FACTORS AFFECTING AGE-APPROPRIATE TIMELINESS OF MEASLES VACCINATION AMONG CHILDREN AGED 9 TO 59 MONTHS IN REHOBOTH URBAN, HARDAP REGION, NAMIBIA

A THESIS

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ABSTRACT

Measles remains a significant public health concern among children, particularly in low- and middle-income countries, where high vaccination coverage may mask delays in vaccine administration. This study aimed to assess the timeliness and determinants of measles-containing vaccine (MR) administration among children aged 9–59 months in Rehoboth Urban, Namibia.

A convergent parallel mixed-methods design was employed to provide a comprehensive understanding of the issue. In the quantitative phase, an interviewer-administered questionnaire was used to collect data from caregivers on vaccine timeliness and associated factors. Quantitative data were analyzed using SPSS v.26, with Kaplan-Meier survival analysis, Fisher's exact test, Mann-Whitney U test, and logistic regression. Statistical significance was set at $p<0.05$, with a 95% confidence interval. In the qualitative phase, key informant interviews were conducted with healthcare workers, and data were analyzed thematically using Atlas.ti version 24.

The study revealed high measles vaccination coverage - 99.1% for MR1 and 88.6% for MR2. However, timely administration was suboptimal, with only 69.9% of children receiving MR1 and 31.3% receiving MR2 within the recommended age window. Multivariate analysis identified several significant predictors of delayed vaccination, including being aged 13–24 months (AOR = 4.54; 95% CI: 1.80–11.44; p = 0.001) and residing in blocks B (AOR = 3.85; 95% CI: 1.42–10.42; p = 0.008) and D (AOR = 5.07; 95% CI: 1.49–17.28; p = 0.009). Qualitative findings highlighted key barriers such as long waiting times at health facilities, caregiver forgetfulness, child illness at the time of scheduled vaccination, and geographic inaccessibility.

These findings underscore a critical gap between vaccination coverage and timeliness. Delayed administration of MR vaccines compromises herd immunity and heightens the risk of measles outbreaks. To address these challenges, the study recommends the implementation of electronic or manual reminder systems, community-based outreach services, and continuous caregiver education to promote timely vaccination and strengthen routine immunization performance.

Keywords: Measles vaccination, vaccine timeliness, immunization coverage, caregivers, healthcare workers

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND OR ACRONYMS

ANC	Ante Natal Care
AOR	Adjusted Odds Ratio
BCG	Bacillus Calmette Guerin
CI	Confidence Interval
DEC	Decentralized Ethics Commission
DHIS2	District Health Information System 2
EPI	Expanded Program of Immunization
HBM	Health Belief Model
IQR	Interquartile Range
MCV	Measles-containing vaccine
MCV 1&2	Measles-containing vaccines 1 and 2
MEAC	Ministry of Education, Arts and Culture
MMR	Measles, Mumps, Rubella
MMR1&2	Measles, Mumps, Rubella 1 and 2
MR	Measles-Rubella
MR1&2	Measles-Rubella 1 and 2
PCV	Pneumococcal Conjugate Vaccine
PMT	Protection Motivation Theory
PNC	Post-Natal Care

SPSS	Statistical Package of Social Services
WHO	World Health Organization

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DECLARATIONS

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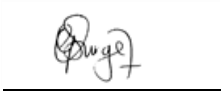
Gertruida F. Burger		October 2025
Name of student	**Signature**	**Date**

CHAPTER 1: INTRODUCTION

This chapter presents the study's background, problem statement, aim of the study, specific objectives, significance, delimitations, and definition of critical concepts.

1.1 BACKGROUND OF THE STUDY

Measles is a highly contagious, acute febrile disease caused by the measles virus primarily affecting children (1,2). The measles virus is transmitted through airborne droplets when an infected individual coughs or sneezes and can remain viable on surfaces for up to two hours (1,2). Characteristic symptoms include fever and generalized maculopapular rash accompanied by one or more of the following: cough, coryza (running nose), or conjunctivitis (1,2). Potential complications include pneumonia, severe diarrhea, otitis media, blindness, encephalitis, and mortality (3).

Although a significant reduction in measles cases and associated mortality was reported in 2023 compared to 2000 on a global scale, morbidity and mortality rates could be further diminished owing to the vaccine-preventable nature of measles, which confers lifelong immunity post-vaccination (4). In 2023, approximately 10.3 million measles cases were reported globally, resulting in an estimated 107,500 fatalities. The African region reported the highest incidence among all WHO regions, with an estimated 4.8 million cases and 75,942 deaths (5). Namibia experienced a steady decline in measles incidence from 2,698 cases during 2010-2016 to 113 cases during 2017-2023 (6). Nevertheless, the country has reported measles outbreaks in various regions in recent years: the Omusati Region in 2022, Kunene Region in 2023, and Erongo Region in 2024. Rehoboth District reported two confirmed measles cases in 2022, both occurring in the urban setting, whereas no cases were reported in 2023.

Regarding global measles-containing vaccine (MCV) immunization coverage for 2023, MCV1 coverage was 83% and MCV2 was 74%. In Africa, the coverage for MCV1 reached 70% and MCV2 49% in 2023 (5). In Namibia, MCV1 coverage was 91% in 2022 and 79% for MCV2 (6). In the Hardap Region, the MCV1 coverage was 78% in 2023. The MCV1 vaccination coverage in the Rehoboth district was 59% during the same period and 58% in the district's urban area (7).

The age-appropriate timeliness of measles-containing vaccination has not been systematically monitored at global, regional, or national levels as indicators of routine immunization performance. This is because of the absence of a universally agreed-upon definition of age-appropriate vaccine timeliness across international bodies, leading to ambiguity in determining timeliness (8). Over the past decade, numerous studies have been conducted globally to ascertain the magnitude of and elucidate the barriers contributing to age-appropriate timeliness of measles vaccination. The following statistics were published on age-appropriate measles-containing vaccination timeliness in high-income countries: China at 47.5%, Israel at 58%, and Belgium at 68% (9–11). In low- and middle-income countries, the age-appropriate timeliness for the first dose of measles vaccine was 67.5% in Uganda, 68.3% in West Cameroon, and 71% in South Africa (12–14).

Measles-containing vaccines are effective in preventing outbreaks of measles and rubella; consequently, the incidence of measles can be significantly reduced if these vaccines are administered in accordance with the recommended schedule. The literature indicates that measles outbreaks are susceptible to occurrence in populations lacking timely vaccination despite high routine vaccination coverage (10). Vaccination delays postponing full protection in children, compromises herd immunity, and expands the interval between the loss of protection from maternal antibodies and full

protection from vaccine-induced immunity (11). Transplacental immunity rapidly diminishes in the first year after birth. Therefore, timely immunization is crucial to ensure that children respond adequately, reduce individual susceptibility, and prevent disease outbreaks in communities (15). Untimely vaccination may result in children being vulnerable to vaccine-preventable diseases, with an outbreak potential for extended periods.

Various factors can influence age-appropriate timeliness, as identified through research, including the caregiver's failure to recall the child's appointment, the presence of a greater number of children in the family, and the child's birth order (16). Furthermore, a study conducted in China revealed that high maternal education levels and employment status are associated with an increased likelihood of delayed measles vaccination (16).

1.2 PROBLEM STATEMENT

According to the Namibian-adapted immunization schedule, Measles-Rubella one (MR1) is to be administered at 9 months of age and Measles-Rubella two (MR2) at 15 months of age; however, these vaccines can still be administered at any time after the due date up to five years of age. The routine immunization data collection tools only provide a provision to capture MR1 in two categories: under one year or above one year. It is not possible to determine if children below 1 year of age received their dose of measles vaccine in a delayed or timely manner. With regard to MR2, vaccine doses are captured under MR2 in the category above one year, without indicating whether the dose is timely or delayed. The routine data collection tools lack the ability to capture the exact age at which MR1 and MR2 vaccines are administered, making it difficult to determine whether vaccinations are received at the recommended ages.

Data extracted from the District Health Information System (DHIS2) on the children who received their MR1 dose after 12 months indicated that 16% (2022) and 7% (2023) of children in Namibia had a delayed first dose. In the Hardap region, 22% (2022) and 4% (2023) of the children received MR1 doses after 12 months of age. Additionally, in the Rehoboth district as well as in the urban setting, 7% (2022) and 3% (2023) of children received MR1 after 12 months in each setting (7). These data alone are insufficient to determine the true magnitude of the age-appropriateness of measles-containing vaccines.

Moreover, the Rehoboth district has not achieved the expected 95% measles vaccination coverage set by the WHO in the last three years. The MR1 vaccination coverage was 65%, 68%, and 59% in 2021, 2022, and 2023, respectively. The majority (87%) of the under-1-year-old population of the district resides in the urban setting, yet the MR1 vaccination coverage was 66%, 67%, and 58% in the last three years in this setting (7). These subnational coverages were affected by children presenting for vaccination outside of their age-appropriate timeframes. Suboptimal immunization coverage and untimely vaccination in children could increase the population of children susceptible to vaccine-preventable diseases (14).

As a result, the true magnitude of age-appropriate timeliness remains unclear. Furthermore, no local studies have been conducted in Namibia to investigate the factors contributing to delayed measles vaccination, limiting the ability to design context-specific interventions. This study was therefore conducted to establish the magnitude of age-appropriate measles vaccination and to explore the barriers to timely uptake in the Rehoboth urban setting against those identified by other researchers, as documented in the literature. The qualitative part of the study explored the perspectives

of healthcare workers regarding barriers to timely measles vaccination of children, which has only been conducted in two other studies in China and Ethiopia.

1.3 PURPOSE OF THE STUDY

This study aimed to investigate the factors influencing the age-appropriate timeliness of measles vaccination among children in Rehoboth Urban areas.

1.4 OBJECTIVES

1. To determine the magnitude of timely vaccination in children administered MR1 and MR2 vaccines.
2. To assess the barriers to timely vaccination of children with MR1 and MR2 vaccines among parents/caregivers.
3. To explore the perspectives of healthcare workers regarding barriers to timely vaccination of children with MR1 and MR2 vaccines.

1.5 SIGNIFICANCE OF THE STUDY

This study aimed to address the gap in the literature regarding age-appropriate timeliness and the factors influencing measles vaccination in the Namibian context by generating scientific evidence to facilitate decision-making and promote public health actions within the Expanded Program on Immunization (EPI) of the Ministry of Health and Social Services at all levels. Moreover, this study's significance is underscored by the potential of the public health community to utilize the findings for further research and educational purposes. Subsequent to this study, baseline information could be employed to educate caregivers on the importance of vaccination timeliness, while healthcare workers could implement recommendations to address barriers to ensure the timely vaccination of children.

1.6 DEFINITION OF KEY CONCEPTS

The following key operational definitions were used in this study.

Barriers are defined as factors or reasons that impede children from receiving measles-containing vaccines (14).

Vaccine coverage is defined as vaccine uptake measured without considering any timing measure (14).

Age-appropriate timeliness/vaccination timeliness refers to vaccines administered within a specified period following the recommended age of vaccination. MR1 timeliness was calculated from the first to the last day of 9 months, and MR2 timeliness from the first to the last day of 15 months (4).

Early vaccination was defined as vaccine administration before the first day of nine months for MR1 and the first day of 15 months for MR2 (4).

Delayed vaccination is a continuous measure of vaccine delay. MR1 refers to receiving the vaccine from the first day of 10 months and MR2 refers to receiving the vaccine from the first day of 16 months (14).

Due, but not late, refers to children who are eligible to receive the measles vaccine within the recommended timeframe, but have not yet exceeded the acceptable delay period. Given the substantial number of children in this category, its inclusion in the analysis was deemed essential for accurately assessing vaccination timeliness (14).

1.7 LIMITATIONS OF THE STUDY

The number of children per household per block was not available, hence the researcher used the number of households per block instead. Some of the sampled

households either did not have an eligible child or were uninhabited. However, the researcher replaced these households by continuing to sample households with eligible children until the sample size was reached. The data will not be generalized to the rural setting, as the settings vary.

1.8 DELIMITATIONS

The decision to limit the study to urban settings was predicated on resource constraints, specifically regarding the time and transportation expenses associated with accessing various farms in rural areas. Consequently, this study focused exclusively on the urban environment.

1.9 STRUCTURE OF THE THESIS

Chapter 1 provides an overview of this study, presenting essential information regarding its background, problem statement, purpose and objectives, significance, and delimitations. Chapter 2 focuses on the literature review, which examines and identifies knowledge gaps from various sources. Chapter 3 elucidates the research methodology, including the research design, data collection methods, and procedures employed by the researcher, along with the rationale for their application to the study. This study used a mixed-method approach. Chapter 4 presents the results of the study and emphasizes their implications. Chapter 5 discusses the study's findings and compares the evidence generated by other researchers in terms of similarities and differences. Chapter 6 presents the conclusions based on the findings of the study, as well as recommendations, limitations, and areas for future research.

1.10 SUMMARY

The background of this study is explained in the introductory chapter. This encompasses a concise overview of the researcher's rationale for conducting the current investigation. This chapter comprises the following components: the study's background, problem statement, purpose and objectives, significance, and delimitations. The following chapter primarily addresses the literature review.

CHAPTER 2: LITERATURE REVIEW

Chapter 2 provides a literature review and critical information regarding vaccine timeliness for measles-containing vaccines globally, in Africa and Namibia. The objective of the literature search was to identify relevant academic sources from academic databases and platforms, that provide background, context, and theoretical perspectives on the barriers to age-appropriate timeliness for measles-containing vaccines. Furthermore, it examines the factors influencing vaccine timeliness, as documented by other researchers, and elucidates the theoretical framework of this study.

2.1 AGE AT VACCINATION

Approximately 85-90% of children develop protective antibody levels following the administration of a single measles-containing vaccine dose in the first year of life, indicating that a subset of children may remain unprotected (17). Consequently, it is imperative to administer a second dose of a measles-containing vaccine during the second year of life. The provision of a second measles-containing vaccine dose serves the dual purpose of immunizing children who did not develop a protective immune response to the initial dose due to primary vaccine failure as well as vaccinating those who did not receive the first dose (17).

One of the most significant factors influencing a child's immunological response to MCV is the age at which vaccination occurs; older children frequently exhibit a more robust response than younger children. The mean age of infection and age-dependent increase in seroconversion rates following measles vaccination were considered when determining the optimal age for immunization (17). Consequently, in regions with high measles virus transmission, the mean age of infection tends to be lower, necessitating

earlier vaccination against measles than in areas with low measles virus transmission. The optimal age for vaccination must achieve a balance between the age-related increase in the risk of measles virus infection prior to immunization and age-related decrease in the probability of primary vaccine failure (17).

2.2 PASSIVELY ACQUIRED MATERNAL ANTIBODIES

The presence of passively acquired maternal antibodies confers protection to young infants during the initial months of life (17). These antibodies provide immunity against the wild-type measles virus. Furthermore, they impede immune responses to MCV by inhibiting replication of the attenuated vaccine virus, thereby limiting a robust immune response to the vaccine. Maternally acquired antibodies diminish over time and are no longer detectable in most children aged 6–9 months (17).

2.3 WORLD HEALTH ORGANIZATION RECOMMENDED MEASLES VACCINE SCHEDULE

The World Health Organization recommends that, in countries with ongoing transmission of measles, MCV1 should be administered at 9 months of age and MCV2 between 15-18 months of age, with a minimum interval of 4 weeks (18). Given that the majority of measles cases occur among non-vaccinated children older than 12 months, routine administration of MCV should not be restricted to infants aged 9-12 months for MCV1 and 15-18 months for MCV2. The WHO further recommends that all available opportunities be utilized to ensure that children who miss one or both routine doses of MCV receive vaccination (18). Each country can adapt its national immunization schedule in accordance with these recommendations. In Namibia, MCV1 is administered at 9 months of age and MCV2 at 15 months of age; however, delayed doses can still be administered upon first contact at any age prior to 59 months.

2.4 IMPORTANCE OF AGE-APPROPRIATE TIMELINESS

The significance of vaccination timeliness is increasingly being recognized and is emerging as a crucial indicator of vaccination coverage (11). While vaccination coverage reflects the quality of the vaccination program, timeliness ensures optimal protection for children (11). Insufficient measles vaccination coverage in the WHO African region creates favorable conditions for the occurrence of sporadic measles cases and clusters of measles outbreaks (19). The implementation of age-appropriate immunization schedules is of paramount importance in ensuring vaccine effectiveness against vaccine-preventable disease outbreaks (14). Several researchers have demonstrated that inadequate vaccination timeliness could lead to a resurgence of measles cases or vaccine-preventable disease outbreaks in high-, middle- and low-income countries, despite high vaccination coverage (10,11,13,20,21). Further research is necessary to elucidate the barriers to age-appropriate timeliness of measles vaccination, as high levels of vaccination coverage may obscure low levels of timeliness (8).

2.5 PREVALENCE OF MEASLES-CONTAINING VACCINE TIMELINESS IN PREVIOUS STUDIES

Age-inappropriate timeliness of vaccination appears to be a global phenomenon, as evidenced by both developed nations with more robust vaccination systems and developing countries facing challenges in maintaining stable vaccination programs due to conflict situations and resource constraints (8). A study conducted in Saudi Arabia reported that 85.9% of children received their measles dose in a timely manner, whereas 14.10% experienced delays. More significant delays were observed among children receiving MMR1 (measles, mumps, and rubella) at 12 months and MMR2 at 18 months, with rates of 25.5% and 23.2%, respectively (16). Research published in

Israel indicated that the timeliness of measles vaccination is only 58%, with 42% being delayed (9). Similarly, in Belgium, 68% of children received timely measles vaccine, whereas 32% received a delayed dose (11).

On the African continent, a study conducted in central Ethiopia revealed that only 44% of children received their first measles vaccine dose at an appropriate age, 20.9% received the measles vaccine earlier than the recommended national schedule, and 26% had a delayed dose (15). A South African study reported that 71% of children had timely uptake of the first measles vaccine dose, 6.7% had early uptake, and 22.3% had delayed uptake. Additionally, 29.3% of children received a second measles dose later than recommended (14). Furthermore, a study conducted in Uganda reported a vaccine timeliness of 67.5%, with 10.7% receiving the measles dose too early and 21.8% experiencing delays (12).

Although no studies have been conducted on the age-appropriate timeliness of measles-containing vaccines in Namibia, data extracted from the District Health Information System (DHIS2) indicated that 16% of children in 2022 and 7% of children in 2023 received a delayed dose of MR1 (7). It is not feasible to determine the number of children who received their first dose between 10 and 12 months of age, as they were aggregated in the under-one-year age group. In the Hardap Region, 22% (2022) and 4% (2023) of children received a delayed dose of MR1 after 12 months of age. Additionally, in the Rehoboth district and in the urban setting, 7% and 3% of children received an untimely dose of MR1 in 2022 and 2023 after 12 months of age, respectively (7).

