the number of contacts with the study population and the reference period of the study. The quantitative approach was used to collect the numerical and the categorical data through the household and health workers' surveys at Mabanga area.

3.3 Study Area

Mabanga area is located in Karisimbi municipality, in Goma city which is the capital of North-Kivu province located at East of the Democratic Republic of Congo. It is subdivided into North-Mabanga administrative quarter and South-Mabanga administrative quarter, each of them has 10 streets, which meant 20 streets for the entire

Mabanga area. The population is estimated at 129728 inhabitants; more than 9 health facilities are implementing routine immunization process. The mothers/guardians are required to pay the equivalent of one United States of America dollar for getting an immunization card. Multiple ethnic groups live at Mabanga area.

3.4. Target Population

The population in this area was estimated at 129728 inhabitants. The proportion of under 5 children is 20 % of the total population representing 25946 children. But the 12-23 months aged children, whose caretakers consented to participate in the study were our target population. In addition, 3 health workers per health facility in the 9 health facilities meant all technical managers of health facilities and 2 health workers directly implicated in routine immunization activities.

3.5 Sampling Procedure

3.5.1 Procedures

Two-stage cluster sampling was used. The first stage was to divide twenty streets into 20 sub-locations or clusters meant 10 streets at North Mabanga, and 10 streets at South-Mabanga. Then select randomly five clusters at North- Mabanga and five clusters at South-Mabanga. The second stage is to look at the eligible contiguous households up to 50 within each cluster. In the case of more than one child aged 12-23 months in the same household, one child will be chosen randomly.

3.5.2. Sample Size Determination

The size was calculated by Fisher`s formula:

$$Sample, n = \frac{Z^2 \times P(1-P)}{d^2}$$

n: minimum size of the sample

Z: The standardized normal distribution value is determined at each confidence interval, in this case, the confidence interval ɑ used is 95 % and Z=1.96

P is 0.5 as the prevalence is unknown in this area.

d: degree of precision (1-ɑ) is 5%.

$$Sample, n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.05)^2}$$

$$= 384, \text{plus a 10 \% estimated non}$$

$$- \text{response rate that brings it to 423}$$

3.6. Criteria of Inclusion and Exclusion

3.6.1. Inclusion Criteria

i. Any children aged from 12 to 23 months on interview day whose caretakers hadn't communication impairments and who agreed with the participation.

ii. Health workers who were implicated in routine immunization activities for at least one year in one of the 9 health facilities located in Mabanga area.

iii. Verbal or written consent to partake in the study.

3.6.2 Exclusion criteria

i. The eligible children who were visitors at Mabanga on interview day.
ii. Children aged 12-23 months whose caretakers had communication impairments and were unable to consent.
iii. Health workers implicated in routine immunization who declined the partaken.

3.7. Validity and Reliability

3.7.1. Validity

We supposed that face validity was assured, but to ensure the content, concurrent and predictive validities, our data collection tools have been well structured and approved by the supervisors. Moreover, tools collected primary data and 92% of vaccination information was collected from the vaccination cards.

3.7.2. Reliability

To maximize reliability and minimize inconsistency, the instruments were supervisors approved by the supervisors. In addition, the pre-testing was carried out on 10 % of our sample in Virunga area which is in Goma city. The assistants were trained before the data collection and supervised during the process.

3.8. Methods of Data Collection

The data collection was done using a structured questionnaire, which was made up of two sections:

Section one was addressed to caretakers in households with children aged from 12 to 23 months as a structured interview and collected data related to objectives one, two, three, and four. In other words, socio-demographic and other associated factors data; child vaccination status, number and type of vaccines received, sequence of vaccines received, and the timings of vaccination. This information was drawn from the vaccination cards for 92%(n=389) and from a coherent recall of caretakers completed by the health facilities record located in Goma town for 8%(n=34) of the children.

Section two was administered to 27 health workers implicated in routine immunization in the nine health facilities and has drawn the information for objective five of the study. Four assistants have been trained for three days by the researcher, to impart their skills and knowledge in the household survey.

3.9. Operational Definition of Variables

Socio-demographic factors: age, sex, birthplace, address, birth order for the child; Sex, Age, Marital status, Religion, relationship to the child, educational level, partners` education level, current occupation, spouse current occupation, size of family, attendance of ante-natal clinic, and the number of sessions.

Other factors: possession of child`s vaccination card, information related to starting and completion of vaccination schedule, facilities, and indication by caretakers of BCG and MCV sites of injection.

Coverage: proportion between vaccinated children by the targeted children for the vaccine at the required age accordingly to the schedule.

In-sequence of vaccination: is defined as receiving vaccines from the health facility by the following schedule:

- At Birth: BCG and OPV dose 0
- At 6 weeks or 42 days: Pentavalent dose 1, Rotavirus dose 1, PCV dose 1, and OPV dose 1
- At 10 weeks or 70 days: Pentavalent dose 2, Rotavirus dose 2, PCV dose 2, and OPV dose2
- At 14 weeks or 98 days: Pentavalent dose 3, Rotavirus dose 3, PCV dose 3, IPV, and OPV dose 3
- At 9 months or 274 days: MCV, and AAV.

Out of sequence (OS) or out-of-order vaccination: administration of vaccines as:

- Either receiving BCG vaccine after other vaccines except for $OPV_{0,\ or}$
- receiving Pentavalent, Rotavirus, Pneumococcal conjugate, Polio vaccines with or after the couple Measles Conjugate Vaccine and Anti-Amaryl Vaccine or

- Receiving respective Pentavalent, Rotavirus, Pneumococcal conjugate, and Polio on different days.

Timing of vaccination: is either early or timely or delayed vaccination

- Early vaccination: vaccination occurred more than 4 days before recommended age for each vaccine, except for MCV and AAV doses if given more than 2 weeks.
- Delayed vaccination: defined as any vaccine administered to a child at more than 14 days after the recommended age for OPV, Pentavalent, Rotavirus, IPV, PCV, and BCG, but MV and AAV when administered more than 31 days.

Complete or Full immunization: defined as vaccination of 1 dose of BCG, 4 doses of OPV, 3 doses of Rotavirus, 3 doses of Pentavalent, 3 doses of PCV, 1 dose of IPV, 1 dose of AAV, and 1 dose of MV.

Attitude: is assessed by risk perception of COVID-19, perception of vaccine provision, fear and beliefs about COVID-19, and Perception of curability of COVID-19 formulated in questions using the Likert scale and weighed from 1 to 5.

Full immunization by one year: in-sequence vaccination of 1 dose of BCG, 3 doses of Rotavirus, 3 doses of Pentavalent, 3 doses of PCV,1 dose of IPV, 1 dose of AAV, and 1 dose of MV by the age of one year.

Partial immunization: vaccination of 1 dose of BCG, 4 doses of OPV,3 doses of Pentavalent, 3 doses of Rotavirus, 3 doses of PCV, 1 dose of IPV excluding 1 dose of MCV, and 1 dose of AAV.

3.10 Data Analysis and Presentation

The instruments or tools have collected the categorical or qualitative and numerical or quantitative data. These data from the field have been daily checked for accuracy and completeness purposes, and then coded and cleaned. Descriptive statistics found out the frequency, proportion, and mode for categorical data; and mean, median, mode, standard deviation, and other statistics for numerical data. The analyses were done by SPSS version 20 and Excel.

Objective number 1: descriptive statistics generated the proportion, mean, median, and standard deviation. The simple and multiple logistic regression was conducted to find out the factors associated with complete immunization and partial immunization coverage regarding COVID-19 occurrence. The unadjusted odds ratio, adjusted Odds ratio, P-value ≤ 0.05, and confidence interval at 95%. Excel was used to generate some figures.

Objective number 2: Descriptive statistics generated proportion in pre-pandemic and the pandemic period for each vaccine; the inferential statistics used paired t-tests to compare the vaccine coverages before and during the Pandemic with a 95 % confidence interval. The Chi-square for Goodness of fit assessed the difference between the full immunization coverage and the country target coverage, and the coverage found in the others areas.

Objective number 3: the proportions were used to measure the out-of-order levels of vaccination, and in-order levels of vaccination; t-tests were used to compare the out-sequence before the COVID-19 period and during the COVID-19 period. The Chi-square test for independence assessed dependency or not between the full immunization and out-of-sequence vaccination.

Objective number 4: proportions were used to assess the level of early, timely, and delayed vaccination, each antigen was assessed whether early, timely, or delayed administered, paired t-test was used to compare the mean of timely doses and untimely doses for 17 vaccines.

Objective number 5: the data related to attitude and perception collected through the Likert scale means categorical data. Descriptive statistics summarized the point of attitudes towards routine immunization, and the point of perception of change in vaccine provision accordingly to Sex, Age, and Period in the service of routine immunization during the COVID-19 period. Simple and multiple ordinal regressions were used to assess the association using the Odds ratio, confidence interval, and P-value. Excel software was used to calculate the odds ratio and confidence interval for ordinal regression.

3.11. Ethical Considerations

The approval was sought and obtained from the Kenya Methodist University Science and Ethics Review Committee (SERC) after the submission of our research proposal. The clearance letters were sought from the Karisimbi Health zone management, and municipality authority also. The main objective of the study was explained to Health zone management, municipality authority, Health workers, and caregivers. Participation in the study was voluntary and free, informed consent was sought, and a confidentiality guarantee.

CHAPTER FOUR

RESEARCH FINDINGS AND DISCUSSION

4.1 Introduction

The study aims to assess the effect of COVID-19 on Routine Immunization at Mabanga in Goma city in the Democratic Republic of Congo. The chapter presents the results in descriptive and inferential ways and their interpretations.

4.2 Demographic Characteristics of Respondents

Table 4.1. described the socio-demographic factors of the respondents. The minimum age, the maximum age, the average age, and the standard deviation age of caretakers were respectively 18 years, 56 years, 29 years, and 6 years. By grouping the age into three categories, the 16-33 years bracket age has represented the highest proportion 50.6 %(n=214), and the bracket aged 34 and above years represented the lowest proportion with 20.6 %(n=87).

The majority of the respondents were females 94.1%(n=398), whereas 5,9%(n=24) were males. 90.8%(n=384) of the respondents have been the biological mothers of children and 5,7%(n=15) biological fathers, and 3.5 %(n=15) have been represented by sisters, brothers, aunts, and uncles. The majority of the respondents were married 96.2% (n=407) and less than 4% were included in the other categories (singles, widows, widowers).

Table 4.1

Demographic Characteristics of Respondents

Variables		**Frequency (%)**
Age	18-25	122 (28.8)
	26-33	214(50.6)
	≥34	87(20.6)
Gender	Male	25(5.9)
	Female	398(94.1)
Relationship to the child	Biological mother	384(90.8)
	Biological father	24(5.7)
	Others	15(3.5)
Marital status	Married	407(96.2)
	Other	16 (3.8)
Education level	Primary school	101(23.9)
	Secondary school	260(61.5)
	Tertiary school	62 (14.7)
Partners education level	Primary school	30(7.1)
	Secondary school	221(52.2)
	Tertiary school	172(40.7)
Current occupation	Employed	66(15.6)
	Unemployed	357(84.4)
Spouse current occupation	Employed	280(66.2)
	Unemployed	143(33.8)
Religion	Christian	379(89.6)
	Muslim	15(3.5)
	Other	29(6.9)
Size of family	1-5	151(35.7)
	6-10	247(58.4)
	11-15	25 (5.9)
ANC	YES	422(99.8)
	NO	1 (0.2)
Number of visits	<3	107(25.3)
	>3	315(74.6)

61.2 %(n=260) of the respondents attained secondary education, and 23.9(n=101) had primary education, 14.7%(n=62) had tertiary education. Conversely, the respondents indicated that 92.9%(n=393) of their partners had achieved at least secondary education, and only7.1 %(n=30) had achieved primary education.

The majority of the surveyed were officially unemployed (84.4%, n=357), whereas the employed represented only 15.6 %(n=66). Nevertheless, 66.2 %(n=280) of their partners were officially employed versus 4.8%(n=18) who were officially unemployed, and 29.5(n=125) were implicated in the survival daily activities.

The majority of the caretakers have been practicing the Christian religion 90%(n=378, 6.9 %(n=29) have been practicing other religions (Kimbangu, traditional…), and 3.5 %(n=15) have been practicing Islam religion.

The Mean number of members in the household was 7, with a minimum of 1 member and a maximum of 15 members. By grouping into 3 categories, 58.4% (n=247) of families were made up of 6 to 10 persons. The families with 1 to 5 persons and the families with 11 to 15 persons were respectively 35.7% (n= 151) and 5.9%(n=25).

On the one hand, 99.5 %(n=421) of caretakers declared that they followed up on the antenatal process during the child's pregnancy. On the other hand, 0.5%(n=2) haven`t attended antenatal visits. Among 95.5%(n=421) who followed the ANC,74.6%(n=315) attended three and more sessions, and 25.3%(n=107) attended one or two sessions.

Table 4.2. presents the socio-demographic characteristics of the 423 children. The children bracket age of our investigation is 12-23 months; this bracket age has been classified into two categories, the categories of 12-17 months have represented 60.5%(n=256) and the 39.5 %(n=167) for the category of 13-23 months. The male children were higher 53.9 %(n=228) than the female children 46.1%(n=195). 94.8% (n=401) of the children were

born in the health facility setting, and 5.2 %(n=22) in other places (home, traditional midwives…)

Table 4.2

Children socio-demographics characteristics

Variables		Frequency (%)
Age(months)	12-17	256(60.5)
	18-23	167(39.5)
	Total	423(100)
Sex	Males	228(53.9)
	Females	195(46.1)
	Total	423(100)
Place of delivery	Health facility	401(94.8)
	No health facility	22 (5.2)
	Total	423(100)
Order of birth	$1^{st}$to $3^{rd\ born}$	232(54.8)
	4^{th} to 6^{th} born	154(36.4)
	7^{th} and above	37(8.7)
	Total	423 (100)

The children birth`s order in our sample ranges from first to twelfth. In concision, it was classified into 3 categories: the first to third born, the fourth to sixth born, and the seventh born and above. Consequently, the high proportion was in the first group 54.8 %(n=232) and the low proportion was observed for the third class 8.7 %(n=37).

Table 4.3 shows that 97.4%(n=412) of the caretakers declared that children had been fully immunized, and 11(2.6%) recognized that their children hadn`t completed the immunization process. The reasons elucidated for not completing the childhood vaccination programme were: Fear of being infected with COVID-19 (63%, n=7), Migration (18.2%, n=2), Vaccines not being available at the health facilities (9%, n=1), not time (9%, n=1).

Table 4.3

Additional information on child`s vaccination

Variable	Frequency (%)
Confirmation of full immunization	
Yes	412(97.4)
NO	11(2.6)
Total	423(100)
Possession of vaccination cards	
Yes	389(92)
NO	34(8)
Total	423(100)
Indication of BCG site of injection	
Good indication	407(96.2)
Bad indication	16(3.8)
Total	423(100)
Indication of MCV site of injection	
Good indication	387(91.5)
Bad indication	36 (8.5)
Total	423(100)

On the one hand, 92.4 %(n=391) of the caretakers or respondents have declared the possession of vaccination cards for their children, while 7,6%(n=32) declined the possession. But from 391 caretakers who have declared possession of vaccination cards, only 389(92%) have presented the children’s vaccination cards, from which information about vaccination, was taken. While 34(8%) haven’t presented the children’s vaccination cards. Therefore, the vaccination information has been taken from their caretaker's recall coupled with checking of the health facilities' records. The 34 respondents who haven`t shown the vaccination cards presented the following reasons: location not known (53%, n=18), lost (29%, n=10), family migration (8.8%, n=3), and others (8.8%, n=3).

