



School of Postgraduate Studies

Evaluation of Health Facility Performance in Childhood Immunization Services in Selected Facilities of Sikongo District in the Western Province of Zambia.

By

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Declaration

I hereby declare that this research dissertation is my original work and has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the dissertation. This dissertation has not been submitted for any degree in any other university.

Student Signature:  Date: 26/07/2026

Approval for Submission

This research dissertation has been submitted with my/our approval as university supervisor.

"
Supervisor Signature:  Date: _____

Dedication

I dedicate this study to my father Mr. Smart Kankung'a for his clear message from childhood on the importance of education. My wife Nalishebo Muyauka and my brothers who rendered their utmost support during this study. Without their support, I would not have managed to accomplish this work.

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Abbreviations

Acronym	Full term
EPI	Expanded Programme on Immunization
WHO	World Health Organization
DQI	Documentation Quality Index
DTP	Diphtheria–Tetanus–Pertussis (often whole cell formulation, DTwP)
BCG	Bacillus Calmette–Guérin (tuberculosis vaccine)
OPV0	Oral Poliovirus Vaccine, birth dose
OPV4	Oral Poliovirus Vaccine, fourth dose
IPV	Inactivated Poliovirus Vaccine
MR1	Measles–Rubella vaccine, first dose
RHC	Rural Health Centre
HP	Health Post
SIA	Supplementary Immunization Activity
RED	Reaching Every District (WHO immunization strategy)
DHS	Demographic and Health Survey
SSA	sub–Saharan Africa
MR	Measles–Rubella
DQR	Data Quality Review
DHIS2	District Health Information System, version 2

Abstract

Background: Despite the fact that immunization is an essential component of all countries, there are still gaps in terms of coverage, timeliness and equity in several parts of those countries, especially in low resource settings. The primary aim of this dissertation was to identify the gaps within the immunization programs of Sikongo District in the Western Province of Zambia by assessing various aspects of the immunization records of children within health facilities in the district.

Methods: A retrospective cross-sectional study was performed using the child health registers and under 5 cards in five health facilities. Each document was scored for its quality according to the completeness of the documents, availability of the documents, legibility of the documents and accuracy of the information within those documents to create a document quality index (DQI).

Based on Zambia's EPI cycle vaccine specific coverage, the percentage of children who drop out between doses of the vaccines was calculated, as was the percentage who received each of the three types of doses (early, on time, and late). Tests that did not assume anything about the distribution of variables within the sampling areas were used to compare the facility-level comparisons. Such as the Pearson's chi-square test. Additionally, logistic regression was used to determine which variables were associated with the likelihood that a child would be late in receiving the complete immunization series or would be fully immunized.

The indicator pathway that linked vaccination documentation to vaccination itself and timeliness in receiving the vaccines was calculated using linear mixed modelling techniques. Spatial autocorrelation analyses (both global and local Moran's I statistics) were used to determine which geographic areas within the selected catchment areas of Sikongo District in the Western province of Zambia had high vaccine coverage for several antigens and which had lower rates, including any villages that exhibited "cold spots" in relation to vaccination.

Results: The documentation quality index (DQI) for all primary vaccination records was generally high; 80.6% of documentation records had high DQI scores and low instances of missing variables or missing data. Furthermore, vaccination quality was significantly associated with full immunization (95% of the children who were fully immunized had documentation records that reflected high DQI scores). However, this association requires cautious interpretation as both measures were derived from the same documentation.

Coverage exceeded 95% for DTP1–3 and IPV with minimal dropout between intermediate doses. Higher dropouts were observed between BCG and OPV0 as well as between IPV and MR1 (4.6% and 6.6% respectively).

The timeliness of these vaccines was lower than the coverage. While birth doses were generally administered in time with more than 80% of BCG and OPV0 doses administered within the recommended timeliness window, timeliness declined for later doses, with only around one-third of DTP3 and IPV doses administered within the recommended age window. Overall, 53.4% of children had at least one late dose.

Nyengo and Tuuwa had the highest mean vaccine coverage among the five selected facilities. Mwenyi had the lowest. Spatial analysis identified areas with clustering of fully immunized children and villages with few fully immunized children. Children who lived further from the clinics, who missed more clinic appointments, and who were classified as “defaulter” children had higher odds of being late or not being fully immunized. Higher documentation quality is associated with lower odds of late or incomplete immunization. This relationship is to be interpreted cautiously as the documentation quality and vaccination outcomes were derived from the same routine records.

The sex of the child was not associated with the outcomes, as was the number of health workers at the clinics or the number who performed health outreach within the clinics.

Conclusion: The five clinics had high vaccine coverage for several antigens and documentation of those vaccinations. However, there were gaps in the rates of success with providing birth doses and MR1 vaccines to the children, and the timeliness with which they received those vaccines. Greater distance to the health facility was associated with poorer immunization outcomes. Most underperforming facilities were in Mwenyi. Recommendations for the clinics include the administration of catch-up vaccines for MR1 vaccines, strengthening immunization programmes within underperforming clinics, improving the provision of birth doses (especially to Nyengo clinic), improving appointment management and defaulter management within clinics, and performing health outreach to the specific villages with identified gaps in providing vaccines to their populations. Additionally, timeliness within clinics should be more closely monitored, and documentation processes should be strengthened, standardised and streamlined across facilities.

Key Words

Key Word	Definition
Expanded Programme on Immunization (EPI)	A global and national initiative to ensure that all children are protected against vaccine preventable diseases through routine immunization services.
Immunization coverage	The proportion of a target population that has received a given vaccine dose or series by a specified age or time.
Timeliness of vaccination	The extent to which vaccines are administered within recommended age windows or time intervals, rather than early or late.
Dropout rate	The proportion of children who start but do not complete a defined vaccine series (e.g. from DTP1 to DTP3 or from BCG to MR1).
Defaulter	A child who has started with the immunization (received at least one dose) but failed to receive the remaining doses within the recommended timeframe
Documentation Quality Index (DQI)	A tool to assess the quality of the child health records. The DQI classifies records as having poor, fair, moderate, or high quality
Missed appointment	A child who missed attending the appointment for immunization as recorded in the facility registers.
Missed opportunity for vaccination	Any encounter with health care services by a person who is eligible for one or more vaccines, but who does not receive all doses of vaccines for which they are eligible and who have no reasons to exclude receiving those vaccines (WHO definition).
Full immunization	Having received all vaccines and doses as recommended in the national schedule by a specified age (e.g. by 12 months).

Late vaccination	The receipt of a vaccine dose after the upper age limit for vaccination as defined as “on time” in the national or WHO schedule.
Spatial clustering	The pattern in which areas with high or low rates of immunization are clustered.
Moran’s I	A statistic that measures spatial clustering of a particular variable.
Getis-Ord Gi*	A statistic that measures “hot spots” (clusters of high values) and “cold spots” (clusters of low values) in each variable.
Cold spot village	A village with relatively low immunization performance in comparison to surrounding villages.
Microplanning	Planning activities at the facility-level to determine which villages (catchment areas) to vaccinate, and how many children will be vaccinated during fixed and outreach immunization sessions. This approach is promoted by the WHO in their RED (Reaching Every District) approach.
Outreach session	An immunization session held outside of the facility; usually mobile immunization teams visit each village within the catchment area.
Routine/static session	An immunization session held at the health facility.
Indicator pathway	A method of calculating immunization that tracks each child through three stages: documented, vaccinated, and vaccinated on time

Kruskal-Wallis test	A non-parametric statistical test used to compare the distributions of a variable across three or more independent groups and assumptions for parametric comparisons are not met
Logistic regression	A regression model often used to calculate the association between multiple variables and a binary (yes/no) variable; in the case of immunization, the variable is whether each child was fully immunized.
Linear mixed model	A regression model that includes both fixed and random effects variables; in the context of immunization, the fixed effects might include variables relating to the child, while the random effects may include variables related to the health facility.

Table 1.0 Showing Key Words

1.0 Chapter One: Introduction

1.1 Background

The ability of many children throughout sub-Saharan Africa to initiate, complete or receive those vaccines on time remains significantly impacted by systemic and community level barriers – despite the effectiveness of such childhood immunization interventions relative to other public health efforts (Musa et al., 2018). Global recent disruptions have exposed the fragility of such services and coverage, with an estimated 67 million children experiencing missed vaccinations over a three-year period (WHO, 2020).

Zambia's Expanded Programme on Immunization (EPI) enjoyed high levels of coverage of many antigens within the nation, using periods of twice-yearly Child Health Weeks to deliver both outreach and intensified efforts (Shamazubaula and Chiluba, 2024; WHO, 2020). Subnational analyses within the country, however, showed significant differences in performance between and within districts – especially in those remote and rural areas that featured few facilities and access points, challenging terrains and seasonal access issues. High and equitable vaccination coverage in such areas depended upon all these factors (Mochida et al., 2021a).

Evidence exists from other African settings regarding facility-level aspects of vaccination coverage and outcomes, but most studies have looked at aggregate coverage indicators rather than the processes responsible for such variations between individual facilities (Winter, A et al., 2022; WHO, 2020; Peters et al., 2008). Documentation systems are well known as important elements of monitoring, defaulter tracing and micro planning – but their role in facility performance and tracking accuracy remains an area of limited empirical study (WHO, 2020). The potential influence of geographic location and catchment areas is also recognised as useful in understanding both service use and vaccination timeliness – making spatial analyses a valuable but underused approach to uncovering the reasons for low performance in particular locations (Musa et al., 2018).

Sikongo District in the Western Province of Zambia is predominantly rural and flood-prone (Shamazubaula and Chiluba, 2024; Mwansa et al., 2023). The area is accessed via a small network of health posts and centres and the mini hospital – early data collected indicated high uptake of initial vaccines but variable dropout and delays for later vaccines across the facilities (Cassocera et al., 2023; Magambo et al., 2020). An understanding of how facility characteristics,

missed appointments and documentation relate to coverage, timeliness and defaulter outcomes at this level is clearly important and relevant to achieving targets like 90% full immunization coverage (Cassocera et al., 2023).

The aim of this study was therefore to investigate the performance of each of five health facilities within the district in relation to immunization – assessing both outcomes related variables as well as those related to facility characteristics and supply side aspects (Mochida et al., 2021b). The study provided a level of facility analysis that encompassed aspects of immunization coverage and documentation quality. Such an integration of system factors, service delivery elements and spatial dimensions provided a more complete assessment of performance than is typically contained in routine reports (Peters et al., 2008; WHO, 2020).

1.2 Statement of the problem

Childhood immunization is amongst the most cost-effective interventions in public health preventing 2 3 million deaths each year (WHO, 2024); yet major implementation gaps remained in rural health facilities throughout sub-Saharan Africa. While Zambia saw improvements in national immunization coverage, disparities between urban and rural areas remained with districts like those in the Western Province seeing suboptimal coverage figures.

Factors like seasonal flooding, geographic isolation, poor transport and staffing availability all contributed to fragile supply chains and service delivery within Sikongo. While early vaccines showed strong coverage within the facility, other factors such as dropout, delayed vaccinations and differences in performance could not be explained solely by distance from facilities. Poor documentation quality may further limit the ability of health facilities to accurately track vaccination status, identify defaulters and overall assess programme performance.

A critical piece of existing knowledge is lacking district-level data but facility specific elements of structural, process and outcome factors within immunization efforts (Mutale et al., 2021). Such a knowledge gap impacts effective intervention strategies and efficient resource allocation. Without such evidence, it is not possible to recognize high performing facilities for replication or struggling facilities for prioritized efforts surveillance remains weak and this sustains inequities and affected community trust.

This research helps to address such gaps and limitations through the generation of facility-level performance assessments supporting better interventions, better resource use and stronger immunization systems within flood-prone and rural settings like Sikongo.

1.3 Research Objectives

1.3.1 General Objective

The primary objective of this study was to provide an assessment of immunization performance across the five health facilities within Sikongo District.

1.3.2 Specific Objectives

- To measure and compare immunization coverage (e.g. Penta/DTP3, Measles Rubella 1, fully immunized child) and dropout rates across five selected health facilities within the Sikongo District.

- To determine associations between facility-level characteristics (e.g. distance to facility, facility type, missed appointments as a proxy for process performance) and immunization outcomes (full immunization, late vaccination).
- To evaluate the relationship between documentation quality indicators (documentation quality index, completeness, card availability/retention, legibility, accuracy) and immunization tracking outcomes (defaulter status, late vaccination, full immunization).
- To analyze the spatial distribution and clustering of immunization coverage and late vaccination across facility catchment areas using geographic coordinates, Global Moran's I and Local Getis-Ord Gi (Getis-Ord) statistics.

1.4 Research Questions

- What are the levels of coverage for each antigen (BCG, OPV0, DTP1 3, IPV, MR1) and full immunization for children who attended these five facilities and how do such levels vary by facility?
- What are the dropout rates between antigen pairs (BCG→OPV0, OPV0→DTP1, DTP1→DTP3, DTP3→MR1) and do these differ significantly between facilities?
- How are facility-level characteristics (distance to facility, facility type, missed appointments, outreach related variables where available) associated with full immunization status and late vaccination?
- How do documentation quality indicators (DQI category; completeness, card score, legibility, accuracy) relate to defaulter status, late vaccination and probability of being fully immunized?
- Are there spatial clusters (hotspots and cold spots) of low immunization coverage and/or high rates of late vaccination across catchment areas?

1.5 Study Justification

This study is justified for three main reasons.

First, achieving high and timely coverage for each antigen requires both facility-level and catchment area specific analyses of coverage and timeliness of immunization in line with WHO monitoring guidance and EPI standards (WHO, 2020).

Second, established frameworks including Donabedian models, Andersen's Behavioural Model, Tanahashi's coverage framework and implementation science approaches (Peters et al., 2008) do suggest such links between various elements of immunization programs. However rural Zambia studies rarely include consideration of both facility characteristics and documentation quality aspects (Mutale et al., 2021).

Third, the setting of Sikongo is itself highly flood-prone and dispersed as was seen in the same province during 2024 campaigns. Spatial analyses like Moran's I or Getis-Ord Gi statistics* may reveal more specifically which facilities require intensified outreach or data improvements efforts (Assefa et al., 2025; Bantie et al., 2024).

2.0 Chapter Two: Literature Review

Introduction

This chapter presents a review of evidence on health facility performance and immunisation both general and in the context of Zambia and other African settings as it relates to both

informing and motivating the analysis within Sikongo District and in summarising research gaps.

2.1 Frameworks and Evidence

2.1.1 Models

Donabedian's Structure Process Outcome Model

Donabedian's model maps structural elements of health facilities and services to the processes that occur within those settings and facilities, and the resulting outcomes (Moore et al., 2015, Donabedian, 1988). Studies performing evaluations within health facilities in Ghana and Kenya have applied this model using health facility surveys and register based reviews each of which typically only focussed upon dozens to a few hundred health facilities to relate structural elements (staffing levels, stock outs, outreach frequency) with the completion of vaccine series (Antwi et al., 2020).

Such studies indicated consistent findings regarding all aspects of shortfalls and missed opportunities for immunisation particularly for vaccines administered later within infancy such as the measles containing vaccine (Antwi et al., 2020). The same conclusions are found within Zambia through both routine and campaign-based facility evaluations, as well (Sakas et al., 2024). Yet most such studies stop with describing such associations between structural readiness and coverage. This Sikongo based study aims to incorporate elements of documentation quality and spatial clustering within such a Donabedian type framework.

The Tanahashi coverage model conceptualised effective coverage as dependent upon availability, accessibility, initial contact, continued utilisation and quality each loss points along the way contributing to reduced effective coverage (Amouzou et al., 2019; Juran et al., 2018; Tanahashi, 1978). Studies in Ghana and Kenya have implemented this model using household survey data and associated facility information samples of several thousand children have been used to reveal drop offs between initial contact with immunisation services (BCG or first pentavalent dose) and completion of the vaccination schedule (Kwamie et al., 2018).

These analyses revealed that high levels of availability did give way to bottlenecks in access to sessions and continued use of the health facilities leading to major reductions in effective coverage of services like measles and later infant vaccinations (Kwamie et al., 2018). The same has been reported for rural Zambia, where initiation rates were very high yet dropout and late vaccination for later doses was marked (Shamazubaula and Chiluba, 2024). Existing applications of such coverage cascades in the region rarely linked them directly with facility documentation audits or spatial statistics hence the extension of such work in the present study

to understand how availability, accessibility and utilisation relate to register quality and spatial clustering of under immunisation within Sikongo.

Andersen's Behavioural Model

Andersen's Behavioural Model considers the multiple determinants of health service use both at the household and facility-level (Babitsch et al., 2012; Levesque et al., 2013). In Kinshasa in the Democratic Republic of Congo, a facility linked household study used ordered logistic regression models based on samples of several thousand children and their caregivers among dozens of health facilities to assess the receipt of BCG and hepatitis B vaccines (Kabia et al., 2021). The resulting study indicated the importance of facility readiness (opening hours, availability of vaccines and staff), maternal education and parity levels, and neighbourhood type (slums versus more advantaged areas) but also showed that enabling factors like outreach activities and session convenience have a stronger influence than distance alone (Kabia et al., 2021).

Systematic reviews and analyses of several different countries show the same general factors and domains (Philips et al., 2018; Phillips et al., 2022; Lakew et al., 2023). These studies mainly used large scale national surveys or exemplar districts, however and rarely incorporated spatial clustering elements or documentation-based measures. Such aspects are addressed by applying Andersen's model to a census or near census of facilities within Sikongo, with linkages to register based outcomes and geospatial data. Several more recent frameworks have built upon and extended the classic models such as Donabedian, Tanahashi and Andersen.

The WHO five lens model of healthcare quality incorporates elements of Donabedian's framework with system functions, quality activities and dimensions providing a more systems-oriented view of how structural and process elements lead to desired outcomes (WHO, 2018). Effective coverage cascades make an operationalised and updated approach to the domains of Tanahashi's coverage concept in steps such as contact, readiness, quality adjusted and outcome adjusted coverage which can be applied to programs like RMNCH, and for bottleneck and system performance monitoring in low- and middle-income settings (Amouzou et al., 2019; Juran et al., 2018).