2.6 FACTORS ASSOCIATED WITH DELAYED MEASLES VACCINATION

Understanding the factors contributing to the delayed uptake of MCVs may assist health ministries in developing targeted interventions to mitigate the impact of vaccine delays by parents/caregivers or the health system. In a study conducted in Saudi Arabia, forgetting a child's appointment was cited as the most common reason for delay, in addition to having a greater number of children in the family (16). Furthermore, according to a study performed in China on the barriers to age-appropriate timeliness, parents were unaware that vaccination was necessary, they were unfamiliar with the immunization schedule, they were concerned about the side effects of the vaccine, and their child was ill during the recommended period (10). This was corroborated by another study conducted in China in 2021, in which poor vaccination knowledge among primary guardians, weak vaccine confidence, and low degree of satisfaction with vaccination services were highlighted as reasons for low measles vaccine timeliness (22). In an Israeli study, delayed vaccination was associated with a high birth order, ethnicity, and children born in winter (9).

In an Ethiopian survey, 28.3% of respondents cited a lack of information as the primary reason for not adhering to the appropriate vaccination schedule, followed by 25.3% of respondents who feared adverse effects following immunization (15). Notably, in a study conducted in Malawi, a delay in measles vaccination was associated with living farther away from the road, living with more than five children, maternal farming, and non-facility birth (23). The upper-middle socioeconomic status of parents was found to contribute to vaccination delays in South Africa, which could be attributed to parents' inability to allocate time to their busy work schedules to take their children for vaccination (14). In a Ugandan study, barriers included having more than one child in the household, a child born outside the hospital, the child's household being poor, and the respondent being unmarried (12). Other barriers in low- and middle-income

countries that could be attributed to untimely vaccination include vaccine hesitancy, issues with access to healthcare services, or other socioeconomic factors (8).

2.7 FACTORS ASSOCIATED WITH MEASLES VACCINE TIMELINESS

Mothers who delivered in hospital settings exhibited 2.5 times higher odds of adhering to timely vaccination schedules for their children than those who opted for home births. Furthermore, maternal knowledge regarding child vaccination was associated with a threefold increase in the likelihood of timely immunization adherence as opposed to mothers with insufficient knowledge (15). However, a study conducted in Uganda revealed that maternal education was not an independent predictor of timely vaccination; despite 60% of mothers having attained secondary education or higher, only 65.7% of children received timely immunization (12).

2.8 GAPS IDENTIFIED IN PREVIOUS STUDIES

Various quantitative cross-sectional studies have been conducted worldwide on vaccine timeliness. Some studies were conducted on health facility-based records, such as registries (9,14), while others were community-based (10,12,13). Only two studies conducted in Ethiopia and China used a mixed-methods design (15,22). A mixed-method study design enables researchers to acquire deeper insights into existing barriers and document new barriers by incorporating the perspectives of healthcare workers, which was identified as a gap in a study conducted in China and Israel (9,10). The Israeli study primarily assessed sociodemographic factors and did not evaluate health-related variables; hence, we included a qualitative component to incorporate perspectives from healthcare workers (9). A South African study highlighted a gap in the reasons that upper-middle socioeconomic status could contribute to a delay in vaccination timeliness, which could be attributed to the demanding work schedules of

parents/caregivers (14). Including variables on socioeconomic status in the study will enable researchers to explore the reasons for providing evidence that could elucidate this barrier.

The acquisition of scientific information and knowledge pertaining to these barriers could contribute to the existing body of knowledge and inform district and national strategies to address these impediments and enhance timeliness of vaccination.

2.9 THEORETICAL FRAMEWORK

The theoretical foundation of this study on the factors affecting age-appropriate timeliness of measles vaccination among children draws upon two complementary behavioral theories: the Protection Motivation Theory (PMT) and the Health Belief Model (HBM). Both theories are rooted in expectancy-value principles, where motivation stems from the interaction between the value an individual ascribes to health outcomes and the expectation that a specific behavior will yield the intended result (24). Parents function as surrogate decision makers for their children in matters of immunization. Parental decisions are influenced by perspectives, beliefs, and opinions regarding vaccination (25).

According to the PMT model, behavior modification results from two critical processes. The first is threat appraisal, which evaluates an individual's perceived vulnerability to consequences and their severity. This study evaluated parental perception of the vulnerability of their children to measles disease and assessed parental understanding of the severity of measles disease and its potential consequences. In coping appraisal, the likelihood that a proposed course of action mitigates threat is considered. Expectations that follow this course of action involve challenges, psychological costs, and the individual's capacity to modify their behavior

(26). This study examined parental beliefs about vaccination effectiveness in preventing measles, perceived barriers, and their capacity to follow vaccination schedules.

A study conducted in China utilized the PMT and identified five categories: susceptibility to measles, severity of measles, benefit of measles-containing vaccines, barriers to vaccination, and knowledge of measles-containing vaccination (10). The following were found to be significant: barriers to vaccination, perception of susceptibility, and knowledge about measles-containing vaccination (10).

The HBM complements the PMT by providing additional constructs relevant to vaccination behavior, namely, modifying factors, individual beliefs, and the likelihood of action, as illustrated in Figure 1.

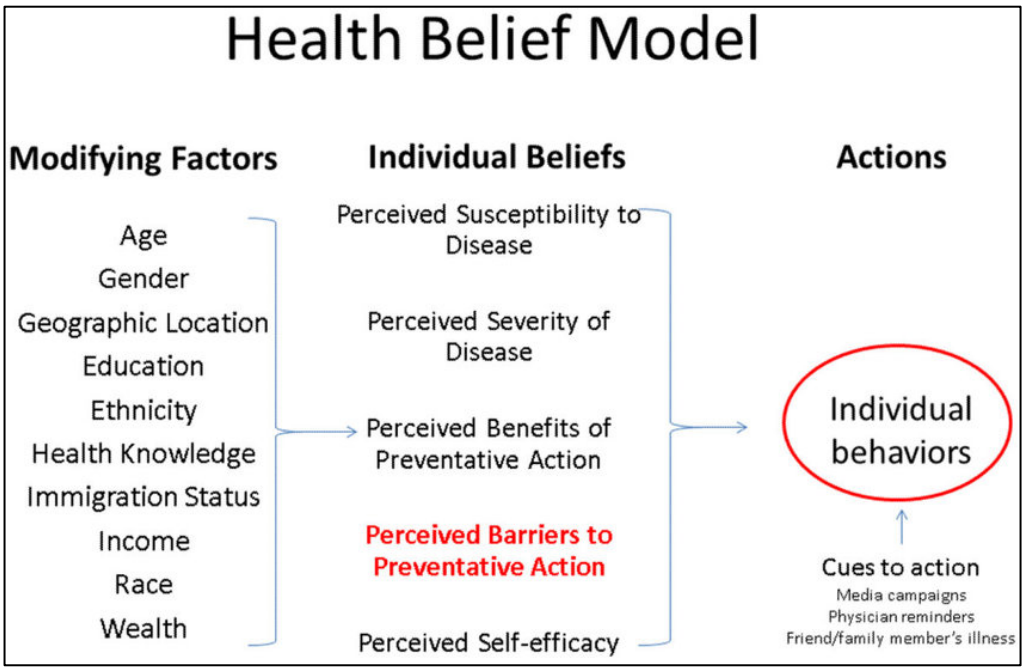


Figure 1: Conceptual framework using the Health Belief Model theory

Source: www.researchgate.net

Demographic, structural, and psychosocial characteristics are among the modifying factors. Demographic factors included race, ethnicity, age, sex, and education.

Knowledge of, and prior exposure to, a particular health issue are examples of structural variables. Psychosocial variables include personality, peer influence, and socioeconomic norms (25).

Individual perceptions or beliefs refer to personal views and attitudes toward a disease and the importance of health for an individual. Perceived susceptibility is defined as an individual's perception of their likelihood of contracting a disease, whereas perceived severity refers to the individual's perception of the consequences of the illness. The likelihood of action is determined by the perceived advantages (benefits) and obstacles (barriers) of engaging in recommended health-promoting behaviors. Additionally, a cue for action, which may arise from symptoms of the disease or advice from others, is necessary to facilitate the decision-making process for accepting health-related activities (25). Self-efficacy is defined as the degree to which an individual believes that they can act successfully. This directly influences whether an individual engages in the intended activity (27).

The HBM was employed in a study conducted in Saudi Arabia, wherein six concepts were measured: perceived children's susceptibility, perceived severity, perceived benefits, cues to action, perceived barriers, and perceived self-efficacy (16). Perceived susceptibility, perceived barriers, and self-efficacy were identified as significant predictors of parental nonadherence (16). The HBM also served as the theoretical framework in studies to understand individuals' intentions to be vaccinated against COVID-19, as well as to determine the factors influencing parents' decisions to vaccinate their children against influenza (25).

Consequently, the HBM was selected as the primary theoretical framework underpinning this study while incorporating elements of PMT to provide a

comprehensive foundation for examining the age-appropriate timeliness of measles vaccination. Additionally, the HBM has a robust ability to capture both individual-level factors and systemic barriers influencing vaccination timing, whereas PMT addresses threat and coping mechanisms. The HBM guided the study in the selection of variables (demographic and socioeconomic), knowledge assessment, barriers to timely vaccination, and self-efficacy measurement. The theoretical framework guided the data analysis by examining the relationship between modifying factors and measles vaccination timeliness, assessing perceived barriers, and evaluating the influence of knowledge and beliefs on adherence to measles vaccination schedules. This comprehensive theoretical approach allowed for a nuanced understanding of not just whether children received their measles doses in a timely manner but specifically the factors that influence the timeliness of measles vaccination. This further provides a strong foundation for developing targeted interventions to improve vaccination timeliness in the future.

2.10 CHAPTER SUMMARY

Chapter 2 presents a literature review of the vaccine timelines. This chapter discusses the prevalence of the age-appropriate timeliness of the measles vaccine globally and in Africa. In addition, it highlights barriers to age-appropriate timeliness, as identified by previous researchers. The health belief model theory was also examined as a theoretical framework for this research. The subsequent chapter addresses this methodology.

CHAPTER 3: RESEARCH METHODOLOGY

Chapter 2 presents a comprehensive review of the relevant literature. This chapter delineates the research methodology employed in this study, elucidates the methods utilized, and justifies their selection. This chapter covers the research approach, design, study population, sampling methods, research instruments, data collection procedures, data analysis techniques, and ethical considerations.

3.1 RESEARCH DESIGN

Research design constitutes a comprehensive plan or framework that guides the conduct of research. It functions as a blueprint for study implementation, encompassing the methodologies and techniques employed for data collection and analysis. Furthermore, it ensures the fulfillment of research objectives and validity and reliability of the study outcomes (28). The convergent parallel design entails the concurrent collection of both quantitative and qualitative data, which are analyzed independently and subsequently integrated to offer a nuanced perspective on the research problem (29).

The adoption of a convergent parallel mixed-methods design was deemed appropriate to comprehensively address the research objectives. This approach facilitated the simultaneous collection and independent analysis of both quantitative and qualitative data, allowing for a robust exploration of the magnitude and determinants of untimely measles vaccination.

Figure 2 illustrates the convergent parallel mixed method design employed in this study.

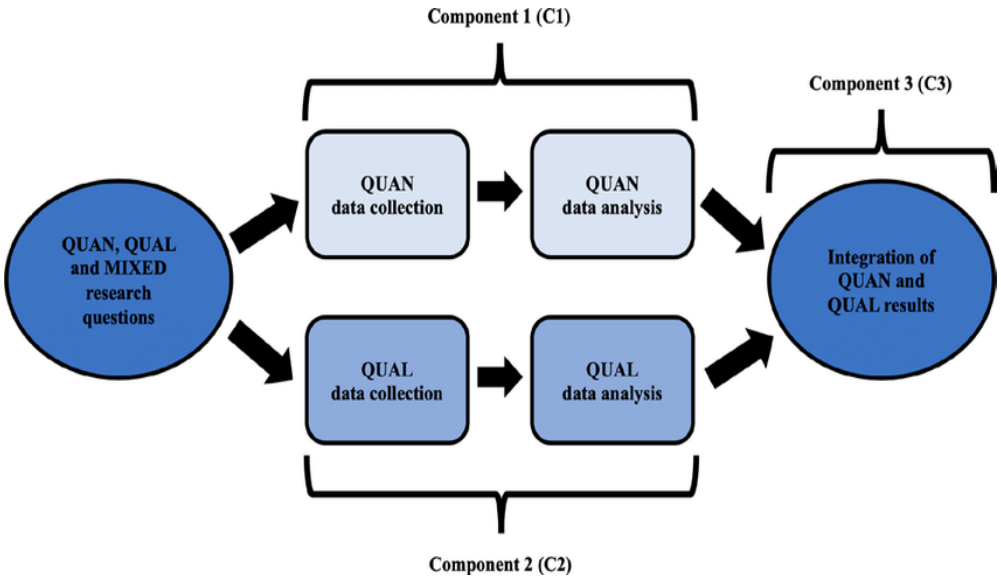


Figure 2: Convergent parallel mixed-method design

Source: www.researchgate.net

The quantitative strand enabled the identification of patterns and prevalence of delayed vaccination from the caregivers' perspective, while the qualitative strand provided in-depth insights into contextual and health system-related barriers as perceived by healthcare workers. Integrating findings from both strands enhanced the depth and breadth of understanding, promoted methodological triangulation, and strengthened the overall validity of the study outcomes

3.1.1 Study population

The study population was defined as the target group. The samples were drawn from the study population (30). The quantitative component of this study included caregivers/parents aged 18 years and above with children aged between 9 and 59 months residing in various urban residential blocks. Children's vaccination records were examined to verify their immunization status. The population for the qualitative component of the study comprised of healthcare professionals, including nurses administering vaccinations to children, community healthcare workers screening and referring unvaccinated or under-vaccinated children to the health facility, and

pharmacist assistants managing vaccine inventories at both the Rehoboth Clinic and Rehoboth Health Centre.

3.1.1.1 Inclusion and exclusion criteria

Inclusion criteria identified the study population in a consistent, reliable, uniform, and objective manner (31). The quantitative inclusion criteria were caregivers aged 18 years or older with children aged 9-59 months who resided in Rehoboth, had maintained residence at the address for the past month, and had received measles-containing vaccines between January 1, 2018, and December 31, 2022. The qualitative inclusion criteria comprised nurses, community health workers, and pharmacist assistants involved in vaccination services at the Rehoboth Clinic and Rehoboth Health Centre.

The exclusion criteria encompassed factors or characteristics that rendered the recruited population ineligible for the study (31). The quantitative exclusion criteria stipulated that only one child per household of eligible age was interviewed. In households with more than one eligible child, only one child was randomly selected to mitigate the bias. Children without vaccination cards were excluded from the study to prevent a recall bias. Caregivers younger than 18 years of age and those who declined to participate in the study were excluded. The qualitative exclusion criteria comprised nursing students and newly appointed healthcare workers with less than six months of experience, as they might lack familiarity with the barriers to timely vaccination in this community, and those who declined participation in the study were excluded.

3.1.2 Study setting

This study was conducted in the Rehoboth district of the Hardap Region, which has a population of 41,772 in 2022. Rehoboth, a town with approximately 5,451 children

under five years of age, is divided into two urban constituencies: the East constituency (blocks B, C, and E) and the West constituency (blocks A, D, F, and G).

3.2 SAMPLING

3.2.1 Sampling methods

Sampling involves the selection of a subset of individuals (a sample) from a larger population, ideally to ensure that the selected individuals are representative of the broader group from which they were chosen (30).

Quantitative sampling: The probability sampling method was employed in the quantitative phase of this study. This approach involves a random sample of a population, ensuring that each member of the population has an equal probability of being selected for the sample (30). Multistage sampling, a more complex form of cluster sampling comprising two or more stages in sample selection, was utilized. In multistage sampling, large clusters of the population are subdivided into smaller clusters in several stages to facilitate primary data collection (32). Using the multistage sampling technique, five blocks were randomly selected using Epi Info in the first stage: two blocks from the east constituency and three blocks from the west constituency. For the second stage, the initial household with an eligible child per block was randomly selected, followed by systematic sampling applied to every 20th household in the right direction. In households with more than one eligible child, only one child was randomly selected to mitigate the bias.

Qualitative sampling: Purposive sampling was implemented during the qualitative phase of this study. This sampling strategy involves selecting participants who are considered representative of a wider population. As the sample was not randomly

selected, the extent to which it represented the study population was indeterminate (30). Healthcare workers were sampled purposively based on their roles and experiences.

3.2.2. Sample size

The sample size refers to the number of participants in a study (30).

Quantitative sampling size: A sample of 316 households was determined using a single population proportion formula with a 95% confidence interval and 5% margin of error.

$$n=\frac{Z\frac{\propto}{2}^{2}P(1-P)}{W^{2}}$$

Z = 1.96 with 95% confidence interval

P= 71% (proportion of measles vaccine timeliness from South African study)

W = 5% margin of error

$$\text{Sample size} = \frac{(1.96)^{2}*0.71(1-0.71)}{0.05^{2}} = 316$$

Qualitative sample size: The selection of participants for the qualitative component was guided by purposive sampling, a non-probability technique commonly used in qualitative research to ensure the inclusion of individuals with specific knowledge, experiences, and roles relevant to the research topic. Healthcare workers from the Rehoboth Clinic and Rehoboth Health Centre were intentionally selected based on their direct involvement in immunization service delivery and community health services. This approach ensured the collection of rich, context-specific data on barriers to timely measles vaccination. The sample included a diverse mix of cadres—nurses, community health workers, and pharmacist assistants—thereby enabling a multifaceted understanding of operational challenges. The final sample size of twelve participants was determined by the principle of data saturation, whereby recruitment

was concluded once no new themes or insights emerged from successive interviews, indicating that the data collected was sufficient to address the research objectives.

3.3 DATA COLLECTION

Research instruments are defined as devices utilized for the systematic collection of data, including tests, questionnaires, or interview schedules (30).

Quantitative research instrument: An interviewer-administered questionnaire comprising closed-ended questions was used to collect data from the caregivers. The questionnaire sections were adapted from studies conducted in China and Saudi Arabia using the health belief model (9). The questionnaire was developed in English and was subsequently translated into Afrikaans to accommodate the local population. The instrument consisted of two sections: Section A captured sociodemographic data, while Section B gathered information on barriers to timely vaccination, including an assessment of the knowledge of caregivers on measles vaccination.

Qualitative research instrument: A semi-structured interview guide was used to investigate barriers to timely MR vaccination among healthcare workers. The following inquiry regarding barriers to timely vaccination was posed: "Tell me about the barriers to age-appropriate timeliness of measles vaccination among children in Rehoboth urban." The guide incorporated questions on caregiver-related, healthcare worker-related, healthcare facilities, and other barriers to obtain comprehensive insights. Key Informant Interviews were conducted in English and audio-recorded to ensure accuracy.

3.4 PROCEDURE FOR DATA COLLECTION

Data collection encompasses systematic observations, measurements, and documentation of information within a study (30).

Quantitative data collection: Data were collected by a researcher and a trained research assistant. The research assistant underwent a two-day training session on the study protocols and data-collection instruments. Potential field scenarios and inquiries were also addressed. Data collection involved face-to-face interviews with caregivers at the household level in both the east and west constituencies in Rehoboth Town. During these interviews, the questions were read aloud to participants, and their responses were recorded by the data collectors. The questionnaire required approximately 20–25 minutes to complete, and each caregiver provided informed consent.