The majority of the respondents 96.2%(n=407) indicated correctly the site of BCG injection which is the entrance antigen. Conversely, 4.3%(n=18) of them did not show a good indication. In the same way, 91.5 %(n=387) of them indicated well the injection site of MCV which is the exit antigen. The minority 8.5 %(n=36) indicated badly the MCV site of injection.

Additionally, the question of where the children started and completed the process of immunization. In this way,100 %(n=423) of the respondents recognized that their children had started the immunization process. The main cited health facilities were Military hospital (26.2 %, n=111), Amani health center (11.3%, n=48), Konde clinic (9%, n=38), Mabanga health center (7.8%, n=33), Murara health center (6.2%, n=26), Katoyi health center (5,4%, n=23), Dimajelo clinic (4,3%, n=18), CEBCA hospital (4%, n=17), HEAL Africa hospital (4%, n=17). Also, other health facilities have been cited such as AMIKIVU clinic, Carmel clinic, Gesom clinic, DOCS hospital, Charite hospital, Kabaya clinic, Adebelo clinic, INPP clinic, Lubango clinic, Kimuti clinic, Hope clinic, universal clinic…. (21.8%, n=92).

The main health facilities of vaccination completion cited were: Military hospital 26.2%(n= 108), Amani health center 11.4%(n=47), Konde clinic 9.9%(n=41), Mabanga health center 8.0%(n=33), Katoyi health center 5.4%(n=23), Murara health center 7,8%(n=32), Dimajelo clinic 4.1%(n=17), CBCA hospital center 3.9% (n=16), HEAL Africa hospital 4.1%(n=17), and others 18.9%(n=78).

4.3 Role of Children`s Sex on Full Immunization Coverage

There was a negative association between children gender and full immunization in simple regression, OR =0.626, P-value is 0.393, CI [0.213,1.835]; likewise, in the multiple regression AOR =0.558, P-value=0.323; CI: [0.182-1.705]. Moreover. By considering the females as a reference we got the unadjusted OR for the males of 1.599, ([P-value= 0.393: CI: [0.545-4.690]). This suggests that males' children had a high chance of full immunization coverage compared to females' children but not statistically significant. It could be explained by the higher proportion of males than females in our sample. A high proportion of male children have been found in a study on the causes of incomplete immunization among children aged less than five years in Goma (Kabudi et al., 2015). In the same way, Acharya et al. (2018) found a high proportion of males compared to females, but it was not significantly associated with full immunization during the 12-23 months in the Democratic Republic of Congo. Also, Mohamed et al. (2016) have found a high proportion of males but the association with full immunization was not statistically significant among the under five years children in Somalia; and the males have been higher (51.6%) than the females (48.4%) for the bracket age 12-23 months in two settlements in Nairobi Kenya (Mutua, 2017). The overall full immunization coverage is not statistically affected by the children's sex.

4.4 Role of Place of delivery on Full Immunization Coverage

The relationship between the place of delivery and full immunization coverage was positive and not significant OR =3.242, p-value .140, CI [0.679, 15.472] on simple regression, and so confirmed by multivariate regression OR: 128.316, P-value 0.144, CI: [0.738-18.603]. For every one-unit -increase in place of delivery, the likelihood of full immunization coverage increases. In the other words, the children who have been delivered at Health facilities had more likelihood of full immunization compared to those who haven`t been delivered in health facilities but not at a statistical significance level. This could be explained by the awareness of the immunization programme during the period of delivery at the Health facility. Many studies have highlighted the association between being born in health facilities:

Acharya et al. (2018) set up a significant relationship between completed immunization coverage and being delivered in the health facility [AOR: 2.37; 95% CI: 1.52,3.72] in the study of determinants of vaccination in DRC.

Chandir et al. (2020) have observed a high immunization rate for children born in a Health facility in Sindh, Pakistan; and that relationship was statistically significant (RR:1.09;95% CI: 1.04-1.15)

Adedire et al. (2016) found an association between place of birth and full immunization coverage on the determinants of immunization among children aged between 12-23 months in Osun state, Nigeria. But this association was not being significant [OR:1.3;95% CI:0.8-2.2]. The place of birth has not statistically affected the overall full immunization coverage.

4.5 Role of Caretakers' relationship to the child and Full Immunization Coverage

The OR = 0.922, with a p-value of 0.892 there is a negative relationship between the children's caretakers and the full immunization coverage. By considering the biological father as a reference, the odds ratio for the biological mother was 2.818, and P-value:0.355, CI [0.594-13378]. The multiple regression revealed AOR:14.202, P-value:0.230, CI [0.186,1083.280]. In other words, Children whose caretakers had been their biological mothers had 14 times the likelihood of full immunization compared to the children whose caretakers had been in the other categories (father, sister, brother, Aunt, Uncle, other) but not significant. The biological mothers are so keen on the children's sake such as routine immunization compared to the other categories of caretakers. The overall full immunization coverage was not affected by the nature of the relationship between the child and his/her caretaker.

4.6 Role of Child`s birth order on Full Immunization Coverage

The OR =0.675, p-value = 0.309, CI [0.316, 1.440]. Higher the birth order, the less the likelihood of full immunization, i.e., for every one-unit increase in birth order, the likelihood of full immunization decreases. But not statistically significant.

By considering the 7^{th} and above birth order as a reference, we got a positive OR for the first to third born of 1.261, P-value: 0.834, CI [0.143,11.108], and negative OR for the fourth to sixth born of 0.507, P-value=0.528, CI [0.61,4.184]. On multiple regression, the AOR for the first class (first to third born) became negative of 0.307, p-value:0.799, CI [0.186,1083.280] and the negative odd ratio of second class (fourth to sixth born) of 0.001, p-value:0.101, CI [0.00,4.408]. We can assume that the children belonging to the interval of seven and above born have got more likelihood of full immunization followed by those belonging to first to third born. The less likelihood of full immunization was for children belonging to the interval of fourth to sixth born but not at a statistically significant level. The sixth birth order and above has been found negatively associated with full immunization among 12-23 months children in the Northwest part of Ethiopia (Gelagay et al., 2021). Conversely to this lesson from Ethiopia, the birth order has not affected overall full immunization coverage

4.7 Role of Caretakers' age on Full Immunization Coverage

There was a negative relationship between the age of caretakers and full immunization (OR:0.840, p-value:0.652, CI [0.392,1.797]); in other words, for each unit increases in caretakers` age, the likelihood of being fully immunized for the child decreases. By taking into consideration the bracket age of 34 and above years as a reference; we got the positive odds ratio for 26-33 years of 1.175, p-value:0.806, CI [0.325,4.248]; and negative odd ratio for the 18-25 years bracket age of 0.703, p-value:0.626, CI [0.171,2.893]. In multiple regression AOR for 26-33 years became now statistically significant positive ratio of 35.06, p-value:0.016, CI [2.938,426.032]. Also, the odd ratio became statistically significant for the bracket age of 18-25 years OR=20.762, P-value 0.038, CI [0.265, 3.564]. Consequently, the children whose caretakers belonged to bracket ages 18-25 and 26-33 years old had more chance of full immunization than those whose caretakers belonged to bracket ages 34 and above at a statistically significant level. The caretakers belonging to these bracket ages are so keen on bearing and providing children care. The bracket aged 35 and above has been found negatively associated with full immunization coverage in the Northwest part of Ethiopia (Mekonnen et al., 2020). The results reveal that full immunization is greatly affected by age. The older the person, the poor the immunization uptake.

4.8 Role of Caretakers' Gender and Full Immunization Coverage

There was a positive but not significant association between the caretakers` gender and full immunization OR: 1.725, P-value is=0.135, CI [0.285, 6.062] and AOR: 0.495, p-value: 0.864, CI [0.000, 1508.179]. The female caretakers had more likelihood of full immunization for their children compared to the male caretakers. In most African societies, taking child care or a breastfeeding child is the women's attribute. The gender of caretakers has not affected the overall full immunization coverage at a significant level.

4.9 Role of Family Size on Full Immunization Coverage

OR=0.769, P-value 0.579, CI [0.304, 1.943]. The likelihood of full immunization decreases, for each –unit increase in the family size, but not statistically significant. By creating a dummies (0/1 for each) category and by taking the size family 6-10 persons as a reference, we have got OR=1.390, p-value:0.590, CI [0.420,4.594] for 1-5 persons family size, and negative odd ratio (0.908) for a family size of 11-20 persons, P-value: 0.928, CI [0.110,7.472]. In multiple regression, the family of 1 to 5 persons got a negative odd ratio of 0.057, p-value:0.273, CI [0.000,9.614]. In addition, the family of 11 and above persons got also a negative odd ratio of 0.361, P-value:0.846, CI [0.000,9.614]. For this reason, we can assume that children living in a family of 6 to10 persons have got a high chance of full vaccination, followed by those living in a family of 1 to 5 persons. This could be explained by the fact that 94.1% of children, in our sample, have been living in the family of 1 to 10 persons. Apart from this, the size of Congolese households taken into consideration in the socio-demographic surveys is 7. The parents got used to living in these families' sizes and fulfilled the immunization needs. But the chance of the child being Fully immunized becomes low when the family size goes beyond 10 persons. The size of the family has not affected the full immunization coverage at the significance level.

4.10 Role of Religion on Full Immunization Coverage

There is a positive relationship between religion and full immunization coverage, but not statistically significant OR: 1.127, p-value:0.831, CI [0.375,3.387]and the AOR: 0.168, P-value:0.490, CI [0.001,26.623]. Children from Christian families are more likely to be fully immunized compared to those from Muslims and other religions, but not at a significant level. The high proportion of Christians (89.6%) in our sample could impact the analysis. Religion has not affected the overall full immunization coverage.

4.11 Role of caretakers' level of Education on Full Immunization Coverage

There is a negative relationship between the caretakers' level of education and full immunization coverage. But this relationship is not statistically significant OR= 0.945, P-value: 0.898, CI [0.397,2.248]. By setting up the tertiary education as a reference, we got a positive odd ratio for primary education of 1.233, P-value:0.789, CI[0.267,5.703] and positive odd ratio for secondary education of 1.838, P-value:0.388, CI[0.461,7.319]; likewise in the multivariate regression revealed the positive odds ratios for caretakers primary education AOR=1.633, P-value:0.886, CI[0.002,1296.056], and so for secondary education AOR=53.033, P-value:0.199, CI[0.123,22793.537].This meant that the children from the caretakers with secondary education had more likelihood of full immunization compared to those with tertiary education, the chance of full immunization decreases when the caretaker`s education level increases but at no significant level. The caretaker's education has not affected the full immunization coverage at a significant level.

4.12 Role of Partner levels of Education on Full immunization coverage

There is a positive but not significant relationship OR=1.080 P-value=0.862, CI [0.455,2.565]. By considering the primary education as a reference, we got a positive odd ratio for secondary education of 1.390, p-value:0.763, CI [0.163,11.820], and positive odd ratio for tertiary education of 1.190, p-value: 0.835, CI [0.145,10.940]. In multivariate regression the tertiary education had negative but not significant relationship (AOR=0.417, p-value: 0.752, CI [0.002,94.959]), and secondary education had a positive odd ratio of 1.141, p-value:0.970, CI [0.001,1152.251]. The children whose caretakers' partners achieved secondary education had more likelihood of full immunization than those who achieved tertiary education. Likewise, those who achieved only primary education were not at a statistical significance level. The secondary education of the father has been positively and significantly associated with full immunization coverage in nine Sub-Saharan countries (Fenta et al., 2021). This could be explained by an easy understanding of the usefulness of immunization and the right leadership in their families. The overall full immunization coverage was not affected by the level of education of the caretaker`s partners at a significant level.

4.13 Role of caretakers` occupation in Full Immunization Coverage

There is a positive and statistically significant relationship between current occupation and full immunization coverage OR=3.169, P-value:0.04, CI [1.027,9.778]. The positive significant relationship remained in the multivariate regression OR:74.868, p-value:039, CI [1.401,499802]; In another world, for each unit increases or changes in caretaker's occupation, the chance of full immunization increases. We can assume that the children whose caretakers were unemployed had more likelihood of full immunization compared to those whose caretakers were officially employed. This could be explained by the high proportion of caretakers unemployed in our sample. Moreover, hustlers, housewives, and small traders have more time to spend in the household and taking care of children. The full immunization was affected by the caretaker's occupation.

4.14 Role of Partners` occupation on Full Immunization Coverage

There was a positive relationship between the spouse's current occupation and full immunization OR=1.084, P-value:0.795. This relationship became negative in multivariate regression AOR:0.049, p-value:0.197, CI [0.000,4.816]. We can assume that for every unit increases in the spouse's current occupation category, the likelihood of full immunization decreases. This means the chance of full immunization has been high for the children whose caretakers partners category were employed than for the unemployed category but at a not significant level. The occupation respondents' partners have not affected the full immunization coverage.

4.15 Role of Vaccination Card possession on Full Immunization Coverage

The possession of a vaccination card has been statistically associated with Full immunization OR=10.205, P-value: 0.000, CI [3.310,31.464]. The multiple regression strengthened the positive relationship OR=49.79, p-value:0.026, CI [73, 9.489]. Shortly the children whose caretakers presented the vaccination cards during our interview had almost forty more likelihood of their children been fully immunized compared to those whose caretakers didn`t present the vaccination cards at a significant level. Similarly, Mbengue et al. (2017) stated that the possession of immunization cards has been statistically significantly associated with complete immunization coverage among the 12-23 months children in Senegal, but the proportion of caretakers who showed the vaccination cards were (37.5%) lower than in our study 92%. The possession of vaccination cards has positively affected full immunization coverage. The more the parents keep the vaccination card; the more interested in their children being fully immunized.

4.16 Role of indication of MCV injection site on Full Immunization Coverage

There was a significant relationship between the good indication of MCV site of injection and full immunization coverage OR:18.143, p-value:0.000, CI [5.885,55.936]. But, in multiple regression, the relationship became negative and not significant OR=0.381, P-value:0.699, CI [0.003,50.487]. For each unit changed from indication of MCV site of injection (from Good to bad indication) the chance of full immunization decreased. In other words, children whose caretakers have shown correctly the injection site of MCV had more likelihood of full immunization compared to their counterparts. The remembrance of MCV which is the last vaccine on the EPI schedule has not affected the full immunization coverage at a significant level.