On the demand side of services, Levesque's access to care framework presents a more contemporary understanding of Andersen's model considering how service characteristics

contribute to accessibility for various population abilities (approachability, acceptability, availability, affordability, appropriateness) (Levesque et al., 2013). More recent quality improvement and systems thinking literature suggests updating Donabedian models to complex, adaptive health systems and dynamic learning/improvement cycles (Moore et al., 2015). Each of these newer frameworks does not replace the classic Donabedian, Tanahashi or Andersen models but presents modern, operational extensions.

2.1.2 Zambia Specific Immunization Context

Coverage Trends and Facility Performance

The country has experienced substantial gains in routine childhood immunization coverage from around 46% in 1990 to around 73% in 2010 thanks to pentavalent and other child health initiatives (Colson et al., 2015; Bednarczyk et al., 2022). Such estimates are drawn from nationally representative household surveys (such as DHS and MICS surveys) with sample sizes well over 3,000 children aged 12–23 months again using standard vaccination indicators (Colson et al., 2015). However, the picture at the district-level reveals disparities. Districts like Sikongo in more remote parts of the nation mostly underperform both nationally and relative to provincial averages (Arambepola et al., 2021; Shamazubaula and Chiluba, 2024).

Studies that link facility data to outcomes at the national and subnational levels in Zambia and elsewhere in Africa show that high performing facilities (often with a degree of purposeful selection as exemplary sites) exhibit higher immunization coverage, fewer dropouts and higher timeliness in completing such vaccinations (Philips et al., 2018; Sakas et al., 2024). Such analyses may often focus upon facility readiness indicators or case study facilities but do not typically provide systematic assessments across all facilities within a single rural district.

Determinants of Facility Performance and Uptake

The success factors evident in both Zambian and regional studies relate to governance structures, community engagement efforts, health system investments and adaptations of service delivery models (Sakas et al., 2024; Ogutu et al., 2024). Facility readiness factors have been proven crucial to immunization coverage levels from multi country analyses that combine facility assessments with vaccination data from households (Philips et al., 2018; Feldhaus et al., 2019). Each of these studies uses cross sectional data from several hundred facilities and applies multivariable or multilevel models to show such relationships. Barriers to access (distance, flooding) or knowledge and beliefs within communities have been documented from mixed methods studies throughout Zambia and neighbouring countries again using household samples of several hundred caregivers and focus group discussions to uncover reasons for under immunization (Masilani, 2011; Bangura et al., 2020; Kashinka, 2022; Shamazubaula and Chiluba, 2024). Yet few studies have directly stratified such determinants across flood-prone versus non-flood-prone catchments or considered interactions between outreach/ session factors and geographic barriers an angle this Sikongo focused research has addressed.

Health System Constraints and External Shocks

Constraints upon the health system workforce shortages, funding and infrastructure deficits continue to undermine facility performance, particularly in rural Zambia (Chama Chiliba et al., 2017; Chompolola et al., 2024). Such constraints are well described in health systems research using facility surveys, interviews with district managers and budget/expenditure analyses from multiple districts (Chama Chiliba et al., 2017). The additional disruptions of the COVID 19 pandemic were documented in similar ways, revealing decreases in immunization sessions and health worker workload and temporary suspensions of such activity's effects followed by recovery efforts (Simuyemba et al., 2024; Mwangilwa et al., 2024; Winter et al., 2022). The extent of such resilience has been documented in some better resourced or accessible districts. Each of these studies rarely looked at the highly flood-prone and sparsely populated settings like Sikongo. The current study thus contributes evidence specific to such a context regarding health system constraints.

Documentation Quality and Data Systems (Card Retention and Register Quality)

The quality of documentation and vaccination records is increasingly recognized as central to understanding both coverage and defaulters. In Cameroon, a facility linked household study revealed retention rates of roughly 30 50% (based upon interviews with several hundred caregivers and child records against facility registers) (Noh et al., 2022). The study employed logistic regression methods to uncover factors related to documentation, concluding that poor availability impacted accurate assessments of immunization and defaulters (Noh et al., 2022). The World Health Organization and equity analyses make similar points about incomplete registers, inaccurate recording and weak data systems drawing upon desk-based reviews of national HMIS data and programs (WHO, 2020). Few quantitative studies take issue with documentation quality indicators and child level outcomes. Conducting a structured audit of child registers present across all or a clearly defined sample of facilities within Sikongo directly addresses this knowledge gap.

Spatial Analytic Methods and Geospatial Evidence (Hotspot Detection and Geospatial Modelling)

Spatial analytic methods including both Global Moran's I and Local indicators of spatial association (LISA) techniques such as Local Moran's I and Getis-Ord Gi* have been widely used to reveal spatial elements of low immunization coverage or susceptibility throughout sub-Saharan Africa. More recent studies in Ethiopia, Madagascar and Zambia have used geolocated data from thousands of children to reveal both high immunization hotspots and low areas of under immunization (Bantie et al., 2024; Assefa et al., 2025). In Zambia, studies such as that within Choma District have used household mapping and zero dose classifications to identify both undersupplied areas and the best locations for new outreach sites (Arambepola, 2021).

Each of these approaches used large samples of the province or country and involved more advanced approaches to modelling and targeting. Most routine EPI analyses in Zambia, however, did not go beyond district-level mapping or plots. Such spatial clustering studies within sub-Saharan Africa have indicated that low vaccination rates may be clustered even within nationally relatively high levels including Zambia and Malawi (Brownwright et al., 2017). The Sikongo research applied Moran's I and local hotspot analyses at catchment level using the district wide facility frame and linked spatial findings to facility structures, processes and documentation quality

2.2 Conceptual Framework

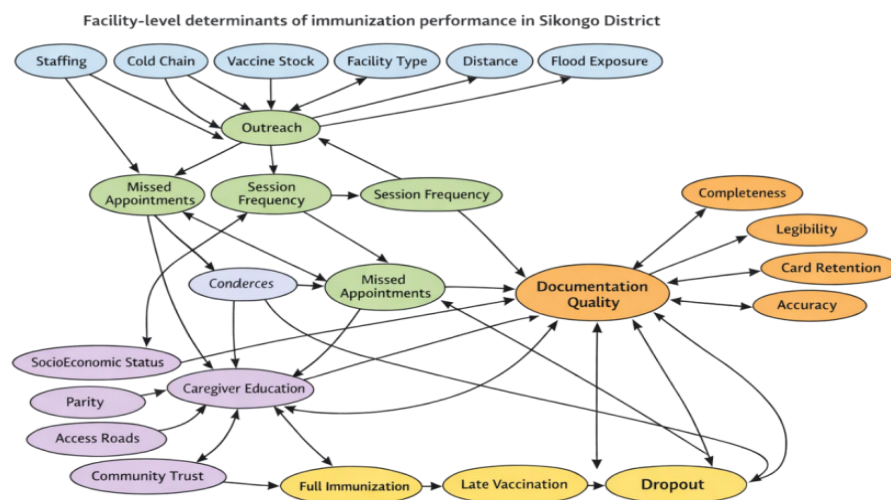


Figure 1: Conceptual Framework for Health Facility Performance and Childhood Immunization Outcomes.

The conceptual framework showed the relationships between health system factors, community characteristics, and child immunization outcomes. At the centre, child immunization status was conceptualised as being associated with facility-level factors such as health facility type, outreach services, and distance to the facility, as well as household and community level factors such as village location, accessibility, and local vaccination campaigns.

The framework also revealed possible mediating pathways for instance, the effect of facility outreach strategies upon attendance at the facility and immunization coverage.

The model also featured an indicator pathway element showing how documentation quality may influence a facilities ability to track vaccination, appointments and defaulters. In this study it was treated as a process, performance and/or measurement indicator. Not as a direct cause of immunization timeliness or completion.

The study did include elements to account for confounding variables like age, sex and vaccination history aspects that contribute to baseline differences among populations.

The clear mapping of such relationships helped to frame, and the study led to the identification of intervention areas such as outreach efforts within underserved villages. The framework was also helpful in understanding the spatial clustering aspects of the immunization data.

2.3 Research Gap

While the models developed by Donabedian, Tanahashi, Andersen and implementation frameworks by Peters et al. are highly relevant to understanding immunization performance, empirical studies applying such models together within small area or facility-level contexts have been limited (Peters et al., 2008; Amouzou et al., 2019; Babitsch et al., 2012; Moore et al., 2015).

Most existing African research into immunization studies these aspects separately and on either regional or national scales mostly through large survey based or program review studies. Such studies have rarely combined elements like detailed facility characteristics (staffing, outreach, stock outs), documentation quality metrics and tracking accuracy, and spatial statistics to assess immunization coverage patterns across catchment areas (Philips et al., 2018; Carcelen et al., 2022).

Within Zambia itself, while there is evidence of both growth in child immunization coverage rates, there are also clear inequities between districts and health facilities underperforming areas like Sikongo presenting specific challenges. High performing facilities are primarily understood through case study examples rather than through systematic mapping of all

facilities within underperforming districts (Sakas et al., 2024; Arambepola et al., 2021; Chompolola et al., 2024).

The existing body of work in the area therefore relies mainly upon national surveys, program reviews and selected case studies with limited integration of Donabedian type structures and measures, Tanahashi type coverage aspects, Andersen type household/enabling factors, documentation audits and small area spatial clustering methods (Moore et al., 2015; Babitsch et al., 2012).

The study in Sikongo District was thus specifically designed with such an approach using a clearly defined facility frame for sampling, extracting data relating to children of a defined birth cohort, assessing documentation quality through quantitative metrics, and applying spatial and regression methods within this integrated framework. The study aimed to provide district specific and facility-level evidence for improving interventions, planning and Zambia's routine immunization strategies in rural and flood-prone contexts (Micek et al., 2021; Sakas et al., 2024).

This chapter reviews relevant conceptual frameworks and empirical studies of facility performance, immunization coverage and documentation quality and spatial patterns within Zambia and similar African settings identifying key gaps that the Sikongo District study was designed to address.

3.0 Chapter Three: Methodology

Introduction: This chapter details the way in which the study was designed and implemented in relation to assessing immunization performance across five health facilities within Sikongo District. The chapter includes descriptions of the population, sampling efforts, data collection tools and methods, analyses and considerations regarding ethics in the study.

3.1 Study Design

The study used a retrospective cross sectional data design for assessing immunization records from five health facilities in the district. While the data was evaluated at only a single point in time for retrospective assessment, the study also incorporated analyses of various elements along the vaccination pathway (overall coverage, dropouts and timeliness), health facility comparisons and methods like regression models and spatial analyses to understand immunization performance.

The data collection element of the study was therefore essentially cross sectional, but the analysis included elements focused upon pathway based and spatial analyses of immunization trajectories according to the routine vaccination schedule. Such an approach enabled the assessment of facility-level features including differences in coverage, timeliness, dropouts and documentation quality all while identifying factors related to delayed or incomplete vaccination.

3.2 Study Population

Children 12-23 months at time of data collection were included from the immunization data available at health facilities in the district. This age group is the usual population selected for analysis of immunization coverage because children in this age group have crossed the age by which all routine immunizations should have been received and their immunization status can therefore be ascribed as complete or incomplete. Children included in the study were those with a birth date and immunization data available at one of the five facilities in the health delivery system which also served the geographically and hydrologically diverse rural communities in the district.

3.3 Study Sample

Children aged 12-23 months at the time they were included in the study and with immunization data available from the facility immunization records over a 24-month period were included in the sample. Because data were collected retrospectively, the sample includes children that crossed into the 12–23-month age range at different times during the 24-month study period and therefore represent different service delivery settings (outreach programs, Child Health Week events, and routine immunization), seasonal service availability issues, catchment areas and time periods across the five facilities.

3.4 Sample Size

Cochran's formula was used to determine a minimum sample size.

The formula is:

where:

$Z = 1.96$ (for 95% confidence)

$p = 0.50$ (assumed proportion)

$1 - p = 0.50$

$e = 0.05$ (5% margin of error)

The minimum number of records required for the study without adjustment can be determined using standard formulas for studies such as this. However, the number of eligible records available at each of the five sites was greater than this minimum. Using the objective of the study, a larger number of records was also indicated. Thus, 824 records were selected as the final sample size. This sample size was useful for child representation across the five sites, comparisons within sites, and the precision of the estimates.

The final sample was allocated proportionally across facilities according to both under two population and availability of eligible records. The allocation was as follows: Mwenyi Health Post (160), Tuuwa Rural Health Centre (164), Nyengo Rural Health Centre (176), Liumena Rural Health Centre (164) and Sikongo Mini Hospital (160). This ensured that each facility contributed enough records for comparison yet maintained representation across facility types and accessibility profiles.

3.5 Sampling Strategy

A stratified purposive sampling strategy selected the five health facilities according to four predetermined criteria. These criteria ensured that each selected facility represented an aspect of the population being evaluated. The four aspects included both type of facility (Hospital, Rural Health Centre, Health Post), volume of patients (high vs. low volume facilities), accessibility (proximity to vs. distance from district Centre) and levels of seasonal flooding exposure. Within each selected facility, systematic random sampling determined each sample from registers of routine immunizations – using calculated sampling intervals – and the samples were also taken according to stratified quarters to distribute the selection over the 24-month study period.

3.6 Data Collection

Data was collected using a standardized data extraction form (Appendix B) from registers of routine immunizations and under five cards. The data collection tool included variables relating to the individual records as well as the receipt of each antigen (BCG, OPV0, DTP1–3, IPV, MR1, OPV4). Other variables included date of birth and vaccination, sex, facility of registration, distance from child’s residence to facility (in either km or categorical midpoint) and defaulter status. The documentation quality variables were similarly collected with composite documentation quality index (DQI) scores categorized as poor, fair, moderate or high.

A more structured questionnaire was deployed among facility staff (Appendix A) to collect information regarding type of facility (health post, rural health centre, mini hospital), staffing levels, vaccine supply frequency, outreach activity schedules, cold chain functionality and processes like missed appointments. The geographic coordinates were available for each facility and/or the centroids of their catchment areas. Anticipated challenges associated with this data collection included incomplete records and accessibility challenges during specific seasons – but these challenges were accounted for with multiple visits to each facility and standardized verification protocols. Given the focus of the study (and immunizations in particular), early indicators such as lateness were prioritized over final defaulter status to enable proactive intervention strategies prior to the occurrence of defaults.

3.7 Data Analysis

3.7.1 Data cleaning and missing data

The analysis proceeded from an assessment of data quality to descriptive epidemiology before arriving at the more detailed analyses. Such an approach enabled a comprehensive consideration of documentation quality aspects, immunization, dropout and timeliness as well as the determinants of late versus complete vaccination and geographic clustering of performance across the five facilities.

Data was coded within Microsoft Excel but subsequently cleaned within R – making possible checks for duplicates, out of range figures or internal inconsistencies (such as vaccination dates prior to the child’s date of birth). Missing data was noted both in total and according to facility for key variables. Proportions of missing data were tabulated both according to each variable and facility. All facilities featured less than 10% missingness for the key immunization variables – within accepted thresholds for surveillance datasets. Analyses were performed according to available cases and reported according to the number of observations that performed each analysis. For models in which missingness was more substantial (e.g. distance measurements), observations with missing covariate values were excluded listwise.

Objective	Variables/outcomes	Main analysis
1. Compare coverage and dropout	Vaccine receipt, full immunization, dropout	Frequencies, percentages, 95% CIs, chi-square/Fisher's exact
2. Assess facility-level characteristics	Distance, facility type, missed appointments; full immunization/lateness	Bivariable analyses and logistic regression
3. Assess documentation quality	DQI/components; defaulter status, lateness, full immunization	Cross-tabulations, categorical tests and exploratory regression
4. Assess spatial distribution	Coordinates, coverage, full immunization, lateness	Global Moran's I and Local Getis-Ord Gi*

Table 1 Framework linking objectives to analyses

3.7.2 Descriptive analysis

Descriptive statistics performed enabled the achievement of the first objective of the study – quantitative assessment of coverage, dropout, documentation and timeliness. Frequencies, percentages, confidence intervals and tables allow for easily interpretable data – the standard approach to monitoring such immunization programmes (WHO Expanded Programme on Immunization). Most variables within the study were based upon binary data (vaccinated or not vaccinated, on time or late, documentation category), making descriptive statistics the most appropriate means of summarizing the data prior to performing inferential analyses.

Coverage statistics were determined for each vaccine dose (BCG, OPV0, DTP1–3, IPV, MR1, OPV4) within the population – along with 95% confidence intervals provided for both facility and all coverage figures where appropriate. Dropout rates were calculated between various pairs of key vaccines (as the percentage difference between initiators of the first dose and those who completed the subsequent one – e.g. BCG→OPV0, OPV0→DTP1, DTP1→DTP3, DTP3→MR1). Levels of timeliness were assessed according to each antigen relative to Zambia MOH target age cut offs. Such assessments classified vaccination outcomes according to whether the date of vaccination occurred in relation to the child’s date of birth.

Documentation quality was assessed according to categories of the DQI (poor, fair, moderate, high) through frequencies and percentages indicators, as were the relationships with full immunization status or defaulter outcomes.

3.7.3 Comparative and non-parametric analysis

Comparative analyses were conducted to assess whether differences between facilities were statistically significant. Methods that do not rely on normality or large sample size assumptions were used often as many outcomes were binary and the number of participating facilities were small.

Categorical immunization outcomes (such as vaccine receipt, full immunization and late vaccination) were compared across facilities using Pearson’s chi-square test. Fisher’s exact test was used where cell frequencies were too small for the chi-square approximation. These tests evaluate associations between categorical variables without distributional assumptions.

Non-parametric methods were applied for continuous or ordinal variables that did not meet normality or linearity assumptions. Including tests for ordered outcomes that do not assume normally distributed outcomes and are robust to variance heterogeneity.

3.7.4 Regression modelling

Regression models were used to uncover the independent predictors of late versus complete immunization. Such an analysis allowed consideration of the simultaneous effects of multiple variables. The main outcomes (late vaccination, full immunization) were binary in form; thus, making logistic regression the most appropriate method for such analyses.