Qualitative data collection: Key informant interviews were conducted with nurses, community health workers, and pharmacist assistants at the Rehoboth Clinic and Rehoboth Health Centre. All interviews were audio-recorded and transcribed, and field notes were documented. Each interview lasted for 30–35 minutes. All interviewees provided informed consent. Additionally, an open-ended question on the quantitative questionnaire elicited supplementary qualitative insights into barriers to timely vaccination if the sampled child was delayed or unimmunized from the caregiver's perspective. Data saturation was deemed to have been achieved after conducting interviews with twelve healthcare workers, as no new themes or substantive insights emerged from the final interviews.

3.5 PILOT STUDY

The pilot study is a small-scale investigation conducted before the main study to identify potential deficiencies in the data collection instruments and methodologies

(30). A pilot study was conducted on 5% of the intended sample population to assess the clarity, relevance, and appropriateness of the data collection instruments. This preliminary study was carried out in the Otjomuise suburb of Windhoek, a setting with similar characteristics to the main study site. For the quantitative component, the structured questionnaire was administered to sixteen caregivers, and their responses were recorded. In the qualitative component, three healthcare workers—a nurse, a pharmacist assistant, and a community health worker—were interviewed using the semi-structured interview guide. None of the participants involved in the pilot study was included in the main study to avoid response bias. Findings from the pilot led to minor revisions to the data collection tools, primarily aimed at improving question clarity and refining response options.

3.6 DATA ANALYSIS

Data analysis is the process through which data are systematically organized to facilitate comprehension of behavioral patterns within the target population (30).

Quantitative data analysis: Data were analyzed using Microsoft Excel and Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics were used to calculate the means and interquartile ranges (IQR). The data are presented in tables and graphs. Inferential statistics were employed to analyze the data using various tests, including Kaplan Meier's survival analysis, Fisher's exact test, Mann-Whitney U Test, and bivariate and multivariate logistic regression with a 95% confidence interval (CI) to determine the statistical significance of different independent variables in relation to the dependent variables. The results were deemed statistically significant if the p-value was < 0.05. A five-point Likert scale was used in selected sections of the

questionnaire to assess caregivers' attitudes and health beliefs, with responses ranging from "strongly disagree" to "strongly agree."

Qualitative data analysis: A thematic analysis approach was employed to analyze the data from key informant interviews. Thematic analysis is a fundamental method used in qualitative research to identify patterns in data. Within the thematic analysis framework, researchers examine qualitative data to organize and describe their datasets through themes and motifs that emerge from the data itself (33). Audio recordings were transcribed using Turboscribe and subsequently assessed for accuracy and completeness by comparing them with the original recordings. Thematic analysis was conducted using Atlas Ti. version 24, wherein initial coding was performed to identify preliminary categories and patterns within the data. Through coding and categorization, five themes emerged from the analysis of the open-ended questions on the quantitative questionnaire with caregivers and key informant interviews with healthcare workers. These themes represent the primary barriers to timely MR vaccination. Themes were further refined and consolidated to ensure that they accurately reflected the data and research objectives. Overarching themes, such as caregiver behavior, health facility-related factors, and transport problems, were identified in the responses of both caregivers and healthcare workers.

3.7 MEASURE TO ENSURE RELIABILITY AND VALIDITY

Reliability: This indicates the extent to which a measure, procedure, or instrument yields consistent results in repeated trials (30). Two methods to ensure reliability are stability, which refers to the consistency of scores over time, and internal consistency, which denotes the degree to which all questions or items assess the same characteristic, skill, or quality (30). The questionnaire was designed to minimize the influence of the

participants' mood or concentration, as evaluated in the pilot study. To enhance reliability and reduce recall bias, children with vaccination cards were included to verify immunization status.

Validity: This refers to the extent to which a study accurately reflects or assesses the specific concept that the researcher is attempting to measure (30). Several types of validity exist, including face-, criterion-related, construct-, and content validity (22). A mixed-methods research design enhances the validity of the study by using both qualitative and quantitative methods to measure the same concept, allowing for a more comprehensive understanding and cross-validation of the findings.

Face validity pertains to the apparent appropriateness of a measure or procedure (30). To ensure face validity, a well-structured questionnaire was used that was segmented into distinct sections to improve comprehension and readability.

Content validity is analogous to face validity, with the distinction that the researcher intentionally solicits opinions on the validity of the measure from individuals recognized as experts in the subject area (30). Content validity was established using a questionnaire that focused solely on capturing information relevant to the study, specifically addressing barriers to timely vaccination.

Measures to ensure reliability and validity encompassed a comprehensive review of the barriers to the age-appropriate timeliness of measles-containing vaccines from existing literature. Based on the identified barriers, the data collection instruments were developed and reviewed by the supervisor and relevant ethical committees for approval. Additionally, the content and face validity were addressed through expert consultation and pilot testing of the instruments.

3.8 MEASURE TO ENSURE TRUSTWORTHINESS

To ensure trustworthiness in the study, four measures were considered: credibility, dependability, confirmability, and transferability (34).

Credibility is a researcher's capacity to demonstrate that the object of a study is accurately identified and described based on the methodology of the study (30). The credibility of the qualitative data was ensured through prolonged face-to-face engagement, iterative questioning, transcription of key informant interviews, and supervisor verification of the emerging themes.

Dependability refers to the ability to account for changes in the study design and evolving conditions surrounding the study (30). The dependability of the qualitative data was ensured through thorough documentation of the findings and analysis process. Triangulation was applied by comparing data from caregivers with data from key informant interviews, to identify consistencies and discrepancies.

Confirmability occurs when the findings of a study can be corroborated by another researcher conducting the same study (30). Confirmability was ensured by employing multiple data collection methods, including field notes, audio recordings, and key informant interviews, to enhance data richness and minimize researcher bias.

Transferability is equivalent to external validity in positivist research (also referred to as applicability). A study is considered transferable if its findings are applicable to contexts beyond the immediate study situation. To transfer the findings to other settings, readers require sufficient information to assess the extent to which a specific research setting is similar to other settings (30). Transferability was ensured by providing detailed descriptions of the study methodology, including sample selection,

sample size calculation, and study setting, enabling others to assess the applicability of the findings in different contexts.

3.9 RESEARCH ETHICS

Ethical approval was obtained from the University of Namibia's Decentralized Ethical Committee (DEC) (Appendix A) and Ministry of Health and Social Services (Appendix B). Authorization was secured from the Regional Health Director of the Hardap Region.

Multiple ethical principles were adhered to throughout the study, including respect for persons, justice, beneficence, and non-maleficence (35).

3.9.1 Respect for persons

To respect an individual entails recognizing their intrinsic (priceless) worth or dignity (36). This study upheld the principle of respect for persons by acknowledging the autonomy of the research participants. To ensure voluntary participation, participants were provided with accurate information about the study's purpose, potential benefits and risks, and intended use of the data. Caregivers above 18 years of age and healthcare workers provided written consent after making an informed decision, and were informed of their right to withdraw at any point during the study. To ensure anonymity, no names were collected except for the child's date of birth.

Confidentiality was maintained by storing data on a password-encrypted laptop with sole access to the researcher. Data from caregivers were collected at the household level to ensure privacy. Key informant interviews with healthcare workers were conducted privately in the boardrooms.

3.9.2 Justice

Justice is conceptualized as fair, equitable, and appropriate treatment for individuals (37). The principle of justice was upheld through the impartial selection of the respondents. This was ensured by applying rigorous sampling techniques and methodological approaches to minimize bias and promote equitable treatment. All the respondents were selected using impartial procedures.

3.9.3 Beneficence and non-maleficence

The principle of beneficence is the obligation of the physician to maximize the benefit of the patient and support several moral rules to protect and defend the rights of others, prevent harm, remove conditions that will cause harm, help persons with disabilities, and rescue persons in danger (37). Non-maleficence is the obligation of a physician to avoid harming the patient. This principle supports several moral rules such as do not kill, do not cause pain or suffering, do not incapacitate, do not cause offense, and do not deprive others of the goods of life (37).

No intentional harm was inflicted on the respondents, as the researcher and research assistant demonstrated high levels of professionalism and competence throughout all phases of the study. The data collection process was non-invasive and did not involve procedures such as blood sample extraction, ensuring that no respondent experienced physical harm. Additionally, the study's findings may contribute to informed decision making at a higher level, potentially benefiting the community in the future.

3.10 CHAPTER SUMMARY

This chapter presents the methodology of the study. A comprehensive description of the research methods employed in the investigation was provided, encompassing the study design, setting, population, sampling techniques, data collection procedures, and analytical approaches. Ethical considerations pertaining to both quantitative and

qualitative components were also addressed. Chapter 4 delineates the findings of this study.

CHAPTER 4: RESULTS

The previous chapter discussed the methodology employed in this study. This chapter presents the results of a mixed-methods analysis conducted to explore the barriers to age-appropriate timeliness for MR1 and MR2. The quantitative data obtained from the interviewer-administered questionnaire assessing the magnitude and barriers of caregivers, as well as the qualitative data from the key informant interviews with healthcare workers from their perspectives, were analyzed and presented in a descriptive and analytical format using tables and graphs in accordance with the objectives of the study to provide a comprehensive understanding of the barriers to the age-appropriate timeliness of measles vaccination.

4.1 FIELD PROCEDURE AND CHANGES IN METHODOLOGY

The following modifications to the data collection procedures were implemented in the field: children without a vaccination card were excluded from the study to mitigate recall bias from parents regarding vaccination dates, which could have influenced timeliness. For qualitative data analysis, the researcher opted to use Atlas Ti. version 24 instead of Open Access as it offers more comprehensive analytical capabilities.

4.2 QUANTITATIVE RESULTS

4.2.1 Objective 1

The vaccination status of 316 children was assessed in this study. The mean age of children was 33 ± 12.99 months. The sex distribution of the study population showed a slight predominance of females, with females constituting approximately 51.27% (162) of the total and males 48.73% (154), as illustrated in Figure 3. The majority of

children were in the age groups of 25–36 months (93; 29.71%) and 37–48 months (92; 28.75%). The smallest cohort was observed in the 9–12-month age group (20, 6.33%).

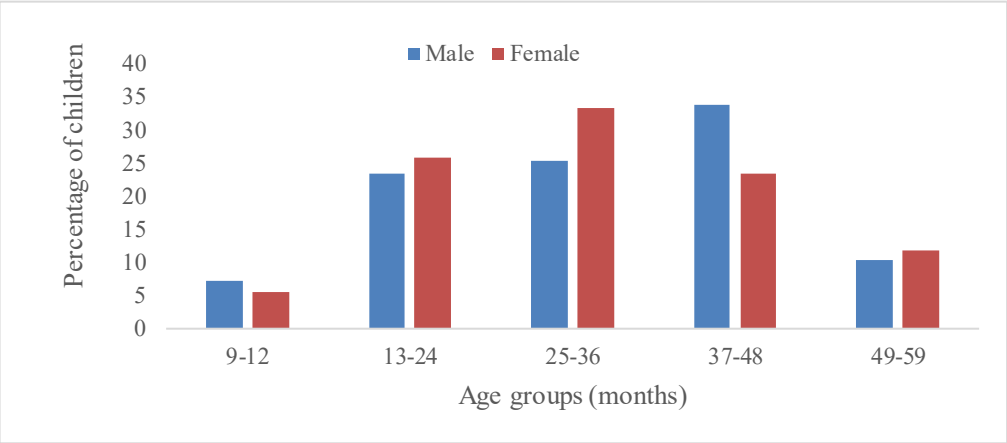


Figure 3: Age and sex distribution of children

Of 316 children, 313 (99.05%) received MR1. Although the remaining three children were nine months old, they were unvaccinated, but not yet considered late, as they were still within the designated time range. A total of 221 (69.94%) children were immunized in a timely manner with MR1, whereas 79 (25%) received delayed immunization, indicating satisfactory compliance with vaccination timeliness. Forty-seven (59.49%) of the delayed children were female. Among males, the cohorts aged 25–36 months and 37–48 months exhibited the highest percentage of delayed children, with 21 (65.63%) males, whereas in females, the cohorts aged 13–24-months and 25–36 months demonstrated the highest percentage of delayed children, with 30 (63.83%) children, as illustrated in Figures 4 and 5. Statistical analysis revealed no association or statistical significance for cohorts with MR delays.

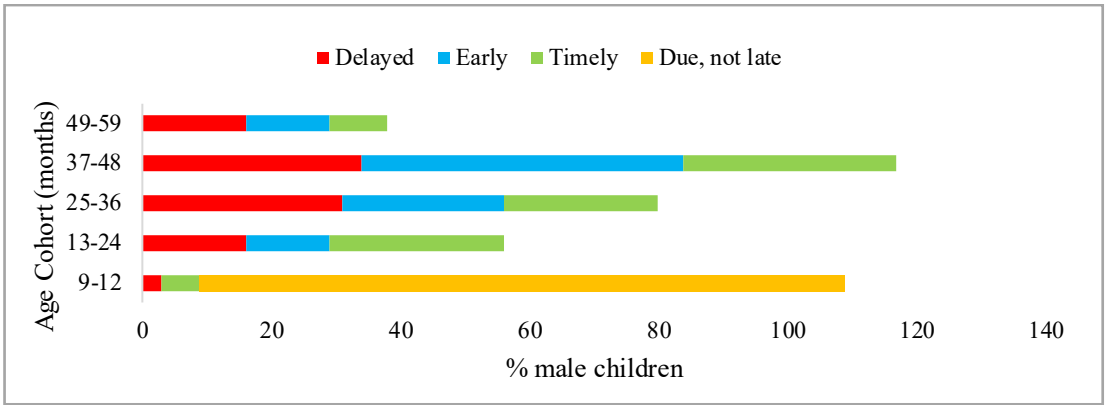


Figure 4: MR1 Vaccination status for males by age cohort

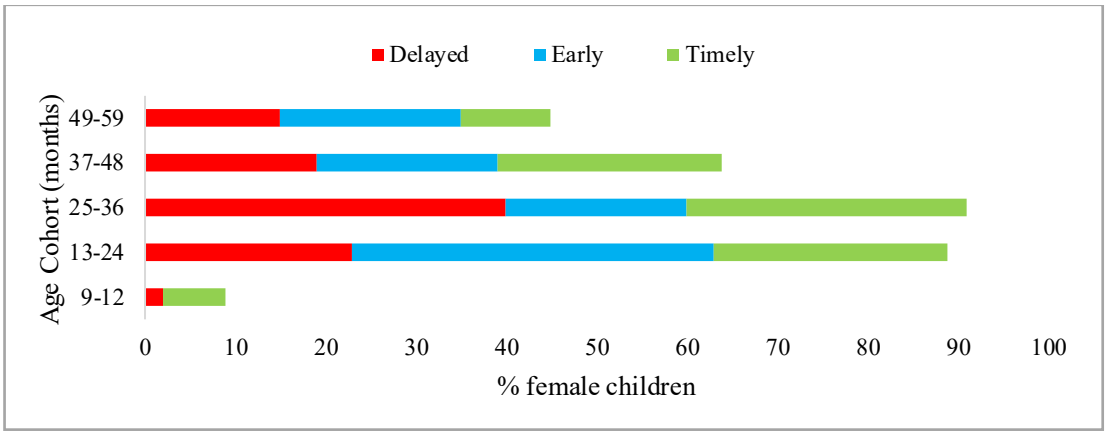


Figure 5: MR1 Vaccination status for females by age cohort

Figures 6 and 7 delineate the cohort and sex distribution of the MR2 vaccination status. While the sex distribution remained consistent with MR1, only 99 (31.3%) children received timely MR2 immunization, whereas 177 (56.0%) experienced delayed immunization, indicating suboptimal adherence to vaccination timeliness. A total of 36 children (11.39%) had not yet reached the appropriate age for their second MR dose. Ninety-six (54%) of the children with delayed vaccination were female. In both the male and female cohorts, the age groups of 25-36 months and 37-48 months exhibited the highest percentage of delayed vaccinations, with 61 (75.3%) males and 61 (63.5%) females, respectively. A high proportion of delayed MR2 vaccinations was observed across all age groups, accompanied by a low rate of early vaccination. Decreasing rates

of timely vaccination were noted in older age groups. Fisher's exact test revealed a strong association between cohorts and delayed outcomes for MR2 vaccination ($p<0.001$). Bivariate analysis indicated that children in the 13-24 month cohort were four times more likely to experience delayed MR2 vaccination than those in the 49-59 month cohort (OR=4, p=0.002).

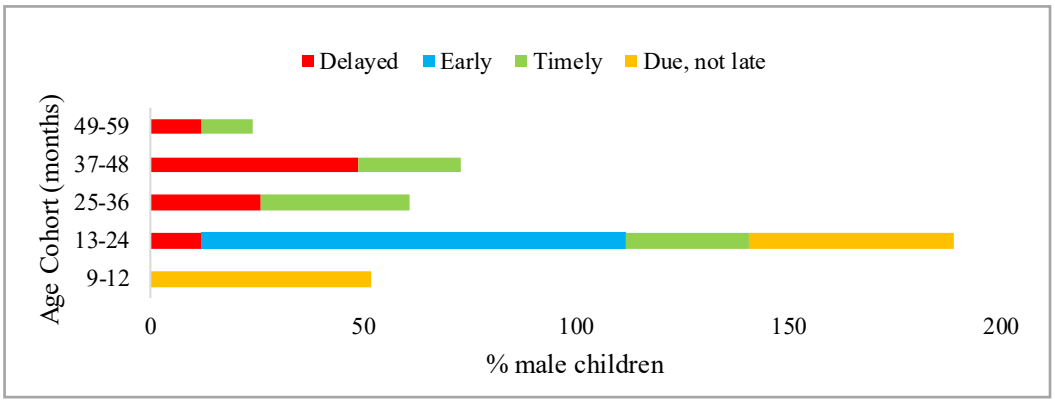


Figure 6: MR2 Vaccination status for males by age cohort

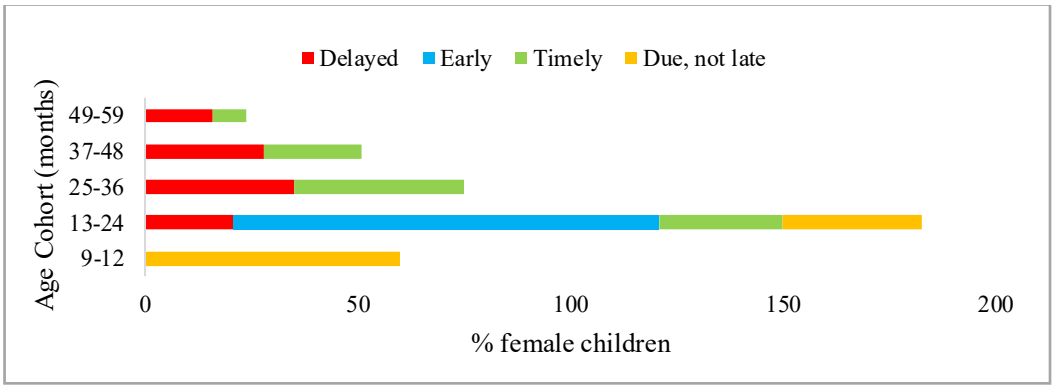


Figure 7: MR2 Vaccination status for females by age cohort

The vaccine coverage was 99.10% for MR1 and 88.60% for MR2, whereas vaccine timeliness was 69.90% and 31.3%, respectively. Among 25.00% of children with delayed MR1 vaccination, the number of days delayed ranged from 1 to 1327 days, whereas among 56.00% with delayed MR2 vaccination, the number of days delayed ranged from 3 to 1207 days. A small proportion of children received immunizations

earlier than the scheduled date for both MR1 (13, 4.10%) between 1-30 days early and MR2 (4, 1.30%) between 1-113 days early. The median days delayed and interquartile range were 65.50 (8.88-237.00) for MR1 and 127.00 (55.00-407.00) for MR2.