4.17 Role of Declaration of Immunization Completion on Full Immunization Coverage

There was a positive and significant relationship between the caretaker's declaration of immunization completion and Full immunization coverage on simple regression OR= 180.044, P-value:0.000, CI [38.202,852.319]. This relationship remained positive and significant in multiple regression AOR=26, P-value: 0.009, CI [73.217,9.489]. Hence, children whose caretakers confirmed that they had completed the vaccination schedule during the interview had more likelihood of full immunization than those whose caretakers didn`t confirm the vaccination completion. Similarly, the knowingness of the schedule of immunization has been the predictor of full immunization in Ethiopia among 12-23 months (Nour et al., 2020). Conversely, the poor knowledge of routine vaccination by caretakers had been almost 6 times associated with incomplete vaccination in Enugu state, Nigeria (Eze et al., 2021). The overall full immunization coverage has been affected by the caretaker's declaration of schedule completion. The more the caretakers were concerned about children's immunization, the more their children achieved full immunization.

4.18 Role of Children's Age on Full Immunization Coverage

There was a positive, but significant relationship between children's age in months and full immunization coverage, OR: 1.181, P-value: 0.770, CI [0.389, 3.586]. We can say for each unit month increased in child age; the likelihood of full immunization increased also. The children's age in months has not affected significantly the overall full immunization coverage.

Four variables had a significant relationship with the full immunization coverage regardless of the occurrence of COVID-19: Age of caretakers, caretakers' occupation, possession of vaccination cards, and caretaker's declaration of immunization completion.

On the one hand, no child in our sample has received MCV and AAV before COVID-19. On the one hand, this fact led to null Full immunization coverage before the COVID-19 period. On the other hand, we would like to compare the socio-demographic factors and immunization coverage before COVID-19 and during the COVID-19 period. For achieving our first objective. Thus, we have considered variable″Partial immunization coverage ″ or Full immunization coverage excluded AAV and MCV or immunization coverage from BCG to IPV. Consequently, compare the factors which got significant relationships in multiple regression before COVID-19 and those which got significant relationships in multiple regression during COVID-19 periods.

The overall partial immunization coverage for two periods was 99.1%. The partial immunization coverage before the COVID-19 period was 100 %(n=44) and the partial immunization coverage during COVID-19 was % 98.9 %(n=379)

4.19 Predictors of Partial Immunization Coverage before the COVID-19 Period.

There was a positive but not significant relationship between partial immunization coverage and caretaker's occupation OR= 3.970, p-value: 0.845, CI [0.816, 019313].

The relationship was positive but not significant for caretakers` declaration of immunization completion and partial immunization coverage AOR: 4243, p-value: 0.999, CI [0.000, 2.304]

There was a positive no significant relationship between caretakers` possession of child`s immunization cards and partial immunization coverage OR: 1.731, p-value: 0.486, CI [0.307, 8.104].

There was a negative, not significant relationship between the bracket age 26-33 years and partial immunization coverage AOR= 0.648, p-value:0.182, CI [0.678,7.828]. But the relationship between the bracket age 18-25 years and partial immunization coverage was negative and significant AOR=0.211, p-value:0.014, CI [0.061,0.734]. By considering the caretakers' bracket age 34 and above as a reference, we can assume that the children whose caretakers belonged to 34 and above years had more chance of partial immunization than those whose caretakers belonged to 18-25 years at a statistically significant level. Conversely, the children whose caretakers belonged to 26-33 years had less chance to be partially immunized compared to those whose caretakers belonged to 34 and above years but at a significant level.

There was a negative and statistically significant relationship between the partial immunization coverage and the gender of the children AOR=0.454, P-value: 0.031, CI [0.221, 0.931]. This means for each unit change in gender (living from a male child to a female child) the partial immunization coverage decreases at a statistically significant level. This meant that the male children had more chance of partial immunization coverage before the COVID-19 period compared to the females.

Shortly, two variables predicted negatively partial immunization coverage before the COVID-19 period: the child sex and caretakers bracket age of 18-25 years old, and among the 4 predictors of full immunization coverage had not remained predictors of partial immunization coverage before the COVID-19 period.

4.20 Predictors of Partial Immunization Coverage During COVID-19 Period

The relationship was negative and not significant between the caretakers' occupation and partial immunization coverage OR= 0.662, p-value: 0.475, CI [0.213, 2.053].

There was a positive but not significant relationship between partial immunization coverage and the caretakers' bracket aged 26-33 years old. OR=1.483, P-value:0.346, CI [0.653,3.370].

The relationship was negative and not significant for the caretakers` declaration of immunization completion and partial immunization OR= 0.274, p-value: 0.287, CI [0.025,2.975].

The relationship was positive and not significant between partial immunization coverage and caretakers' possession of child vaccination cards OR= 1.645, p-value:0.368, CI [0.556,4.868].

There was a positive and significant relationship between the caretakers' bracket age 18-25 years and partial immunization coverage OR= 3.572, p-value:0.030, CI [1.128,11.316]. Hence, children whose caretakers belonged to the 18-25 years old had a high probability of being fully immunized compared to those whose caretakers belonged 34 and above years old at a significant level. Likewise, when compared to those whose caretakers belonged 26-33 years old at no significant level.

There was a positive relationship between the children's gender and partial immunization coverage at a significant level OR= 2.324, p-value: 0.016, CI [1.170, 4.618]. In other words, each unit increases in children's gender (change from male to female) the full immunization coverage increases at a significant level. Hence, during the COVID-19 period, two variables (children's gender and caretakers aged from 18 - 25 years) were statistically significant as before the COVID-19 period. But the direction of the relationship changed from negativity before the COVID-19 period to positivity during the COVID-19 period. In other words, before COVID-19 male children had a high probability of partial immunization from BCG to IPV. But during the COVID-19 period, female children got a high probability of partial immunization. In the pre-pandemic period, the children whose caretakers belonged 18-25 years old had less probability of being partially vaccinated when compared to the children whose caretakers belonged to 34 and above years old. Now got a high probability of being partially immunized compared to those whose caretakers belonged to 34 and above years old at a significant level. Also, compared to those whose caretakers belonged 26-33 years old at no significant level. The caretaker's bracket age between 18-25 years was the predictor of full immunization coverage, of partial immunization coverage in the pre-pandemic period and during the pandemic period. These 18-25 years' bracket age have been positively associated with partial immunization (AOR=1.44,95CI:1.11,1.85) in the East part of Ethiopia (Dheresa et al., 2021). The caretakers aged between 18-25 years old and the children's sex has affected significantly the partial immunization coverage for the two periods.

Table 4.4

Comparison of Full immunization and partial immunization coverages

Predictors of Full immunization coverage	Predictors of partial immunization coverage before the COVID-19 period	Predictors of partial immunization coverage during the COVID-19 period	The direction of the relationship
Unemployment	NO	NO	+
Possession of cards	NO	NO	+
18-25yrs old for caretakers	YES	YES	-/+
26-33yrs old for caretakers	NO	NO	+
Declaration of full vaccination	NO	NO	+
-	Child sex	Child Sex	-/+

The table above shows the possession of child vaccination cards, brackets ages of 18-25 and 26-33 years, and declaration of full vaccination by the caretakers were the predictors of Full immunization. Only the bracket aged 18-25 years remained as predictors of partial immunization coverage. Therefore, its odds ratio inverted from negative before COVID-19 period to positive during COVID-19 period. The child sex was not a predictor of full immunization coverage but became a predictor of partial immunization coverage with a negative odd ratio before COVID-19 which changed to a positive odd ratio during COVID-19 period.

Table 4.5

Health facilities comparison table for starting and completion of vaccination schedule

Health facilities N=422(n, %)	**Starting (n, %)**	**Completion (n, %)**	**Balance (n, %)**
Military hospital	111(26.3)	108(25, 6)	-3(-0.7)
Amani health center	48(11.4)	47(11.2)	-1(-0.2)
Konde clinic	38(9.0)	41((9.8)	3(0.8)
Mabanga health center	33(7.8)	33(7.8)	0 (0)
Murara health center	26(6, 2)	23(5.4)	-3(-0,8)
Katoyi health center	23(5.4)	23(5.4)	0(0)
Dimajelo clinic	18(4.3)	17(4,0)	-1(-0.3)
CEBCA hospital	17(4.0)	16(3.8)	-1(-0.2)
HEAL Africa hospital	17(4.0)	17(4.0)	0(0)
Others	92(21.8)	87(20.6)	-5(-1.2)
Total	423(100)	412(97.3)	-11(-2.7)

The respondents indicated where their children started vaccination and where ended the vaccination process, these health facilities in Table 4.8 have been cited.

By performing paired samples T-test, we have found that the difference is not statistically significant between the set of children starting immunization and the set of children who completed immunization (t=0.542, df=9, P-value=0.691); the health facilities cited above have implemented routine immunization activities in a good.

Table 4.6 shows the number of children born before the occurrence of the Pandemic (8th September 2019 to 9th March 2020) was 42.8%(n=181); among them, 22 were born in September 2019, 62 from October 2019 to December 2019, and 97 from 1st January to 9th

March 2020. Those born during the pandemic period (from 10th March 2020 to 22 August 2020) were 55.5% (n=243).

Table 4.6

Children numbers regarding COVID-19 occurrence

Period	**Frequency (%)**
Born before COVID-19	181(42.8)
Born during COVID-19	242(57.2)
Total	423(100)

Table 4.7

Overall immunization coverage

	Overall coverage.		**Pre-COVID-19 period coverage.**		**During COVID-19 coverage.**	
	Freq.	N (%)	Freq.	N (%)	Freq.	N (%)
BCG	423	423(100)	151	151(100)	272	272(100)
OPV_0	423	423(100)	151	151(100)	272	272(100)
$Pentavalent_1$	422	423(99.8)	120	120(100)	302	303(99.7)
$Rotavirus_1$	422	423(99.8)	120	120(100)	302	303(99.7)
PCV_1	422	423(99.8)	120	120(100)	302	303(99.7)
OPV_1	422	423(99.8)	120	120(100)	302	303(99.7)
$Pentavalent_2$	422	423(99.8)	79	79(100)	343	344(99.7)
$Rotavirus_2$	422	423(99.7)	79	79(100)	343	344(99.7)
PCV_2	422	423(99.8)	79	79(100)	343	344(99.7)
OPV_2	422	423(99.8)	79	79(100)	343	344(99.7)
$Pentavalent_3$	421	423(99.5)	42	42(100)	379	381(99.5)
$Rotavirus_3$	421	423(99.5)	42	42(100)	379	381(99.5)
PCV_3	421	423(99.5)	42	42(100)	379	381(99.5)
OPV_3	420	423(99.3)	43	43 (99.7)	377	380(99.2)
IPV	419	423(99.0)	43	43(100)	375	380(98.7)
AAV	410	423(96.9)	0	0(0)	410	423(96.9)
MCV	410	423(96.9)	0	0(0)	410	423(96.9)
Partial immunization coverage	420	423(99.3)	44	44(100)	376	379(99.2)
Full immunization coverage	409	423(96.7)	0	0(0)	409	**423(96.7)**

Nota bene: the pre-COVID-19 period in our study covered the period from 8th September 2019 to 9th March 2020.Whereas the COVID-19 period covered from 10th March 2020 to 22nd August 2021.

The overall coverages, the coverages in the pre-COVID-19 period, and the coverages during the COVID-19 period for each vaccine antigen were described in table 4.6. Only the coverages BCG and OPV_0 did not vary. But we observed a considerable increase for MCV and AAV and; a slight decrease in coverages for $Pentavalent_{1,}$ $Rotavirus_{1,}$ $PCV_{1,}$ $OPV_{1,}$ $Pentavalent_2$, PCV_2, OPV_2, $OPV_{,3}$.by comparing the two periods. The high immunization coverage overall was BCG and OPV_0 (100%) and the low immunization coverage overall was for IPV (99.0%). The high immunization coverage during the pre-COVID-19 period were 100% for BCG, OPV $_{0,1,2,3}$, $Pentavalent_{1,2,3,}$ $PCV_{1,2,3}$, $Rotavirus_{1,2,3}$ and the low immunization coverage was 0 % for MCV and AAV. The high immunization coverage during the COVID-19 period was100 % for BCG and $OPV_{0,1}$. The partial immunization coverage decreased from 100% in the pre-pandemic to 99.2% during the pandemic period. Therefore, the full immunization coverage was 0% before the pandemic period because no child has received AAV and MCV. This full immunization coverage is 96.7% during the pandemic.

The coverages in the pre-COVID-19 period were high for almost all vaccines. These findings corroborated with those found in 204 territories and countries worldwide. Their analysis showed that the coverages of OPV, $MCV_{1,}$ and DTP_3 had increased from 42.6 % to 79.8%, from 38.5% to 83.6%, and from 39.9% to 81.6% respectively from 1980 to

2019; and so, stated the progress to immunization agenda 2030 set up by WHO and others stakeholders (GAVI, 2020).

The difference in mean coverages between the pre-COVID -19 period and the COVID-19 was statistically significant T Calculated -9.932 < -2.120, df=16, P-value .000, CI [-314.353, -203.765]. The negativity of our t- calculation meant that the mean of vaccine uptake has been higher during COVID-19 than the mean of vaccine uptake in the pre-COVID-19 period. But some vaccines increased in coverage and others decreased in coverage. This situation could be explained by the fact that our COVID-19 period included almost 17 months versus almost 6 months the before COVID-19 period. Moreover, the fact that no child has received the MCV and AAV during COVID-19 period decreased the number in favour of COVID-19 period. There is a need to compare the equal periods and assess the trend of uptake over the period. The BCG, Pentavalent3, and MCV coverages are slightly higher compared to 94.7%, 72.7%, and 82.6% found in Senegal (Mbengue et al., 2017).