For both regression and inferential analyses, the concept of timeliness was dichotomized according to on time versus delayed vaccination – as frequencies of early vaccinations were very low for most antigens. Generalized linear models using logit link functions were fitted to assess the effect of each variable on individual level immunization outcomes. The binary outcome of full immunization was modelled according to distance travelled, sex of child, missed appointments and facility type. Model fit was assessed through residual checks, pseudo R² and Hosmer Lemeshow considerations where appropriate. Some outcomes (especially defaulter status) featured limited variability – hence the results are to be interpreted with care. Such cautions are in line with known issues in logistic regression using sparse data sets and separation of outcomes.

Odds ratios along with 95% confidence intervals and p values were reported for each predictor – with missed appointments included as such a key process-based variable given both descriptive and correlational findings relating to the phenomenon.

Models including documentation quality and DQI category as predictors of defaulter status and full immunization were also explored. Results were reported but interpreted with a lot of care given quasi complete separation and very low variability in defaulter outcomes. The documentation aspects and outcomes are derived from the same health records – thus the predictors were not fully independent. Therefore, coefficients relating to documentation quality were presented mainly as associations and indicators of health system performance.

For timeliness of specific doses (such as DTP1), separate logistic regression models with binary outcomes (late vs. on time vaccination) were created with distance as the main predictor. Statistical significance was assessed at a two-sided alpha level of 0.05; p values were also interpreted alongside effect sizes and confidence intervals.

Regression models did not include highly correlated predictor variables together – to improve stability and reliability of models. Correlation and variance inflation factor assessments show which variables were highly collinear and thus were not entered simultaneously into any one model. Given the small number of facilities and the limited variability in some outcomes, such models were kept relatively parsimonious. Some outcomes (especially sparse or highly imbalanced) were treated as exploratory rather than confirmatory.

3.7.5 Spatial analysis

Given the importance of geographic features and accessibility as a determinant of immunization service utilisation within rural districts like Sikongo, spatial analysis was undertaken as an additional method to conventional statistical analyses. The conventional methods assumed independence between observations an element that could not be readily established to determine whether similar immunization outcomes were being witnessed within neighbouring communities. The spatial statistical methods thus provided additional information regarding whether under immunization was occurring geographically clustered and where interventions may be most beneficial.

Global Moran's I was selected as the measure of comprehensive spatial autocorrelation within the aspects of immunization coverage and late vaccination within the district the standard global measure for determining whether geographic patterns differ from random distributions. Following the identification of statistically significant spatial clustering, Local Getis-Ord G_i^* analysis of hotspots helped to reveal the specific villages and facility catchment areas that contributed to such clusters. This type of analysis thus provided practical planning evidence for the district focusing upon communities where additional outreach or immunization activities may be beneficial.

Spatial analysis was undertaken using both facility and catchment area coordinates and the relevant immunization or late vaccination indicator data. The Global Moran's I measure was used to determine aspects of complete spatial autocorrelation in immunization rates (such as full immunization or MR1 coverage) and late vaccination with evaluation of statistical significance based upon permutation tests. The Local hotspot analysis then utilised the Getis-Ord G_i^* method to reveal specific facilities or catchment areas that featured statistically significant hotspots of low coverage or high late vaccination activity as well as cold spots of

better performance. The Z scores and p values from the Gi* analysis was likewise mapped to visualize such spatial patterns and inform the interpretation of findings.

3.8 Data Management and Quality

The researcher ensured good data management and quality in accordance with the following guides: Access to verified and reliable medical records and their standardization according to an information extraction format throughout available records was ensured.

Any inconsistencies in the data were identified and appropriately addressed. Records with missing or incomplete information on key variables were excluded from the relevant analysis using available-case analysis, so that only complete and verifiable data points were retained prior to converting the collected data into a suitable analytical format.

The data was validated against original health facility records to ensure accurate reflection of that source

The research data was securely stored within an encrypted database. Data backup procedures were implemented to prevent data loss due to technical issues or other problems.

Statistical considerations included the identification and assessment of any outliers (which could influence findings), potential biases or confounding variables (and which were addressed), as well as the performance of sensitivity analyses to test the robustness of findings relative to different assumptions and methods for dealing with missing data.

3.9 Ethical considerations

Ethical clearance was obtained from the Research Ethics Committee (REC). The researcher is also registered with the National Health Research Authority as a Researcher with file number NHRAR R 3061/30/07/2025. The introductory letter on the study was distributed to both the Province Health Office (Appendix D and E). Permissions were secured from both the District Health Office and facility in charges.

The researcher further ensured: Confidentiality of patient information prior to analysing the data. As there was no way to gain permission prior to access or use of personal data, the protocol was reviewed and approved by the REC. The REC reviewed the study and confirmed both that it respected the rights and privacy of participants giving official permission for the retrospective use of such data and information, even where individual consent was not obtained. Client

confidentiality was maintained through data anonymization with any unique identifying information replacing personal information.

Written informed consent was obtained from all health facility staff prior to their participation in the interviews.

Summary: This chapter makes clear the research approach a cross sectional, register based and facility survey design employing systematic sampling with rigorous data and record cleaning processes, followed by descriptive, non-parametric, regression and spatial analyses all conducted underpinned by sound data quality procedures and ethical approvals.

4.0 Chapter Four: Results

Introduction: In this chapter, the main findings on the documentation of the immunization of children for the five facilities in Sikongo District will be presented. The findings will utilize the descriptive statistics, non-parametric tests, regression models and the techniques in spatial statistics to describe immunization coverage, dropout, timeliness, full-immunization status and associated factors across the locations.

4.1 Documentation quality and predictors

4.1.1 Missing data patterns

Variable	% Missing
Vaccination dates	4.2%
Facility identifiers	0.0%
Geographic coordinates	7.8%

Documentation variables	1.3%
Defaulter status	0.0%
Distance to facility	7.8%

Table 2 Summary of Specific Missing Data Items

Missing data were minimal for most analytic variables, with no missing facility identifiers or defaulter status, and modest missingness in vaccination dates and geographic coordinates.

Facility	N	bcg_missing	opv0_missing	dtp1_missing	mr1_missing
Nyengo Rural Health Centre	176	8	32	4	4
Liumena Rural Health Centre	164	12	16	4	12
Tuuwa Rural Health Centre	164	4	4	4	16
Mwenyi Health Post	160	12	20	4	32
Sikongo Mini Hospital	160	12	8	4	16

Table 3: Missing data for specific vaccines by facility

The health post with the highest number of missing MR1 records is Mwenyi (32 records) - the same facility that has the lowest coverage for MR1 (80%). The Nyengo facility exhibits a high number of missing OPV0 records (32) despite having high coverage for most other vaccines, which explains the relatively low OPV0 coverage (84.1%) at the facility.

The number of missing records for vaccines administered early in the primary vaccination cycle is low across all health facilities (<12 records missing at any facility). The pattern of missing MR1 records suggests the need for improved data collection at Mwenyi Health Post for MR1 vaccination compared to catch up vaccination for MR1.

4.1.2 Documentation Quality Index (DQI) definition

Component	Coding
Record completeness	1 = Complete/Mostly complete
Card availability	1 = Card available
Data legibility	1 = Clear

Data accuracy	1 = All dates recorded
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Table 4: DQI components and coding

Score	Category
0–1	Poor
2	Fair
3	Moderate
4	High

Table 5: Documentation score (sum of 4 components, 0–4)

Documentation Category	N	%
Poor	8	1.0%
Fair	32	3.9%
Moderate	120	14.6%
High	664	80.6%
Total	824	100%

Table 6: Distribution of documentation quality

Documentation quality was generally high, with 80.6% of records classified as high quality. However, 19.4% of records exhibited moderate to poor documentation quality, indicating potential data reliability concerns in a non-trivial proportion of child records.

Doc Quality	On time (0)	Late (1)	Total
Poor	4	4	8
Fair	16	16	32
Moderate	32	88	120
High	284	380	664
Total	336	488	824
Test Statistic	Value	Df	p value
χ^2	12.40	3	0.0061

Table 7: Documentation quality and timeliness

There was a statistically significant association between documentation quality and late vaccination ($p = 0.006$). Children with moderate documentation quality had the highest proportion of late vaccinations compared to those with high documentation quality. Thus, documentation quality may reflect some other aspect of health care quality or patient engagement altogether.

Doc Quality	Not Fully Immunized	Fully Immunized	Total
Poor	4	4	8
Fair	24	8	32
Moderate	44	76	120
High	32	632	664
Total	104	720	824
Test Statistic	Value	Df	p value
χ^2	222.60	3	< 0.001

Table 8: Documentation quality and full immunization

There was an extremely strong association between documentation quality and immunization completion ($p < 0.001$).

Documentation quality was statistically associated with full immunization. ($\chi^2 = 222.60$, $df = 3$, $p < 0.001$). The magnitude of the association should be interpreted cautiously as both DQI and full immunisation measures were derived from the same records.

Of the children with poor and fair documentation records, there were high failure rates to complete immunizations: 50% (4/8) of those with poor documentation records were not fully immunized compared to 75% (24/32) of those with fair documentation records.

Conversely, 95% (632/664) of children who were fully immunized had documentation of high quality.

While these two variables are associated with one another, it is important to note that both variables are collected from the same database and depend upon the same records to determine their values.

4.1.3 Immunization Coverage and Dropout

Vaccine	Coverage (%)
BCG	94.17
OPV0	90.29

DTP1	97.57
DTP2	97.09
DTP3	95.15
IPV	95.15
MR1	90.29

Table 9: Vaccine coverage from birth to last dose

Excellent early coverage: DTP1 and DTP2 are the highest at 97.57% and 97.09%, respectively. BCG followed at 94.17%.

Measles vaccine: MR1 and OPV0 were the lowest at 90.29%.

Declining vaccination rates between DTP1 and MR1 suggest issues in vaccine retention at the endpoints.

From	To	Dropout rate (%)	Initiated N
BCG	OPV0	4.64	776
OPV0	DTP1	1.61	744
DTP1	DTP2	1.99	804
DTP2	DTP3	2.00	800
DTP3	IPV	0.00	784
IPV	MR1	6.63	784
MR1	OPV4	0.00	744

Table 10: Dropout between consecutive vaccines (overall)

Critical dropouts at transition points: 4.64% dropout from BCG to OPV0 and 6.63% dropout from IPV.

Excellent retention in the mid schedule: Only 1.6% to 2.0% of children dropped out from DTP1 to DTP3.

Perfect retention of IPV vaccine: There was 0% dropout from DTP3 to IPV.

Dropout pair	Label	Dropouts	N	Dropout proportion
rec_bcg to rec_opv0	rec_bcg → rec_opv0	36	804	0.0448
rec_opv0 to rec_dtp1	rec_opv0 → rec_dtp1	8	772	0.0104
rec_dtp1 to rec_dtp2	rec_dtp1 → rec_dtp2	16	812	0.0197
rec_dtp2 to rec_dtp3	rec_dtp2 → rec_dtp3	16	800	0.0200

rec_dtp3 to rec_mr1	rec_dtp3 → rec_mr1	48	784	0.0612
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Table 11: Alternative detailed dropout table

Highest dropout at DTP3→MR1 transition (6.12%) - Measles vaccination is a critical point of dropout.

BCG to OPV0 has a dropout of 4.48% - a considerable drop between the first two vaccinations.

Only 1-2% of children dropout in the DTP vaccinations.

There is a need for interventions to improve the MR1 and birth dose vaccinations.

The dropouts increase at the end of each vaccination schedule.

Vaccine	χ^2	df	p value	Significant?
BCG	2.15	4	0.71	No
OPV0	14.8	4	0.005	Yes
DTP1	2.42	4	0.66	No
DTP2	8.92	4	0.06	Borderline
DTP3	15.2	4	0.004	Yes
MR1	21.3	4	<0.001	Yes

Table 12: Chi square tests for coverage across facilities

Uniform early coverage: BCG, DTP1 show no facility differences. Progressive divergence at OPV0, DTP3, MR1. MR1 exhibits largest disparity ($\chi^2=21.3$).

4.1.4 Immunization by Facility

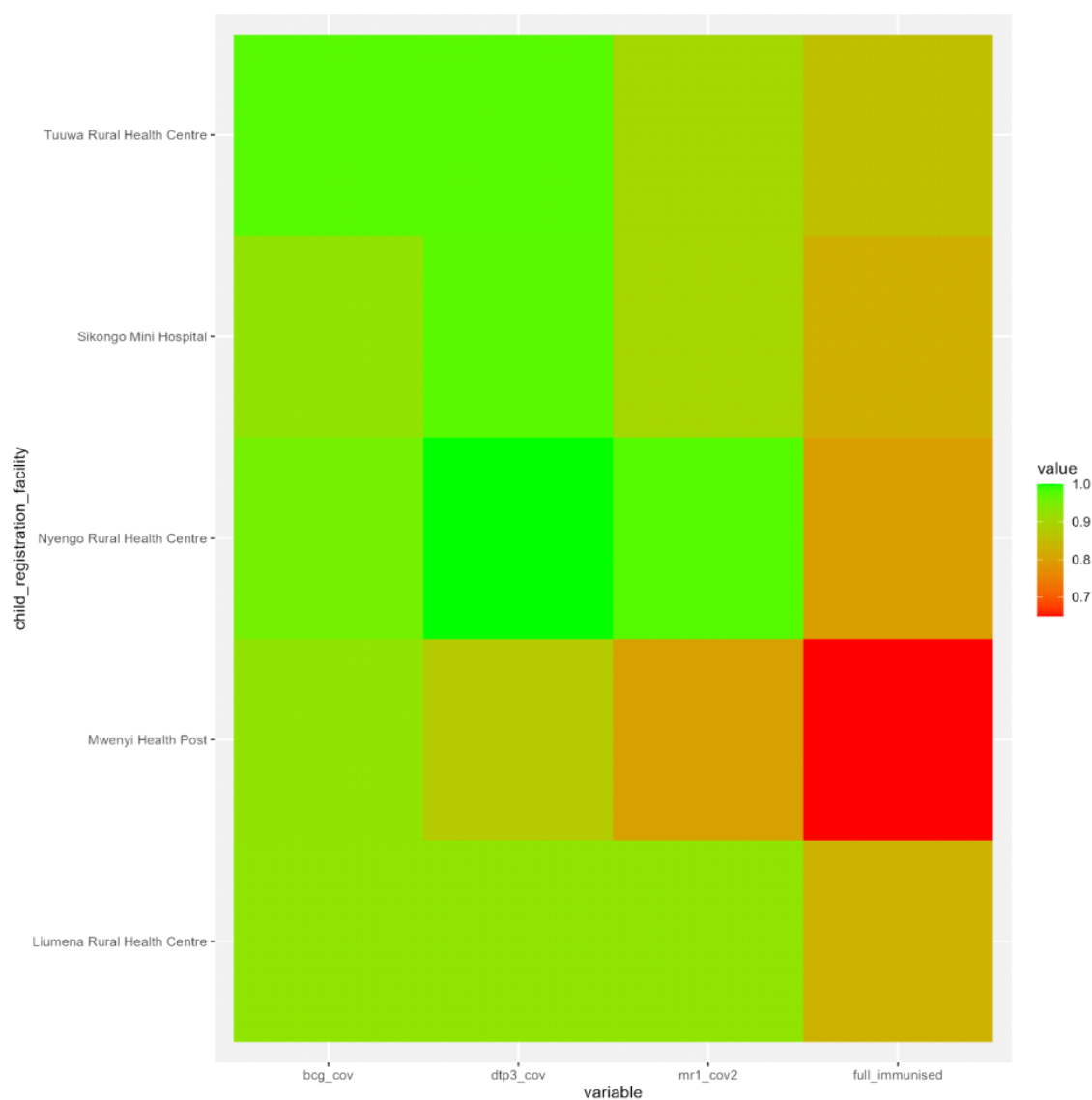


Figure 2: Vaccine Coverage by Facility

Facility	rec_bcg	rec_opv0	rec_dtp1	rec_dtp2	rec_dtp3	rec_mr1
Liumena Rural Health Centre	0.976	0.976	0.976	0.951	0.927	0.951
Mwenyi Health Post	0.975	0.900	0.975	0.925	0.875	0.800
Nyengo Rural Health Centre	0.977	0.841	1.000	1.000	1.000	0.977
Sikongo Mini Hospital	0.950	0.975	0.975	0.975	0.975	0.900
Tuuwa Rural Health Centre	1.000	1.000	1.000	1.000	0.976	0.902

Table 13: Coverage by facility

All facilities achieved high coverage with BCG and DTP1 vaccines, with some variation in OPV0 and MR1 coverage.

Nyengo and Tuuwa have near complete coverage across OPV0 doses.

Mwenyi (and to a lesser extent Liumena) have relatively low coverage with the MR1 vaccine.

Nyengo has excellent coverage with DTP vaccines but has relatively low coverage with OPV0.

Mwenyi has the lowest coverage with the MR1 vaccine.

All facilities have high coverage with BCG vaccine.

The most notable vulnerability with the MR1 vaccine is at Mwenyi with only 80% coverage compared to Nyengo's 97.7%

	Comparison	p value
MR1	Mwenyi vs Nyengo	<0.001
	Mwenyi vs Liumena	0.002
	Mwenyi vs Sikongo	0.02
	Nyengo vs Tuuwa	0.002
	Mwenyi vs Tuuwa	0.01
	Liumena vs Nyengo	0.003

Table 14: Post hoc pairwise facility vaccine coverage comparisons (Bonferroni, $\alpha=0.005$)

Mwenyi Health Post has significantly lower coverage of MR1 than top performers Nyengo (97.7%) and Liumena (95.1%). Sikongo difference is borderline (90.0%).

Mwenyi Health Post has significantly lower coverage of MR1 than top performers Nyengo (97.7%) and Liumena (95.1%). Sikongo difference is borderline (90.0%).

Nyengo Rural Health Centre has the highest DTP3 coverage at 100%, significantly outperforming Mwenyi (87.5%) and Liumena (92.7%).

Facility	Mean Coverage	Rank
Nyengo	96.6%	1
Tuuwa	96.4%	2
Sikongo	95.6%	3
Liumena	95.6%	4
Mwenyi	93.2%	5

Table 15: Mean coverage and rank

b – Mwenyi significantly lower overall coverage.