Figure 8 presents a quantitative analysis of the delay duration, measured in months, for both MR1 and MR2 administration. Most children received delayed MR1 and MR2 doses between two and five months of age, as evidenced by the median delay period.

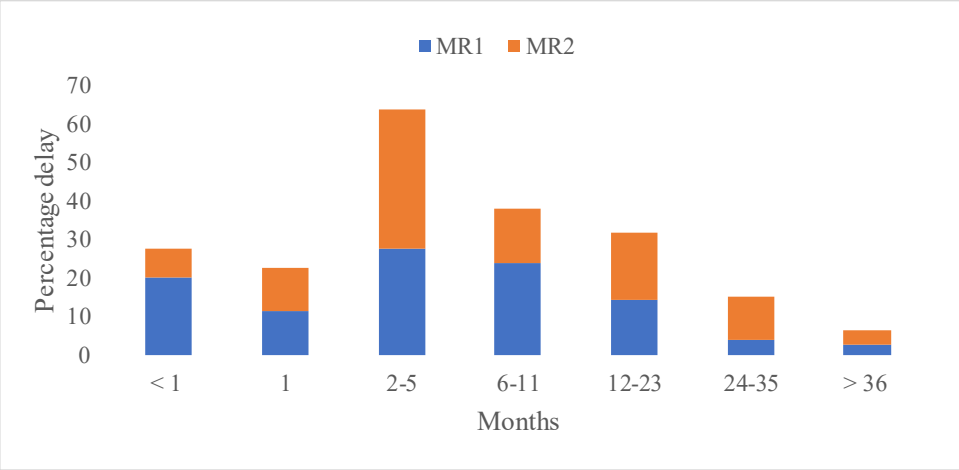


Figure 8: Distribution of timing of vaccine dose administration following the recommended age

Kaplan Meier Survival Prediction

The Kaplan-Meier survival prediction method is considered the most straightforward approach for calculating survival over time (38). In this study, survival prediction pertained to the probability of not receiving MR2 (an event). This prediction methodology is valuable for estimating and visualizing the temporal distribution and likelihood of achieving immunity in children aged 9-59 months. The following section outlines Kaplan-Meier survival prediction for MR1. Notably, no follow-up was conducted at the end of the study to determine MR2 survival prediction.

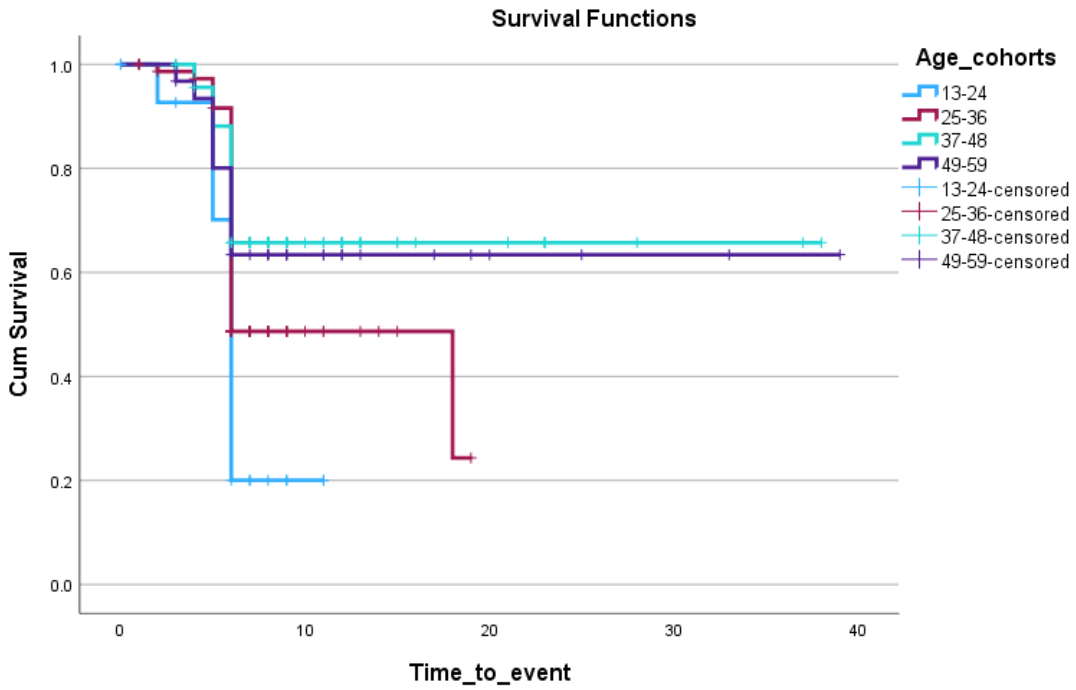


Figure 9: Kaplan Meier Survival Prediction for MR1

Early cumulative survival declines were most pronounced in the 13-24 month cohort. This observation suggests that the survival probability (likelihood of not receiving MR2) decreased rapidly owing to the high rate of MR2 administration in this age range. Less than 20% of this cohort had not received MR2 vaccination by the interview date, as evidenced by a survival probability of less than 0.2. The survival probabilities (likelihood of not receiving MR2) for cohorts of 25–36, 37–48, and 49–59 months were significantly higher and demonstrated greater consistency. This implies that children in these older age groups were less likely to receive MR2 on time, and that a larger proportion remained unvaccinated at the time of the interview. Children who had not received MR2 by the date of the interview, but remained enrolled in the study, were represented by small crosses on each line, denoting censoring. A substantial

proportion of the children did not receive MR2 by the interview date, as indicated by the censored cases across all age cohorts, particularly in the older groups.

4.2.2 Objective 2

Tables 1a and 1b presents the descriptive and statistical analyses of the sociodemographic characteristics of MR1 and MR2 for the delayed and non-delayed outcomes. Cross-tabulations were used to display the descriptive data, while Fisher's exact test was employed, as it is appropriate for tables with low expected counts and provides an exact significance level. This test was used to determine whether there were significant associations between two categorical variables. Subsequently, bivariate logistic regression was used to ascertain the significance and strength of the association between the dependent variable (outcome of delayed and not delayed) and various independent variables. The analysis indicated which covariates might be included based on the strength of the association in the multivariate logistic regression analysis. Throughout this analysis, a p-value < 0.005 was considered statistically significant.

Among the 316 caregivers interviewed, 241 (76.27%) were mothers. The mean age of caregivers was 31 ± 7.43 years. Additionally, only 26.58% (84) of the fathers' information was obtained, as they were predominantly not involved with the child or mother. These limited data were excluded from the analysis.

Table 1a: Cross-tabs, Fisher's Exact and Bivariate Logistic Regression for MR1 and MR2 on Socio-demographic variables

Factors		MR1					MR2				
		Cross-tabs Delayed 79 (25%)	Cross-tabs Not delayed 237 (75%)	Fisher's exact P-value	Bivariate Analysis		Cross-tabs Delayed 177 (56%)	Cross-tabs Not delayed 139 -44%	Fisher's exact P-value	Bivariate Analysis	
					p-value	OR (95%CI)				p-value	OR (95%CI)
Child's birth weight (g)	< 2500	7 (15.60)	38 (84.40)	0.37	0.44	2.71 (0.22-34.15)	25 (55.60)	20 (44.40)	0.86	0.47	0.40 (0.03-4.74)
	2500-3999	68 (26.80)	186 (73.20)		0.8	1.37 (0.12-15.33)	144 (56.70)	110 (43.30)		0.43	0.38 (0.03-4.27)
	4000-4999	3 (21.40)	11 (78.60)		0.66	1.83 (0.12-27.80)	7 -50	7 -50		0.6	0.50 (0.04-6.86)
	Not recorded	1 -33.3	2 (66.70)		0.57	2.00 (ref)	1 (33.30)	2 (66.70)		0.57	2.00 (ref)
Birth order of child	First born	15 (18.30)	67 (81.70)	0.41	0.3	1.87 (0.57-6.08)	35 (42.70)	47 (57.30)	**0.04***	**0.04***	3.22 (1.04-9.99)
	Second to third born	40 (27.60)	105 (72.40)		0.87	1.09 (0.36-3.30)	87 (60.00)	58 (40.00)		0.4	1.6 (0.54-4.78)
	Fourth to fifth born	19 (26.40)	53 (73.60)		0.8	1.16 (0.36-3.74)	43 (59.70)	29 (40.30)		0.41	1.62 (0.52-5.09)

	Sixth to nineth born	5 -29.4	12 (70.60)		0.1	2.40 (ref)	12 (70.60)	5 -29.04		0.1	0.42 (ref)
Number of siblings	0	10 (15.60)	54 (84.40)	0.24	0.11	2.40 (0.82-7.01)	25 (39.10)	39 (60.90)	**0.01***	**0.01***	3.51 (1.33-9.28)
	1-2	38 (26.80)	104 (73.20)		0.67	1.22 (0.49-3.03)	82 (57.70)	60 (42.30)		0.28	0.65 (0.67-4.04)
	3-4	23 (27.40)	61 (72.60)		0.74	1.18 (0.45-3.08)	52 (61.90)	32 (38.10)		0.5	1.39 (0.54-3.55)
	> 5	8 -30.8	18 (69.20)		0.06	2.25 (ref)	18 (69.20)	8 -30.8		0.06	0.44 (ref)
Number of family members	< 5	19 (21.10)	71 (78.90)	0.54	1	0.00 (NA)	49 (54.40)	41 (45.60)	0.56	1	0.00 (NA)
	> 5	60 (26.70)	165 (73.30)		1	0.00 (NA)	128 (56.90)	97 (43.10)		1	0.00 (NA)
	Unsure	0 0	1 (100.00)		1	1615372799.00 (ref)	0 0	1 (100.00)		1	1615346040.00 (ref)
Residential block	Block B	37 (21.90)	132 (78.10)	0.15	**0.04***	2.68 (1.03-6.98)	99 (58.60)	70 (41.40)	0.06	0.1	2.03 (0.87-4.71)
	Block D	7 -31.8	15 (68.20)		0.62	1.31 (0.45-3.80)	34 (68.00)	16 (32.00)		**0.01***	3.72 (1.30-10.65)
	Block E	8 -18.6	35 (81.40)		**0.02***	2.19 (1.11-4.31)	22 (51.20)	21 (48.80)		0.23	1.50 (0.77-2.93)
	Block F	8 -25	24 (75.00)		0.23	1.84 (0.69-4.91)	14 (43.80)	18 (56.30)		**0.03***	2.73 (1.09-6.84)
	Block G	7 -31.8	15 (68.20)		0.09	1.63 (ref)	8 (36.40)	14 (63.60)		0.01	0.47 (ref)

Type of settlement	Informal	42 (27.50)	111 (72.50)	0.36	0.33	0.78 (0.47-1.29)	81 (52.90)	72 (47.10)	0.31	0.29	1.27 (0.82-1.99)
	Formal	37 (22.70)	126 (35.10)		0	3.41 (ref)	96 (25.60)	67 (41.10)		0.02	0.70 (ref)
Age of caregiver	< 20	3 (30.00)	7 (70.00)	0.59	0.59	2.33 (0.11-50.98)	6 (60.00)	4 (40.00)	0.81	1	1076880042.00 (NA)
	20-30	30 (22.90)	101 (77.10)		0.4	3.37 (0.20-55.45)	71 (54.20)	60 (45.80)		1	165059208.00 (NA)
	31-40	34 (24.30)	106 (75.70)		0.43	3.12 (0.18-51.20)	77 (55.00)	63 (45.00)		1	1321625506.00 (NA)
	> 40	11 (33.30)	22 (66.70)		0.64	2.00 (0.11-35.09)	21 (63.60)	12 (36.40)		1	923040035.80 (NA)
	Missing	1 (50.00)	1 (50.00)		1	1.00 (ref)	2 (100.00)	0 (0.00)		1	0.00 (NA)

***Fisher's Exact statistically significant at p-value < 0.05** ***ref-reference**

***Bivariate logistic regression analysis statistically significant at p-value < 0.05** ***NA-Not Applicable**

Table 2b: Cross-tabs, Fisher's Exact and Bivariate Logistic Regression for MR1 and MR2 on Socio-demographic variables

Factors		MR1					MR2				
		Cross-tabs Delayed 79 (25%)	Cross-tabs Not delayed 237 (75%)	Fisher's exact P-value	Bivariate Analysis		Cross-tabs Delayed 177 (56%)	Cross-tabs Not delayed 139 -44%	Fisher's exact P-value	Bivariate Analysis	
					p-value	OR (95%CI)				p-value	OR (95%CI)
Marital status of caregiver	Unmarried	44 (23.50)	143 (76.50)	0.57	1	0.00 (NA)	107 (57.20)	80 (42.80)	0.49	1	0.00 (NA)
	Married	19 (27.90)	49 (72.10)		1	0.00 (NA)	41 (60.30)	27 (39.70)		1	0.00 (NA)
	Cohabitation	0 (0.00)	2 (100.00)		1	1.00 (NA)	1 (50.00)	1 (50.00)		1	0.00 (NA)
	Divorced	1 (100.00)	0 (0.00)		1	0.00 (NA)	0 (0.00)	1 (100.00)		1	1.00 (NA)
	Widowed	15 (26.30)	42 (73.70)		1	0.00 (NA)	28 (49.10)	29 (50.90)		1	0.00 (NA)
	Separated	0 (0.00)	1 (100.00)		1	1614991150.00 (ref)	0 (0.00)	1 (100.00)		1	1615734884.00 (ref)

Educational status of caregiver	No school education	2 (40.00)	3 (60.00)	**0.05***	1	0.00 (NA)	3 (60.00)	2 (40.00)	0.83	1	1077008299.00 (NA)
	Primary education	13 (46.40)	15 (53.60)		1	0.00 (NA)	18 (64.30)	10 (35.70)		1	897506912.00 (NA)
	Secondary education	61 (22.70)	208 (77.30)		1	0.00 (NA)	147 (54.60)	122 (45.40)		1	134076544.00 (NA)
	Tertiary education	3 (23.10)	10 (76.90)		1	0.00 (NA)	8 (61.50)	5 (38.50)		1	10096995281.00 (NA)
	Unsure	0 (0.00)	1 (100.00)		1	1615415625.00 (NA)	1 (100.00)	0 (0.00)		1	0.00 (NA)
Employment status of caregiver	Unemployed	49 (24.70)	149 (75.30)	0.08	1	0.00 (NA)	112 (56.60)	86 (43.400)	0.85	0.85	0.77 (0.05-12.45)
	Employed	27 (31.80)	58 (68.20)		1	0.00 (NA)	49 (57.60)	36 (42.40)		0.83	0.74 (0.04-12.14)
	Self-employed	3 (9.70)	28 (90.30)		1	0.00 (NA)	15 (48.40)	16 (51.60)		0.97	1.07 (0.06-18.62)
	Blank	0 (0.00)	2 (100.00)		1	1615277718.00 (ref)	1 (50.00)	1 (50.00)		1	1.00 (ref)
Monthly income of caregiver (N$)	< 500	42 (21.20)	156 (78.80)	0.28	0.81	0.83 (0.17-3.97)	108 (54.50)	90 (45.50)	0.66	0.25	0.48 (0.14-1.68)
	500-1999	19 (35.80)	34 (64.20)		0.27	0.40 (0.08-2.03)	31 (58.50)	22 (41.50)		0.19	0.41 (0.11-1.56)
	2000-4999	8 (30.80)	18 (69.20)		0.44	0.50 (0.09-2.86)	17 (65.40)	9 (34.60)		0.11	0.30 (0.07-1.32)

	5000-9999	2 (22.20)	7 (77.80)		0.82	0.78 (0.09-6.98)	5 (55.60)	4 (44.40)		0.39	0.46 (0.08-2.76)
	> 10000	6 (31.60)	13 (68.40)		0.43	0.48 (0.08-2.95)	12 (63.20)	7 (36.80)		0.16	0.33 (0.07-1.56)
	Unknown	2 (18.20)	9 (81.80)		0.05	4.50 (ref)	4 (36.40)	7 (63.60)		0.37	1.75 (ref)
Distance to healthcare facility	< 2	32 (20.50)	124 (79.50)	0.15	0.23	2.21 (0.61-8.03)	85 (54.50)	71 (45.50)	0.3	0.25	0.48 (0.13-1.70)
	2-5	43 (28.90)	106 (71.10)		0.6	1.41 (0.39-5.06)	88 (59.10)	61 (40.90)		0.15	0.40 (0.11-1.41)
	> 5	4 (36.40)	7 (63.60)		0.37	1.75 (ref)	4 (36.40)	7 (63.60)		0.37	1.75 (ref)
Mode of transport	Foot	53 (25.40)	156 (74.60)	1	0.83	0.92 (0.42-2.00)	121 (57.90)	88 (42.10)	0.57	0.71	0.88 (0.45-1.72)
	Public transport	16 (24.60)	49 (75.40)		0.92	0.96 (0.39-2.37)	33 (50.80)	32 (49.20)		0.69	1.17 (0.54-2.56)
	Own car	10 (23.80)	32 (76.20)		0	3.20 (ref)	23 (54.80)	19 (45.20)		0.54	0.83 (ref)
Time to reach healthcare facility	< 30 minutes	48 (21.40)	176 (78.60)	0.07	0.11	1.92 (0.87-4.26)	124 (55.40)	100 (44.60)	0.31	0.37	0.71 (0.34-1.50)
	30-60 minutes	20 (33.30)	40 (66.70)		0.92	1.05 (0.42-2.59)	38 (63.30)	22 (36.70)		0.13	0.51 (0.21-1.22)
	> 60 minutes	11 (34.40)	21 (65.60)		0.08	1.91 (ref)	15 (46.90)	17 (53.10)		0.72	1.13 (ref)

***Fisher's Exact statistically significant at p-value < 0.05** ***ref-reference**

***Bivariate logistic regression analysis statistically significant at p-value < 0.05** ***NA-Not Applicable**

Children with low birth weight (< 2500 g) exhibited lower rates of delayed MR1 (15.60%), but higher rates of MR2 delay (55.60%). Normal birth weight (2500–3999 g) was associated with the highest rates of both MR1 (26.80%) and MR2 (56.70%) delays.

Examination of the relationship between sociodemographic variables and MR vaccination delay revealed notable patterns. The initial descriptive analysis through cross-tabulation indicated that first-born children demonstrated the lowest rates of delayed MR1 (18.30%) and MR2 (42.70%), whereas later-born children (5th-9th) exhibited the highest rates of MR1 (29.40%) and MR2 (70.60%) delays. However, the bivariate analysis revealed different significant associations for MR2, with first-born children found to have a 3.22 times higher likelihood of experiencing a delayed MR2 dose (OR=3.22, p=0.04) compared to children who were later-born (5th-9th). Furthermore, birth order demonstrated an association with Fisher's exact test (p=0.04).