Table 4.8

Vaccination frequency trend in pre and during COVID-19 period

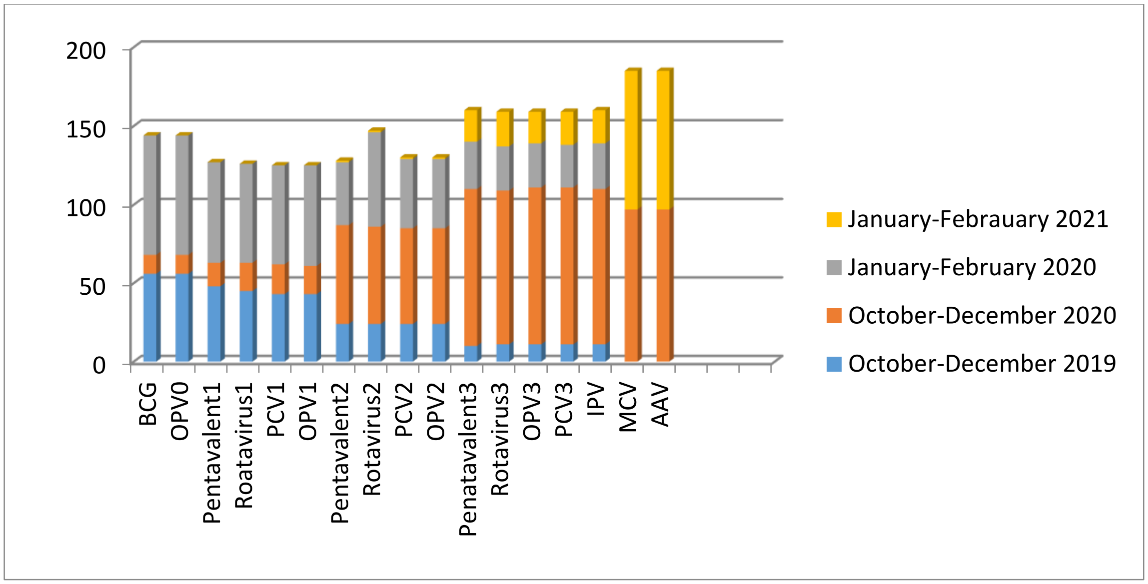
		October, November, and December 2019	October, November, and December 2020	January, February 2020	January, February 2021
1	BCG	56	12	76	0
2	OPV_0	56	12	76	0
3	$Pentavalent_1$	48	15	64	0
4	$Rotavirus_1$	45	18	63	0
5	PCV_1	45	19	63	0
6	OPV1	43	18	64	0
7	$Pentavalent_2$	24	63	40	1
8	$Rotavirus_2$	24	62	40	1
9	PCV_2	24	61	44	1
10	OPV_2	24	61	44	1
11	$Pentavalent_3$	10	100	30	20
12	$Rotavirus_3$	11	98	28	22
13	OPV_3	11	100	28	20
14	PCV_3	11	100	27	21
15	IPV	11	99	29	21
16	MCV	0	97	0	88
17	AAV	0	97	0	88

On the one hand, the difference in the uptake Mean of vaccines between the last term of 2019(pre-pandemic period) and the last term of 2020(during the pandemic period) is statistically significant (T calculated -5.551 < -2.120 critical value df =16, P-value 0.021, CI [-63.872, - 5.893]. Meaning the uptake of vaccines decreased for the first set of vaccines (BCG, OPV_1) and the second set of vaccines ($Pentavalent_{1,}$ $Rotavirus_1$, $PCV_{1,}$

OPV_1) from 48.00 doses to 16,67 doses. But the uptake Mean increased from 16.67doses to 81.67doses for the third set (Pentavalent$_{2,}$ Rotavirus$_{2,}$ $PCV_{2,}$ $OPV_{2,}$), the fourth set (Pentavalent$_3$, Rotavirus$_{3,}$ OPV_3, PCV_3, IPV), and the last set (MCV, AAV) in favour of the last term 2020. On the other hand, the difference in uptake Mean is also statistically significant between January February 2020 or in the pre-pandemic period and January - February 2021 or in during the pandemic period T Calculated 2.12 equal to 2.120, df=16, P-value:0.050, CI [7.484,50.163]. In the other words, there was a significant decrease in vaccines uptake mean from 47.73 doses to 7.2 doses for the first, second and third set of vaccines (BCG, $OPV_{0,}$ Pentavalent1, Rotavirus1, PCV_1 and $OPV_{1,}$ Pentavalent$_{2,}$ Rotavirus2, $PCV_{2,}$ and OPV_3, $PCV_{3,}$]. Conversely, we only observed the increase of uptake Mean for IPV, AAV, and MCV by comparing January- February 2020(pre-pandemic period) with January- February 2021(during the pandemic period). Considering the decline of BCG from 100%(n=76) to 0% (n=0) is high compared to 40.6% found in Sindy in Pakistan by evaluating the impact of the Pandemic on routine immunization (Chandir et al., 2020). The decline was also considered when compared to 47.0% found in the northern part of Ghana in the level 6 hospital (Bimpong et al., 2021). Likewise, considerable when compared to the 25% found in the study of disruption of BCG coverage by COVID-19 in 28 countries (Shaikh et al., 2021). Shortly. The entrance antigens specifically BCG have been more disrupted by the occurrence of COVID-19. This could be explained by the Lockdown measures and movement restrictions in most of the countries which experienced the pandemic for the first time.

Figure 4.1

Stacked bar of the trend of vaccine frequency in pre and during the COVID-19 period.



The figure illustrates the variation in vaccines uptake during each period:

- For October, November, and December 2019, the variation was in decrescendo mode. In other words, the uptake started at 56 for BCG, Pentavalent1, $PCV_{1,}$ or the first and second set of vaccines, then decreased from $Pentavalent_{2,}$ PCV_2, Pentavalent3, OPV_3, and $IPV_{,}$ became null for AAV and MCV.
- For October, November, and December 2020: conversely to the last term of 2019, the variation was in Crescendo mode; i.e., slight increase for the BCG, $Pentavalent_{1,}$ $PCV_{1,}$ or first and second set of vaccines, then increased much from $Pentavalent_2$, PCV2, $Pentavalent_3$, OPV_3, and IPV, and so achieved its high level for MCV and AAV.

- For January and February 2020: the uptake started at 76 for BCG, slightly decreased from $Pentavalent_1$ (64) to PCV_1 maintained the pace till PCV_1 then much decreased from $Pentavalent_2$ to IPV; became null for MCV and AAV.
- For January and February 2021: the uptake was null for the BCG and $Pentavalent_1$, with a slight increase from one unit from $Pentavalent_2$ to PCV_3, then a considerable increase from $Pentavalent_3$ to AAV.

Table 4.9

Comparison of immunization coverages among one-year-old children

	Overall coverage		Pre-COVID-19 period coverage		During the COVID-19 period coverage	
	Freq.	N (%)	Freq.	N (%)	Freq	N (%)
BCG	420	423(99.29)	149	149(100.00)	271	274(98.91)
OPV_0	412	423(99.29)	149	149(100.00)	271	274(98.91)
$Pentavalent_1$	418	423(98.82)	120	120(100.00)	297	302(98.34)
$Rotavirus_1$	418	423(98.82)	120	120(100.00)	297	302(98.34)
PCV_1	418	423(98.82)	120	120(100.00)	297	302(98.34)
OPV_1	418	423(98.82)	120	120(100.00)	297	302(98.34)
$Pentavalent_2$	410	423(96.93)	79	79(100.00)	331	344(96.22)
$Rotavirus_2$	410	423(96.93)	79	79(100.00)	331	344(96.22)
PCV_2	410	423(96.93)	79	79(100.00)	331	344(96.22)
OPV_2	410	423(96.93)	79	79(100.00)	331	344(96.22)
$Pentavalent_3$	416	423(98.11)	44	44(100.00)	365	379(96.30)
$Rotavirus_3$	416	423(98.11)	44	44(100.00)	365	379(96.30)
PCV_3	416	423(98.11)	44	44(100.00)	365	379(96.30)
OPV_3	416	423(98.11)	42	43(97.67)	371	380(97.63)
IPV	404	423(97.64)	42	43(97.67)	362	381(90.07)
MCV	379	423(89.60)	0	0(0.00)	379	423(89.60)
AAV	379	423(89.60)	0	0(0.00)	379	423(89.60)
Full immunization	366	423(86.60)	0	0(0.00)	366	423(86.52)

Freq: frequency

The Mean of vaccine uptake between the two periods is statistically significant calculated: -12.439 < -2.12. $p<0.05$.

Table 4.10

Comparison of Full Immunization Coverage

Full immunization coverage calculated from caretakers` declaration in August 2021	Full immunization coverage calculated from cards and health facilities records	Full immunization coverage among children at one -year –old.
N= 423 412/423=97.3%	N=423 409/423=96.7%	N= 423 366/423=86.6%

By performing the Chi-square test for goodness of fit. On the one hand, the difference was not statistically significant between the full immunization coverage calculated from caretakers` declarations and the full immunization coverage calculated through the data from children's vaccination cards and health facilities records (χ^2= 2.544, df=1, P-value=0.111). On the other hand, the difference is significant between the full immunization coverage calculated from the cards and health facilities records and the full immunization coverage at one year old (χ^2=47.192, df=1, P-value=0.00). It is also different from 74.3 % of the full immunization calculated in Goma among under five years children (Kabudi et al., 2015), [χ^2=106.138, df=1, P-value=0.000]); the country has set the target of full immunization at 75% (Programme for Appropriate Technology in Health [PATH], 2022). Consequently, the difference is statistically significant between the full immunization calculated from the vaccination cards combined with the health facilities records of 96.7% and the country target of 75%. (χ^2=106.138, df=1, p-value=0.000). The emergency plan for the revitalization of routine immunization launched in 2018 has been implemented at Mabanga in Goma city, North-Kivu province, specifically the objective related to increasing the coverage of vaccination.

96.7% as full immunization coverage observed at Mabanga in Goma city is better. Because Acharya et all (2018) found 70.6%in Goma city, which was the highest full immunization coverage in the country using 2013-2014 Demographic and Health Survey Data. Also, stated that there was a variation of full immunization coverage across the 26 provinces from 5.8% (Mongala) to 70.6%(North-Kivu), with a country average of 45,3%. By performing the Chi-square test for goodness of fit, we observed that 96.7% of full immunization coverage in Goma is statistically different (P-value<0.05)from 72.5% found in Lubumbashi city in Democratic Republic of Congo (Mukalay et al.,2021), from 67% in Nairobi in Kenya (Mutua et al., 2016), from 80.2% in Kakamega county in Kenya(Sunguti,2016), from 70.9% in Senegal (Sarker et al., 2019), from 58.4% in Northern Ethiopia (Tesfaye et al., 2018), from 39% in Kersa in Ethiopia (Dheresa et al., 2021), from75.6% in Minjar-Shenkora district in Ethiopia (Mekonnen et al., 2019). It is also statistically different from 43.98% in Amritsar city in Somalia (Singh et al.,2018), 62.8% in Senegal (Mbengue et al., 2017), from 73 % in Malawi (Mmanga et al., 2021), from 67% in Indonesia (Suwantika, 2020). This high coverage could be justified by the urban character of the study population. In addition, the geographical location of Goma city offers more opportunities for transport to capital cities of neighboring countries such as Kigali, Kampala, and Bujumbura. Also, the Presence of multiple Non-Governmental Organizations intervening with urgent projects after disasters. Goma detained the store for vaccines for provision in some Eastern provinces. The overall full immunization coverage is highly different from the country target and other African countries.

Despite this high full immunization coverage,14 children haven`t been fully immunized and 92.9% (n=14) haven't received MCV and AAV.

The children who haven't completed the schedule are usually caught-up during the mass vaccination campaigns by Community Health Volunteers.

Table 4.11

Children Vaccines Incompleteness

Vaccines	**Frequency (%)**
BCG	0(0)
OPV_0	0(0)
OPV1	1(0.7)
OPV_2	1(0.7)
OPV_3	3(21.4)
$Rotavirus_1$	1(0.7)
$Rotavirus_2$	1(0.7)
$Rotavirus_3$	2(14.3)
PCV_1	1(0.7)
PCV_2	1(0.7)
PCV_3	1(0.7)
IPV	3(21.4)
$Pentavalent_1$	1(0.7)
$Pentavalent_2$	2(0.7)
$Pentavalent_3$	2(0.7)
MCV	13(92.9)
AAV	13(92.9)

Table 4.10 shows that MCV and AAV have been the most missed opportunity vaccines for children who haven`t achieved full immunization. Nevertheless, the totality of the children has received BCG and OPV_0.

4.21 Sequences of the Vaccines

In-sequence vaccination: 262/423*100= **60.756%**

Out-of-sequence vaccination = 166/423*100=**39.243%**

-BCG-penta1:138/422*100= 32.701%

-Penta1 -Penta2: 8/422= 1.896%

-Penta2-penta 3: 18/421*100= 4.256%

-Penta3-MCV: 2/410*100= 0.488%

Table 4.12

Comparison of out-of-sequence vaccination for two periods

		BCG-penta1 N=422, %		Penta1-penta2, N= 422, %		Penta2-Penta3 N=421, %		Penta3-MCV N=410, %		Overall N=423, %
	F		F		F		F		F	
Before	31	7.346	3	0.711	3	0.713	-			166
During	107	25.355	5	1.185	15	3.563	2	0.488		39.244

The variation of out–of–sequence vaccination for two periods was been high between BCG and Penta1, and the low rate was between Penta3 and MCV. By performing a two-tailed paired T-test df =1, at 0.05 our T calculated = -1.295 is greater than our critical value of -12. 706.Meaning that the difference between the out-of-sequence Mean before COVID-19 and during the COVID-19 period was not statistically significant at 0.05 level.

Despite that, the out-of-sequence Mean of vaccination during the COVID-19 period was been higher than the out-of-sequence Mean vaccination before COVID-19.

The 39.24% overall out-of-sequence vaccination in this study was high compared to 22% found in the three slums in Nairobi, Kenya by 22% (Mutua et al., 2016). It was also, higher than 5% and 4% respectively between BCG-DTP1 and DTP1- DTP3 found in Burkina Faso (Ouédraogo et al., 2013). The proportion of out-sequence is high, there is a need to fill the gap; because several studies highlighted the consequences of out-sequence vaccination specifically childhood mortality:

Eze et al. (2021) elucidated that childhood mortality had been higher among the children who received DTP with or after MCV than those who received MCV after DTP. Also, highlighted that the OPV vaccination campaigns reduced the infant mortality associated with this disruption in their study conducted in the North region of Ghana.

Thysen et al. (2019) stated that the out-sequence was more associated with infant mortality than in-sequence vaccination in the study conducted in Guinea-Bissau.

Aaby et al. (2021) stated in the same way by stating that the case fatality was high among the children who had received the trivalent (DTP_3 with or after MCV compared to those who received MCV compared to those who had received the MCV after three doses of DPT in Guinea-Bissau.

Clipet-Jensen et al. (2021) stated that the mortality rate ratio was 14.83 for the children who had received the DTP vaccine after MCV. In addition, they stated that MCV administered after DTP had a mortality rate ratio of 0.56 in their study conducted in Bangladesh among the 36650 children born between 1986 and 1999.

The out-sequence vaccination is independent or dependent on full immunization, we set up our contingency table

Table 4.13

Relationship between out-of-sequence level and full immunization coverage.

	Out-of-sequence vaccination			
Full		YES	NO	Total
immunization	YES	161	248	409
coverage	NO	5	9	14
Total		166	257	423

X^2= 0.002 less than our critical value of 3.841, the null hypothesis was not rejected; the out-sequence vaccination and full vaccination coverage are independent.

Table 4.14

Chi-square contingency table

		Column1	Column2	Total
Row1 Observed		161	248	409
Expected		160.51	248.49	409
	O-E	0.49	-0.49	-1.93
	$(O-E)^2/E$	0.00	0.02	0.02
Row2 Observed		5	9	14
	Expected	5.33	8.74	16.07
	O-E	-0.33	0.26	-0.07
	$(O-E)^2/E$	0.00	0.00	0.00
Total	observed	159	264	423
	Expected	159	264	423
	$(O-E)^2/E$	0.00	0.00	0.00

Chi-square calculated is 0, the degree of freedom=1, our chi-square critical value at α=0.05 is 3.841, Chi-square calculated less than our critical value, our null hypothesis is accepted and stated that the out-sequence doses are independent of full immunization coverage, P-value 0.157.