4.1.5 Timeliness

Vaccine	Target age (days)
BCG	0
OPV0	0
DTP1	42
DTP2	70
DTP3	98
IPV	98
MR1	270
OPV4	450

Table 16: Zambia Expanded Programme on Immunization target ages

These targets were used to classify vaccination as early, on time, or late.

Vaccine	Early (%)	On time (%)	Late (%)
BCG	0.0	80.93	19.07
OPV0	0.0	87.63	12.37
DTP1	1.99	61.19	36.82
DTP2	2.50	46.50	51.00
DTP3	1.53	31.12	67.35
IPV	1.53	31.12	67.35
MR1	8.06	47.31	44.62

Table 17: Zambia Expanded Programme on Immunization target ages

Table 17 Timeliness of all Vaccinations

Birth doses (BCG, OPV0) were mostly on time. More than 80% of BCG and OPV0 doses fell within the recommended window. Timeliness deteriorated progressively, with only about one third of children DTP3 and IPV doses being administered on time.

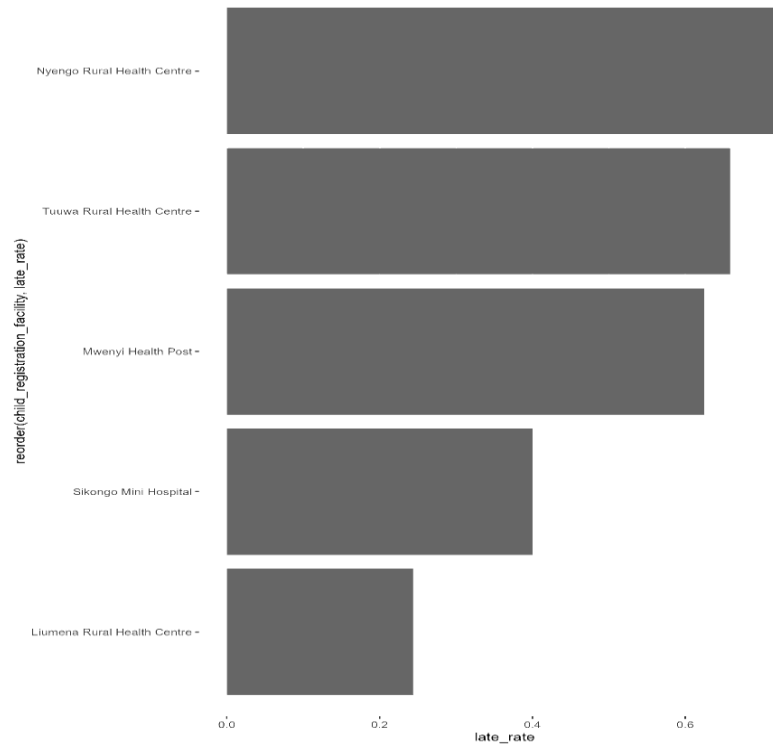


Figure 3: Vaccine Lateness by facility

Vaccine	Late proportion
late_bcg	0.1443
late_opv0	0.1237
late_dtp1	0.1045
late_dtp2	0.2450
late_dtp3	0.3980
late_ipv	0.3929
late_mr1	0.0269
late_any_zambia	0.5340

Table 188 Late proportion per vaccine and any late

Over half of children experienced at least one late vaccination, highlighting timeliness as a key performance gap.

4.7 Facility-level late vaccination and regression analyses

4.7.1 Late rates per facility

Facility	n	late_rate
Nyengo Rural Health Centre	176	0.7273
Tuuwa Rural Health Centre	164	0.6585
Mwenyi Health Post	160	0.6250
Sikongo Mini Hospital	160	0.4000
Liumena Rural Health Centre	164	0.2439

Table 19: Late Rate by Facility

Nyengo, Tuuwa, and Mwenyi have the highest late rates; Liumena and Sikongo Mini Hospital the lowest.

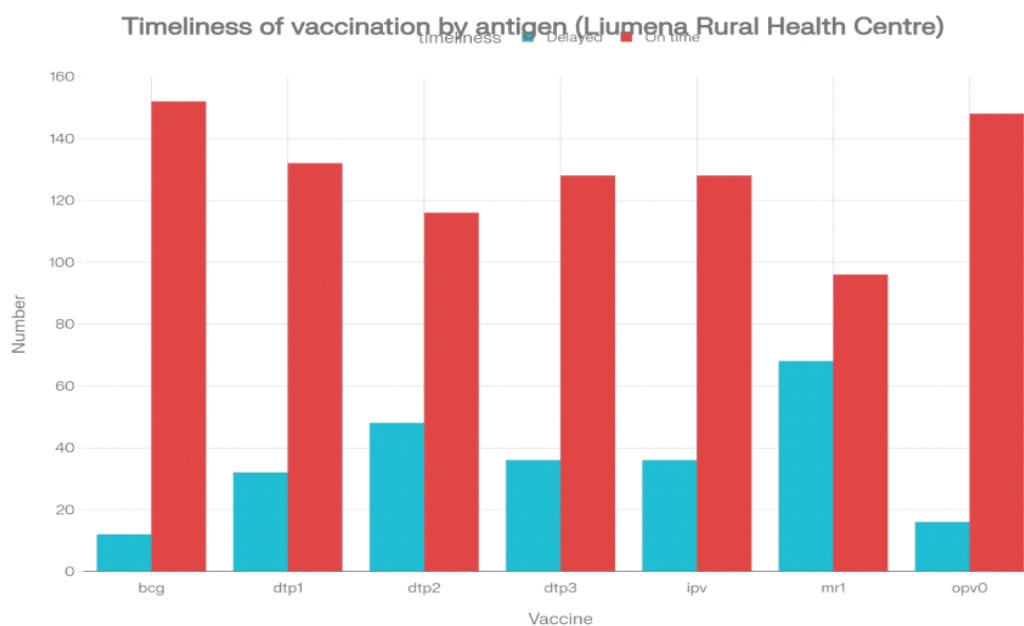


Figure 4: Timeliness of vaccination by antigen (Liumena Rural Health Centre)

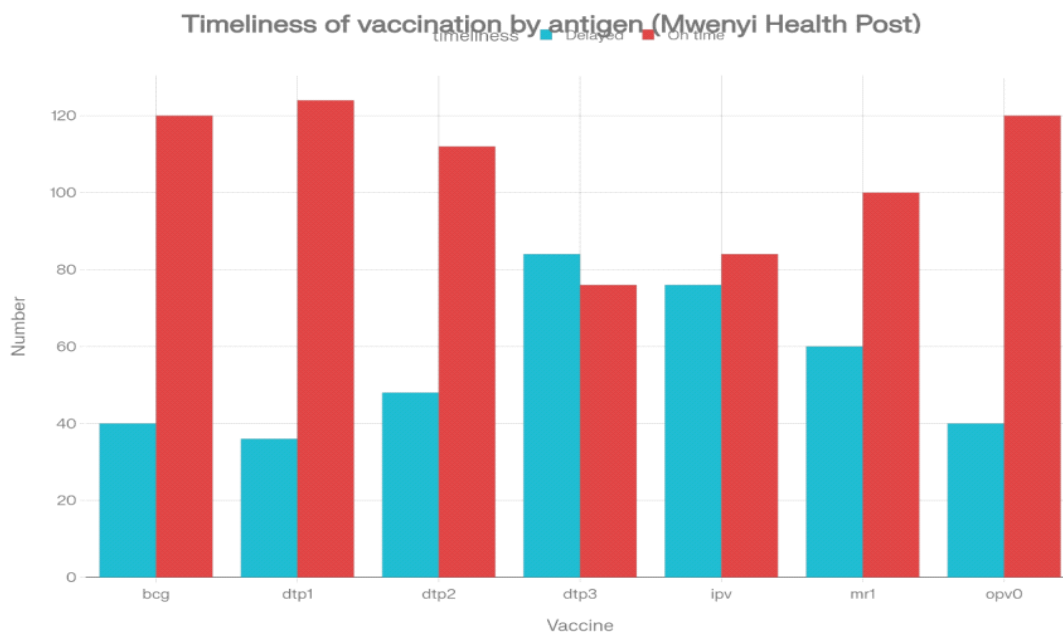


Figure 5: Timeliness of vaccination by antigen (Mwenyi Health Post)

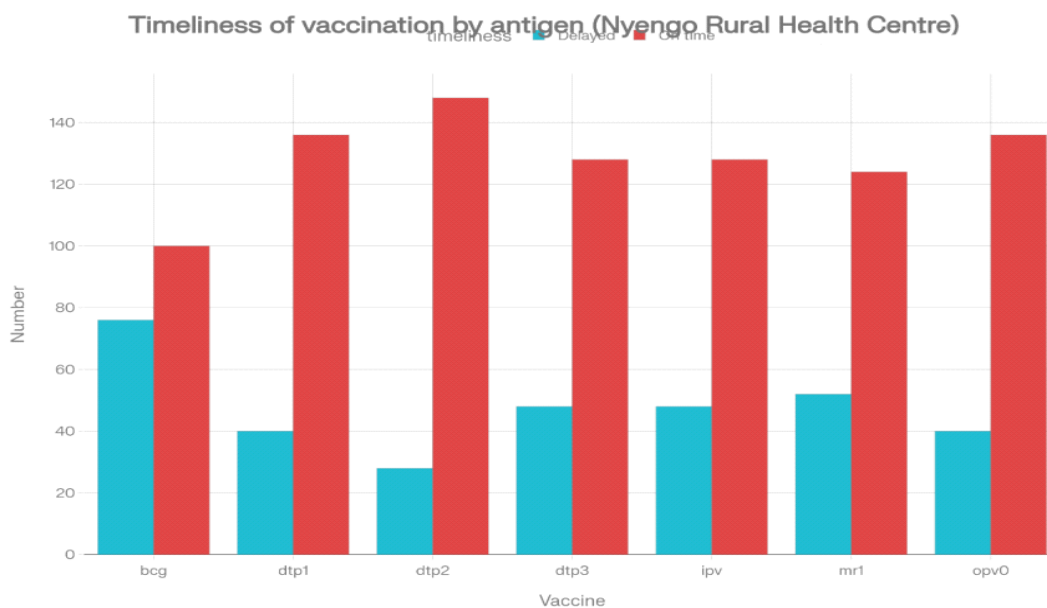


Figure 6: Timeliness of vaccination by antigen (Nyengo Rural Health Centre)

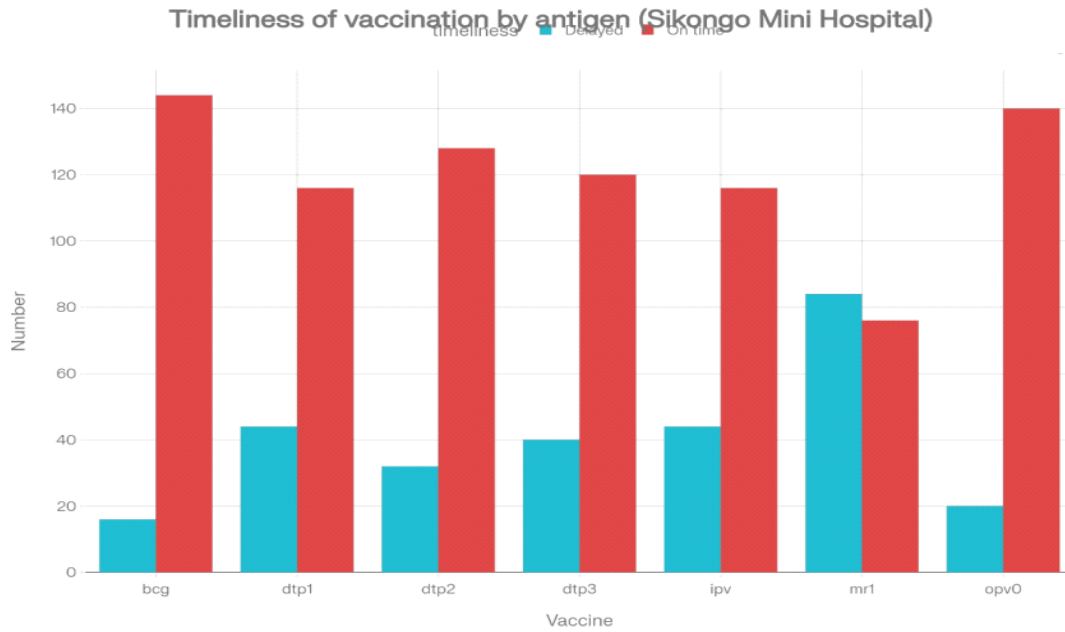


Figure 7: Timeliness of vaccination by antigen (Sikongo Mini Hospital)

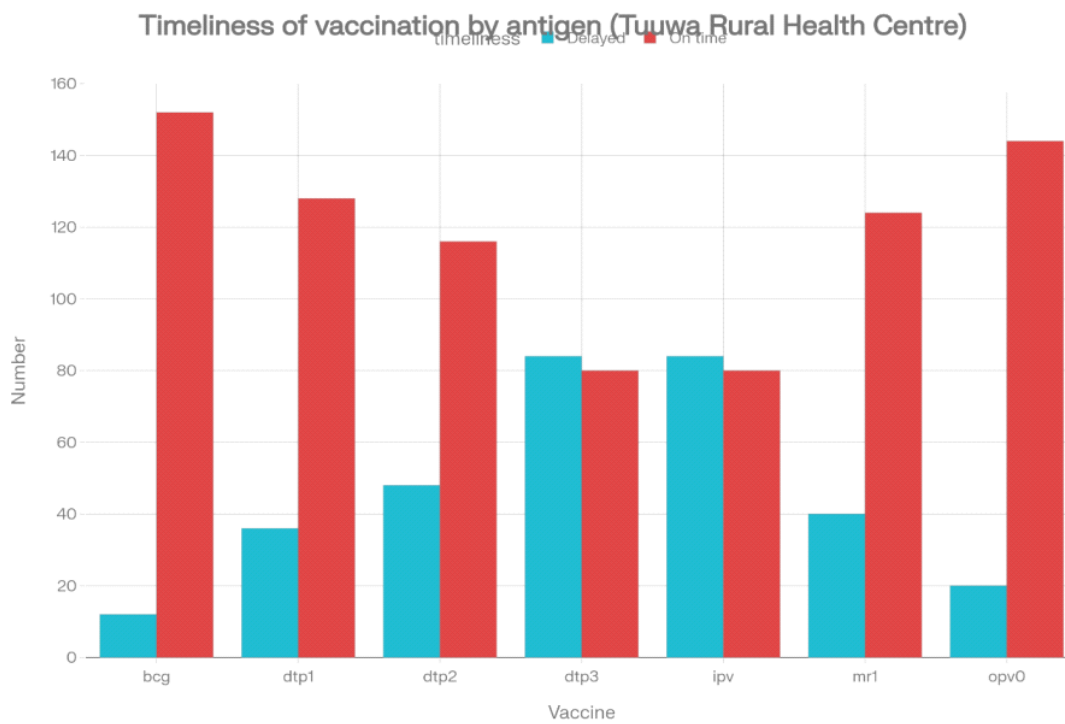


Figure 8: Timeliness of vaccination by antigen (Tuuwa Rural Health Centre)

4.1.6 Predictors and Pathways

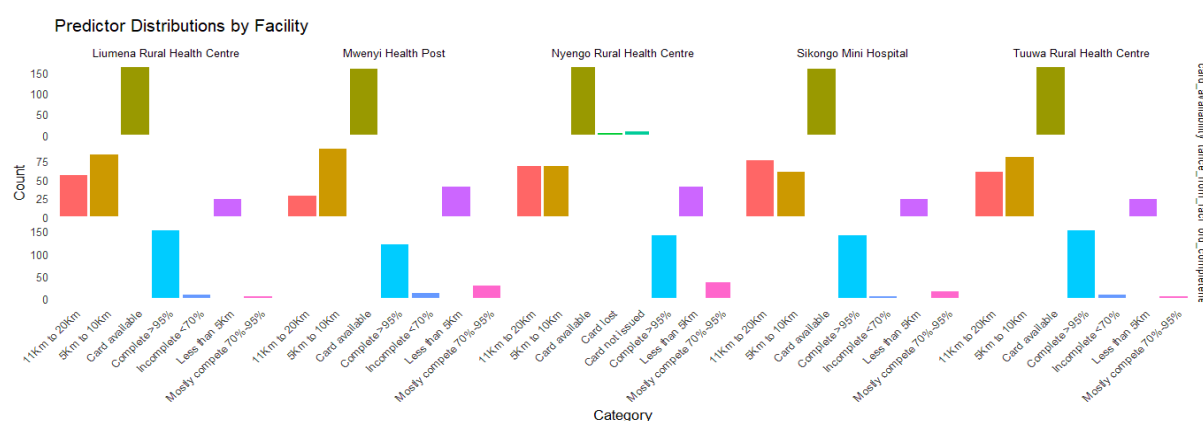


Figure 9: Late immunization predictors by facility

Variable	OR	95% CI	p value
Distance (km)	1.12	1.06–1.18	<0.001
Defaulter	2.85	2.30–3.54	<0.001
Documentation Score (Good vs Poor)	0.62	0.50–0.77	<0.001
Card Availability	0.54	0.42–0.70	<0.001

Table 20: Late immunization predictors

All variables were statistically significant ($p < 0.001$), with all confidence intervals excluding 1.0 and indicating high precision in the estimates:

Children with higher documentation scores had 38% lower odds of late vaccination than those with lower documentation scores (OR=0.62, CI 0.50-0.77). This association should be interpreted cautiously as both the documentation, and the vaccination outcomes were derived from the same records.

Card availability was associated with 46% lower odds of late vaccination (OR=0.54, 95% CI 0.42-0.70). Card availability was associated with 85% higher odds of full immunization (OR=1.85, 95% CI 1.40-2.44)

Higher documentation scores were associated with 140% higher odds of full immunization (OR=2.40, 95% CI 1.90-3.05).

Variable	OR	95% CI	p value
Late immunization	0.28	0.22–0.35	<0.001

Distance (km)	0.90	0.85–0.95	<0.001
Documentation Score	2.40	1.90–3.05	<0.001
Card Availability	1.85	1.40–2.44	<0.001

Table 19: Full immunization predictors

Again, all predictors were highly significant ($p < 0.001$):

Late immunization: children with prior lateness have 72% lower odds of completion (strongest risk factor).