Children with five or more siblings exhibited the highest rates of delayed MR1 (30.80%) and MR2 (69.20%) vaccinations than those without siblings, who demonstrated lower rates of delayed MR1 (15.60%) and MR2 (39.10%) vaccinations. The number of siblings showed an association in Fisher's exact test (p=0.01), and a distinct pattern emerged in the bivariate analysis: children without siblings were found to be statistically significant and exhibited a 3.51 times higher likelihood of experiencing a delayed MR2 dose (OR=3.51, p=0.001) compared to children with more than five siblings. Children from larger families ($\geqslant$ 5 members) had higher rates of delayed MR1 (26.70%) and MR2 (56.09%) than those from smaller families (<5 members).

Children from informal settlements exhibited higher rates of MR1 delays (27.50%) and MR2 vaccinations (52.90%) than those from formal settlements (22.70% and 25.60%, respectively). Block D demonstrated the highest rates of delayed MR1 (38.00%) and MR2 (68.00%) vaccination. Block E presented the lowest rate of delayed MR1 (18.60%) vaccination, whereas Block G showed the lowest rate of MR2 (36.80%) vaccination. In the bivariate analysis, children from blocks B (OR=2.68, p=0.04) and E (OR=2.19, p=0.02) had a higher likelihood of experiencing a delayed MR1 dose than those from Block G. Moreover, children from blocks D (OR=3.72, p=0.01) and F (OR=2.73, p=0.03) also exhibited a higher likelihood of experiencing a delayed MR2 dose than those from block G.

Caregivers older than 41 years demonstrated the highest rates of delayed MR1 (33.30%) and MR2 (63.60%) vaccinations. Married caregivers exhibited the highest rates of delayed MR1 (27.90%) and MR2 (60.30%) vaccination. Caregivers with lower education levels (no schooling or primary only) displayed higher rates of delayed MR1 (40-46%) and MR2 (60-64%) vaccinations than those with secondary or tertiary education. Fisher's exact test revealed a marginally significant association between the educational status of the caregiver and MR1 delay (p=0.05); however, bivariate analysis yielded no statistical significance.

Regarding both MR1 and MR2 vaccination delays, self-employed caregivers exhibited the lowest rates at 9.70% and 48.40%, respectively, whereas employed caregivers demonstrated the highest delay rates at 31.80% for MR1 and 57.60% for MR2. Caregivers earning N$500-N$1999 per month exhibited the highest rate of delayed MR1 vaccination at 35.80%, whereas those earning N$2000-4999 demonstrated the highest MR2 delay rate of 65.40%.

Children residing more than 5 km from a healthcare facility exhibited the highest rate of delayed MR1 (36.40%), and those residing between 2 and 5 km from a healthcare facility showed the highest rate of MR2 (59.10%). Those residing less than 2 km away demonstrated the lowest MR1 delay (20.50%) but still exhibited a moderate MR2 delay (54.50%). Walking is the most prevalent mode of transportation. Caregivers traveling on foot to healthcare facilities exhibited the highest rates of delayed MR1 (25.40%) and MR2 (57.90%) vaccinations, whereas those with private transport demonstrated lower delays for MR1 (23.80%) and MR2 (54.80%). Longer travel times to healthcare facilities (>60 min) were associated with higher rates of delayed MR1 (34.40%), and travel times between 30-60 minutes were associated with higher rates of delayed MR2 (46.90%).

Utilization of health services by the mother

Table 2 delineates the findings regarding maternal utilization of health services during the peripartum period, encompassing the pregnancy, labor/delivery, and postpartum phases.

Table 3: Cross-tabs, Fisher's Exact and Bivariate Analysis of factors related to health services by mother for MR1 and MR2

Factors		MR1					MR2				
		Cross-tabs Delayed 79 (25%)	Cross-tabs Not delayed 237 (75%)	Fisher's exact P-value	Bivariate Analysis		Cross-tabs Delayed 177 (56%)	Cross-tabs Not delayed 139 (44%)	Fisher's exact P-value	Bivariate Analysis	
					p-value	OR (95%CI)				p-value	OR (95%CI)
Attended ANC	Yes	75 (24.50)	231 (75.50)	0.17	0.14	6.16 (0.55-68.90)	173 (56.50)	133 (43.50)	0.39	0.73	1.54 (0.14-17.14)
	Unsure	2 (28.60)	5 (71.40)		0.28	5.00 (0.27-91.52)	2 (28.60)	5 (71.40)		0.28	5.00 (0.27-91.52)
	No	2 (66.70)	1 (33.30)		0.57	0.50 (ref)	2 (66.70)	1 (33.30)		0.57	0.50 (ref)
Number of times	1-4	20 (32.80)	41 (67.20)	0.16	0.26	4.10 (0.35-47.95)	37 (60.70)	24 (39.30)	0.15	0.84	1.30 (0.11-15.11)
	5-6	43 (21.80)	154 (78.20)		0.11	7.16 (0.63-80.89)	103 (52.30)	94 (47.70)		0.63	1.83 (0.16-20.46)
	> 6	0 (0.00)	2 (100.00)		1.00	3230949729.00 (NA)	0 (0.00)	2 (100.00)		1.00	3230949732.00 (NA)
	Unsure	14 (26.40)	39 (73.60)		0.17	5.57 (0.47-66.33)	35 (66.00)	18 (34.40)		0.98	1.03 (0.09-12.12)
	NA*	2 (66.70)	1 (33.30)		0.57	0.50 (ref)	2 (66.70)	1 (33.30)		0.57	0.50 (ref)
Information on immunization during ANC	Yes	27 (18.80)	117 (81.30)	**0.01***	0.08	8.67 (0.76-99.10)	76 (52.80)	68 (47.20)	0.74	0.64	1.79 (0.16-20.18)
	No	33 (35.90)	59 (64.10)		0.31	3.58 (0.31-49.94)	53 (57.60)	39 (42.40)		0.76	1.47 (0.13-16.81)
	Unsure	17 (22.10)	60 (77.90)		0.12	7.06 (0.60-82.63)	46 (59.70)	31 (40.30)		0.81	1.35 (0.12-15.51)
	NA*	2 (66.70)	1 (33.30)		0.57	0.50 (ref)	2 (66.70)	1 (33.30)		0.57	0.50 (ref)

Place of birth	Hospital	77 (25.30)	227 (74.70)	0.74	0.50	0.59(0.13-2.75)	171 (56.30)	133 (43.80)	0.77	0.67	0.78 (0.25-2.47)
	At home	2 (16.70)	10 (83.30)		0.04	5.00 (ref)	6 (50.00)	6 (50.00)		1.00	1.00 (ref)
Information on immunization during labour	Yes	28 (19.40)	116 (80.60)	**0.05***	0.33	1.38 (0.72-2.65)	76 (52.80)	68 (47.20)	0.47	0.22	1.41 (0.81-2.47)
	No	31 (33.70)	61 (66.30)		0.21	0.66 (0.34-1.28)	52 (56.50)	40 (43.50)		0.53	1.22 (0.66-2.24)
	Unsure	20 (25.00)	60 (75.00)		0.00	3.00 (ref)	49 (61.30)	31 (38.80)		0.05	0.63 (ref)
Attended PNC	Yes	76 (24.80)	231 (75.20)	0.71	0.33	1.38 (0.72-2.65)	173 (56.40)	134 (43.60)	0.44	0.24	0.26 (0.03-2.51)
	No	2 (40.00)	3 (60.00)		0.21	0.66 (0.34-1.28)	3 (60.00)	2 (40.00)		0.31	0.22 (0.01-3.98)
	Unsure	1 (25.00)	3 (75.00)		0.00	3.00 (ref)	1 (25.00)	3 (75.00)		0.34	3.00 (ref)
Number of times	< 3	60 (26.40)	167 (73.60)	0.39	0.50	1.86 (0.30-11.38)	132 (58.10)	95 (41.90)	0.49	0.93	1.08 (0.18-6.59)
	> 3	15 (19.20)	63 (80.80)		0.28	2.80 (0.43-18.27)	40 (51.30)	38 (48.70)		0.71	1.43 (0.23-9.00)
	Unsure	2 (33.30)	4 (66.70)		0.82	1.33 (0.11-15.70)	2 (33.30)	4 (66.70)		0.38	3.00 (0.26-35.33)
	NA*	2 (40.00)	3 (60.00)		0.66	1.50 (ref)	3 (60.00)	2 (40.00)		0.66	0.67 (ref)
Information on immunization during PNC	Yes	41 (23.00)	137 (77.00)	0.18	0.39	2.23 (0.36-13.79)	96 (53.90)	82 (46.10)	0.63	0.79	1.28 (0.21-7.86)
	Unsure	15 (20.80)	57 (79.20)		0.33	2.53 (0.39-16.56)	45 (62.50)	27 (37.50)		0.91	0.90 (0.14-5.73)
	No	21 (34.40)	40 (65.60)		0.80	1.27 (0.20-8.20)	33 (54.10)	28 (45.90)		0.80	1.27 (0.20-8.17)
	NA*	2 (40.00)	3 (60.00)		0.66	1.50 (ref)	3 (60.00)	2 (40.00)		0.66	0.67 (ref)

***Fisher's Exact statistically significant at p-value < 0.05** ***ref-reference**

***Bivariate logistic regression analysis statistically significant at p-value < 0.05** ***NA-Not Applicable**

Antenatal Care (ANC)

Antenatal care was attended by 306 (96.84%) mothers. Seventy-five (24.50%) of those who attended ANC experienced delayed MR1 vaccination, compared to 2 (66.70%) of those who did not attend. One-hundred and seventy-three (56.50%) ANC attendees experienced delayed MR2 compared to two (66.70%) non-attendees. Most women had between 5-6 ANC visits during pregnancy. Mothers with one to four ANC visits exhibited the highest rates of delayed MR1 (32.80%) and MR2 (60.70%), whereas those with more than six ANC visits exhibited no delayed vaccinations for either MR1 or MR2. Approximately 47.06% (144) of the women reported receiving immunization information during their ANC visits. Mothers who did not receive immunization information during ANC exhibited higher rates of delayed MR1 (35.90%) and MR2 (57.60%) than did those who did (18.80% and 52.80%, respectively). Fisher's exact test revealed an association between MR1 vaccination delay and immunization information received during ANC ($p=0.01$); however, no further statistical significance was observed in the bivariate analysis.

Childbirth (labor)

The majority of the children in the study were born in hospital settings (304, 96.20%). Children born at home exhibited a lower MR1 delay (16.70%) than those born at hospitals (25.30%). For MR2, home births demonstrated a 50.00% delay, in contrast to the 56.30% for hospital births. A total of 144 mothers (47.37%) received immunization information during their hospital stay after delivery. Mothers who did not receive immunization information during hospital admission exhibited higher delayed MR1 (33.70%) and MR2 (56.50%) vaccination rates than those who received information (19.40% and 52.80%, respectively). Fisher's exact test revealed a

marginally significant association between MR1 vaccination delay and immunization information received during labor (p=0.05); however, no further statistical significance was observed in the bivariate analysis.

Postnatal Care (PNC)

PNC was attended by 97.15% (307) of the mothers. Among the women who attended the PNC services, 76 (24.80%) exhibited delayed MR1 vaccination compared with two (40.00%) non-attendees. One hundred and seventy-three (56.40%) PNC attendees demonstrated delayed MR2 vaccination compared to three (60.00%) non-attendees. On average, 73.94% (227) of the women who attended PNC had fewer than three visits. Mothers with fewer than three PNC visits exhibited higher rates of delayed MR1 (26.40%) and MR2 (58.10%) vaccinations than did those with more than three visits (19.20% and 51.30%, respectively). Of the 97.15% of mothers who attended the PNC, 59.98% (178) received immunization information during PNC visits. Among the mothers who received immunization information during PNC, 41 (23.00%) exhibited delayed MR1 vaccination, and 96 (53.90%) exhibited delayed MR2 vaccination. Furthermore, higher delays were observed among those who did not receive immunization information for MR1 (21, 34.40%) and MR2 (33, 54.10%) during the PNC period. No statistical significance was found in inferential statistics.

Immunization Services

In Table 3, immunization services are evaluated against the MR1 and MR2 vaccinations.

Table 4: Cross-tabs, Fisher's Exact and Bivariate Analysis of factors related to immunization services for MR1 and MR2

Factors		MR1					MR2				
		Cross-tabs Delayed 79 (25%)	Cross-tabs Not delayed 237 (75%)	Fisher's exact P-value	Bivariate Analysis		Cross-tabs Delayed 177 (56%)	Cross-tabs Not delayed 139 (44%)	Fisher's exact P-value	Bivariate Analysis	
					p-value	OR (95%CI)				p-value	OR (95%CI)
Vaccines free of charge	Yes	72 (25.20)	214 (74.80)	1.00	0.64	0.59 (0.68-5.17)	157 (54.90)	129 (45.10)	0.08	1.00	1327354474.00 (NA)
	No	6 (25.00)	18 (75.00)		0.67	0.60 (0.58-6.21)	14 (58.30)	10 (41.70)		1.00	1153901729.80 (NA)
	Unsure	1 (16.70)	5 (83.30)		0.14	5.00 (ref)	6 (100.00)	0 (0.00)		1.00	0.00 (ref)
Private vs public	Public	73 (24.70)	223 (75.30)	0.60	0.60	1.31 (0.49-3.53)	168 (56.80)	128 (43.20)	0.36	0.31	0.62 (0.25-1.55)
	Private	6 (30.00)	14 (70.00)		0.08	2.33 (ref)	9 (45.00)	11 (55.00)		0.66	1.22 (ref)
Know working hours of healthcare facility	Yes	74 (24.50)	228 (75.50)	0.26	1.00	4977464375.00 (NA)	168 (55.60)	134 (44.40)	0.32	1.00	0.00 (NA)
	No	4 (30.80)	9 (69.20)		1.00	3634858853.00 (NA)	9 (69.20)	4 (30.80)		1.00	0.00 (NA)
	Unsure	1 (100.00)	0 (0.00)		1.00	0.00 (ref)	0 (0.00)	1 (100.00)		1.00	1615517202.00 (ref)
Convenient working hours	Yes	71 (23.90)	226 (76.10)	0.16	0.42	3.18 (0.20-51.55)	167 (56.20)	130 (43.80)	0.36	1.00	0.00 (NA)
	No	7 (41.20)	10 (58.80)		0.81	1.43 (0.08-26.90)	10 (58.80)	7 (41.20)		1.00	0.00 (NA)

	Unsure	1 (50.00)	1 (50.00)		1.00	1.00 (ref)	0 (0.00)	2 (100.00)		1.00	1615463112.00 (ref)
Waiting time for immunization services	< 30 minutes	7 (24.10)	22 (75.90)		0.73	1.57 (0.12-20.06)	13 (44.80)	16 (55.20)		0.71	0.62 (0.05-7.57)
	30 min to 1 hour	8 (29.60)	19 (70.40)		0.89	1.19 (0.94-15.04)	15 (55.60)	12 (44.40)		0.48	0.40 (0.03-4.96)
	1 and 3 hours	11 (19.60)	45 (80.40)	0.78	0.57	2.05 (0.17-24.65)	28 (50.00)	28 (50.00)	0.39	0.58	0.50 0.04-5.84)
	>3 hours	52 (25.90)	149 (74.10)		0.77	1.43 (0.13-16.13)	120 (59.70)	81 (40.30)		0.38	0.34 (0.03-3.78)
	Unsure	1 (33.30)	2 (66.70)		0.57	2.00 (ref)	1 ((33.30)	2 (66.70)		0.57	2.00 (ref)
Satisfaction with immunization services	Very Unsatisfied	0 (0.00)	1 (100.00)		1.00	706770253.20 (NA)	1 (100.00)	0 (0.00)		1.00	0.00 (NA)
	Unsatisfied	13 (35.10)	24 (64.90)		0.65	0.81 (0.32-2.03)	20 (54.10)	17 (45.90)		0.67	1.21 (0.50-2.89)
	Neutral	6 (22.20)	21 (77.80)	0.41	0.45	1.53 (0.51-4.62)	16 (59.30)	11 (40.70)	0.98	0.96	0.98 (0.37-2.57)
	Satisfied	46 (22.40)	159 (77.60)		0.25	1.51 (0.75-3.07)	113 (55.10)	92 (44.90)		0.66	1.16 (0.61-2.21)
	Very Satisfied	14 (30.40)	32 (69.60)		0.01	2.29 (ref)	27 (58.70)	17 (41.30)		0.24	0.70 (ref)

***Fisher's Exact statistically significant at p-value < 0.05** ***ref-reference**

***Bivariate logistic regression analysis statistically significant at p-value < 0.05** ***NA-Not Applicable**

Regarding vaccine affordability, a substantial proportion of caregivers acknowledged that vaccines were offered without cost; however, 72 (25.20%) of those who reported vaccines were free had delayed MR1, compared to 6 (25.00%) of those who reported vaccines were not free. For MR2, among those indicating vaccines are free, 157 (54.90%) had delayed vaccination, compared to 14 (58.30%) for those who reported vaccines are not free. The majority of caregivers used immunization services at public health facilities (296, 93.68%). Public facilities exhibited slightly lower delay rates for MR1 (24.70%) than private facilities (30.00%), but an inverse trend was observed for MR2, where private facilities demonstrated lower delay rates (45.00%) than public facilities (56.80%).

Of the 316 caregivers, 302 (95.57%) were cognizant of the operating hours of healthcare facilities and reported fewer delays in MR1 (24.50%) and MR2 (55.60%). Among those caregivers who considered operating hours to be inconvenient (297, 93.99%), fewer delays were observed in both MR1 (41.20 %) and MR2 (58.80). However, higher delays were noted among those who were unfamiliar with operating hours and did not perceive operating hours as convenient.

Delays were least frequent when waiting times were less than 30 minutes for MR1 (24.10%) and MR2 (44.80%). Extended waiting times (>3 hours) were associated with the highest delays for both vaccines (MR1-25.90% and MR2-59.70%, respectively). Higher satisfaction levels were associated with fewer delays. For instance, caregivers who reported satisfaction or very high satisfaction exhibited the lowest delay rates for MR1 (22.40% and 30.40%, respectively) and MR2 (55.10% and 58.70%, respectively). Dissatisfaction and neutrality correlated with higher delays.

Multivariate logistic regression analysis for MR2

Multivariate Logistic Regression Analysis is a statistical method used to examine multiple predictor (independent) variables, multiple outcome (dependent) variables, or both. This approach enables researchers to investigate the relationship between two variables, while concurrently controlling for the influence of other variables (30).