4.22 Timing of Vaccination

Table 4. 15:

Early, Timely, and delayed vaccines

N^0		Early Vaccines		Timely Vaccines		Delayed Vaccines		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
1.	BCG			235	55.6	184	44.4	423	100
2.	OPV_0			241	57	182	43	423	100
3	$Pentavalent_1$	198	46.8	133	31.4	91	21.5	422	100
4	$Rotavirus_1$	197	46.6	132	31.1	93	22.2	422	100
5	PCV_1	196	46.3	132	31.2	94	22.2	422	100
6	OPV_1	194	45.9	133	31.4	95	22.5	422	100
7	$Pentavalent_2$	148	35.0	123	29.1	151	35.7	422	100
8	$Rotavirus_2$	150	35.5	97	23	175	41.4	422	100
9.	PCV_2	150	35.5	97	23	175	41.5	422	100
10	OPV_2	150	35.5	96	22.8	176	41.6	422	100
11	$Pentavalent_3$	150	35.5	73	17.3	198	47	421	100
12	$Rotavirus_3$	127	30.0	95	22.6	199	47.0	421	100
13	PCV_3	127	30.0	95	22.6	199	47.0	421	100
14	OPV_3	127	30.2	95	22.6	199	47.0	421	100
15	IPV	125	29.9	95	22.7	198	47.4	418	100
16	MCV	110	26.8	215	52.4	85	20.7	410	100
17	AAV	110	26.8	214	52.2	86	21.0	410	100

Freq: Frequency. %: Percentage.

High proportions of early vaccination were observed for $Pentavalent_1$ (46.8%), $Rotavirus_1$ (46.6%), and PCV_1 (46.3%). The high proportions of delayed were observed for IPV (47.4%), PCV3 (47.0%), $Pentavalent_3$ (47.0%), $Roatavirus_3$, and OPV_3 (47.0%). Whereas the low proportions for early vaccination were represented by MCV (26.8%) and IPV (29.9%), on the one hand. While MCV (20.7%), and AAV (21.0%) have represented the low proportions of delayed vaccination, on the other hand. Nevertheless, the high proportions of timely vaccination have been represented by BCG (55.6%), OPV (55%), and low proportions by $Pentavalent_3$ (17.3%), and PCV3(22.6%). These findings of the highest timely vaccination are almost the same as those found in Uganda (Babirye et al., 2012). Our high proportions of early and delayed vaccination per antigen have been low compared to those found in the west Kajiado constituency in Kenya. For instance, early given antigens: $Pentavalent_1$ 55.0 versus 46.8%, Rotavirus1 63.7% versus 46.6%, PCV1 60.4% versus 46.3%. Also, delayed given antigens: Measles 57.1% versus 20.7%, PCV_3 39.6% versus 30. %. But Measles have been slightly higher for Early given antigen 20.3%versus 26,8% (Pertet et al., 2018). This high proportion of early and late given antigens to the children could be explained by the rural setting and unstable pastoralist population compared to Mabanga which is an urban setting with a stable population.

Mekonnen et al. (2020) found a critical situation in the Northwest region of Ethiopia by underlining that only 31.9% of children were timely fully vaccinated. In addition, they noticed that 37.6% of BCG doses and 13.9% of doses of $Rotavirus_1$ were delivered in delay mode, which meant less than 44.4% for BCG and 22.2% for $Pentavalent_1$ found in this study. Blose et al. (2021) described the vaccination timeliness and found that the trivalent3 vaccine (DTP_3) had the 34.6% highest proportion of delayed antigen in Cape Town in South Africa. And stated that the low and middle socioeconomic conditions were associated with the vaccination delay. However, the vaccination delay for three doses of OPV and Pentavalent had higher because more than 90 % of children received them beyond 180 days of life in the South part of Nepal (Hughes et al., 2016). Our low proportions of delayed vaccines 20.7% for MCV and 21.5% for Pentavalent1 are less than those found in India 34.8% for MCV and 29.3% for $Pentavalent_1$. Moreover, highlighted that children from low-income families, and whose mothers had low education levels had more affected by delay (Choudhary et al., 2019). Similarly, our delay proportion for BCG (44.4%), $Pentavalent_3$ (47.0%), and MCV (20.7%) remained low compared to 76%,51%, and 36% respectively for respectively BCG, $Pentavalent_{3,}$ and MCV found in Bangladesh in the study of causes of incomplete vaccination among the children (Sheikh et al., 2018). Consequently, early or delayed vaccination is common in most low- and middle-income countries with variation among them

Nevertheless, routine immunization aims to vaccinate timely for effectiveness. The vaccines delivered early or delayed are supposed invalid. What is the extent of the invalid vaccination?

Table 4.16

Timely versus Early and delayed vaccines

		Timely vaccination		Early and delayed vaccination		Total
	Vaccines	Fr	%	Fr	%	N
1	BCG	235	55.6	184	44.4	423
2	OPV_0	241	55	182	43.0	423
3	$Pentavalent_1$	133	31.5	289	68.5	422
4	$Rotavirus_1$	132	31.3	290	68.8	422
5	PCV_1	132	31.3	290	68.8	422
6	OPV_1	133	31.5	289	68.5	422
7	$Pentavalent_2$	123	29.2	271	64.2	422
8	$Rotavirus_2$	97	23.7	325	77.0	422
9	PCV_2	97	23.7	325	77.0	422
10	OPV_2	96	22.7	326	77.3	422
11	$Pentavalent_3$	73	17.3	348	82.7	421
12	$Rotavirus_3$	95	22.6	326	77.4	421
13	PCV_3	95	22.6	326	77.4	421
14	OPV_3	95	22.6	326	77.4	421
15	IPV	95	22.7	323	77.3	418
16	MCV	215	52.4	195	47.6	410
17	AAV	214	52.2	196	47.8	410

The overall timely vaccination Mean and Median uptake were respectively 135.35 doses and 123.00 versus 283.18 and 290.00 as the overall untimely vaccination Mean and Median. By the mean of paired T, we would like to see whether the Mean difference between the supposed valid vaccines and supposed invalid vaccines is different or not at $\alpha=0.05$. Two-tailed test results with a degree of freedom =16, our $t = -5.428 < -2.120$, p-value =0.000 We conclude that the difference is statistically significant between the supposed valid vaccination uptake Mean and supposed invalid vaccination uptake Mean, the Mean of supposed invalid vaccination uptake has been higher for all vaccines than the

Mean of supposed valid vaccination uptake except for BCG, OPV_0, MCV, and AAV. The exception could be explained by the absence of early vaccination for BCG and OPV_0 delivered from some hours to some days after birth. For MCV and AAV, their interval set for early and delayed were large compared to the other vaccines. By comparing the supposed valid vaccination uptake Means and supposed invalid vaccination uptake Mean for the last term of 2019 and the last term of 2020.

Table 4.17

Comparison of vaccines timing between last term 2019 and last term2020

	Last term 2019					Last term 2020				
	Timely Vaccines		Early and delayed vaccines			Timely vaccines		Early and delayed vaccines		
Vaccines	F.	%.	Freq.	%	N	Freq	%	Freq.	%	N
BCG	36	64.3	20	35.7	56	2	16.7	10	83.3	12
OPV_0	36	64.3	20	35.7	56	2	16.7	10	83.3	12
$Pentavalent_1$	10	22.2	35	77.8	45	2	9.0	17	89.5	19
$Rotavirus_1$	10	22.2	35	77.8	45	2	9.0	17	89.5	19
PCV_1	11	25.6	32	74.4	43	1	5.3	18	94.7	19
OPV_1	11	25.6	32	74.4	43	1	5.3	18	94.7	19
$PENTAVALENT_2$	6	25	18	75	24	20	32.2	42	67.7	62
$Rotavirus_2$	6	25	18	75	24	20	32.2	42	67.7	62
PCV_2	6	25	18	75	24	20	32.2	42	67.7	62
OPV_2	6	25	18	75	24	20	32.2	42	67.7	62
$Pentavalent_3$	1	10	9	90	10	21	21.7	76	78.4	97
$Rotavirus_3$	1	10	9	90	10	21	21.7	76	78.4	97
OPV_3	1	10	9	90	10	21	21.7	76	78.4	97
PCV_3	1	10	9	90	10	21	21.7	76	78.4	97
IPV	1	9.09	10	90.9	11	28	28.3	71	71.7	99
MCV	0	0	0	0	0	52	56.5	40	43.5	92
AAV	0	0	0	0	0	52	57.1	39	42.9	91

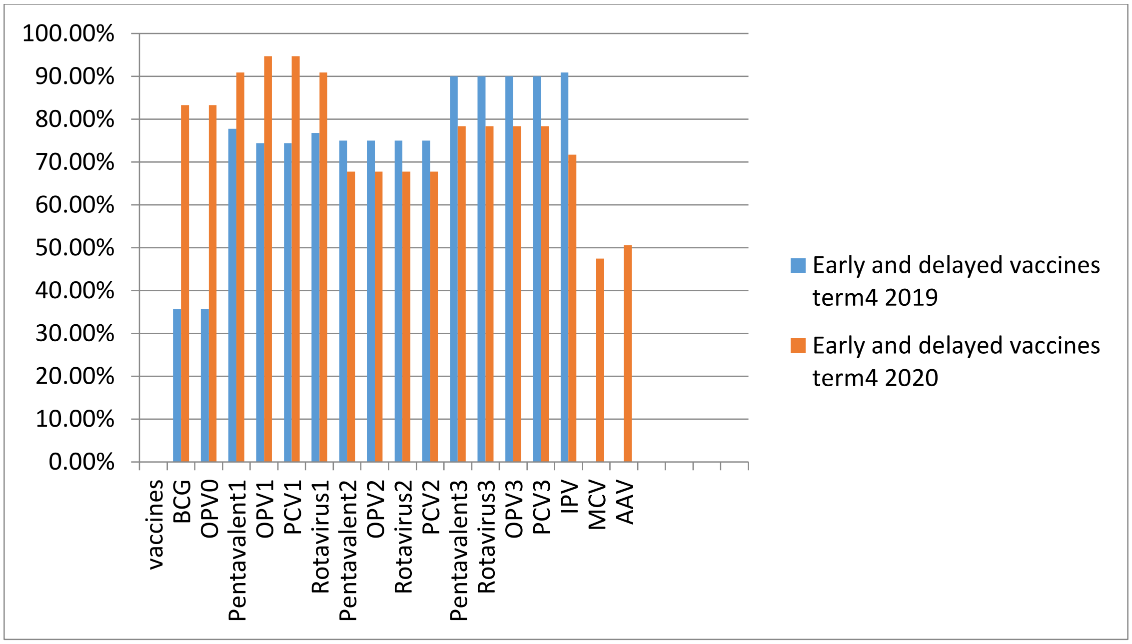
Freq: Frequency. %: Percentage.

The timely vaccination uptake Mean for the last term of 2019 was 8.41 doses and the Median was 6 doses versus 17 doses as the Mean and 20 doses as the Median for the last term of 2020(Table 4.16). In the same way, the Mean and Median for early and delayed vaccination for the last term of 2019 were 17.18 doses and 18.00 doses while for the last term of 2020 they were 41.88 doses and 42.00 doses.

The paired T-test showed that T_{cal}= -1.561 was greater than our critical value -2.120 at α=.05 and degree of freedom 16. The null hypothesis is not rejected i.e., there is no significant difference between the mean doses of timely administered vaccines for the last term of 2019 and the last term of 2020. Moreover, our P-value of 0.138 is greater than 0.05 and our confidence interval ranges from [-18. 866 to 2.866] includes 0 confirming that the null hypothesis is not rejected. Therefore, the comparison of early and delayed vaccines for last term 2019 and last term 2020 showed a significant difference between the early and delayed doses for the 2 terms: Tcal: -3.040 less than our critical value of -2.120 at 16 degrees of freedom. The finding was confirmed also by the p-value:0.008 and confidence interval which has not include 0: [-41.935 –7.477]. Consequently, the proportions of supposed invalid vaccine doses were greater for the last term of 2020 (during covid-19) than for the last term of 2019 (before COVID-19). The vaccination delay was highlighted during the COVID-19 period in Saudi Arabia 17. % for IPV, Pentavalent, and Rotavirus at 6 months and 11.3% for MCV at 9 months (Alsuhaibani & Alaqeel, 2020).

Figure 4.2

Comparison of early and delayed vaccines for last term 2019 and last term 2020



The figure shows how the proportion of early and late vaccines to children was high for the BCG, OPV_0, $Pentavalent_1$ Rotavirus1, $PCV_{1,}$ and $OPV_{1,}$ during the last term of 2020 (during the COVID-19 period). Conversely, the proportion of early and late vaccines was high in the last term of 2019(before COVID-19) for $Pentavalent_{2,}$ $Rotavirus_2$, $PCV_{2,}$ OPV_2, $Pentavalent_3$, $Rotavirus_{3,}$ OPV_3, PCV_3, IPV, MCV, AAV. Consequently, the proportion of invalid vaccines has been high for the first set, and the second set of vaccination. Then started to decrease from the third, fourth, and fifth set of vaccination; but considering our T-test negative (-3.040) means that the mean of supposed invalid vaccines during COVID-19 was higher than the mean of supposed invalid vaccines before the COVID-19 period. The difference between the two means is statistically significant (P-value:0.008, CI [-41.935, -7.040]

Table 4.18

Comparison of vaccine timing between January-February 2020 and January-February 2021.

Vaccines	January-February 2020				January-February 2021			
	Timely doses		Early and Delayed doses		Timely doses		Early and delayed doses	
	F	N(%)	F	N(%)	F	N(%)	F	N(%)
BCG	54	76(71)	22	76(29)	0	0(0)	0	0(0)
OPV_0	54	76(71)	22	76(29)	0	0(0)	0	0(0)
$Pentavalent_1$	12	64(19)	52	64(81)	0	0(0)	0	0(0)
$Rotavirus_1$	12	63(19)	51	63(81)	0	0(0)	0	0(0)
PCV_1	12	63(19)	51	63(81)	0	0(0)	0	0(0)
OPV_1	12	64(19)	52	64(81)	0	0(0)	0	0(0)
$Pentavalent_2$	8	40(20)	32	40(80)	0	0(0)	1	1(100)
$Rotavirus_2$	8	40(20)	32	40(80)	0	0(0)	1	1(100)
PCV_2	7	44(16)	37	44(84)	0	0(0)	1	1(100)
OPV_2	7	44(16)	37	44(84)	0	0(0)	1	1(100)
$Pentavalent_3$	5	30(17)	25	30(83)	0	0(0)	20	20(100)
$Rotavirus_3$	8	28(29)	20	28(71)	0	0(0)	22	22(100)
OPV_3	8	28(29)	20	28(71)	0	0(0)	20	22(90.9)
PCV_3	8	28(29)	20	28(71)	0	0(0)	21	21(100)
IPV	7	27(26)	20	27(74)	0	0(0)	21	21(100)
MCV	0	0(0)	0	0(00	50	88(57)	37	88(42)
AAV	0	0(0)	0	0(0)	47	47(53)	41	88(47)

The Mean of timely doses for January-February 2020 was 13.06 versus 5.71doses for January-February 2021. While the mean of untimely doses for January-February 2020 was 29.00 doses versus 11.12doses for January-February 2021. By the mean of paired T-test, we observed that the Mean is not statistically different for the timely doses between January-February 2020 and January-February 2021: t-calculated= 1.173 less than 2.120 the critical value for a two-tailed test, degree of freedom: 16, P-value:0.258, CI[-

5.937,20.643]. Therefore, the Mean is different for the untimely doses between January – February 2020(pre-COVID-19 period) and January February 2021(during COVID-19 period): t-calculated: 2.509 greater than 2.120 ($t_{\alpha/2}$), degree of freeedom:16, P-value:0.023, CI[32.991,2.509]. The untimely doses have been greater in January-February 2020 than in January-February 2021.