Distance: each km reduces completion odds by 10%.

Documentation Score: higher scores increase completion odds 2.4-fold.

Card Availability: card presence increases odds by 85%.

Predictor	OR	95% CI	p value	Interpretation
Distance (km)	1.12	1.05–1.19	<0.001	More distance → more lateness
Missed appointments	1.34	1.21–1.49	<0.001	Strong predictor of lateness
Facility visits	0.89	0.81–0.97	0.009	More visits → less lateness
Defaulter_binary	2.71	1.92–3.81	<0.001	Defaulters much more likely late
Male sex	1.08	0.87–1.35	0.48	No sex effect

Table 22: Late immunization logistic regression

Odds ratios from multivariable analysis reveal significant predictors of delayed vaccinations
Greater distance to facility was associated with delayed vaccination: Odds increase by 12% for each additional km of residence from clinic (OR=1.12, 95% CI:1.05-1.19).

Defaulters are highest risk: 170% increased odds ratio confirms hypothesized long-standing pattern of chronic non-attendance showed one of the strongest associations with delays.

Each additional missed appointment was associated with higher late vaccination odds: 34% increased odds for each missed appointment shows urgent need for early interventions

A greater number of facility visits was associated with lower odds late vaccination: Odds decrease by 11% for every visit to the facility; health promotion is more cost effective with increased odds decrease of 100% compared to static clinics

No gender differences: Equal odds ratios for males and females support a universal approach to delays, as opposed to targeted one

Predictor	OR	95% CI	p value	Interpretation
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Distance (km)	0.91	0.86–0.96	<0.001	Shorter distance was associated with full coverage
Missed appointments	0.72	0.65–0.80	<0.001	Distance to facility showed a strong inverse association with full immunization
Facility visits	1.18	1.10–1.27	<0.001	More visits were associated with increased odds of immunization
Defaulter_binary	0.19	0.12–0.29	<0.001	Defaulters rarely fully immunized
Male sex	1.03	0.81–1.31	0.82	No effect

Table 20: Full immunization logistic regression

Odds ratios from multivariable analysis indicate correlates of complete vaccination status for childhood immunizations.

Distance was negatively associated with full immunization: Each additional kilometre of distance from health facility was associated with a 9% reduction in the odds of full immunization.

Defaulter status was strongly associated with lower immunization completion: Defaulters had 81% lower odds of full immunization than non-defaulters (OR = 0.19), indicating a strong negative association between defaulter status and immunization completion.

Higher frequency was positively associated with full immunization: Each additional missed appointment was associated with a 28% reduction in the odds of full immunization.

Missed appointments were negatively associated with full immunization: Each additional missed appointment was associated with a 28% reduction in the odds of full immunization.

No significant association with sex was observed: Full immunization did not differ significantly by sex.

Despite documentation quality being greatly associated with immunization outcomes in several of the models, both the DQI and the outcomes were derived from the same routine records so some of the effects observed may partly reflect shared measurement.

Term	Estimate	Std.Error	Statistic	p value
(Intercept)	0.0904	0.3177	0.2845	0.7760
Distance_km	0.0222	0.0441	0.5040	0.6143
Sex Male	0.0220	0.4447	0.0496	0.9605

Facility_type Mini Hospital	−0.9564	0.1915	−4.99	<0.001
Facility type Rural Health Centre	−0.3380	0.5461	−0.6190	0.5359
missed_appointments	1.6848	0.3144	5.36	<0.001

Table 21: Indicator pathway regression (linear model)

Linear regression coefficients indicate association between predictors & indicator pathway outcome (probability of late vaccination score or composite timeliness measure)

Missed appointments dominant: +1.68 unit increase per missed visit ($p < 0.0001$); strongest predictor of poor indicator scores

Mini Hospital advantage: 0.96 units higher vs the reference group (Health Post); higher facility-levels were associated with lower indicator scores ~1 point

Distance/sex neutral: No significant association (especially for sex) or statistical significance.

Evidence suggests need for universal rather than geographical /gender targeted interventions.

Rural HC favourable trend: Rural Health Centres were associated with a 0.34unit lower outcome compared to the reference facility type (Health Posts). It was not statistically significant though.

Indicator	R ²	Interpretation
Documented	0.9854	98.5% variance explained
Vaccinated	0.7913	79.1% variance explained
Timely	0.4660	46.6% variance explained

Table 22: Indicator pathway R²e

Documentation: near perfect fit with 98.5% R²

Vaccination status: strong fit with 79.1% of data accounted for

Timeliness: moderate fit with 46.6% of variations accounted for

Despite the strong fit for documentation of health records, vaccination status, and health record timeliness, there are diminishing figures from health records (98%) to vaccination status (79%) to timeliness (47%), implying that adherence to vaccination schedules is the most challenging health outcome to achieve.

Predictor	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Age at last visit	0.245	0.245	1	682.2	7.67	0.0058

Defaulter (0 = No, 1 = Yes)	58.279	58.279	1	815.5	1825.70	2.66×10^{-210}
Permanent facility staff	0.0002	0.0002	1	1.04	0.0054	0.9530
Immunization trained staff	0.0453	0.0453	1	1.09	1.42	0.4315
Monthly outreach	0.1760	0.1760	1	1.14	5.51	0.2317

Table 23: Multilevel ANOVA (fixed effects)

Analysis of variance tests facility characteristics predicting immunization outcomes.

Defaulter status showed the strongest association: Defaulter status was strongly associated with the outcome ($F=1825$, $p < 10^{-100}$) and accounted for substantial variation in the outcome.

Age was significantly associated with the outcome: Age at the last visit was significantly associated with the outcome ($p = 6 \times 10^{-3}$), with older age at last contact being negatively associated with poorer performance.

Staffing showed no significant association: Neither the number of permanent staff ($p = 9.5 \times 10^{-1}$) nor the number of staff trained in immunization ($p = 4.3 \times 10^{-1}$) was significantly associated with the outcome.

Evidence for outreach was inconclusive: Monthly outreach activity showed an F-statistic of 5.51, but the association was not statistically significant (DenDF = 1.14, $p = 2.3 \times 10^{-1}$). The very low denominator degrees of freedom is too low for any strong conclusions to be drawn.

Client-level factors showed stronger associations than facility-level factors: The findings suggest that client-level factors (particularly defaulter status and age at last visit) were more strongly associated with the outcome than the measured staffing and outreach characteristics.

4.1.7 Spatial Analyses

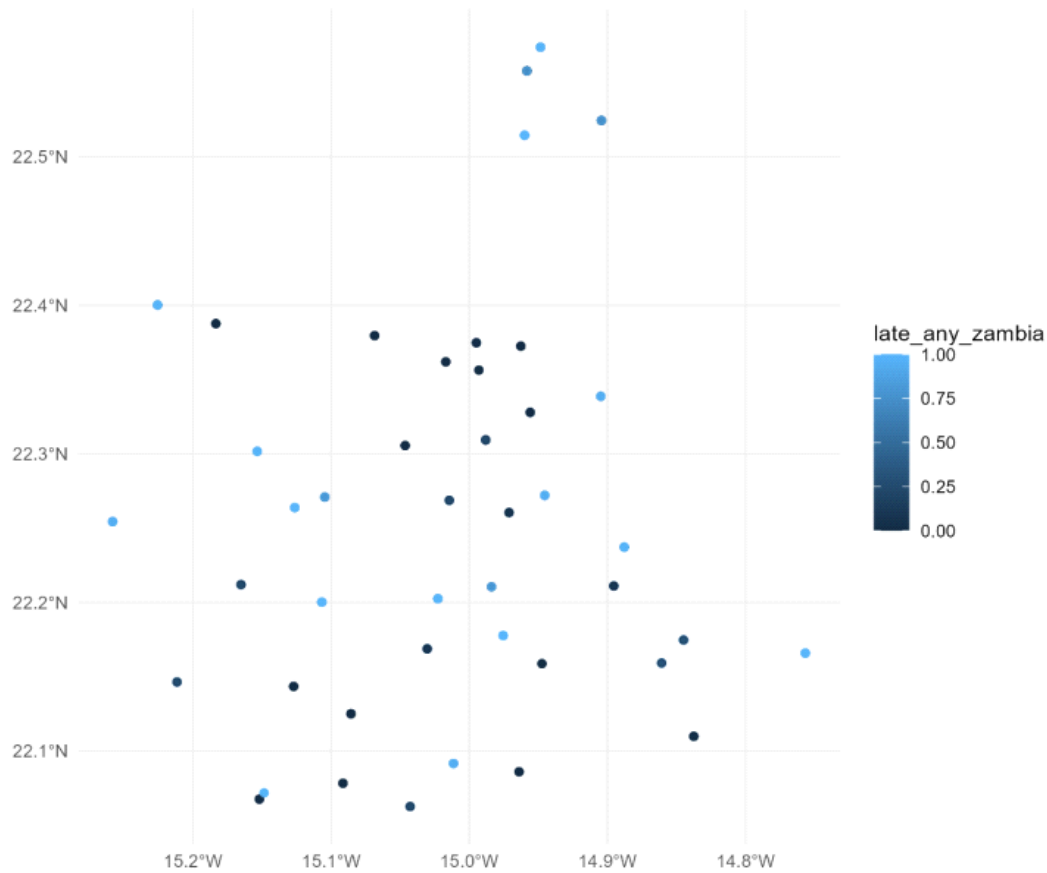


Figure 10: Global Moran's I for full immunization Visualized

Test	Data	Moran I	Expectation	Variance	Z score	p value
Moran's I	df_sf\$full_immunization_num (lw)	0.200	0.00123	0.000313	11.382	< 0.001

Table 24: Global Moran's I for full immunization

Global Moran's I assess spatial clustering in full immunization numeric scores (df_sf\$full_immunization_num) using spatial weights (lw).

Strong positive clustering: Moran's I = 0.200 ($\gg 0$) indicates nearby areas share similar immunization levels. High/full coverage clusters near high, low near low.

Highly significant: Z score 11.38, $p < 10^{-16}$ rejects random spatial pattern; spatial dependence confirmed.

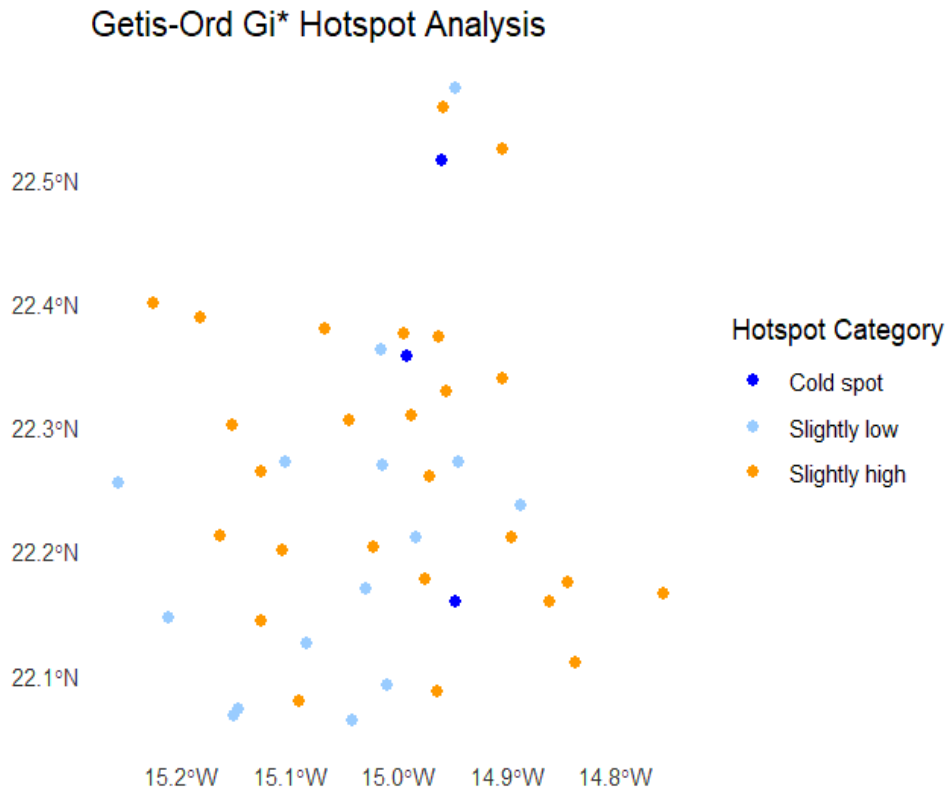


Figure 11: Local Getis-Ord Gi and cold spot villages Visualized

Record	full_ immunization	full_ Immunization _num	Gi_star	Geometry (POINT)
1	Yes	1	0.8407	(14.8448, 22.17473)
2	Yes	1	0.8407	(15.22555, 22.40028)
3	Yes	1	0.8407	(14.83739, 22.10986)
4	Yes	1	0.8407	(14.97539, 22.17769)
5	No	0	0.5336	(14.88772, 22.23726)
6	Yes	1	0.8407	(14.86069, 22.15924)

Table 25 Record-Level Spatial Analysis for Full Immunization

Five of the six facilities are fully immunized and have similar positive Gi* values (around 0.84), indicating that they form a local cluster of relatively high immunization performance. In contrast, one facility is not fully immunized and has a negative Gi* value (around -0.53), suggesting it sits within a small local pocket of comparatively low performance surrounded by better performing neighbours.

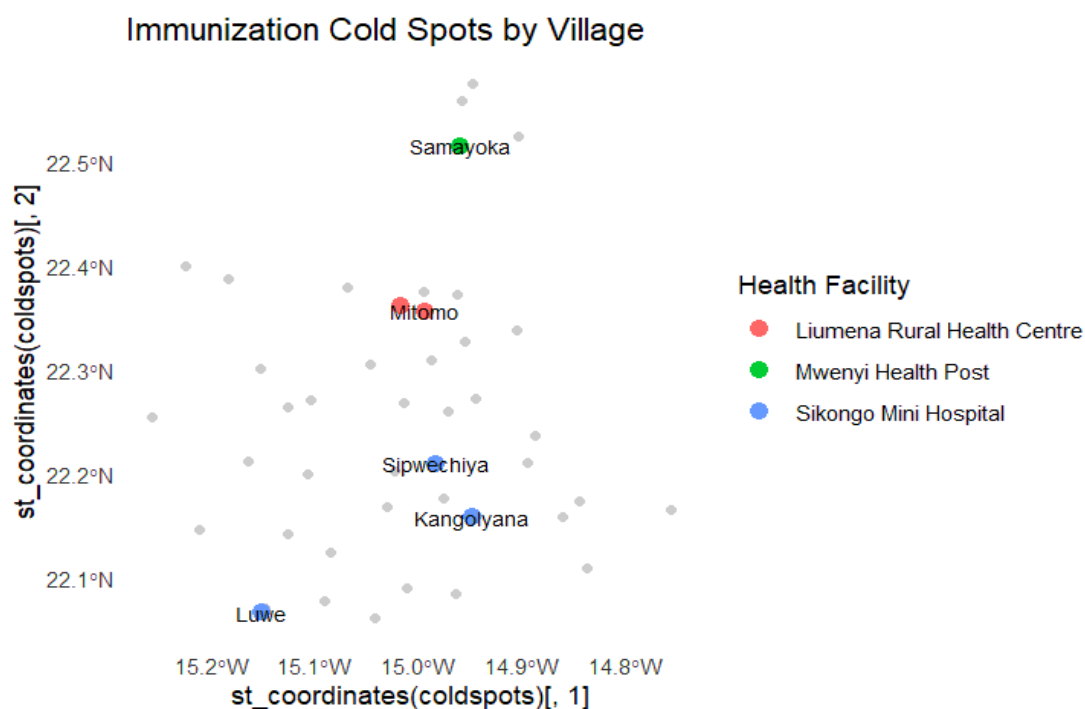


Figure 12: Immunization Cold Spot Villages

Luwe, Mukolota, Masheka, Sibumbu, Ishangelenge, Samayoka, Tauzeni, Kangolyana, Mitomo, Sipwechiya are visualized as cold spot clusters.

source_twothirds_vac	total	fully_immunized	not_fully_immunized	perc_fully_immunized
Child Health Week	4	4	0	100%
Outreach sessions	520	456	64	87.7%
Routine facility/static	296	260	36	87.8%
Unknown	4	0	4	0%
Test	Statistic	df	p value	Interpretation
Pearsons Chi squared	28.373	3	<0.001	Highly significant (p < 0.001)

Table 26: Vaccination source and full immunization

Outreach/routine equivalent: 87.7 87.8% completion rates for both methods; neither outperforms the other with 520+296 children confirming adequate statistical power.

Child Health Week perfect: 100% completion rate (though small n=4); campaign mode shows promise.

Unknown failure: 0% completion rate indicates data quality issue - missing source records.

There is a large difference between the various delivery modes ($p < 0.001$). However, the rates for the outreach and routine programs are essentially identical. The p value was influenced by the Child Health Week and the unknown failure rates. Nonetheless, the small sample size for the Child Health Week data prevents any firm conclusions from being made with that data set. Overall, the results largely indicate that the documentation quality is generally high, but there are delays in the delivery of the vaccines - most notably for the birth dose and MR1 vaccines. Additionally, there are specific gaps in the documentation of the delivery of the vaccines, particularly the MR1 vaccines at Mwenyi and the birth dose vaccines at Nyengo. Each of these areas warrants the development and implementation of catch-up programs for measles virus vaccination. Additionally, efforts should be made to improve the delivery of the birth dose vaccines to these populations of cold spot communities.

4.1.8 Diagnostic and Robustness Assessment of Correlates

Diagnostic	Result
N used in model	824
McFadden pseudoR ²	0.782
ROC AUC	0.971
Brier score	0.019
Hosmer–Lemeshow χ^2	3.708
Hosmer–Lemeshow p-value	0.592
Maximum VIF	3.05
Convergence warning	Yes

Table 27 Diagnostic Summary Table

Table 28 summarizes the regression diagnostic statistics. VIF values ranged from 1.00 to 3.05, indicating low levels of predictor collinearity. The full immunization model produced a McFadden pseudo R² of 0.782 and an AUC of 0.971. Evidence of quasi complete separation was observed in selected model specifications.