For MR2, the variables that demonstrated statistical significance included the cohort 13-24 months (OR:4.00; 95% CI 1.69-9.49; p = 0.002), being firstborn (OR:3.22; 95% CI 1.04-9.99; p = 0.04), being the only sibling (OR3.51; 95% CI 1.33-9.28; p = 0.01), and residing in residential blocks D (OR:3.72; 95% CI 1.30-10.65; p = 0.01) and F (OR:2.73; 95% CI 1.09-6.84; p = 0.03). These variables were subjected to multivariate regression analysis, which yielded the following results (Table 4):

Table 5: Multivariate logistic regression analysis for MR2

				95% C.I.	
		p-value	**AOR**	**Lower**	**Upper**
	Cohort (months)	0.00			
	Cohort 9-12	1.00	6158571242.83	.000	.
	Cohort 13-24	**0.001***	4.54	1.80	11.44
	Cohort 25-36	0.18	1.83	0.76	4.42
	Cohort 37-48	0.76	0.09	0.35	2.15
	Birth order	0.56			
	Birth order 1st	0.19	5.61	0.43	73.54
	Birth order 2nd-3rd	0.31	3.33	0.32	34.76
	Birth order 4th-5th	0.35	2.73	0.34	21.86
	Number of siblings	1.00			
	Sibling 0	0.99	1.02	0.11	9.41
	Sibling 1-2	0.96	0.95	0.14	6.63
	Sibling 3-4	0.91	1.10	0.20	5.93
	Residential Block	0.04			
	Residential B	**0.008***	3.85	1.42	10.42
	Residential D	**0.009***	5.07	1.49	17.28
	Residential E	**0.010***	2.98	1.30	6.83

	Residential F	**0.018***	3.73	1.26	11.07
	Constant	.000	0.04		

***Multivariate logistic regression analysis statistically significant at p-value < 0.05**

In the multivariate analysis, the cohort aged 13-24 months (AOR=4.54; 95% CI 1.80-11.44; p = 0.001) and residential areas, specifically Blocks B (AOR=3.85; 95% CI 1.42-10.42; p = 0.008), D (AOR=5.07; 95% CI 1.49-17.28; p = 0.009), E (AOR=2.98; 95% CI 1.30-6.83; p = 0.010), and F (AOR=3.73; 95% CI 1.26-11.07; p = 0.018) demonstrated statistical significance. These results indicate that children in the 13-24 months cohort exhibited a 4.54 times higher probability of receiving a delayed MR2 dose than children in the 49-59 months cohort. Furthermore, the adjusted odds ratio suggested an increased likelihood ranging from 2.98 to 5.07 times for children residing in blocks E, F, B, and D to experience a delayed MR2 dose compared to those residing in block G. Birth order and number of siblings did not exhibit statistical significance.

Knowledge of caregiver on measles vaccination

The knowledge assessment of caregivers regarding measles vaccination has revealed a complex landscape. While participants exhibited varying levels of understanding, as illustrated in Figure 10 below, scoring favorably (above 80%) on six questions, adequately (between 60-80%) on four, and poorly (below 60%) on three; the statistical analysis indicates a multifaceted relationship between knowledge and vaccination delays.

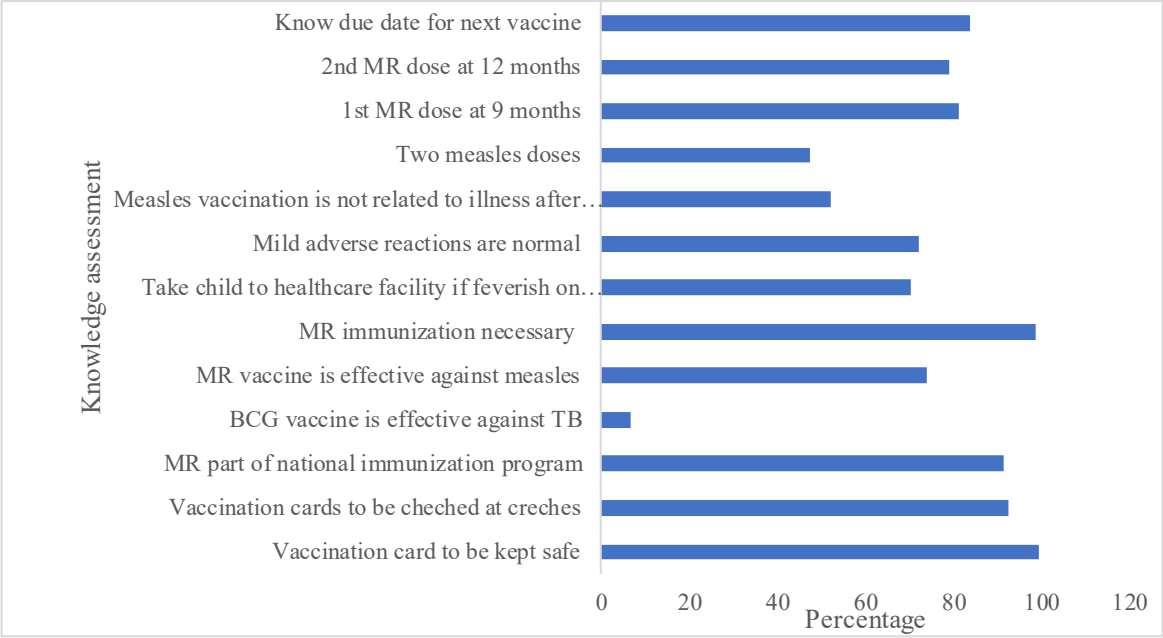


Figure 10: Knowledge of caregivers on measles vaccination

Due to the non-normal distribution of the data, a non-parametric Mann-Whitney U test was employed to compare knowledge levels between the delayed and non-delayed groups for MR1 and MR2 vaccinations (Figure 11 a and b). The Mann-Whitney U test revealed noteworthy findings. For MR1, the difference between the delayed and non-delayed groups was not statistically significant ($p=0.097$). However, the MR2 results demonstrated a marginally significant difference ($p=0.052$), indicating a potential, albeit weak, association between knowledge and second-dose vaccination timing. No significant association between knowledge and delays for either MR1 ($p=0.65$) or MR2 ($p=0.45$) was observed in Fisher's exact test, suggesting that, while subtle variations in caregiver knowledge may exist, these differences do not conclusively predict vaccination timeliness.

These findings elucidate the multifaceted nature of vaccination behaviors. Knowledge alone may not serve as a direct predictor of timely measles immunization. Additional factors, including accessibility, healthcare infrastructure, individual motivation, and

systemic barriers likely exert a significant influence on vaccination adherence. These results necessitate a more comprehensive approach to elucidate and enhance the vaccination rates. While educational interventions remain crucial, they should be integrated into a multifaceted strategy that addresses various potential impediments to timely vaccinations.

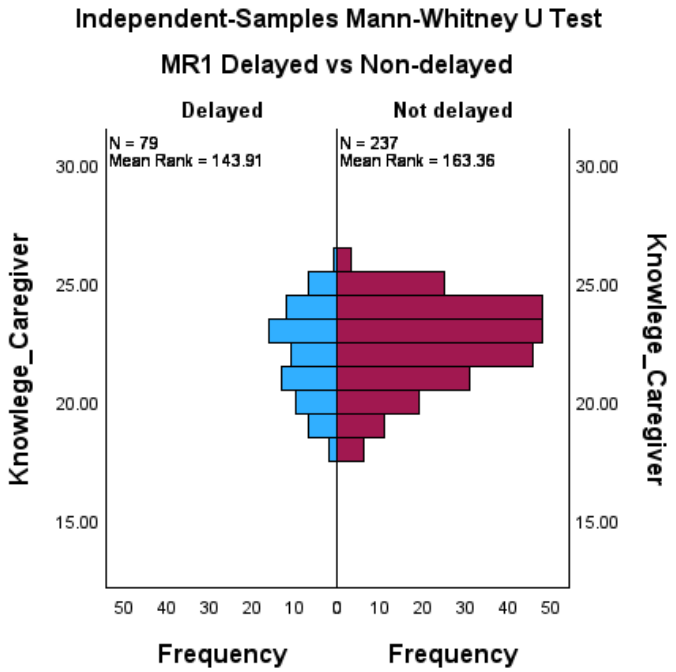


Figure 11 a: Mann-Whitney U Tests for MR1

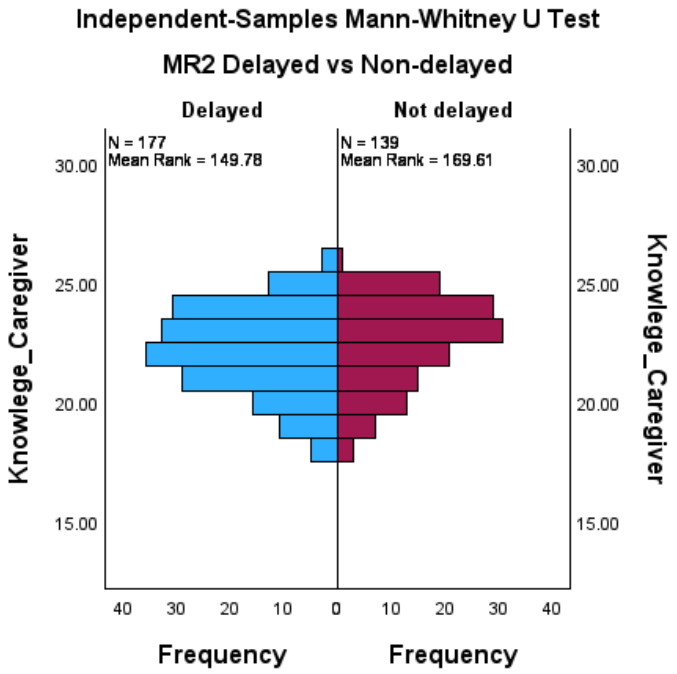


Figure 12 b: Mann-Whitney U Tests for MR2

Health Belief Model

The Health Belief Model analysis elucidated a nuanced understanding of caregivers' attitudes toward measles vaccination, as shown in Table 8. The Shapiro-Wilk and Kolmogorov-Smirnov tests confirmed a non-normal distribution of perception data ($p < 0.001$), necessitating a non-parametric statistical approach. Median values and interquartile ranges (IQR) were used to characterize the dataset. The Mann-Whitney U test results provided critical insights into the relationship between vaccination perceptions and timely immunization.

Table 6: Caregiver attitude and health beliefs towards measles vaccination

Perception of susceptibility to measles (n=316)	**Strongly disagree N (%)**	**Disagree N (%)**	**Unsure N (%)**	**Agree N (%)**	**Strongly Agree N (%)**	**Median (IQR)**
Measles is infectious, and children are more likely to get measles than adults	0 (0.00)	17 (5.38)	22 (6.96)	273 (86.39)	4 (1.27)	
Without vaccination, children will likely get measles	0 (0.00)	15 (4.75)	15 (4.75)	283 (89.56)	3 (0.95)	
Without timely vaccination, children are more likely to get measles	0 (0.00)	38 (12.03)	33 (10.44)	243 (76.90)	2 (0.63)	**20.00 (2.00)**
Without completing two doses of measles vaccines within two years, children are more likely to get measles	0 (0.00)	19 (6.01)	33 (10.44)	264 (83.54)	0 (0.00)	
Without timely and complete measles vaccination, children are more likely to get complications of measles, e.g. pneumonia	0 (0.00)	23 (7.28)	27 (8.54)	266 (84.18)	0 (0.00)	
Perception of the severity of measles (n=316)	**Strongly disagree N (%)**	**Disagree N (%)**	**Unsure N (%)**	**Agree N (%)**	**Strongly Agree N (%)**	
Measles is a serious illness	0 (0.00)	9 (2.85)	13 94.11)	292 (2.41)	2 (0.63)	
Measles is one of the major causes of death among children	0 (0.00)	22 (6.96)	46 (14.56)	248 (78.48)	0 (0.00)	**16.00 (1.00)**
Measles can weaken the child's immune system	0 (0.00)	7 (2.22)	7 (2.22)	301 (95.25)	1(0.32)	
If my child contracts measles, the disease could spread to other family members in the house	0 (0.00)	19 (6.01)	25 (7.91)	272 (86.08)	0 (0.00)	
Perception of benefit from measles vaccination (n=316)	**Strongly disagree N (%)**	**Disagree N (%)**	**Unsure N (%)**	**Agree N (%)**	**Strongly Agree N (%)**	
MR vaccination will protect my child against measles	0 (0.00)	19 (6.01)	6 (1.90)	291 (92.09)	0 (0.00)	**16.00 (0.00)**
MR vaccination will alleviate symptoms of measles	0 (0.00)	18 (5.70)	11 (3.48)	86 (90.51)	1(0.32)	

MR vaccination will stop the transmission of measles among children	0 (0.00)	21 (6.65)	13 (4.11)	282 (89.24)	0 (0.00)	
MR vaccines are safe for children	0 (0.00)	1(0.32)	4 (1.27)	311 998.42)	0 (0.00)	
Perception of barriers to measles vaccination (n=316)	**Strongly disagree N (%)**	**Disagree N (%)**	**Unsure N (%)**	**Agree N (%)**	**Strongly Agree N (%)**	
Two doses of MR vaccine are unnecessary, my child should only get one measles dose	1(0.32)	299 (94.62)	7 (2.22)	9 (2.85)	0 (0.00)	
It is better to get natural immunity by getting measles rather than through immunization	0 (0.00)	306 (96.84)	4 (1.27)	6 (1.90)	0 (0.00)	
MR immunizations are unsafe and have serious side effects	0 (0.00)	313 (99.05)	3 (0.95)	0 (0.00)	0 (0.00)	
Time and transportation to the health facility make it difficult to take my child for vaccination	1(0.32)	288 (91.14)	0 (0.00)	26 (8.23)	1(0.32)	**16.00 (0.00)**
A child can still get measles despite vaccination	0 (0.00)	301 (95.25)	8 (2.53)	7 (2.22)	0 (0.00)	
I do not know when my child needs to get vaccinated	1(0.32)	291 (92.09)	3 (0.95)	21 (6.65)	0 (0.00)	
My child is allergic to vaccines or eggs	0 (0.00)	309 (97.78)	4 (1.27)	3 (0.95)	0 (0.00)	
There is no information available about the safety of MR vaccines	0 (0.00)	306 (96.84)	4 (1.27)	5 (1.58)	1(0.32)	
Perception of cues to action (n=316)	**Strongly disagree N (%)**	**Disagree N (%)**	**Unsure N (%)**	**Agree N (%)**	**Strongly Agree N (%)**	
If MR vaccination is recommended by healthcare workers, I would let my child be vaccinated	0 (0.00)	57 (18.04)	1(0.32)	258 (81.65)	0 (0.00)	**20.00 (2.00)**
If MR vaccination is suggested by relatives, I would let my child be vaccinated	1(0.32)	136 (43.04)	2 (0.63)	177 (56.02)	0 (0.00)	
If there is information available about the safety of MR vaccines, I would let my child be vaccinated	0 (0.00)	28 (8.86)	1(0.32)	287 (90.82)	0 (0.00)	

If MR vaccine is available and accessible, I would let my child be vaccinated	0 (0.00)	16 (5.06)	1(0.32)	299 (94.62)	0 (0.00)	
If I am aware of the vaccination dates on my child's vaccination card, I would let my child be vaccinated	0 (0.00)	1(0.32)	0 (0.00)	314 (99.37)	1(0.32)	
Perception of self-efficacy (n=316)	**Strongly unwilling N (%)**	**Unwilling N (%)**	**Unsure N (%)**	**Willing N (%)**	**Strongly Willing N (%)**	**8.00 (1.00)**
Are you willing to let your child completely participate in the national immunization program?	0 (0.00)	0 (0.00)	0 (0.00)	236 (74.68)	80 (25.32)	
Are you willing to let your child be vaccinated on time?	0 (0.00)	0 (0.00)	0 (0.00)	236 (74.68)	80 (25.32)	

The majority of participants exhibited a high level of awareness regarding measles risks, with widespread consensus on the infectiousness of the disease and importance of vaccination. However, the statistical analysis revealed that subtle variations in perceptions of barriers and self-efficacy can significantly influence vaccination timeliness.

Fisher's exact test further corroborated these findings, demonstrating a strong association between barrier perceptions and MR1 (p=0.002) and MR2 (p=0.003) vaccination delays and a marginal correlation between self-efficacy (p=0.005) and timely immunization. Despite positive attitudes, with nearly all respondents expressing beliefs in vaccine safety and benefits, structural or perceived barriers continue to affect timely vaccination adherence.

These results elucidate the complexity of vaccination behavior. Although caregivers demonstrated substantial knowledge and positive intentions, external factors and personal perceptions could impede timely immunization. The findings suggest that targeted interventions should not only emphasize education, but should also address specific barriers and enhance caregivers' confidence in navigating the vaccination process. This study underscores the necessity of a comprehensive approach that integrates awareness, accessibility, and personalized support to optimize vaccination rates.

Table 7: Mann-Whitney U Test

Perceptions on	**p-value**	
	MR1	**MR2**
Susceptibility	0.896	0.081
Severity	0.629	0.529
Benefits	0.743	0.174
Barriers	**0.019***	**0.008***
Cues to action	0.915	0.893
Self-efficacy	0.410	**0.004***

***Mann-Whitney U Test statistically significant at p-value < 0.05**

While the majority of domains exhibited no statistically significant differences, two critical areas emerged as pivotal in the Mann-Whitney U test (Table 9): perceived barriers and self-efficacy. For MR1, the perceived barriers demonstrated a significant difference (p=0.019). For MR2, the perceptions of both barriers (p=0.008) and self-efficacy (p=0.004) exhibited statistically significant differences between the delayed and non-delayed groups.

Barriers to timely MR vaccination as outlined by caregivers

The reasons provided by caregivers for the delayed administration of MR 1 or 2 were categorized into five primary barriers to timely MR vaccination. The most prevalent were communication and education issues, with the majority of respondents failing to review the follow-up date on their vaccination cards. Additional reasons included the absence of an immunization card and a lack of awareness regarding the significance of immunization. Logistical and accessibility barriers encompassed the unavailability of an escort to accompany the child to the health facility while the mother was engaged in employment, agricultural activities, and distance or transportation limitations. Health system-related issues primarily involve vaccine stockouts and documentation discrepancies. Caregivers' attitudes, such as negligence and apprehension concerning COVID-19, also contributed. Finally, situational and external factors included child illnesses and other uncertainties, as delineated in Table 10.

Table 8: Barriers to timely MR vaccination as outlined by caregivers

Barrier theme	Specific barrier	Frequency
1. Communication and education issues	Forgot to look at dates in vaccination card	89
	Immunization card not given to caretaker	7
	Poor knowledge on importance of vaccination	6

2. Logistical and accessibility issues	Caregiver was at work and no one available to take child	34
	Stayed on farm	28
	Clinic too far, transport issues, no taxi money	20
	Traveled when the vaccine was due	6
	Long waiting times	5
3. Health System related issues	No stock of vaccines at the healthcare facility	20
	Private and public immunization schedules differ	5
	Follow-up date was not recorded	5
	Wrong follow-up date recorded by HCW	5
	Health facility refused to vaccinate visitors	2
	Dr's practice closed for holiday	1
	Unfriendly security guard	1
4. Caretaker Attitudes	Negligence	18
	Fear of COVID-19	11
	Fear of side-effects	1
5. Situational and external factors	Child was sick	19
	Unsure	6

4.3 QUALITATIVE RESULTS

4.3.1 Objective 3

Socio-demographic characteristics of participants

Twelve key participants were interviewed. All respondents were female with a mean age of 44 ± 10.4 years, 50% (6) were nurses, 33% (4) were community health workers, and 16% (2) were pharmacist assistants. The mean years of employment was 7.3±3.4 years.

Themes and sub-themes

When a phenomenon can be explained using abstract and nuanced statements, patterns, or procedures, it is referred to as a theme. The main themes represent the most significant or broad patterns in the data. They offer high-level comprehension of the main ideas or problems found in the data (39,40). The sub-themes are within the

themes. They highlight particular and significant facets of the main organizing idea of a topic, adding another level of depth and nuance (40).