4.23 Attitudes of Health Workers towards routine immunization during the COVID-19 period.

We administered 9 statements on a Likert scale ranging from 1 point to 5 points,6 statements out of 9 were related to attitude toward routine immunization with a maximum point of 30. And 3 statements were related to the perception of change in vaccine provision with a maximum point of 15. The attitude sum point was grouped into two categories (21-25,26-30). The perception sum point was grouped into two categories (6-10, 11-15).

Table 4.19

Attitude and perception of health workers according to their age in years, n=26

	sum points of attitude		sum points of perception	
	21-25	26-30	6-10	11-15
AGE	N (%)	N (%)	N (%)	N (%)
26-37	9(34.61)	8(30.77)	13(50.00)	4(15.38)
38-49	4(15.38)	3(11.54)	6(23.07)	1(3.85)
50-60	1(3.85)	1(3.85)	0(0.00)	2(7.70)

The age of health workers implicated in Routine Immunization ranged from 26 to 72 years, with 38.26 years as the Mean, 10.4214 standard deviations, and a Median of 35 Years. One health worker at 76 years old was considered an outlier. Consequently, his variables have not been included in the analysis. More health workers aged between 26 to 37 years had more sum point of attitude and sum point of perception also on the one hand. Only 2 health workers aged from 50 to 60 years had fewer points of attitude and fewer points of perception than the other hand.

Table 4.20

Attitude and perception of Health workers according to their experience in years   n=26

	Sum points of attitude		Sum point of perception	
	21-25	26-30	6-10	11-15
Experience	N (%)	N (%)	N (%)	N (%)
1-4	5(19.23)	7(26.92)	10(38.46)	2(7.69)
5-8	6(23.07)	4(15.38)	6(23.08)	4(15.38)
9-12	3(11.54)	1(3.47)	3(11.54)	1(3.47)

The health worker's experience in routine immunization ranges from 1 to 20 years with 5.96; 4.155 and 5 years respectively the Mean, the standard deviation, and the Median. The health workers with less than 5 years of experience in the service had more points of attitude and more points of perception. Conversely, those with more than 8 years of experience in the service had fewer points in attitude and perception.

Table 4.21

Attitude and perception of health workers according to their sex

	Sum points of attitude		Sum point of perception	
	21-25	26-30	6-10	11-15
Sex	N (%)	N (%)	N (%)	N (%)
Males	8(30.76)	9(34.62)	13(50.00)	4(15.38)
Females	6(23.07)	3(11.54)	7(26.92)	2 (7.69)

66% of the health workers interviewed were males and 34% were females. But table 4.20 showed that the males had more points for attitude and perception when compared to the females during the COVID-19 period.

By considering sex, age, and experience in routine immunization as independent variables on the one hand. And the attitude toward routine immunization during COVID-19 and the perception of change in the provision of routine immunization as ordinal dependent variables on the other hand. The results from simple ordinal regression stated:

The relationship was positive and not significant between the sex of health workers and perception of change in vaccine provision before and during the COVID-19 period, OR: 181, P-value:0.998, CI [-2.264,1.509]. This means that female health workers have perceived more change than males at the non-significant level.

There was a negative significant relationship between the sex and the attitudes of health workers toward routine immunization during the COVID-19 pandemic OR: 0.094, P-value:0.415, CI: [0.094,2.645]. In other words, the females had more positive attitudes compared to the Males but were not statistically significant.

The health workers bracket age 26-37 years was negatively statistically associated with the perception of change OR=0.158, P-value:0.000 and negatively associated with the attitudes at no significant level OR=0.888, P-value:0.937, CI [0.047,16.646]. In a similar way, the bracket age 38-49 years OR for Perception= 0.243, P-value:0.000, CI [0.243,0.245]. OR for attitudes=0.750, P-value=0.858, CI [0.032,17.492]. The bracket age 50-60 years has been taken as a reference. We can assume that the bracket aged 26-37 years perceived more change, followed by the bracket aged 38-49 years than the bracket aged 50-60 years at a significant level. Also, have more positive attitudes than the bracket aged 50-60 but not statistically significant.

There was a negative and no significant relationship between the health workers with 1-4 years of experience and perception of change in vaccine provision between the pre-COVID-19 and during COVID-19 period UOR:0.560, P-value:0.713, CI [0.039,9.147]. But the relationship between the bracket age of 5-8 years of experience in the service and perception of change was positive and not significant OR=1.999, P-value:0.600, CI [0.150,26.738]. The health workers with 5-8 years of experience have perceived more change than those with 1-4 years and 9-12 years, considered as a reference at no significant level.

The association between experience in service and attitudes was positive and not statistically significant OR=4.200, P-value:0.268, CI [0.332,48.579] for 1-4 years, and OR=1.100, P-value:0.600, CI [0.150,26.738] for 5-8 years. In other words, the health workers who had 1-4 years and 5-8 years of experience in routine immunization had more positive attitudes compared to those who had 9-12 years of experience considered as reference.

By performing multiple ordinal regressions, with 0.470 as P-value for the Goodness-of-Fit test and Nagelkerke coefficient (R-squared) at 0.287 for Attitudes and 0.631 as P-value for Goodness-of-Fit, Nagelkerke coefficient at 0.557 for perception, we have got:

Positive and not significant relationship between sex and attitudes of Health workers AOR: 7,972, P-value:0.075, CI: [0.808, 78.671]. Meaning that, for each unit increase in gender (change from Female to Male), the attitude toward routine immunization service during COVID-19 period changed positively, i.e., the males had more positive attitudes than the females but not at a significant level.

There was a positive association between the Gender of health workers and their perception of change in the provision of vaccines before and during the COVID-19 period AOR: 1817, p-value:0.998, CI [0.171,3.372]. In other words, the male health workers had more perceptions of change than the female health workers. The males perceived more the change than the females but not statistically significant level.

There was a negative association but not statistically significant between the bracket age 26-37 years and 38-49 years of health workers and perception of change, AOR: 0.270, P-value: 0.998, AOR:0.141, P-value:0.997 respectively. The bracket age 50-60 has been set as a reference. These bracket ages have perceived more change than the 50-60 years at no significant level.

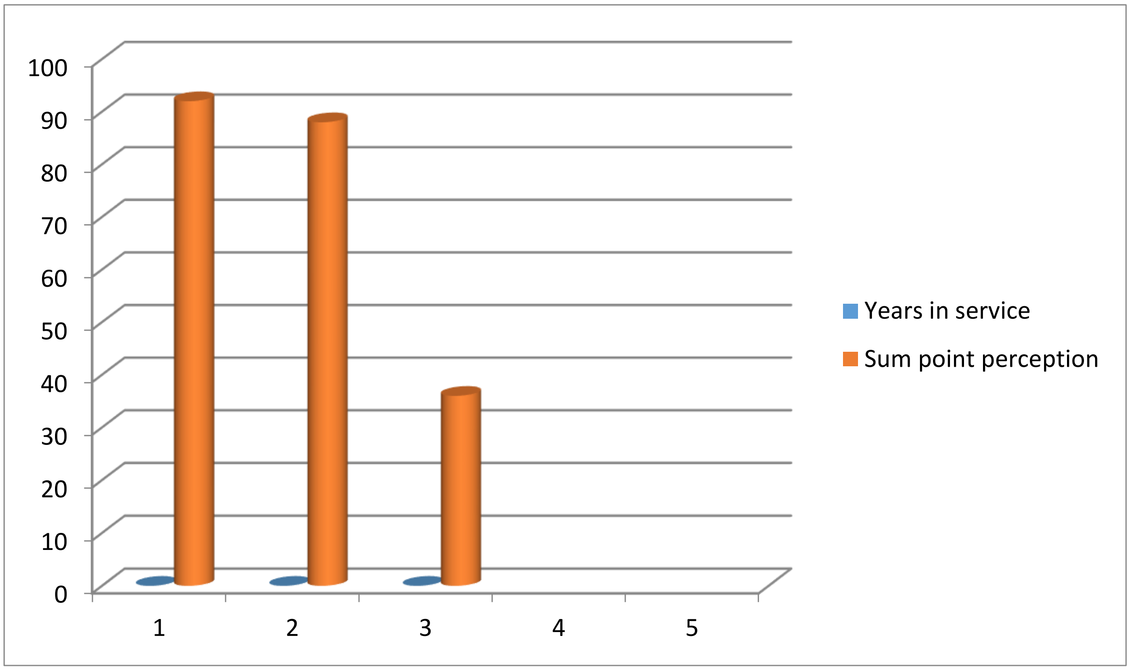
There was a negative and not significant association between the Age of 26-37years health workers and their attitudes towards routine immunization AOR= 0.270, P-value:0.110, and so for the bracket aged 38-49 years AOR:0.096, P-value:0.997. These bracket ages have more positive attitudes than the bracket age 50-60 years considered as reference.

The positive association and statistically significant association between the bracket ages of 1-4 and 5-8 years in routine immunization service and perception of change in the provision of vaccines AOR: 14, p-value: 0.000 CI [8707.94,2481.0] and AOR:27, P-value:0.000, CI [1649.81,2785] respectively. This means that health workers who had 5-8 years in service had almost double perceived the change than those who have 1-4 years of experience, and perceived more the change than those with 9-12 years referenced significant level. The sum points (110) of the statement that the provisions of vaccines have been better before the COVID-19 period than during the COVID-19 period is almost double the sum points (57) of the statement that the provision of the vaccine has been better during COVID-19 period than before COVID-19 period.

The relationship was positive and statistically significant for the health workers who had 1- 4 years of experience and their attitudes towards routine immunization during the Pandemic AOR:60.946, P-value:0.05, CI [0.873,425.915]. And the positive but not significant association between the health workers who had 5-8 years of experience and their attitudes AOR=8.998, P-value:0.193, CI [0.330, 245.555]. The health workers with 1-4 years of experience in service had more positive attitudes compared to those with 5-8 years and 9-12 years of experience. Those who are freshly in service are so keen to perform their tasks and don’t care about a lot of the risk compared to those who have performed for a long period of service for whom the service was routine and fear a lot of the risk of contamination. Consequently, risk of dying.

Figure 4.3

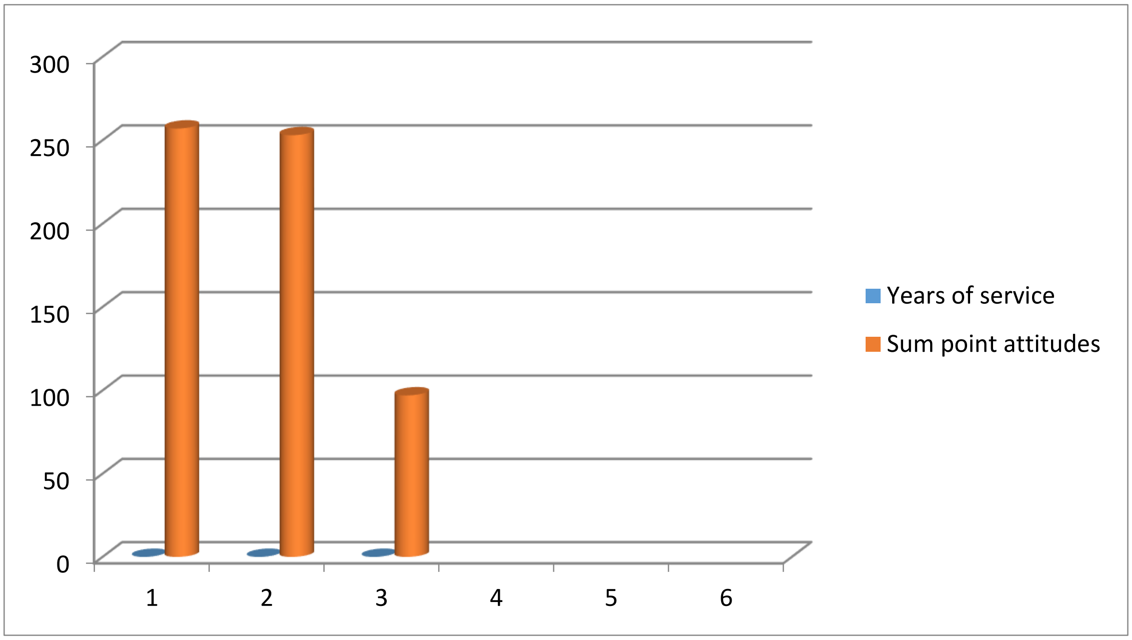
Sum point of perception by the period in service groups.



The highest sum point of perception (92) is represented by the first column from the left for the health workers with 1-4 years of experience in the routine immunization service. And the middle column represented the sum point of perception for the health workers with 5-8 years of experience, and the last represented those who had 9-12 years of experience.

Figure 4.4

Sum point of attitudes by period service groups



The column bar illustrates 3 columns; the first column from the left (the highest) represented the sum point of attitudes (257) for the health workers who had 1 to 4 years of experience. And the second represented the sum point of attitudes (253) for the health workers with 5-8 years of experience. The shortest represented the sum point of attitudes (97) for the health workers with 9-12 years of experience in routine immunization service

The negative attitude of the oldest Health workers toward routine immunization is the expression of their immune system vulnerability during this COVID-19 period. The 51-87 years bracket age have been more confident that the COVID-19 vaccine will protect them from COVID disease (96% vs. 4%) but feared the serious adverse effects of vaccines (75% vs. 25%) in the study conducted in the Caribbean on the attitudes, concerns, and practice of health workforce toward covid-19 vaccination (Pan American Health Organization & WHO regional office of America, 2021).

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1. Introduction

This chapter summarizes the key findings of the effect of the COVID-19 pandemic on the determinants of routine immunization in Goma, conclude and formulates the different recommendations on the research findings and further research.

5.2. Summary

Routine immunization is one of the important and sustainable services that prevent children's morbidity and mortality from vaccine-preventable diseases. The occurrence of COVID-19 pandemic has surely disrupted the health system; but our study aimed to determine its potential effect on the utilization of routine immunization in Mabanga area, in Goma city, in the Democratic Republic of Congo. The specific objectives were to identify the factors associated with the uptake of routine immunization, determine vaccine coverage/uptake, compare the sequences of vaccines, and assess the timings of vaccination. The comparison of the pre-pandemic and Pandemic periods was used to achieve the above objectives. In addition to these four objectives; to explore the attitudes of Health workers and their perception of change in vaccine provision during COVID-19 period. The pre-pandemic period in our sample ranged from 8th September 2019 to 9th March 2020 and during the pandemic the period ranged from10th March to 22nd August 2021. The data were collected from 8th August to 22nd August 2021. The survey was conducted among 423 eligible children. It collected information on immunization from the vaccination cards for 389 and 34 from the coherent declaration of caregivers' cross-tabulated by the health facilities' records. 182 out of 423 were born before the COVID-19 period and 241 were born during COVID-19. Also, questionnaires were administered to 27 Health workers implicated in routine vaccination100% response rate.