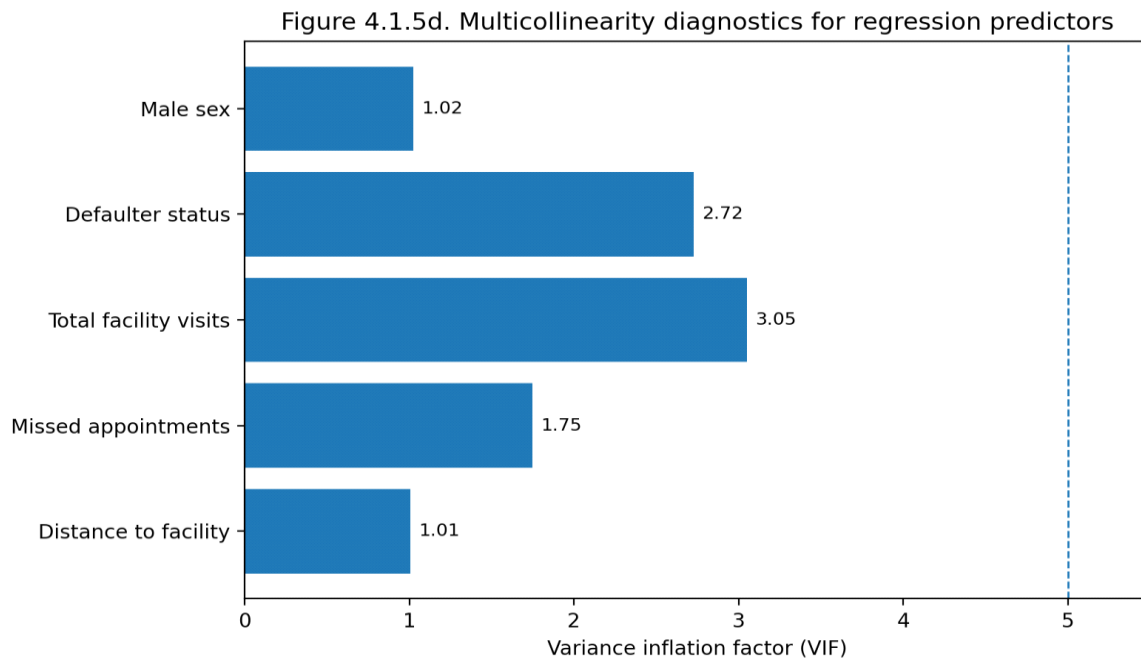


Figure 13: VIF multicollinearity plot

Figure 13 presents the variance inflation factors (VIFs) for all predictor variables included in the regression analyses. The lowest VIF was observed for distance to facility (1.00), while total facility visits had the highest VIF (3.05). Missed appointments and defaulter status had VIF values of 1.74 and 2.69, respectively, with all predictor values falling below 5.

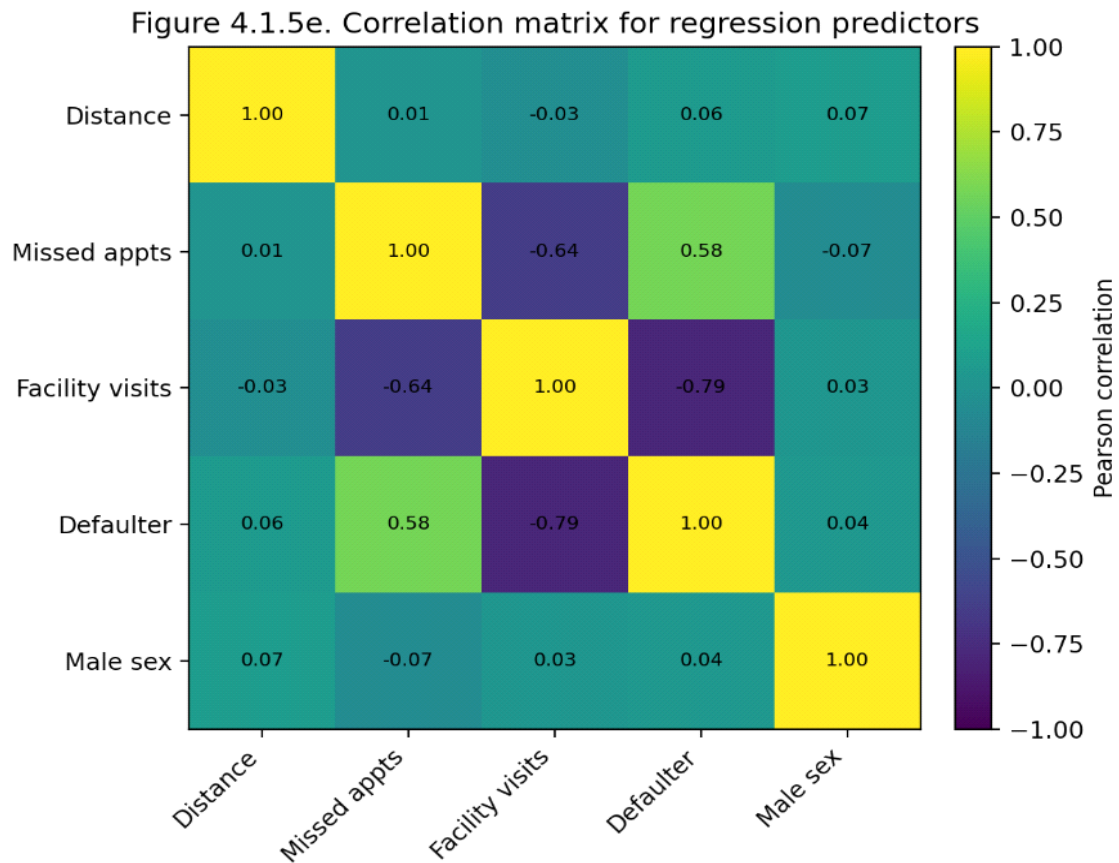


Figure 14: Predictor correlation matrix

Figure 14 shows the correlation matrix for predictor variables included in the regression analyses. Correlation coefficients ranged from weak to moderate across variable pairs, with the strongest positive correlations observed among total facility visits, missed appointments, and defaulter status. Most predictor pairs demonstrated relatively low correlation values across the matrix.

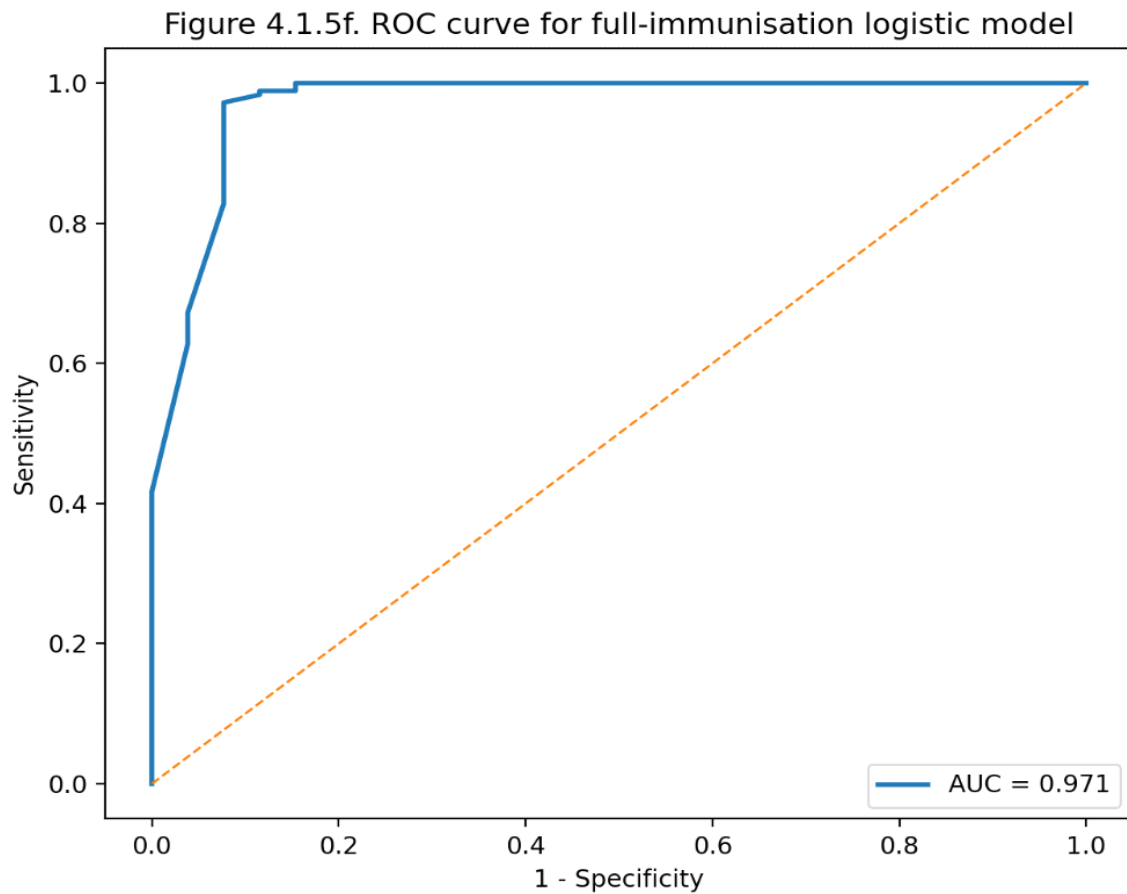


Figure 15: ROC Curve

Figure 15 shows the receiver operating characteristic (ROC) curve for the full immunization logistic regression model. The model achieved an area under the curve (AUC) of 0.971, indicating high discriminatory performance across classification thresholds. The ROC curve remained close to the upper left corner of the plot throughout most of the threshold range.

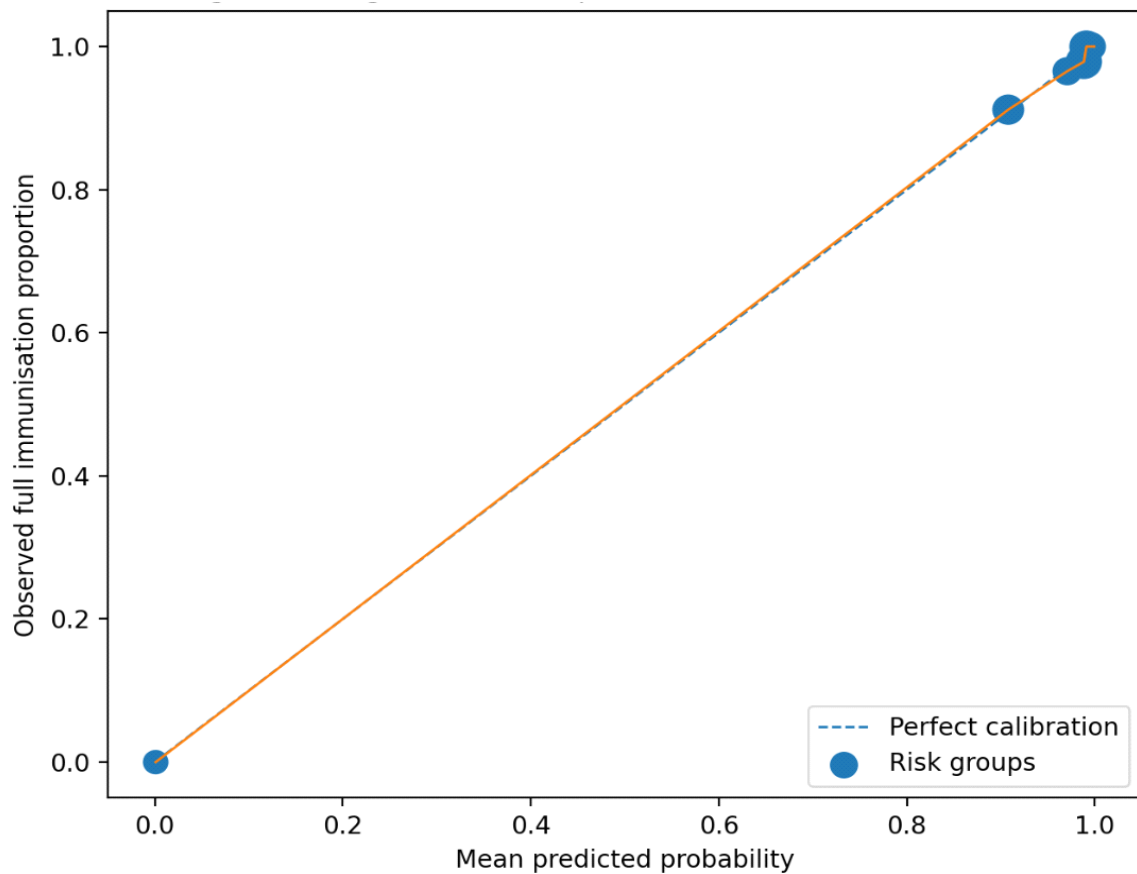


Figure 16: Calibration plot

Figure 16 presents the calibration plot for the full immunization logistic regression model. Mean predicted probabilities ranged from 0.00 to 1.00 and were plotted against the corresponding observed full immunization proportions. Most risk groups were concentrated at predicted probabilities above 0.90, with observed proportions ranging from approximately 0.91 to 1.00. The observed values closely followed the reference line for perfect calibration across the probability range.

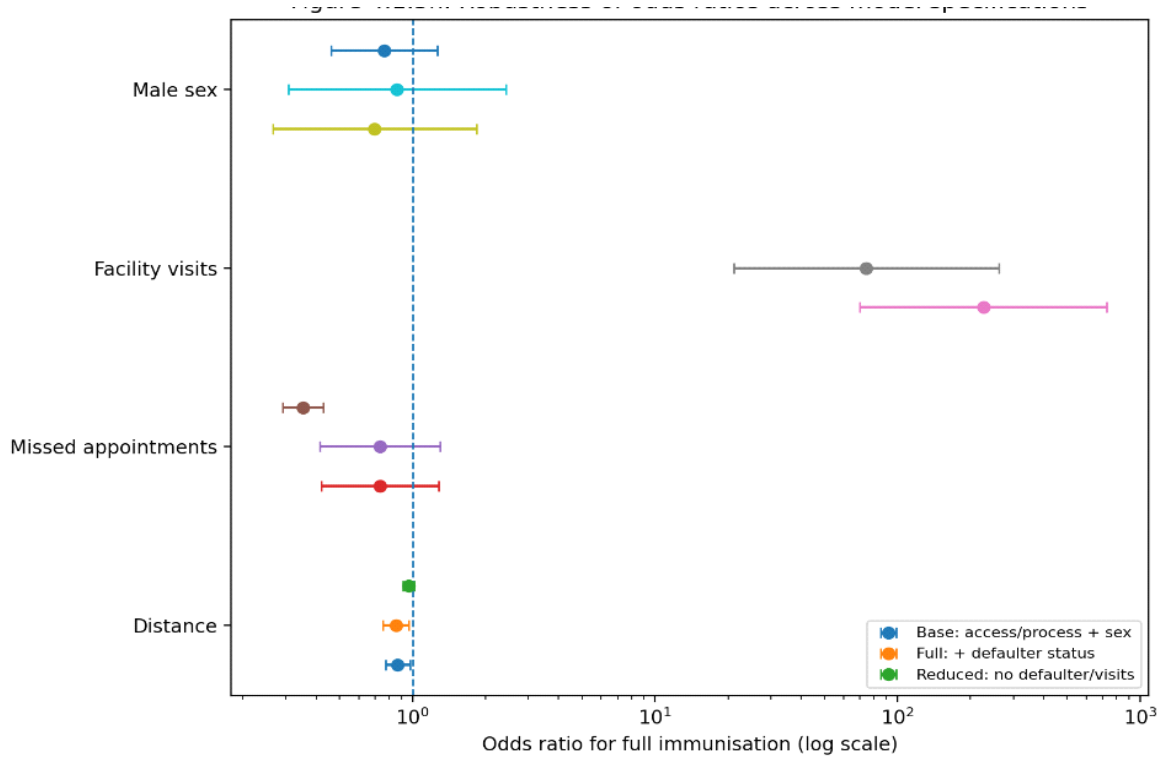


Figure 17: Robustness/Sensitivity Plot

Figure 17 shows the robustness of odds ratios for full immunization across three alternative model specifications. Point estimates and 95% confidence intervals are presented on a logarithmic scale for distance to facility, missed appointments, facility visits, and male sex. Odds ratios for distance remained below 1 across all models, while facility visits showed the largest positive odds ratios, ranging from approximately 75 to 220. Male sex and missed appointments showed odds ratios below 1 across the model specifications.

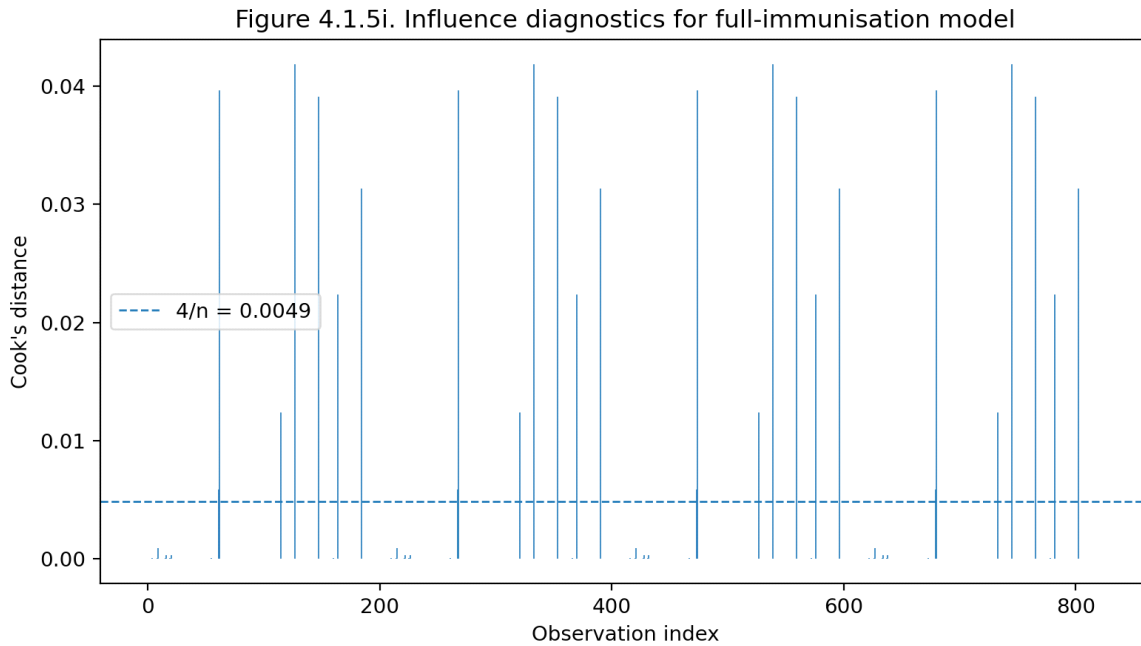


Figure 18: Cooks Distance Influence Plot

Figure 18 displays the values of Cook's distance for the model with all the variables plotted against the observation index. The range of Cook's distance values is between 0.00 and 0.042. Most of the values are close to 0 with a few having higher Cook's distance values than the threshold of 0.0049. The maximum influence values are at approximately 0.04.