Healthcare workers were solicited to provide insight into the barriers contributing to delays in the timely administration of MR immunization in children. The collected responses were analyzed using Atlas ti. version 24 software, leading to the identification of five primary themes and 21 sub-themes.

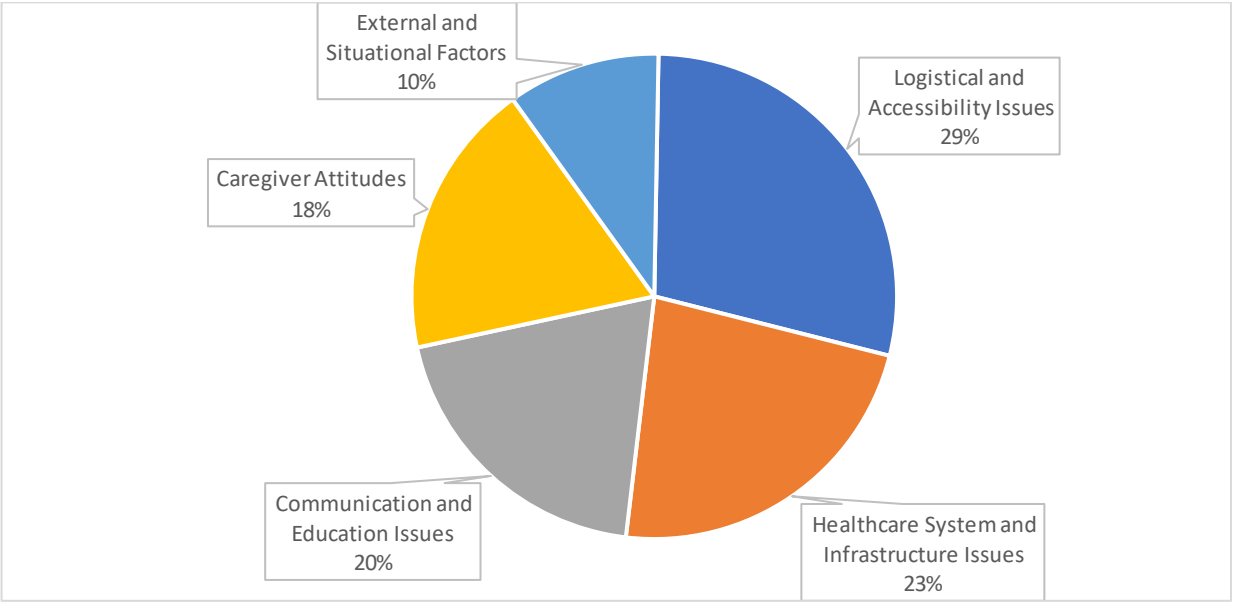


Figure 13: Themes generated from barriers to untimely MR vaccination from healthcare workers' perspectives

Logistical and accessibility issues emerged as the most prevalent themes, accounting for 45 responses (27%). This category encompasses issues such as long waiting times and lack of transport money. Following this, 36 responses (24%) highlighted **healthcare system and infrastructure issues** related to timely MR vaccination, including staff attitudes, staff shortages, and record keeping as significant impediments.

The third most common barrier, cited in 31 responses (20 %), was related to **communication and education issues**, with caregivers forgetting to look at the dates

on the vaccination card and a lack of parental knowledge of health passports. **Caregiver attitudes** were identified in 29 responses (18 %) as another barrier, primarily reflecting issues with caregivers' attitudes and dependency and confusion concerning immunization campaigns. **Under external and situational factors,** 16 responses (10%) indicated that the child being ill on the day of vaccination was a barrier to timely MR vaccination.

4.3.1.1. Theme 1: Logistical and accessibility issues

Among the sub-themes identified by healthcare workers under the category of logistical and accessibility issues were long waiting times, lack of transport and taxi money, children staying with another caretaker, and staying on a farm.

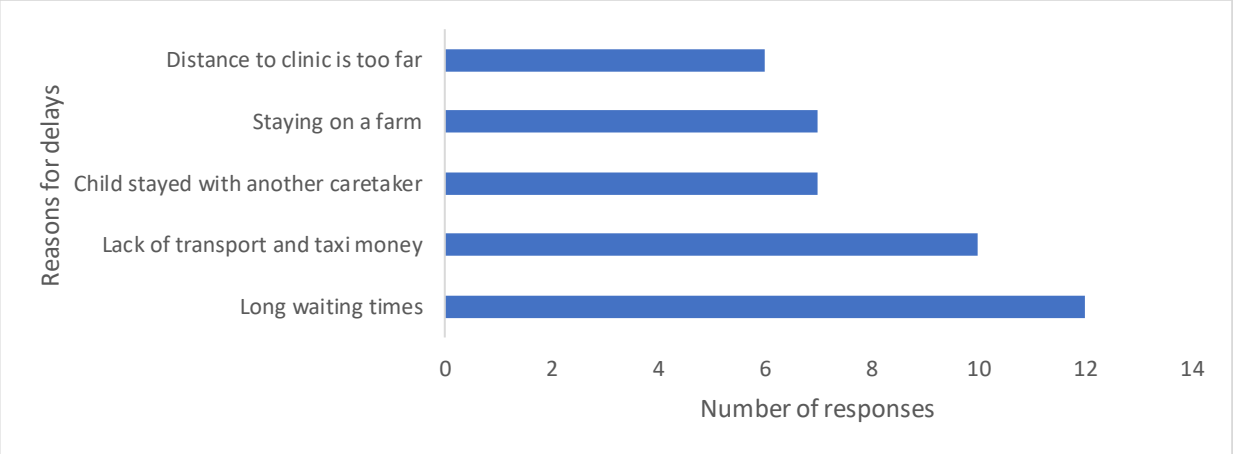


Figure 14: Sub-themes on logistical and accessibility issues impacting MR vaccination timeliness

Sub-themes

1.1 Long waiting times

Several participants highlighted long waiting times as a barrier to timely MR vaccinations. Participants (P) #1 and #5 had this to say about the long waiting times: *"Some parents are difficult to deal with when it comes to immunization, because they complain of long queues at the facilities. Some complain for sitting long at the health*

facility, just waiting for injection." Quote (P#1) and *"There is sometimes in the month, like the beginning of each month, the clinic is full because this is the time when we also have the pensioners pay out and also the people of the farm….And there is really a waiting time until past five, most of the time."* Quote (P#5).

Many healthcare workers indicated that, with the integration model (where all services are offered in each consulting room), caregivers await long periods. Participant #4 had this to say: *"Some will explain of the waiting period outside…I came there six o'clock in the morning and left the clinic five o'clock without being helped…So that integration, I think that one should be checking in there for the babies to be immunized at a designated room and get out of the clinic as quickly as possible. This integration story and immunization, it's not working."* It seems where the model has been adjusted to offer immunization services separately, waiting times have been reduced as was mentioned by participant #8, *"Because due to integration, all the people were being seen in every room. But then we changed that to one room seeing all the babies and all the ANCs. That was because of the fact that most mothers would be like, I was there the whole day, so I went back home…Because the waiting in line is not that long anymore."* Waiting for immunization could result in children and caregivers becoming hungry, angry, and irritable, which could result in them not returning to immunization services. Participants #6, #7 and #9 echoed the same. Below are their responses: Quote (P#6): *"Because if I sit with my child outside and the child is hungry, the child is crying, and then I start to get hungry…So they may leave the facility without getting vaccinations."* Quote (P#7): *"The clinic is very full every day …when we are coming at eight o'clock to the clinic, they are already sitting. And then they are sitting the whole day and maybe when it's four o'clock, they call, sister, I'm sitting here the whole day and it's just for immunization for my child. And then it's five o'clock and then they*

go home and maybe they didn't come back the next day because they said, no, I was sitting the whole day here, I'm hungry, I'm thirsty, so I will check when I will come." Participant #9 said: *"And then the long waiting in the queues, I was at the clinic but then the clinic was too full then I went back."*

1.2 Lack of transport and taxi money

Several healthcare workers indicated that parents would complain about transport issues, ranging from not getting a hike to a lack of finances for taxi fares, preventing them from bringing their children to receive their MR vaccination in a timely manner. Below are some of the responses from the interviewees: P#5 indicated that *"There are transport issues."* Participant #6 highlighted that to reach the facility, caregivers need to hike and subsequently have to pay for the hike, *"We couldn't get a hike, so basically transport problem, probably finance. That's what they say, yes, financial problems."* The next couple of respondents outlined a lack of money and their own transport as barriers. Quote (P #7, P #10, and P #11): *"They haven't got money for transport to the clinic, we haven't got taxi money."* Quote (P #9, P #12): *"We didn't have transport."* and *"There was no transport to reach the health facility."*

1.3 Child stayed with another caretaker

Under this sub-theme, according to healthcare workers, a common excuse cited by parents as to why their children are late for their MR vaccination is that the child was staying with another caregiver, mostly on a farm with grandmothers. This could have resulted in them not knowing when the child was due to their MR vaccination. Participant #10 pointed out that: *"The baby can be moved from the biological mother to the grandmother, because the biological mother got a job somewhere else. The grandmother did not understand the importance of bringing the child for 15 months. The grandmother might come at two years, or the grandmother might come when the*

child gets sick. This is when, as a health worker, you notice that this child didn't get the 15 months." Leaving children with another caregiver due to employment was supported by respondent P #7 who said *"Mostly the grandmothers that are looking at the children when the mothers are working in Windhoek or on the farms."* The next respondents concurred with previous respondents that children can be left with grandparents who might not know the next due date for MR vaccination. Quote P #1 *"And then some kids apparently stay at the farms with grandparents."* Quote P #4 *"The child doesn't stay with me, my mother took the child. So the child stays with the ouma."* Quote (P #5): *"Children in the Rehoboth are mostly with the grandparents. So the grandparents, they did not know that the child is now due for measles and rubella."* Quote (P #9): *"Maybe the child even has gone and stayed with the grandmother. They'll tell you the child has been with the father and I didn't have access to the child."*

1.4 Staying on a farm

Parents would also inform healthcare workers that they were living on a farm as part of the barriers. The scenario in Rehoboth is that there are a lot of farm owners living on commercial farms and a few on communal farms. This led to the employment of farm workers. Normally, children would then go with their families to the farm. These individual farms are not necessarily on the primary healthcare outreach list of the health center, as the focus is on areas with greater concentrations of people. The key response from the following respondents was that they were on the farm: Quote (P #3) *"The only reason they'll give you is the farm."* (Quote P #4, P #11): *"I've been on the farm*." and "*I was on the farm*." Quote (P #5): *"Most of them are on farms*." Quote (P #6, P #12): *"We were staying on the farm*." and "*They were on the farm*." Quote P #8 *"Live on a farm somewhere outside Rehoboth*."

1.5 Distance to clinic is too far

It is not just distances from the farms that are too far; some parents indicated that their house within the urban setting was far from the health facility. Coupled with no money for taxi fares, this becomes a frequently cited reason for delaying MR vaccination in children as outlined in the following responses: Quote (P #1): *"And then also long distances."* Quote P #3: *"The parents, they give reasons of like they are staying far."* Quote (P #5): *"The mommies complain they stay far from the clinic..."* Quote (P #6): *"They are staying too far and coming here is a problem."* Quote (P #10): *"The distance from Block G to the health center, it's a bit far for an elderly person."*

4.3.1.2 Theme 2: Healthcare system and infrastructure issues

Under the theme of health system and infrastructure issues, 11 sub-themes emerged, with the most frequently cited ones being attitudes of healthcare workers, followed by staff shortage, follow-up data not recorded, and non-stock of vaccines.

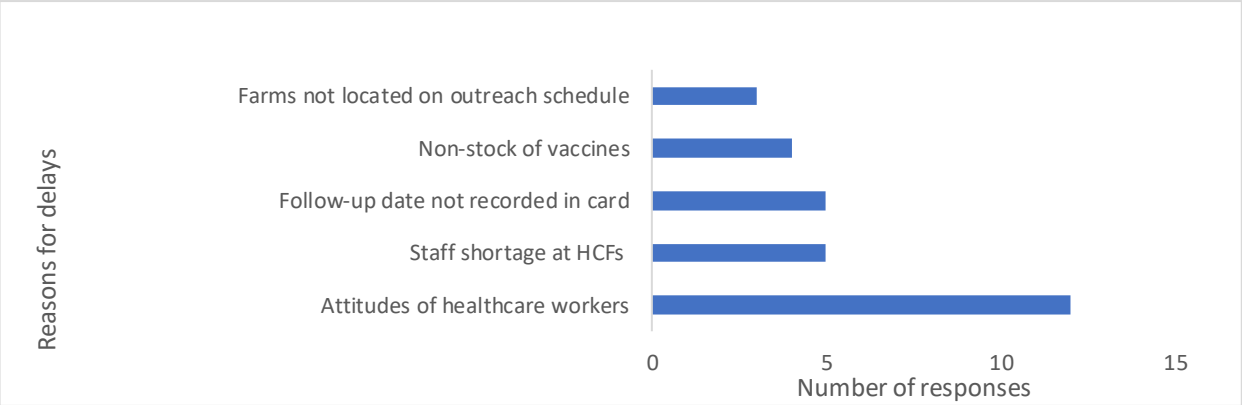


Figure 15: Sub-themes on healthcare system and infrastructure-related issues resulting in untimely MR vaccination

Sub-themes

2.1 Attitudes of healthcare workers

The interviewed healthcare workers raised mixed opinions on the impact of healthcare workers' attitudes on MR vaccination timeliness. Some acknowledged that nurses are

perceived as rude when they are not friendly, provide enough health education, or refuse to open a 10-dose vial to reduce wastage of the vaccine. Quote P #1 *"I probably should also say that sometimes people feel that the nurses are scolding them. They don't take time to explain to the patient. Even when someone is sick, they don't take the time to explain this medication is for what, what, what, what."* Quote P #3: *"It feels like we don't maybe give enough health education or the information, the importance of the immunization or the vaccines, and the person will be like, no, I was treated bad."* Quote (P #5): *"The nurses don't know the importance of timeliness and parents don't even know that vaccines we gave, for what is it. Because we as nurses have neglected that one."* Quote (P #6): *"The nurse is too lazy to get up and come and get the vaccine."* Quote (P #12): *"There are such incidences, like let's say maybe it's a few minutes to five, now you don't want to waste this, open a vial for one child, because of the wastage."* Quote (P #10): *"Then the patient comes while my measles is expired. I only open one vial a day. Because there are 10 doses. I will also cite that we cannot waste economically… It's some health workers are not approachable…The caregiver comes in, you are not welcoming because it's not about verbal talking. It's about non-verbal cues... Then automatically the caregiver will just close or will open up. But when the caregiver comes in, you smile, you try to play with the baby, you crack jokes. You are actually making that caregiver to become calm. You are creating a rapport."* Quote (P #9): *"Even us as health workers, even if I am there now working with those mothers, the way I handle my patient, it will make this patient not keen to come tomorrow…"*

At one facility, it was highlighted that nurses prefer mothers bringing their children for immunization to be attended to first, as this also reduces waiting times. Quote P #2 *"But what Sister does at this facility is a good practice … she calls out the parents who brought the kids for immunization and inject them before she started with other*

people…then the people go home... Because that encourages parents to come because they don't spend a long time at the health facilities."

2.2 Staff shortage at healthcare facilities

Healthcare workers alluded to staff shortages at both healthcare facilities, which resulted in patients being sent back home without attending, and children being brought for immunization could have been among them.

Quote P #4: *"For now, we are only two. We are only getting one relief nurse from Rehoboth HC."* Quote (P #7): *"But you see the numbers increase every day sister. Like when they were busy with the campaign last week, there was only two nurses working here. It was busy. We didn't finish every day. And then we said the patients, but it's now five. Sometimes we work up to half past five…So we asked them, they must come back tomorrow or they must go to the hospital. And then they said we haven't got taxi money."* Quote (P #12): *"From the health facility side, I would say it's the nurse-to-patient ratio, because you find yourself sometimes you're just two at the facility."*

At the other healthcare facility, this was the response: Quote (P #5): *"Sometimes, we have a staff shortage. Because that (EPI/ANC) room, we want two nurses at least. So that one can continue with the EPI and one with the ANC. That's why we take two staff in that room..."* Quote (P #6): *"Due to staff shortage, there are times when we have to send people back. So I think some of those may include children who might have needed the immunization and then are missed..."*

2.3 Follow-up date not recorded in card

Not recording the follow-up date on the immunization card was also noted by some healthcare workers as the reason caregivers failed to bring their children timely for MR vaccination. Some nurses only verbally told mothers to bring their children back

to the next dose. Quote (P #6): *"...some of our nurses would say, okay, bring the baby back when they are six months."* Quote (P #9): *"... Someone doesn't document because now when the child is coming for 15 months, only to discover it's not written on the card, but in the register it's written."*

However, the timeframe between 14 weeks of immunization and the nine-month injection is nearly six months, and that between MR1 and MR2 is also six months, which could lead to the caregiver forgetting unless she has a written date to remind herself. Quote (P #11): *"And sometimes the date when the child was here they don't write that coming back date. So now the mother don't know..."* Quote (P #12): *"Some were not told about follow-up dates or it was not written in the cards."*

2.4 Non-stock of vaccines

MR vaccines have not been out of stock over the past two years, although several other childhood vaccines have been non-stock. It seems that caregivers think that when one vaccine is not available, all vaccines, including MR, are non-stock. Quote P #2 *"There was a time when vaccines were out of stock for a long period of time."* Quote P #3: *"But last year and I think the other year it was, especially the measles."* Quote (P #7): *"There were some times that there were no vaccines at medical stores, like one month there was no vaccine. I can't remember what was it, but there was one time there was no vaccines..."*

4.3.1.3 Theme 3: Communication and education issues

In the sub-themes related to communication and education issues, the main sub-themes were that caregivers forgot to look at the follow-up dates on the vaccination card, parents lacked knowledge of the health passport, children were without the health

passport, and rumors about the non-availability of MR vaccines and working hours for immunization at healthcare facilities.