Descriptive statistics have shown:

1) The 423 respondents were aged from 18 to 55 years old with Mean:28.68 years; and Meadian:28.00 years; 50.6% of them were aged between 26-33 years,28.8% were aged between 18-25 years, and 20.6 aged between 34 to 55 years. The majority of respondents (94.1%) were females, have been children's biological mothers (90.8%).96.2% of respondents were married, have achieved secondary education (61.5%), likewise, their partners (52.2%,).89.6% are practicing Christian Religion 58.4% were living in 6-10-person family size. 84.4% of the respondents were unemployed, but 66.2% of their partners were employed.97.4% of the respondents stated that their children have completed vaccination schedules and proved it by vaccination cards (92%). Also, most of them (96.2%) indicated the BCG site of injection well and so for MCV (91.5%). Conversely to the respondents or caretakers; the males' children represented 59.3%. 94.8% of the children were born in Health facilities (94.8%), and a half (54.8%) of the children were the first to the third born. The coverages of 17 vaccines range from 99% to 100%,0% to 100%, and 99.2% to 100% respectively for the overall, the pre-COVID-19 and during COVID-19 periods.60.76% of vaccination have been in-sequence and 39.24% have been out-of-

sequence for the overall period. The overall timely vaccination coverage ranged from 17.3% for $Pentavalent_3$ to 57% for OPV_0. Therefore, the overall early and delayed vaccination coverages ranged from 26.8% for AAV to 46.8% for $Pentavalent_1$,and 20.7% for MCV to 47.4% for $Pentavalent_3$ respectively. The Mean of timely vaccine uptake was 8.40 doses for the last term of 2019(Pre-COVID-19 period) versus 18 doses for the last term of 2020 (During the COVID-19 period). While the mean of supposed invalid vaccination (early and delayed vaccination) was 17.18 doses for the last term of 2019(pre-pandemic period) versus 41.88 doses (during the pandemic period). The mean and median ages of health workers were 38 and years 35 years. The age was grouped into 26-37 years,38-49 years, and 50-60 years. The experience in service was grouped also into three categories 1-4 years,5-8 years, and 9-12 years. By performing the Chi-square test, multiple logistic and ordinal regression, and paired t-test, we assumed:

2) The caretakers' bracket aged 18-25 and 26-33 years had a high likelihood for their children to be fully immunized when compared to children whose caretakers were aged 34 years and above. The unemployed respondents had less likelihood of full immunization for their children when compared to employed respondents. The respondents who declared that their children had completed the immunization schedule and presented children's vaccination cards, had got a high likelihood of full immunization for their children when compared to their counterparts. But no child in our sample has received MCV before the COVID-19 period. Consequently, we calculated the partial immunization coverage (from BCG to IPV) useful to compare the two periods. The caretakers' age of 18-25 years and children's sex has been

statistically associated with partial immunization coverage before and during COVID-19 periods. The Pandemic has transformed the two predictors from negative association to positive association. In other words, the children whose caretakers were aged 18-25 years old had less likelihood of partial vaccine uptake compared to those whose caretakers were aged 26-33 and 34 and above years old before COVID-19. These children have now been getting a high likelihood of vaccine uptake during this COVID-19 period. Similarly, the female's children who had less likelihood of vaccine uptake before COVID-19 occurrence now have been getting a high likelihood of vaccine uptake during the COVID-19 period.

3) The overall vaccine coverages have been higher during the COVID-19 period than before the COVID-19 period for the overall. But the trend of vaccine uptake showed variability over time. On the one hand, the uptake Mean of BCG, $OPV_{0,1}$, $Pentavalent_{1,}$ $Rotavirus_{1,}$ and PCV_1 decreased from 48 doses to 17 doses. Whereas the uptake Mean of $Pentavalent_{2,3}$, $Rotavirus_{2,3,}$ $PCV_{2.3}$, $OPV_{2,3,}$ AAV, and MCV increased from 17 doses to 81 doses by comparing the last term of 2019(Pre-pandemic period) and the last term of 2020(during Pandemic period). On the other hand; the uptake Mean of all the vaccines, except AAV and MCV, decreased from 48 doses to 7 doses when comparing January-February 2020(pre-pandemic period) and January- February 2021(During the Pandemic period). The overall full immunization coverage of 96.7% exceeded the national target, but 92.9% of 14 children who haven`t attained the Full immunization coverage haven`t received MCV and AAV. The partial immunization coverages were 99.3%,100%, and 99.2% respectively overall, in the pre-pandemic and

during the pandemic period. There was a negative and positive variation in vaccine uptake over time.

4) The difference between out-of-sequence vaccination in the pre-COVID-19 period and during the COVID-19 period is not statistically significant. The overall out-sequence vaccination was 39.243% and the overall in-sequence vaccination was 60.756%. The out-of-sequence vaccination and full immunization coverage were independent.166 children out of 423 have been vaccinated in out-of-sequence mode.
5) The difference was statistically significant between the timely vaccination doses and untimely vaccination doses regardless of the period.in other words, the overall timely doses were 135 doses versus 283 doses for untimely doses (early and delayed doses). Considering the trend over time, the untimely uptake doses increased from 17 doses to 42 doses for all the vaccines except IPV, AAV, and MCV by comparing the two-last term of 2019/2020. The untimely uptake Mean increased from 13 doses to 27 doses for ten antigens and decreased from 36 doses to 2 doses for the 6 antigens by comparison from January February 2020 to January- February 2021. But the doses of the timely vaccines between the pre-COVID and during COVID-19 period were not statistically different. The untimely doses of vaccines administered to children have been higher than the timely doses specifically during COVID-19 period.
6) The health workers with 1-4 years and 5-8 years of experience in routine immunization period perceived more the change in vaccines provision than those with 9-12 years. These health workers observed that the provision of the vaccine has been better before COVID-19 than during COVID-19 period. the sum point of the statement that the provision of vaccines has been better before COVID-19 period (110) is almost the

double sum point that the provision of vaccines has been better during COVID-10 period than before COVID-19 period (57). Also, the health workers with 1-4 years had more positive attitudes toward routine immunization during the occurrence of the Pandemic, conversely, those who had 9-12 years of experience had more negative attitudes. The more experience in immunization service, the less perception of change in vaccine provision, and the less attitude towards immunization during the pandemic.

5.3. Conclusion

5.3.1 Socio-demographic factor associated with uptake of vaccines before and during the COVID-19 periods

Unemployment of the respondents, possession of vaccination card during the survey, declaration of vaccination completion by the respondent during the interview, and respondents aged 18-25 years old, and respondents aged 26-33-year-old were statistically associated with full vaccination coverage disregarding the COVID-19 occurrence. Nevertheless, respondents aged 18-25 years old and children's sex were statistically associated with partial vaccination coverage, but the pandemic changed the direction of their predictivity from negative prediction to positive prediction.

5.3.2 Vaccines coverages/uptake before and during the COVID-19 periods

The full vaccination coverage was high (96.7%) and exceeded the national target (75%) Likewise, the partial immunization coverage in pre-pandemic (100%) slightly decreased during the pandemic periods (89.7%). The uptake Mean of the vaccines administered in three months of life decreased while it increased for the vaccines administered at nine months. COVID-19 has disrupted the trend of vaccine uptake.

5.3.3 Vaccines sequences before and during COVID-19 periods

The Mean of out-of-sequence vaccination was greater during the pandemic than in the pre-pandemic period. The vaccines given at two months were administered more in out-of-sequence mode than the vaccines administered at nine months.

39% of children have received their vaccinations in out-of-sequence mode. However, the pandemic disrupted the trend of out-of-sequence vaccination for the two periods.

5.3.4 Timings of vaccination before and during COVID-19 periods

The timely vaccination was not significantly different for the two periods. But, the Mean of untimely vaccines administered from birth to three months decreased during the pandemic. However, it increased for the vaccines administered from four months to nine months.

5.3.5. Attitudes of health workers and perception of change in provision of vaccines during COVID-19 period.

The health workers with less than 5 years of experience in routine immunization service had a positive attitude and perceived more the change in vaccines provision than those with 5 and more years in the service.

COVID-19 scaled up the positive attitudes of health workers with 1-4 years of experience and the negative attitudes of those with more than 9 years of experience in routine immunization service.

5.4 Recommendation

For the findings

To maintain the high trend of uptake. Motivate the Community Health Volunteers to catch up with the children who are not fully vaccinated, and made more efforts on MCV which represented (92.9%) of missing out on vaccines.

The government with its partners should reinforce the mechanisms to reduce the gap between the in-sequence vaccination and out-of-sequence vaccination. Despite the high coverage, the risk of infant mortality rate is high among the children who are vaccinated in out-of-sequence mode.

The government with its partners should take into consideration not only the coverage but also the timing of vaccination. They should set up a policy for the population and for health workers to avoid invalid vaccination which has risen during the pandemic period. The government should set-up the psychological support for old health workers during the pandemic to avoid their negative attitudes.

For further studies

To conduct research on the determinants of untimely vaccination in this area.

To carry out the study on the Determinants/relationship between out-of-sequence vaccination and childhood mortality either in this area or the entire Goma city.

To set up the programme of mental health support during this COVID-19 period for Health workers specifically for those advanced in age.

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APPENDICES

Appendix I: Consent Form

Effects of COVID-19 on Determinants of routine immunization in Goma, Democratic Republic of Congo.

Investigator`s statement: I am Saleh Mukanda john with my supervisors Dr. Job Mapesa and Ms. Theresia Kyulu are requesting you and your child to participate in this study. The objective of this consent form is to provide research information to decide whether you participate or not. Please, read it carefully and you are free to ask any questions or clarification.

Purpose: the study seeks to assess the effects of COVID-19 on Determinants of Routine Immunization at Mabanga area in Goma city in the Democratic Republic of Congo.

Procedures: The household surveys will be conducted to collect the socio-demographic data and child immunization data through an interview, also, Health worker surveys through a questionnaire.

Duration: We are asking you 15 to 20 minutes of your time to respond to our questions as they will be asked by the interviewer, one session is required, except for completion of information.

Risks: You and your child are not exposed to any risk by participating in the study because, it consists to respond to questions requested, and checking the child immunization card if available, any invasive procedure will not be used.

Benefits: routine immunization protects our children from the vaccine-preventable disease, and correlates with deaths, so, there is a need to maintain it even if the Epidemic or pandemic occurs, by responding to our questions you will contribute greatly to the advancement of the research, and the results will be used by the ministry of health and stakeholders at all levels to manage the routine immunization in the context of epidemic or pandemic.

Confidentiality: firstly, your name will not be taken, and so for the children except for verification on the health facility records, in case of vaccination card missing and coherent recall mother; secondly the other information collected will be kept confidentially and codified during the treatment process.

Thirdly any specific information will not be released to any person without your permission.

Withdrawal: participation in the study is voluntary and free, at any point of the study; each one is free to continue to participate or to withdraw from the study; refusal to participate or withdrawal from the study will not compromise loss of care.

Concern: for any questions about the research matter you can contact the principal investigator Saleh Mukanda John, phone number: (+243)994046144; (+254)729116897; ormukandasa@gmail.com

Consent: If you understand the conditions of the study and you consent to participate, kindly sign or put your thumbprint in the space provided below,

I ……………………………………………… give consent to participate in this study.

Caregiver's signature or thumbprint …………………………………………………...

Appendix II: Questionnaire

SECTION 1: CHILDREN'S CARETAKERS

1. IDENTIFICATION INFORMATION		
	VARIABLE	**WRITE RESPONSE BELOW**
	Street	
	Child identification number	
	Date of interview	
	Name of interviewer	
	Tel. N_0 of an interviewer	

2. SOCIO-DEMOGRAPHIC AND ECONOMIC INFORMATION

1. CHILD		
No	**VARIABLE**	**WRITE OR TICK THE RESPONSE**
	Date of birth	
	Age	Years
		Months
	Sex	1. Male
		2. Female
	Place of delivery	1. Health facility
		2. No health facility
	Birth order	
	Size of family	
3. CARETAKER		
	Age	
	Sex	1. Male
		2. Female
	Relationship to the child	1.Biological mother
		2.Bilogical mother
		3.Sister
		4.Brother
		5.Aunt
		6. Uncle
		7.Other(specify)
	Marital status	1.Married
		2.Single
		3.widow/widower

		4.Other(specify)
	Highest educational level	1.primary school
		2.Secondary school
		3. tertiary school
		4.Other(specify)
	Spouse highest educational level	1.primary school
		2.Secondary school
		3.Tertiary school
		4.Other (specify)
	Current occupation	1. Employed
		2.Unemployed
		3. Housewife
		4.Other (specify)
	Spouse current occupation	1. Employed
		2. Unemployed
		3. Other(specify)
	Religion	1.Christian
		2.Muslim
		4. Other (specify)
	Has the mother attended the ante-natal clinic visits during the pregnancy of the child?	Yes, if yes
		NO
	How many times?	1.Once
		2.Twice
		3.Three times
		4. More than three times.

COVERAGE, TIMING AND SEQUENCING OF VACCINES

N0	QUESTIONS	RESPONSES	SKIP
Q201	Have you or anyone in your household taking the child to the health facility to receive a vaccine since his/her birth?	**Yes: 1**	
		NO: 0	**0→203**
Q202	Which health facility has your child begun the schedule of vaccination?		
Q203	Why have you not taken the child to the health facility to receive the vaccines?	Choose the most reason: 1. Vaccine not needed/ Helpful 2. Fear of injection 3. Fear of COVID-19 4. Migration 5. Had not a time. 6. Other (specify)…………………	
Q204	Did the eligible child complete the immunization schedule?	**Yes :1**	**1→Q207**
		NO: 0	
Q205	Which health facility did the child receive some vaccine and did not complete the immunization schedule?		
Q206	Why did the child not complete the immunization schedule?	Choose the most reason: 1. Had not a time 2. Fear of being infected with COVID-19 3. Lockdown measures 4. Vaccines were not available at the health facility. 5. Unfriendly vaccination staff 6. Migration 7. Other (specify)	
Q207	Which health facility the child has completed the immunization schedule?		
Q208	Do you have a child`s immunization card?	**YES :1**	
		NO: 0	**0→Q210**
Q209	Can we see it ?	**YES:1**	
		NO: 0	

Q210	Why don`t you have a child immunization card?		Choose the common reason: 1. Lost 2. Location not known 3. Migration 4. Other (specify)	
Q211	Could you indicate to us the body site where the child has received the BCG vaccine at the health facility?			
□212	Could you indicate to us the body site where the child has received the Measles vaccine at the health facility?			
Q213	Complete the different dates of each vaccine received and snatch the immunization card with your phone.			
	N_0	**TYPE OF VACCINE**	**RECEIVED DATE**	**OBS.**
	1.	BCG		
	2.	OPV_0		
	3.	PENTAVALENT $_1$		
	4.	$ROTAVIRUS_1$		
	5.	PCV_1		
	6.	OPV_2		
	7.	$PENTAVALENT_2$		
	8.	$ROTAVIRUS_2$		
	9.	PCV_2		
	10.	OPV_2		
	11.	$PENTAVALENT_3$		
	12.	$ROTAVIRUS_3$		
	13.	PCV3		
	14.	OPV_3		
	15	IPV		
	16	MCV		
	17	AAV		
		QUESTIONS	**RESPONSES**	**SKIP**
Q301		Do you know the order of child vaccines scheduled from birth to the ninth month?	YES	
			NO	

Q302		Do you think that the vaccines were delivered orderly before the COVID-19 period?	YES:1	**1 → Q303**
			NO: 2	
Q303		Which vaccines?		
Q304		Do you think that vaccines were delivered orderly during the COVI-19 period?	YES:1	**1 → Q305**
			NO:2	
Q305		Which vaccines?		
Q401		Do you know that each vaccine appointment date is inscribed on the immunization card?	YES:1	
			NO:2	
Q402		Have you observed that vaccines were early delivered compared to the inscribed date before the COVID-19 period?	YES:1	**1 → Q403**
			NO:2	
Q403		Could you indicate to us which vaccines?		
Q404		Have you observed that vaccines were delayed delivered compared to the inscribed date during the COVID-19 period?	YES:1	**Q → Q405**
			NO:2	
Q405		Could you indicate to us which vaccines?		