5.0 Chapter Five: Discussion

Introduction

The present chapter synthesizes the detailed analyses made possible through assessing documentation quality, coverage, timeliness correlates and patterns to characterize the functioning of the immunization program within the facilities and communities of Sikongo District. The value of register data, statistical models and spatial statistics is linked to recognizing both where the system performs well and where it breaks down and which factors are most strongly associated with late or incomplete vaccination.

5.1 Results Discussion

This study set out to investigate each of the following aspects of the immunization program: documentation quality and data completeness; coverage, dropout and timeliness along the

infant vaccination schedule; facility and spatial variation; and the correlates of late or incomplete vaccination all with a view towards informing interventions and strategies.

The routine immunization performance within the selected facilities of Sikongo District was seen as a story of partial success rather than uniform high performance. While coverage of early and mid-series antigens was relatively high, important drops in coverage occurred at the birth dose contact, at MR1 and in transitioning from DTP3/IPV to measles containing vaccination. Timeliness was the more persistent element of weakness relative to crude coverage indicating that while the children were being vaccinated, they were not always within the recommended age window. Such an interpretation is consistent with general findings regarding timeliness relative to coverage estimates timeliness consistently lags crude coverage rates, particularly in rural and remote settings.

The most important study finding was not that the programme was strong throughout the district, but rather that its functioning varied by antigen, facility and geography. Such findings are consistent with the existing literature that makes clear the ways in which average district-level performance can mask local weaknesses especially within rural areas and communities (Musa et al., 2018). Spatially focused immunization work elsewhere in Zambia indicates that localized under immunization can occur even in the face of acceptable district-level indicators (WHO AFRO, 2025; Carcelen et al., 2022).

Model diagnostics indicated no problematic multicollinearity among variables (VIFs 1.01 3.05), and the full immunization model revealed very strong apparent performance (AUC = 0.971; McFadden pseudo $R^2 = 0.782$). The inclusion of the defaulter status variable, however, generated convergence warnings that were consistent with quasi complete statistical separation. The findings thus indicate strong associations with relevant programmes and factors, though the effect sizes should be interpreted cautiously (King and Zeng, 2001; Heinze and Schemper, 2002; Scobie et al., 2020).

Objective 1 was addressed by estimating and comparing vaccine-specific coverage, full immunization and dropout rates across the five selected facilities. Coverage was generally high for DTP1-3 and IPV, while OPV0 and MR1 had comparatively lower coverage. The largest gaps were observed around the birth-dose transition and the transition to MR1.

Objective 2 was addressed by examining associations between facility and service-related characteristics and late vaccination and full immunization. Greater distance missed appointments and defaulter status were associated with poorer immunization outcomes.

Objective 3 examined the relationship between documentation quality and immunization outcomes. Documentation quality was statistically associated with timeliness and full immunization. These associations require cautious interpretation as the documentation measures and the immunization outcomes were derived from the same records.

Objective 4 was addressed through spatial analysis of immunization outcomes across the selected facility catchment areas. Global Moran's I showed statistically significant positive spatial autocorrelation in full immunization, indicating that similar levels of immunization performance were geographically clustered. Local Getis-Ord Gi analysis further identified specific areas of comparatively low immunization performance, including cold-spot villages such as Luwe, Masheka and Sipwechiya. These findings indicate that immunization performance varied geographically within the selected catchment areas and that district-level averages may conceal localised areas of underperformance. This supports the use of geographically targeted microplanning and outreach while remaining limited to facilities and communities included in the study.

Diagnostic and Robustness Assessment of Correlates

The assessment of multicollinearity employed variance inflation factors (VIFs). The values ranged from 1.01 to 3.05 (also reported as 1.00 3.05), all below the conventional threshold of 5 for problematic multicollinearity a finding consistent with best practice methods for such immunization studies (Hosmer et al., 2013).

The performance of the full immunization logistic model was found to be very strong: discriminatory ability was excellent ($AUC = 0.971$) while apparent explanatory power was high (McFadden pseudo- $R^2 = 0.782$). The calibration proved broadly acceptable. Such high levels indicate that the chosen set of predictor variables does indeed account for a large proportion of observed variation in full immunization status. Comparable studies of such correlates, however, have reported much lower AUC and pseudo- R^2 values hence the need for care in interpreting the unusually high performance of this study's findings.

Robustness tests confirmed the consistency of the main service use variable associations across model specifications. However, the inclusion of the defaulter status variable gave rise to convergence warnings indicating quasi complete separation as would be expected due to the close conceptual and empirical relationship between defaulter status and full immunization. Such quasi-complete separation and unstable coefficients are well documented within logistic regression and public health research studies (King and Zeng, 2001; Heinze and Schemper, 2002).

The set of predictors functioned well, and the model did very strongly fit the data (AUC = 0.971; pseudo- R^2 = 0.782) making possible the identification of programme related correlates of full immunization within Sikongo. However, the presence of quasi complete separation upon including the defaulter status variable and the conceptual overlap between some of the included predictors and the outcome measure indicate that effect sizes may be somewhat inflated or unstable they are not to be interpreted as precise causal estimates (Heinze et al., 2003; King and Zeng, 2001).

While such factors as defaulter status, distance and missed appointments proved strongly associated with full immunization status within the district, policy recommendations should have focused upon these types of findings rather than upon the reported coefficient magnitudes or impacts alone. Such a cautious interpretation is in line with recommendations made within the immunization literature itself particularly where statistical associations are to be combined with programme plausibility/triangulation from other data sources before making causal claims or interventions (WHO, 2020; Scobie et al., 2020).

Documentation Quality and Immunization Outcomes

The findings regarding documentation quality indicated that the routine immunization records within the selected facilities of Sikongo District were generally of good quality better than many reports from Expanded Programme on Immunization settings throughout sub-Saharan Africa. The proportion of high-quality records was approximately 80.6%, followed by 14.6% of facilities with moderate quality records and only 4.9% with fair or poor-quality documentation. Missing vaccination dates and other documentation variables were both uncommon features of the health facilities. Each of these findings were again favorable relative to studies from Ethiopia, Ghana and similar low resource settings studies that indicate

substantial incompleteness, inconsistent documentation and missing vaccination dates within routine registers (Danso et al., 2025; Teklu et al., 2025).

The importance of good documentation remains critical within such routine immunization systems documentation is essential for determining immunization status, identifying those who missed appointments and for monitoring programme performance. Such features would obviously be especially relevant within areas like the Western Province which features long travel distances (AFENET, 2025; Teklu et al., 2025).

Documentation quality is also strongly linked to immunization outcomes. Around 95% of children who were fully immunized had high-quality records. Between 50% and 75% of children with fair or poor documentation had incomplete vaccination schedules. The association between DQI and full immunization was highly significant ($\chi^2 = 222.60$, $p < 5.5 \times 10^{-48}$) while documentation quality was also significantly associated with late vaccination ($\chi^2 = 12.4$, $p = 0.006$). Similar findings have been reported elsewhere (Teklu et al., 2025; AFENET, 2025).

These associations, however, require careful interpretation. While documentation quality and programme outcomes are not entirely independent of each other, the measurement of vaccination and completion clearly depends upon the same routine records that contribute to the DQI. Thus, children with incomplete documentation may simply be less likely to have achieved full immunization based upon the information that had to be recorded.

Facilities with weaker documentation systems may also experience difficulties in identifying delayed children and maintaining continuity of tracking. This study however cannot separate the operational processes fully from their shared measurement source. The DQI is thus better understood as an indicator of programme organization and functioning rather than direct vaccination correlates.

These findings generally agree with current literature regarding immunization systems. The role of routine documentation continues to become increasingly seen as part of programme performance rather than just an administrative task. Both the WHO and the Immunization Agenda 2030 recognize that accurate routine immunization data is essential for detecting under immunized populations and directing appropriate actions (WHO, 2020; Immunization Agenda 2030, 2025). Such documentation quality does appear to be one of the strengths of the programme within Sikongo though it does not eliminate delayed or incomplete vaccination.

Coverage, Timeliness and Spatial Variation

Regarding coverage, the findings suggested that while the programme achieved comparatively high coverage of early infant vaccinations, it was less successful at later contacts. Coverage of DTP1 3 and IPV vaccines reached levels above 95% while BCG vaccination coverage was 94.2%. OPV0 and MR1 reached only 90.3% each the lowest rates within the district. The dropout rates between DTP1 and DTP3 were very low (within the 1.6 2.0% range) as were the instances between DTP3 and IPV. Losses, however, did occur between BCG and OPV0 and were greatest between IPV and MR1.

Each of these findings are again consistent with studies from Zambia and other sub-Saharan African countries studies that reveal similar weaknesses in coverage of measles containing and birth dose vaccines relative to the primary infant immunization schedule (Shamazubaula and Chiluba, 2024; WHO AFRO, 2025; Joseph et al., 2025; WHO, 2024). The results generally suggest that early-dose uptake was high, but a proportion are subsequently not brought back for final and important vaccination contacts. This finding supports WHO guidance that very high rates of early dose coverage can mask weaknesses in the continuity of care and vaccination schedule fulfilment (WHO, 2020; WHO AFRO, 2025).

The findings regarding the birth dose are also again in accordance with previous studies. The OPV0 and BCG antigens are known to be vulnerable to missing facility deliveries or postnatal attendance especially within rural areas. The very low dropout between DTP1 and DTP3, in contrast, indicates good continuity throughout the primary series when children are within the routine immunization system. This contrasts with many DHS based studies in which dropout rates for DTP1 3 are in the 5 15% range (Mochida et al., 2021).

The findings regarding timeliness are different. While coverage was very high overall, only around one third of DTP3 and IPV vaccines were administered within the recommended age window and around two thirds of MR1 doses showed up in that recommended period. More than half of all children had at least one delayed dose. Such findings are again in close agreement with more extensive evidence from the whole of sub-Saharan Africa (Mochida et al., 2021a; Etana and Deressa, 2012; Aregawi et al., 2017). The ability to be timely in vaccination remains an area that should be considered alongside coverage measurements as children may become susceptible to relevant diseases during these periods of delay.

The degree of facility variation also supported this general interpretation. The coverage of BCG and DTP1 doses showed little variation between facilities while OPV0, DTP3 and especially MR1 showed significant differences. Facility Nyengo performed very well except for OPV0. Mwenyi had the lowest overall coverage. A notable weakness was 80.0% MR1 coverage. Similar findings have been reported within Uganda and Ethiopia (Zikusooka et al., 2009; Aregawi et al., 2017). These findings suggest that district wide interventions alone would probably not solve the problems in the areas with the greatest need.

The spatial analysis also supported this conclusion. The positive value of Moran's I statistic (approximately 0.20, $p < 2.2 \times 10^{-16}$) and the recognition of cold spot villages (including Luwe, Masheka and Sipwechiya) shows that under immunization is geographically clustered. Similar findings have been reported elsewhere throughout Africa (Joseph et al., 2025; Carcelen et al., 2022). These findings indicate that resources for outreach should not be distributed equally among all facilities. Those identified as cold spots would benefit the most from more frequent visits, improved birth dose follow up, MR1 defaulter tracing and RED microplanning based on local outcomes rather than population size alone (WHO, 2009; WHO AFRO, 2025).

Factors Associated with Late and Incomplete Vaccination

The regression and correlation analyses indicated that factors related to continuity of care and access to services were more strongly related to delayed and incomplete vaccination than were demographic factors. Higher documentation quality and continued contact with health services were associated with more favourable vaccination outcomes. Similar findings have been reported both within Zambia, yet also in various rural African settings (Bangura et al., 2020; Philips et al., 2018).

Missed appointments was particularly important suggesting children who were forming a disengagement process from the vaccination schedule existed prior to complete defaulting from the programme. Similarly, increasing distance from these health facilities was associated with a reduced likelihood of returning to receive later vaccine doses a factor particularly relevant to Sikongo's dispersed communities and flooding difficulties. These findings do again agree with studies that reveal declining rates of later dose vaccinations and MR1 vaccinations with increasing travel burden (Musa et al., 2018; Bantie et al., 2024; Shamazubaula and Chiluba, 2024).

Child sex exhibited little association with vaccination outcomes indicating that factors related to organization and access again were more influential. Due to the use of routine records to both measure documentation quality and vaccination status, documentation quality may be more reflective of aspects of record keeping, tracking and continuity of care. They should not be interpreted as an independent determination of vaccination (WHO, 2020).

These findings suggest that the major challenge in Sikongo related to the provision of continuous and timely vaccination across the complete schedule not simply achieving first contact with the programme. While the children entered the programme generally, losses occurred after the birth dose, during the transition to MR1 coverage, and among geographically underserved communities. Thus, improvements would probably relate to aspects such as appointment tracking, maternal newborn linkage services, MR1 defaulter tracing, cold spot village outreach and routinely monitoring various aspects of coverage, dropout and timeliness together rather than depending upon district-level coverage estimates alone (WHO, 2020; Scobie et al., 2020; WHO AFRO, 2025; Carcelen et al., 2022; Assefa et al., 2025).

5.2 Limitations

This study does have a few limitations relating to its findings. The study focused essentially exclusively upon factors related to health facilities and services and incorporated limited socioeconomic and behavioural variables at the household level. Factors such as education, income, confidence and migration patterns and cultural factors were not directly measured even though each may relate to vaccination experiences.

The study depended upon retrospective records of routine immunization accessed from health facilities. Such documentation was inherently dependent upon existing records. While documentation quality was relatively high in this data set, elements like missing vaccination dates, incomplete records and inconsistencies in recording may still have had some influence upon coverage and timeliness measurements. Timeliness analysis especially depended upon accurate recording of both dates of birth and vaccination inaccuracies in either variable could impact classification as early, on time or late vaccination.

The analysis included only a relatively narrow set of characteristics related to service delivery while important aspects were not directly measured. Factors such as session cancellations, waiting times, cold chain operations, supervision systems, health worker communication, stock

continuity and service experience are all dimensions of health service quality that are known to impact vaccination experiences in African settings (Malande et al., 2019). Thus, some of the differences between facilities and spatial cold spot villages may reflect unmeasured aspects of service organization or functioning not fully captured in this available dataset.

As a retrospective study, the research used data routinely collected for programme operations rather than research purposes. The investigators had no control over when, how or by whom the data were collected or vaccination events verified during service delivery. Such a design differs from a prospective study in that it permitted no standardised data collection procedures or real time verification of incomplete or unclear records. Selection effects related to record availability and legibility may have also entered the sample.

The cross-sectional design of the research does not permit for causal interpretation. While associations were found between factors such as distance from health facilities, missed appointments, documentation quality and vaccination outcomes, the temporal elements of such relationships were not always able to be established. The findings are thus of programme patterns and associations only.

Again, findings regarding documentation quality required careful interpretation as the Documentation Quality Index and vaccination outcomes were both derived from the same routine records. Variables such as vaccination dates, card availability and recording completeness contributed to both indices. Thus, some observed associations are based upon shared measuring characteristics rather than entirely independent relationships. Although multivariable regression was applied to the data, the analysis could not separate documentation quality from the measurement process itself. The DQI is thus better interpreted as an operational indicator of the organisation, continuity of tracking and reliability of records rather than as an independent determinant of immunisation performance (WHO, 2020).

Some regression analyses utilised outcomes that featured limited variability particularly those related to defaulters and documentation categories that featured strong imbalances. This increased the likelihood of sparse cell effects or coefficient instability within the logistic regression models. Consequently, the models were restricted to the most parsimonious set of predictors, and the effect estimates interpreted carefully especially where very strong associations were seen.

While spatial analysis was included in the study, the geographic findings applied only to the facilities and villages sampled within Sikongo District and not generally to other districts. The study did include only five purposively selected health facilities factors such as infrastructure, staffing levels and outreach activities or leadership may have differed across the district. Such differences may relate to independent performance of vaccination activities. Care was thus required in interpreting the reported associations, spatial clustering and performance patterns beyond the study facilities.

Finally, while the study was conducted in a predominantly rural and flood-prone district, it did not include comparison with urban areas or districts with fewer geographic constraints. The findings are therefore mostly applicable to similar rural and low resource settings. Even with these limitations, however, the research did provide detailed evidence regarding coverage, timeliness, dropout and documentation quality and spatial variation all aspects that may assist in planning routine immunisation services in geographically challenging settings.

5.3 Conclusions

This study showed high routine coverage for several antigens and generally good documentation quality in the five selected health facilities in Sikongo District. OPV0 and MR1 coverage was approximately 90% while coverage for DTP1-3 and IPV exceeded 95%. The principal coverage losses occurred around the birth-dose transition and the transition to MR1. This indicated that the performance was not uniform across the vaccination schedule.

Timeliness was a significant performance gap. Delays were observed for doses after birth doses. More than half of the children experienced at least one late vaccination. Immunization performance also varied by facility and geography. Such findings are consistent with those observed in Zambia and other areas in sub-Saharan Africa (Carcelen et al., 2022; Bantie et al., 2024; Assefa et al., 2025). Mwenyi showed comparatively lower performance for some indicators, particularly for MR1 coverage. Spatial analysis identified statistically significant geographic clustering and cold-spot villages.