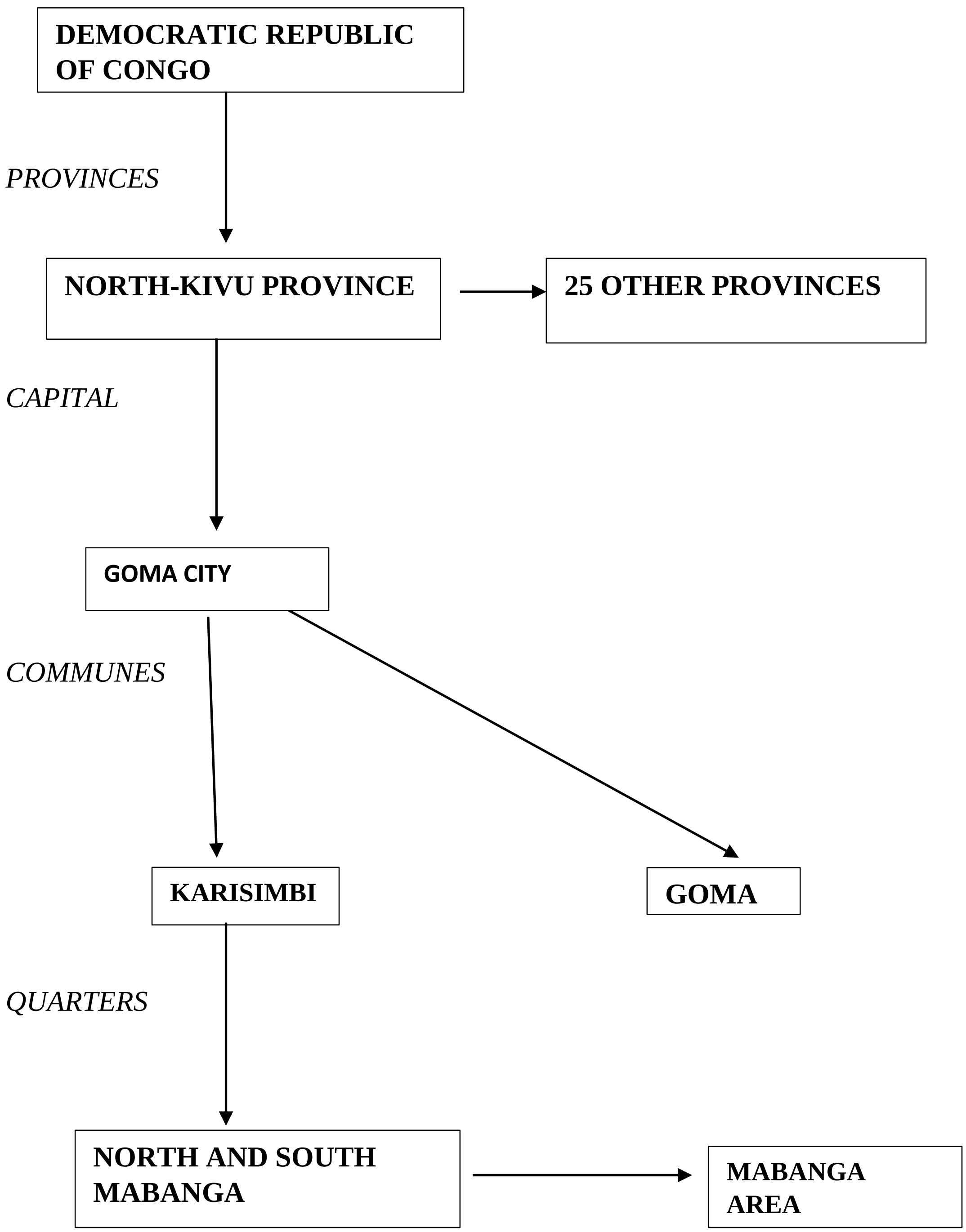
SECTION 2: HEALTH WORKERS
PERCEPTION OR ATTITUDE OF HEALTH TOWARD ROUTINE IMMUNIZATION BEFORE AND DURING COVID-19 PANDEMIC.

Age:
Sex:
How many years of experience in routine vaccination service?
Please tick or circle the most appropriate answer.

No	STATEMENT	RESPONSES				
Q501	The beliefs in the existence of COVID-19 in Goma city.	**Strongly agree 5**	**Agree 4**	**Uncertain 3**	**Disagree 2**	**Strongly Disagree 1**
Q502	Do you think that you could be infected by COVID-19 by providing a vaccine to the children?	**Strongly Agree 5**	**Agree 4**	**Uncertain 3**	**Disagree 2**	**Strongly Disagree 1**
Q503	The fear to be infected by COVID-19 in routine vaccination services.	**Strongly agree 1**	**Agree 2**	**Uncertain 3**	**Disagree 2**	**Strongly Disagree 1**
Q504	COVID-19 is a severe disease	**Strongly agree 5**	**Agree 4**	**Uncertain 3**	**Disagree 2**	**Disagree 1**
Q505	COVID-19 is a curable disease.	**Strongly Agree 5**	**Agree 4**	**Uncertain 3**	**Disagree 2**	**Strongly Disagree 1**

Q506	The readiness to pursue the provision of routine vaccines during the COVID-19 period.	**Strongly Agree** **5**	**Agree** **4**	**Uncertain** **3**	**Disagree** **2**	**Strongly Disagree** **1**
Q507	The change in the provision of routine vaccines before the COVID-19 period and during the COVID-19 period was perceived.	**Strongly Agree** **5**	**Agree** **4**	**Uncertain** **3**	**Disagree** **2**	**Strongly Disagree** **1**
Q508	The provision of routine vaccines was better before the COVID-19 period than during the COVID-19 period.	**Strongly Disagree** **5**	**Agree** **4**	**Uncertain** **3**	**Disagree** **2**	**Strongly disagree** **1**
Q509	The provision of routine vaccines is better during the COVID-19 period than before the COVID-19 period.	**Strongly agree** **5**	**Agree** **4**	**Uncertain** **3**	**Disagree** **2**	**Strongly Disagree** **1**

Appendix III: Localization of Mabanga area in DRC.



Appendix IV: Ethical Clearance Letter

KENYA METHODIST UNIVERSITY
P. O. BOX 267 MERU - 60200, KENYA
TEL: 254-064-30301/31229/30367/31171
FAX: 254-64-30162
EMAIL: serc@kemu.ac.ke

June 21, 2021

KeMU/SERC/PHT/32/2021

Saleh Mukanda John
Kenya Methodist University

Dear Saleh,

SUBJECT: EFFECTS OF COVID-19 ON DETERMINANTS OF ROUTINE IMMUNIZATION IN GOMA, DEMOCRATIC REPUBLIC OF CONGO.

This is to inform you that Kenya Methodist University Scientific Ethics and Review Committee has reviewed and approved your above research proposal. Your application approval number is KeMU /SERC/PHT/32/2021. The approval period is 21st June 2021 – 21st June 2022.

This approval is subject to compliance with the following requirements

I. Only approved documents including (informed consents, study instruments, MTA) will be used.

II. All changes including (amendments, deviations, and violations) are submitted for review and approval by Kenya Methodist University Scientific Ethics and Review committee.

III. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to KeMU SERC within 72 hours of notification.

IV. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to KeMU SERC within 72 hours.

V. Clearance for export of biological specimens must be obtained from relevant institutions.

VI. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal

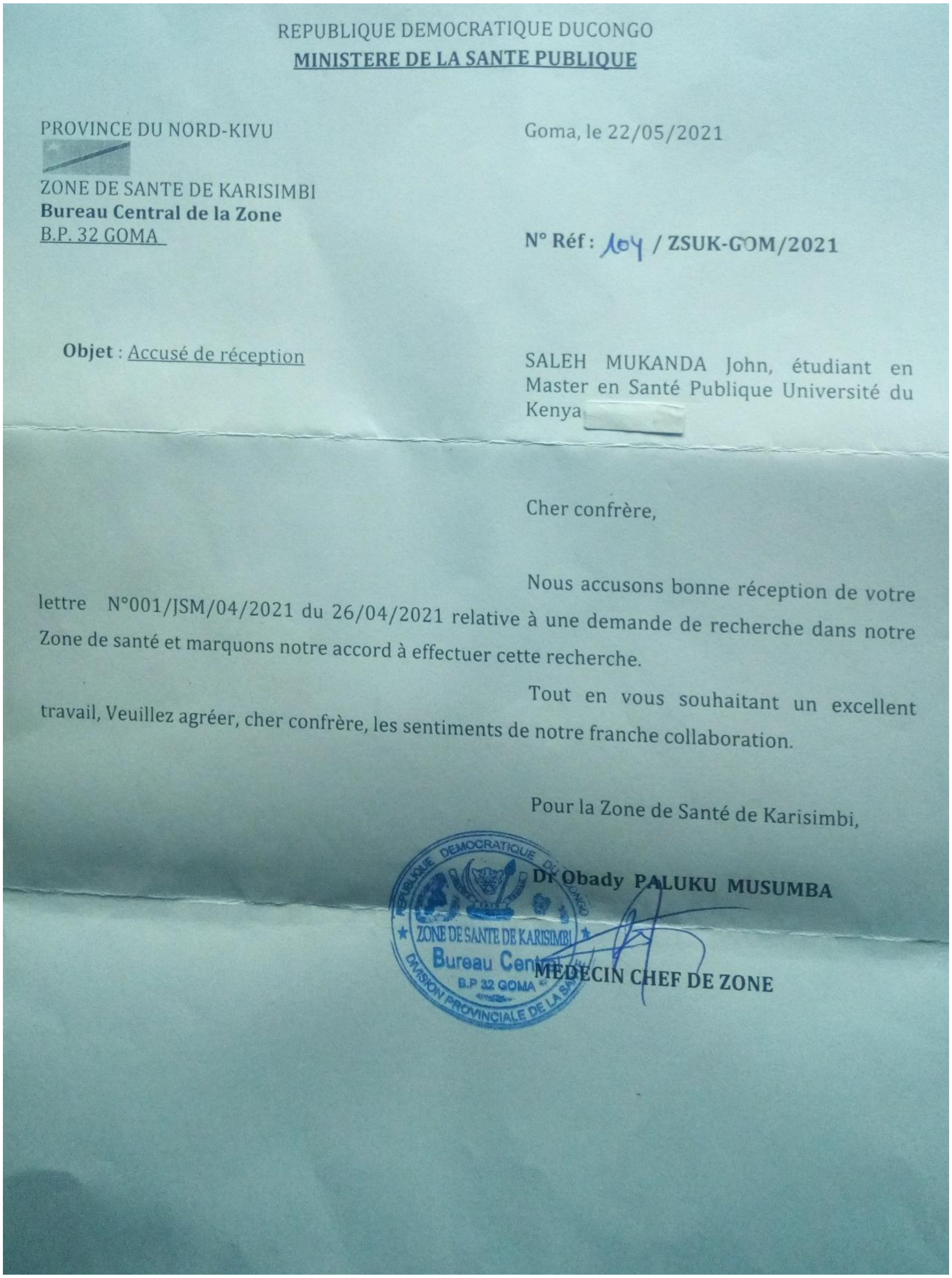
VII. Submission of an executive summary report within 90 days upon completion of the study to KeMU SERC.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely,

Dr. A. WAMACHI
Chair, SERC

Appendix V: Heath Zone Letter


REPUBLIQUE DEMOCRATIQUE DUCONGO
MINISTERE DE LA SANTE PUBLIQUE

PROVINCE DU NORD-KIVU

ZONE DE SANTE DE KARISIMBI
Bureau Central de la Zone
B.P. 32 GOMA

Goma, le 22/05/2021

N° Réf : 104 / ZSUK-GOM/2021

Objet : Accusé de réception

SALEH MUKANDA John, étudiant en Master en Santé Publique Université du Kenya

Cher confrère,

Nous accusons bonne réception de votre lettre N°001/JSM/04/2021 du 26/04/2021 relative à une demande de recherche dans notre Zone de santé et marquons notre accord à effectuer cette recherche.

Tout en vous souhaitant un excellent travail, Veuillez agréer, cher confrère, les sentiments de notre franche collaboration.

Pour la Zone de Santé de Karisimbi,

Dr Obady PALUKU MUSUMBA

MEDECIN CHEF DE ZONE

REPUBLIQUE DEMOCRATIQUE DU CONGO
ZONE DE SANTE DE KARISIMBI
Bureau Central
B.P 32 GOMA
DIVISION PROVINCIALE DE LA SANTE

Appendix VI: Health Zone and Municipality Authorities Clearance Letter

PROVINCE DU NORD-KIVU

DIVISION PROVINCIALE DE LA SANTE
ZONE DE SANTE DE KARISIMBI
Bureau Central de la Zone
BP 32 Goma

ORDRE DE MISSION N°45 / ZSUK / 2021

Les personnes ci-après sont désignées pour effectuer une mission officielle dans la **Zone de Santé de Karisimbi** :

N°	NOM, POST-NOM & PRENOM	FONCTION
1	Dr Saleh MUKANDA John	Superviseur
2	MANARA AKILIMALI Constantin	Enquêteur
3	KAVIRA MAKASI Plaisir	Enquêtrice
4	SALAMA Rachid Michaël	Enquêteur
5	AMURI KATAMBWE Vincent	Enquêteur

MOTIF / OBJET DE LA MISSION : **Collecte des données sur la vaccination de routine des enfants de 12 à 23 mois auprès de ménages éligibles.**

Lieu : Aires de Santé : KATOYI, AMANI, MABANGA

Durée de la mission : 3 semaines

Mode de transport : Motos / Véhicule / Pieds

Itinéraire : BCZS KARISIMBI – Aires de Santé- BCZS KARISIMBI.

Accompagné(e) de : Néant

Début de la mission : 09/08/2021, Fin de la mission : 28/08/2021.

Les autorités tant administratives que militaires sont priées d'apporter assistance au porteur de la présente en cas de nécessité.

Fait à Goma, 06/08/2021

Pour la Zone de Santé de Karisimbi,

Dr Obady PALUKU MUSUMBA

ZONE DE SANTE DE KARISIMBI
Bureau Central
B.P 32 GOMA

MEDECIN CHEF DE ZONE

Vu au bureau Quartier Mabanga Sud

KAVIRA NEZO
Chef de Quartier

Avis de non objection pour les recherches scientifiques dans l'entité MABANGA NORD ce 08/08/2024

Le chef de Quartier

QUARTIER MABANGA-NORD

NZIBIRO SHANDWE Michel
AUTORITE LOCALE
CHEF DE QUARTIER