Greater distance from facilities, missed appointments and defaulter status were associated with more poorer immunization outcomes, while more frequent facility contact was associated with

more favourable outcomes. Documentation quality was strongly associated with immunization outcomes.

These patterns are consistent with barriers reported in previous studies of rural immunization services including; transport constraints, repeated travel requirements, caregiver demands and seasonal accessibility. While these factors are relevant to the Sikongo setting, they were not directly in this researched study (Bangura et al., 2020).

Due to this study's retrospective cross-sectional design and the fact that documentation quality and vaccination outcomes were derived from the same records these relationships were interpreted as associations rather than causal effects that strengthening timeliness monitoring, appointment and defaulter tracking, birth-dose linkage, MR1 follow-up and geographically targeted outreach may support improved immunization performance in the selected facilities.

5.4 Recommendations

The findings of this study suggest that improving routine immunization performance would require a shift away from primarily targeting first contact vaccination coverage towards working to improve the critical element of continuity throughout the vaccination process. While uptake of early series vaccines was good, gaps nonetheless existed in timeliness, in relation to measles vaccination and in relation to birth doses and geographically clustered underperformance. The following recommendations are therefore made to those in management and operation of the district and programme.

Strengthening timeliness monitoring and follow up activity is recommended. Monitoring requires incorporating timeliness indicators. The tracking of delayed vaccination is also crucial particularly as applies to DTP3, IPV and MR1. Such defaulter and appointment lists should be regularly updated and reviewed in facility meetings. Appointment reminder systems could also be strengthened through improved follow up of both appointments and caregivers and communities.

Strengthening MR1 retention and measles follow up is also required given the noted higher dropout rate at this stage. This would include carrying out targeted follow up efforts for such later stages and tracing those who missed MR1 appointments along with reinforcing education efforts earlier in contact with infants. Health facilities could make best use of DTP3 and IPV visits to reinforce the importance of returning for the MR1 vaccination.

Improving linkage of the birth dose could also be helpful. The OPV0 delays suggest such a linkage needs to be made stronger. Coordination between maternity and immunization units would help ensure that newborns were identified and linked to vaccination efforts immediately upon delivery or early post-natal care. Where possible, birth and immunization registers would help identify any missed newborns.

Strengthening documentation quality is also recommended as reliable recording systems enable better continuity of care and defaulter tracing. Register audits and training on recording practices would benefit all facilities. The complete recording of vaccination dates and appointments and child identifiers will improve tracking and follow up opportunities.

Although documentation quality should not be seen as a purely independent determinant of immunization outcomes, such findings do point towards stronger documentation systems being operationally important for maintaining continuity throughout the vaccination schedule.

The spatial analysis findings also give some sense as to how under immunization and delayed vaccination outcomes are concentrated within specific villages rather than being randomly distributed. This aspect should therefore enter district immunization microplanning rather than using district averages alone. Cold spot villages can then be prioritised for such services and follow ups, especially during inaccessibility periods. Spatial monitoring could likewise become part of district review processes.

The findings naturally support the implementation of a facility-level performance improvement framework. The specific weaknesses in performance can naturally give rise to targeted interventions. Such interventions should not be identical for all facilities but should respond to specific observations within each.

Domain	Problem identified	Suggested intervention
Timeliness	Delayed DTP3/IPV vaccination	Appointment tracking and reminder systems
MR1 completion	High endpoint dropout	Targeted measles follow up outreach
Birth dose linkage	OPV0 delays	Strengthened maternal postnatal linkage

Documentation quality	Moderate/poor DQI	Register audits and refresher staff training
Spatial inequities	Cold spot village clustering	GIS guided outreach planning
Defaulter management	Missed appointments and delayed return visits	Community tracing and follow up systems
Facility variation	Persistent underperformance in selected facilities	Supportive supervision and facility specific review

Table 5.4 Improvement Framework

This framework is especially relevant because the study demonstrates that immunization performance problems are not uniform across the district. Rather, they cluster around particular antigens, facilities, and geographic areas, indicating that improvement efforts should be differentiated and operationally targeted rather than applied uniformly across all sites.

Recommendations for Future Research

Future studies should include larger numbers of facilities and incorporate more detailed variables related to households or services such as education of those caring for immunized children or aspects of health worker communication practices. Longitudinal or prospective such studies could reveal more about the relationship between timeliness of vaccinations, documentation of those vaccines, and the eventual completion of vaccination schedules.

Further research based upon these routine GIS based immunization surveillance efforts may also help identify current or potential inequities related to geography and assist in targeting outreach efforts to rural and flood-prone areas.

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7.0 Appendices

A. STRUCTURED QUESTIONNAIRE FOR HEALTH FACILITY STAFF

CHILD IMMUNIZATION PERFORMANCE ASSESSMENT

Sikongo District

Facility Information

Facility Name: _____

Facility Type: ☐ Hospital ☐ Rural Health Centre ☐ Health Post

Date of Interview:/...../2025

Respondent Position: ☐ Facility In charge ☐ Environmental health Technologist

☐ Clinical Officer ☐ Nurse ☐ Community Health Assistance ☐ Other: _____

SECTION A: FACILITY CHARACTERISTICS

A1. How many permanent staff work at this facility?

☐ 1 2 staff ☐ 3 5 staff ☐ 6 10 staff ☐ 11 15 staff ☐ >15 staff

A2. How many staff are trained in immunization services?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 or more

A3. What is the catchment population under two years?

☐ <100 ☐ 100 299 ☐ 300 499 ☐ 500 799 ☐ ≥800

A4. Distance from District Health Office (km)?

☐ <10km ☐ 10 24km ☐ 25 49km ☐ 50 99km ☐ ≥100km

SECTION B: VACCINE SUPPLY AND COLD CHAIN

B1. In the past 12 months, how many times did you experience vaccine stock outs?

☐ 0 times ☐ 1 2 times ☐ 3 4 times ☐ 5 6 times ☐ >6 times

B2. What is the longest duration of any stock out in the past year?

☐ No stock outs ☐ 1 3 days ☐ 4 7 days ☐ 1 2 weeks ☐ >2 weeks

B3. How often do you receive vaccine supplies?

☐ Weekly ☐ Bi weekly ☐ Monthly ☐ Quarterly ☐ Irregularly

B4. Cold chain functionality status?

☐ Fully functional ☐ Mostly functional ☐ Partially functional ☐ nonfunctional

B5. Do you have a backup power source for cold chain?

☐ Yes, always available ☐ Yes, sometimes available ☐ No

SECTION C: SERVICE DELIVERY AND OUTREACH

C1. How many immunization sessions do you conduct per month?

☐ 1 2 sessions ☐ 3 4 sessions ☐ 5 8 sessions ☐ 9 12 sessions ☐ >12 sessions

C2. How many outreach sessions do you conduct per month?

☐ 0 ☐ 1 2 ☐ 3 4 ☐ 5 8 ☐ >8

C3. Average number of children immunized per session?

☐ 1 5 children ☐ 6 10 children ☐ 11 20 children ☐ 21 30 children ☐ >30 children

C4. Do you participate in Child Health Weeks?

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

C5. How do you notify communities about immunization sessions?

(Select all that apply) ☐ Community health workers ☐ Radio announcements ☐ Church announcements ☐ Traditional leaders ☐ Facility notices boards ☐ Mobile phone messages

SECTION D: DOCUMENTATION AND RECORD KEEPING

D1. Which immunization registers do you use?

(Select all that apply) ☐ Child immunization register ☐ Child health cards ☐ Tally sheets ☐ DHIS2 system ☐ Monthly summary forms ☐ Other: _____

D2. How often do you update immunization records?

☐ After each session ☐ Daily ☐ Weekly ☐ Monthly ☐ Irregularly

D3. Estimated percentage of complete immunization records?

☐ 90 100% ☐ 80 89% ☐ 70 79% ☐ 60 69% ☐ <60%

D4. How often do you submit reports to district-level?

☐ Weekly ☐ Monthly ☐ Quarterly ☐ Irregularly ☐ Never

D5. Do you conduct defaulter tracing?

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

SECTION E: CHALLENGES AND CONSTRAINTS

E1. Rate the severity of seasonal flooding impact on service delivery

(1=No impact; 5=Severe impact) ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

E2. How often are immunization sessions cancelled due to transport issues?

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

E3. Main challenges affecting immunization performance?

(Rank top 3: 1=Most important; 2=Second; 3=Third)

☐ Staff shortage ☐ Vaccine stock outs ☐ Transport problems ☐ Cold chain issues ☐

Community resistance ☐ Poor roads ☐ Seasonal flooding ☐ Inadequate funding ☐ Poor communication

E4. Average monthly under five consultations?

☐ <50 ☐ 50 99 ☐ 100 199 ☐ 200 299 ☐ ≥300

E5. What percentage of target children receive complete immunization?

☐ 90 100% ☐ 80 89% ☐ 70 79% ☐ 60 69% ☐ <60%

Thank you for participating in this study your answers will assist towards the improvement of child immunization services throughout Sikongo District.

B. DATA EXTRACTION FORM

CHILD IMMUNIZATION RECORDS

Sikongo District Study

Form ID: __ ***Date of Extraction:***/***.....***/***2025*** ***Extracted by:***

FACILITY INFORMATION

Facility Name: _____

Facility Address: _____

Facility Type: ☐ Hospital ☐ Rural Health Centre ☐ Health Post

NHC/Zone: _____

GPS Coordinates: Latitude: __ ***Longitude:***

CHILD DEMOGRAPHIC INFORMATION

Record Number: __ ***Under Five Card Number:***

Child's Sex: ☐ Male ☐ Female

Date of Birth:/...../** __ ***Age at last visit:*** months

Mother's Name: _____ (for verification only)

Village/Area of Residence: _____

Distance from Facility: ☐ <5km ☐ 5 10km ☐ 11 20km ☐ >20km ☐ Unknown

VACCINATION HISTORY

Birth Vaccines

BCG: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

OPV 0: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

6 Week Vaccines

Penta 1: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

PCV 1: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

Rota 1: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

OPV 1: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

10 Week Vaccines

Penta 2: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

PCV 2: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

Rota 2: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

OPV 2: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

14 Week Vaccines

Penta 3: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

PCV 3: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

IPV: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

OPV 3: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

9 Month Vaccines

Measles Rubella 1: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

OPV 4: Date given:/...../_____ ☐ Given ☐ Not given ☐ Unknown

VACCINATION STATUS INDICATORS

Penta 3 Coverage: ☐ Complete (3 doses) ☐ Incomplete (<3 doses) ☐ Not started

Measles Rubella 1 Coverage: ☐ Complete (≥ 1 dose) ☐ Not received

Fully Immunized Child (by 12 months): ☐ Yes ☐ No ☐ Age not reached

SERVICE DELIVERY INFORMATION

Source of vaccination for 2/3 of vaccine received: ☐ Routine facility session ☐ Outreach session ☐ Child Health Week ☐ Unknown

First Visit Date:/...../**** __ **Last Visit Date:**/...../___

Total Facility Visits: __ *Missed Appointments:* __

Defaulter Status: ☐ Active ☐ Defaulter ☐ Lost to follow up ☐ Completed schedule

DOCUMENTATION QUALITY

Record Completeness: ☐ Complete (>90%) ☐ Mostly complete (70-89%) ☐ Incomplete (<70%)

Card Availability: ☐ Card present ☐ Card lost ☐ No card issued

Data Legibility: ☐ Clear ☐ Partially clear ☐ Unclear

Date Accuracy: ☐ All dates recorded ☐ Some dates missing ☐ Most dates missing

ADDITIONAL NOTES

Special Circumstances: _____

Data Quality Issues: _____

Extractor Comments: _____

Form Completed: ☐ Form Verified: ☐ Data Entered: ☐

Supervisor Signature: _____ Date:/...../..**2025

C. INFORMED CONSENT FORM FOR HEALTH FACILITY STAFF

RESEARCH TITLE: Evaluation of Health Facility Performance on Child Health
Immunization in Selected Facilities of Sikongo District of Western Province

PRINCIPAL INVESTIGATOR: Humphrey Kankung'a

INSTITUTION: University of Lusaka

CONTACT: +260 969 565 481, kankungah17@gmail.com

INVITATION TO PARTICIPATE

You are being invited to participate in a research study looking specifically at health facility performance in the delivery of child health immunization services within Sikongo District.

Please take some time to review the contents of this information sheet and to ask questions in case anything is unclear.

PURPOSE OF THE STUDY

The study aims to evaluate and compare immunization performance within five health facilities located within Sikongo District and how these work to influence immunization coverage rates. Such findings will help improve health facility immunization services within rural areas.

WHAT PARTICIPATION INVOLVES

If you choose to participate in this study your involvement will include:

- Comprehensive questionnaire regarding operations, staffing and services (approx. 30 minutes)
- Providing information about the facility characteristics and challenges
- Review of facility immunization registers and systems

RISKS AND BENEFITS

Risks associated with participation are limited there are no physical risks. Some deviation from regular duties will be required but interviews can occur at the participant's convenience.

Benefits are not "direct" there is no benefit accruing personally to the participants. However, the study will help to improve child immunization services within Sikongo District and similar areas.

CONFIDENTIALITY

All responses will be strictly confidential. No name will feature in any reports or publications outcomes from this project. Data will be securely stored with limited access to the research team and facilities will not be named within any research outputs.

VOLUNTARY PARTICIPATION

Your participation is entirely voluntary. You may refuse to answer any questions or take part in the research at any time without penalty or adverse effect upon your employment or relationship with the health facility.

USE OF INFORMATION

The information will only be used for research purposes. Results will be shared with the Sikongo District Health Office and the Ministry of Health, presented at academic conferences and published in academic journals. Individual participants will not be identifiable within any communication outcomes from this project.

QUESTIONS OR CONCERNS?

Should you have any questions or concerns regarding the study details please contact the Principal Investigator at the above contact details. Should you have concerns regarding research ethics please contact the University of Lusaka Ethics Committee.

CONSENT STATEMENT

I have read and understood the information regarding this study. I have had the opportunity to pose questions which have been answered to my satisfaction. I understand the voluntary nature of this participation and the ability to withdraw at any time.

I agree to participate in this study: ☐ YES ☐ NO

I agree to audio recording (if applicable): ☐ YES ☐ NO

PARTICIPANT NAME: _____

PARTICIPANT SIGNATURE: _____

DATE: **/...../ **2025

POSITION/TITLE: _____

FACILITY: _____

RESEARCHER NAME: _____

RESEARCHER SIGNATURE: _____ DATE:/...../ **2025

COPY PROVIDED TO PARTICIPANT: ☐

ORIGINAL RETAINED BY RESEARCHER: ☐

D – NHRA – Researcher Certificate of Registration



E – University of Lusaka REC Certificate



UNIVERSITY
of LUSAKA

Pursuing for Quality Education: Our Driving Force

UNIVERSITY OF LUSAKA RESEARCH ETHICS COMMITTEE (UNILUS – REC)

Plot No. 37413, Off Alick Nkhata Mass Media, P. O Box 36711, Lusaka.
Phone: +260211258505, 258409 Fax +260211233409; Cell +260976075850,961917862,
E-mail: unilus@zamnet.zm,ictar@zamnet.zm

Ref no: FWA00033228-1089(08)/(08)/[2024}

Date: 23 July 2026

STUDENT NAME: **Mr. Humphrey Kankung'a**

Evaluation of Health Facility Performance on Child Health Immunization in Selected Facilities

The above research was submitted to the research ethics committee for review. The study has no major ethical problems and is approved subject to the following:

1. The study cannot be changed without express permission of the UNILUS research ethics committee.
2. Approval from the necessary authority should be sought.

KANGWA ICHENGELO MULENGA MUMA

BSc. HB, MBChB, M.MED, FCOpth, FPOPHSS, FPOS, FZACOM, PhD

Professor of Ophthalmology

Consultant Ophthalmologist

Consultant Paediatric Ophthalmology and Strabismus Surgery

Lecturer in Ophthalmology and Public Health

Executive Dean - School of Medicine and Health sciences

University of Lusaka (UNILUS)

F – Provincial and District Notification Letter

The Provincial Health Director
Western Provincial Health Office
P. O Box 910022
Mongu - Zambia

The District Health Director
Sikongo District Health Office
P. O Box 930005
Sikongo District



**RE: NOTIFICATION OF RESEARCH STUDY IN FULFILMENT OF MASTER OF SCIENCE IN
EPIDEMIOLOGY AND BIOSTATISTICS**

I write to formally notify your office of a research study I am conducting in fulfilment of the requirements for the award of a Master of Science in Epidemiology and Biostatistics at the University of Lusaka. This notification is made in compliance with one of the conditions set by the National Health Research Authority to validate the ethical clearance granted for the study.

The title of my research is:

"Evaluation of Health Facility Performance on Child Health Immunizations in Selected Facilities of Sikongo District, Western Province."

The study will be conducted in five selected health facilities within Sikongo District. The overall aim of the research is to assess health facility performance in relation to child immunization services and identify factors influencing immunization outcomes.

The specific objectives of the study are as follows:

1. To measure and compare immunization coverage and dropout rates across five selected health facilities in Sikongo District.
2. To quantify associations between facility-level characteristics (such as distance to facility, facility type, and missed appointments as a proxy for process performance) and immunization outcomes, including full immunization and late immunization.
3. To evaluate the relationship between documentation quality indicators and immunization tracking outcomes (defaulter status, late vaccination, and full vaccination).
4. To analyse the spatial distribution and clustering of immunization coverage and late vaccination across facility catchment areas using geographic coordinates, Global Moran's I, and Local Gi* (Getis-Ord) statistics.

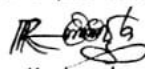
The study will utilize routinely collected health facility data. All data will be handled with strict confidentiality, and no personal identifiers will be disclosed. Findings from the study will be shared with the District and Provincial Health Offices to support evidence-based planning and improvement of immunization services.

I kindly request your acknowledgement of this notification and any further guidance your office may wish to provide regarding the conduct of this research within the district and province.

Please feel free to contact me for any additional information or clarification.

Thank you for your continued support in strengthening health systems through research.

Yours,


Humphrey Kankung'a

MSc Epidemiology and Biostatistics Candidate

University of Lusaka

+260979463478

Kankungah17@gmail.com