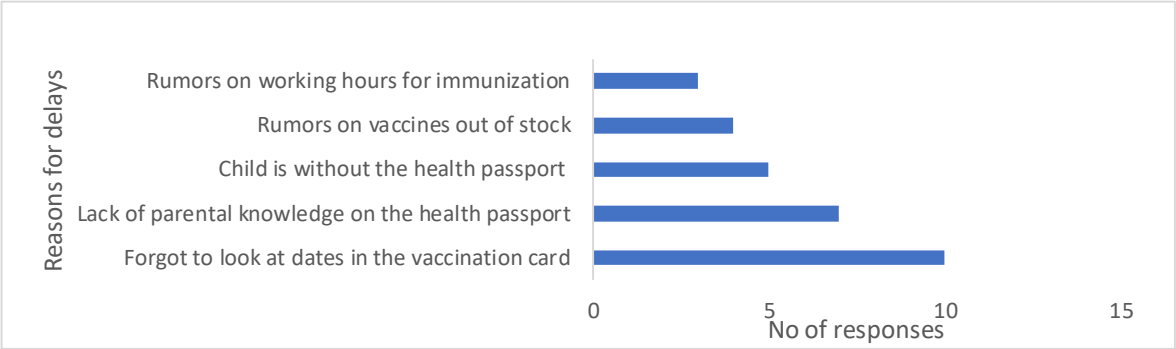


Figure 16: Sub-themes on communication and education issues resulting in untimely MR vaccination

Sub-themes

3.1 Forgot to look at dates in the vaccination card

Among the reasons caregivers forget to look at follow-up dates on the vaccination card is that they still think only one MR vaccine is given as was indicated by respondent R1, *"I would say the main reason is, especially on the 15 months, they forgot about it, because in previous years, we only had one MR rubella vaccine."* Others simply forgot to look at the card, as highlighted by several respondents. Quote (P #5): *"But there is parents, that forget."* Quote (P #6): *"I did not check the passport. So it's just the thing of not really being interested or either just forgetting."* Quote (P #7): *"They forgot about the vaccines. And they didn't check the dates. Or they forgot about the dates."*

3.2 Lack of parental knowledge on the health passport

It seems that parents lack knowledge on how to navigate through the vaccination card; hence, they do not know where to check the date for the next immunization dose or know the importance of the card. This was highlighted by several of the respondents. Quote (P #1): *"We health workers, we understand the cards, but the parents don't*

understand the cards. And mostly we also don't explain to them." Quote (R5, P #5):*" Our parents, they don't understand that passport."* Quote (P #12): *"So it's not really much explained. We have a schedule for after birth, it's written like this, at six weeks, at 10 weeks, at 14 weeks. We don't really explain it like that to the patient. We just give the passport and then just like, there's a date written there, you have to go back to the clinic on that date for the child to get immunized..."*

Some parents might have been illiterate, relying on someone to read the dates, as cited by participant #6. *"So then they can't read, they will not recognize the dates. They have to wait for somebody to come and say is this child due for immunization."*

3.3 Child is without the health passport

When the child is left with a secondary caregiver, the immunization card is not given to them, so they are unaware of when the child should receive the next immunization. This was echoed by the responses of several respondents. Quote (P #12): *"The card was not sent with the child to the grandmother. It's also common. The grandmother is here. The card is in Windhoek with the mother."* Quote (P #10):*" She doesn't hand over properly. And you also find that even the grandmother does not even know where the baby, the birth card is."* Quote (P #9): *"Or sometimes even they come, no passport for the child."* Quote (P #2): *"And when you arrive there, the child is there, but the passport is not there."*

3.4 Rumors about vaccines out of stock

Rumors regarding the non-stock of vaccines circulate in the community. Various vaccines are administered to children before they reach one year of age. Although the MR vaccine has not been out of stock at the district store for the past two years, other childhood vaccines such as pneumococcal, oral, and injectable polio, and rotavirus

vaccines were frequently out of stock. Caregivers would then tell their friends or neighbors that the vaccines are out of stock without indicating which one. Participant #2 had this to say: *"The problem is that people tell each other in the communities, when one goes to the facility and is told there is no vaccine, not making sure which vaccine is out of stock."* Participants #1 and # 4 supported it: *"... especially PCV might be out of stock, then they will tell the next one. Now you are telling this one, your child is due for MR. They will tell you there's no vaccine..."* (Quote P #1). *"One common thing is ... they will come and say you didn't have the measles injection so that one was telling me another one that it is not in stock."* (Quote P #4). Participant #12 recalled a scenario where "*I remember I also had a patient like that, she was like, I was here and then we were told that there's no injection. Now in my mind, I'm like, no, but this injection was never out of stock...."*

4.3.1.4 Theme 4: Caregiver attitudes

Within the theme addressing caregiver attitudes, five sub-themes were highlighted, with the most significant being the attitudes of caregivers, immunization campaigns creating confusion and dependency, and mothers being at work.

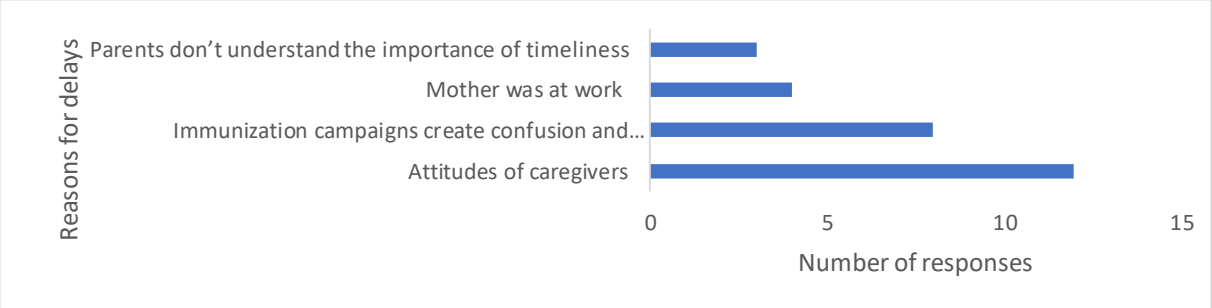


Figure 17: Sub-themes on caregiver attitudes impacting MR vaccine timeliness

Sub-themes

Caregivers' attitudes include negligence, reluctance, and careless attitudes due to being under the influence of alcohol; impatience, depending on immunization campaigns; and a new caregiver that blames the mother for not taking the child for immunization. Participant #1 said: "*Then I would describe it as blame-shifting, because sometimes the kids are staying with grandparents and their cards are with the parents …Even now that the health facility is…two steps from my area, they are still complaining."* Quote P #3: "T*hey don't stay with the kids or it's the sisters or the kids are staying with their grandmothers."*

Another respondent, P #2 highlighted *"Alcohol-consuming parents. Those ones don't care whether their kids are immunized or not. Dependency of those immunization campaigns, some are just reluctant, waiting for the immunization campaigns to be in the communities for them to take the children there."* Quote (P #7): "*And there's some times that the mother is maybe under the influence of alcohol and they didn't bring the child to the vaccination point or to the clinic..."*

Caregivers wait for campaigns to be done in their area as was alluded to by respondent P #4 "*As we have been doing the campaign last week you will see that the child was immunized last year November during the campaign and again now during the campaign not being taken to the clinic. So it seems like the people are sitting and waiting for the campaigns to happen."*

Quote (P #6): "*Parents themselves are just negligent, … because there is means to bring the children and sometimes they come to Rehoboth but they do not visit the clinic…they don't stay non-stop at the farm."* Quote (P #10): "*Then when you talked to the grandmother, why didn't you come for the 15 months? I was not aware that the child has to get the 15 months… You are now talking to a new caregiver after two years.*

No, but the date was written. No, I'm not the mother of the child." Quote (P #11): "*So some will go but then you get the reluctant mothers that need to be pushed to go..."*

4.2 Immunization campaigns create confusion and dependency

Poor information sharing on the purpose of the immunization campaign causes parents not to take children, as they believe the campaign covered routine immunization as well, and parents do not read the immunization card. Participant #1 had this to say *"But we don't explain to them the reasons why the kids are getting the vaccines..."* Quote (P #6): *"They are not given the correct information to say that this mass campaign does not replace the vaccine."* Quote (P #9): *"... So because now when you see that this child is missed nine months, and the child is 11 months, we have a campaign, we give and then we write on the special programs or whatever. And then you need to write the notes like if the child, the mother brought the passport, follow up, then give a month follow up to go now and get the dose that will be written on the other side. So it really confuses them."*

Quote (P #12): *"Yeah, I think it kind of creates a confusion because they feel like, no, my child got during the campaign. So if I have to take my child again because this one is blank, then what if my child gets sick from a double dose or something like that?"* Quote (P #2): *"Because when a child is late, people used to say, no, but I took the child to the immunization when people were sitting where, where. But not reading in their passport of the kids and see according to the ages, how kids are supposed to get the immunizations..."* Quote (P #10): *"Some even come and ask the health workers, my child got this when it was during campaign. Can she get again?"* Quote (P #11): *"Because you get that mothers, they will tell you, no, I was in the campaign and they will show you in the clinic card. The child got that."*

4.3 Mother was at work

Three respondents said that their parents were working and could not get off to take their child to the clinic for immunization. The child is then cared for by someone else, and the passport is not handed to the carer, as the child is not permanently staying with the person.

Participant #11 indicated the following: *"... one reason why some of the kids in our areas are not immunized is because some parents work. And when you arrive there, the child is there, but the passport is not there."* This was supported by participant #6: "*I was at work and I couldn't get off. I couldn't bring the child. So that's why the child is late…Because most of them are domestic workers around here. So it's difficult for them to abandon the work because then you lose your work."*

4.3.1.5 Theme 5: External and situational factors

Several respondents highlighted that the child being ill on the day of vaccination was a common reason for delayed immunization. Additionally, the attitudes of farm owners and employers also negatively impact timeliness.

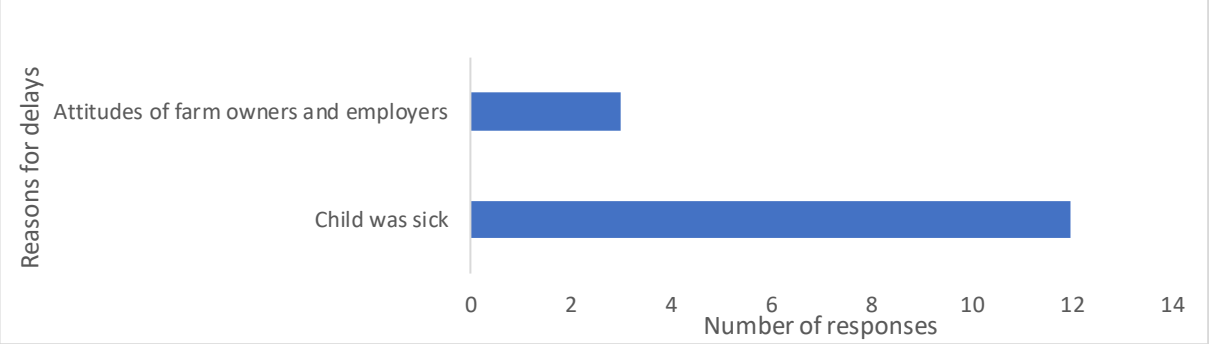


Figure 18: Sub-themes on external and situational factors influencing MR vaccine timeliness

Sub-themes

5.1 Child was ill

All healthcare workers indicated that the child being ill on the day of vaccination was a common excuse for being late; however, the caregiver mostly kept the child at home, so there was no proof that the child was ill and received treatment. One cannot be sure if this excuse is always true, as outlined by respondents P #9, P #11, and P #12. *Quote (P #9): "There's some that will tell you the child was not well. Okay, so if the child...was not well, did you take the child to the clinic? No, I didn't. So for me, there's no evidence in the passport that the child was taken to the clinic." Quote (P #11): "And the mother will always tell you, no, this child was sick for the month and then you will go through the clinic card. I will always ask my mommies, you say your child was sick, why didn't you go to the clinic for this child to get medication?" Quote (P #12): "But now they will say that the child was sick, but then you will not see any history in the card that maybe they brought the child for treatment and then they were told like, okay, bring back the child when the child is fine or something like that. Yeah, so they just keep the child at home and then you don't have that proof to say that the child was really sick."*

Some caregivers would bring the children to the healthcare facility when they are sick for the nurse to decide whether they should immunize the child or treat the child and postpone vaccination.

Quote (P #2): "Tell the nurse that the child is feverish, the child is coughing." Quote (P #3): "I even follow up with the nurse and ask her what she did. Then she just told me, no, I couldn't inject that child. The child was sick." Quote (P #4): The six weeks the ten weeks and then 14 weeks. Then you will see that the child will be brought at four or five months. Yeah for the ten weeks and then they will say that the child was sick for this whole time the child was sick." Quote (P #5): "One of the mothers even told me that the child was in the hospital." Quote (P #7): "This child is sick, they must

come back when it's much better because the temperature is maybe 37 or 38." Quote (P #8): "They probably only came that day because the child was sick." Quote (P #10): "The nurse can see that this child came on this day, but there was fever, there was diarrhea, vomiting."

5.2 Attitudes of farm owners and employers

Some working caregivers found it difficult to get off from work to take their child for immunization, as highlighted by these three responses. *Quote (P #2):" The employers, are strict with their work. They don't want to give the parents up to come and take their children to their facilities." Another respondent (P #5) said:" Owners of the farm just come at five and the mother is not done. So that is sometimes also a reason..." Quote (P #11): "It's those farms that the owner don't want to bring them here because they need to stay there for a specific time."*

6. Recommendations to reduce MR vaccination delays

The respondents were asked to provide suggestions on what they thought could be done to reduce MR vaccination delays in Rehoboth Urban. The following recommendations were made.

6.1 Immunization education and promotion

Quote (P #1): *"To strengthen health education. Timeliness of the vaccine and then why it's important for the kids to be immunized.*" Participant #4 highlighted the importance of giving immunization health education during ANC, *"Banner with schedule, so maybe we need to have something like that outside and talk about spacing of the immunizations and the timeliness and the importance of the measles. Anyway maybe this thing of immunization should start with ANC even when the mother is pregnant. Emphasize the importance of the immunization from birth to six years...*". Quote (P #12): *"On the importance of immunization itself in general.*

Explain the possible adverse effects of immunization. And then maybe we can also touch on explaining the card itself to the parents. And then the importance of follow-up days." Quote (P #7): *"Group health education.*" Quote (P #9): *"Definitely our health education needs to be strengthened. We also had teaching the parents how to actually read the card and to understand what vaccine needs to be given when and for what, what is the advantage of the vaccine. So it still comes down to health education…*"

6.2 Defaulter tracking, immunization scheduling and routine catch-up campaigns or immunization outreach

Quote (P #2): *"Us as health extension workers…we must give health promotion to the parents. And clarify. And for us, health extension workers, as we are working around in our communities, we must make note of kids who have outstanding immunization or who are supposed to get immunization and their dates. And maybe when we get five to six kids who have to get that immunization, on a certain day, maybe come and talk with our supervisors and give a nurse to go with a cool box and just immunize those kids and then come back...*" Quote (P #10): *"We need to ask them, which day are you comfortable within those nine months? Monday, Tuesday, Wednesday, Thursday or Friday... Let's be flexible when it comes to time frame and also giving dates. That will encourage the mother to actually come…Outreach for EPI."* Quote (P #7): *"Maybe more campaigns like they did last week."*

6.3 Designated immunization room with staff, reminder system and wastage reduction

Quote (P #3): *"Maybe we must just have a room for just immunization...*" Quote (P #6): *"So it would help a lot if we have a designated room*." Quote (P #7): "*If I*

can say maybe we can open separately a room in Timosa Clinic just for the immunization...". Quote (P #12): *"Maybe also try a separate immunization room for Timosa.*" Quote (R4): *"Nurse aside just for immunization.*" Quote (P #8): *"Sometimes we just need a reminder also so that maybe we can let them* [community health workers] *do the calling and the following up of the patients…*B*ut we recently got good news from Central Medical Stores. They have procured a five-dose vial. So hopefully that will reduce the wastage rate.*"

6.4 Capacity building of staff

Quote (P #9): *"I think constant trainings are needed for our nurses.…refresher trainings or in service training of staff. Within the in-service training of staff there, we shouldn't forget our attitudes towards the program itself.*" Quote (P #10): *"For the freshmen, they need training.*"

4.4 INTEGRATION OF QUANTITATIVE AND QUALITATIVE FINDINGS

In the final stage of data analysis, quantitative and qualitative findings converged to address the research objectives of identifying factors affecting timely MR1 and MR2 vaccination from both the caregiver and healthcare worker perspectives. This convergent analytical strategy aimed to comprehensively explore and validate these factors through multiple investigative approaches. The convergence of quantitative and qualitative data revealed complex barriers to timely MR vaccination, with significant delays (25% for MR1 and 56% for MR2).

Key findings included transport challenges that emerged as a critical barrier, with low-income caregivers struggling with distance and taxi fare. Healthcare workers and quantitative data have consistently highlighted transportation as a significant impediment to timely vaccination.

Knowledge and awareness gaps were evident, with caregivers frequently forgetting vaccination dates or citing a child's illness as a reason for delay. Healthcare workers noted a lack of verifiable medical evidence for these claims, suggesting potential misunderstandings regarding vaccination protocols. This was supported by respondent 9, who said, *"There's some that will tell you the child was not well. Okay, so if the child, then you ask, if the child was not well, did you take the child to the clinic? No, I didn't. So for me, there's no evidence in the passport that the child was taken to the clinic."*

Systemic issues such as long waiting times (exceeding three hours) and integrated healthcare services further complicate vaccination access. While caregivers perceived vaccine stock-outs, healthcare workers indicated that this was not experienced in the past, potentially stemming from confusion about stock-outs of other childhood vaccines.

Notably, significant statistical associations with factors such as birth order, number of siblings, and residential area were not acknowledged by healthcare workers, suggesting a potential disconnection between quantitative findings and professional perspectives. These converging insights underscore the multifaceted nature of vaccination barriers, highlighting the need for targeted, comprehensive interventions addressing socioeconomic, educational, and systemic challenges.

4.5 CHAPTER SUMMARY

Chapter 4 describes the findings of this study. In summary, the barrier themes provide valuable additional context beyond what is captured in the tables alone. The tables focus more on health system and service delivery factors, while the barrier themes highlight important communication, accessibility, caregiver attitude, and external

factors that also shape vaccination timeliness. Integrating these two data sources provides a more holistic understanding of the factors affecting the age-appropriate timing of measles vaccination. The results are outlined in tables and graphs. The next chapter discusses the study's findings and their relation to other findings.

CHAPTER 5: DISCUSSION

The preceding chapter presents the results of this study. This chapter discusses the principal findings of this study and compares them with those of other researchers in the published literature regarding the barriers to the age-appropriate timeliness of measles vaccination. The quantitative and qualitative results were discussed concurrently.

5.1 DISCUSSION OF FINDINGS

This study revealed significant public health concerns regarding vaccination coverage and timeliness. Although the overall vaccination rates were high for MR1 (99.10%) and MR2 (88.60%), timely vaccination coverage was notably low, with 69.90% for MR1 and a substantially lower 31.30% for MR2. The delay rates are particularly concerning, with MR1 exhibiting a 25% delay and MR2 experiencing a 56% delay, potentially compromising herd immunity and increasing the risk of measles outbreak.

Divergent trends were observed when comparing the international data. In contrast to the current findings, a Chinese study reported lower MR1 timeliness (58.4%) but higher MR2 timeliness (76.9%) (42). MR2 delayed uptake was reported to be 29.3% in a South African study, which was significantly lower than that in Namibia (14). Global measles eradication necessitates timely and comprehensive immunization, in addition to high coverage, as reported by Tang et al. (42).

The substantial disparity in MR2 timeliness, nearly double that observed in other studies, underscores the urgent need to identify and address specific barriers. Understanding how countries such as China achieve better MR2 vaccination timing could provide valuable insights for improving vaccination strategies. High vaccination coverage can potentially mask low levels of timeliness. Subsequently, full

immunization coverage may be hindered by a lack of or poor timing of vaccination (8, 14).

5.1.1 Factors affecting age-appropriate timeliness of MR vaccination

This study examined various sociodemographic factors as potential barriers to timely measles vaccination. Although Fisher's exact test revealed that most factors were statistically insignificant, several notable exceptions emerged. For the first measles vaccination (MR1), significant associations were identified with specific variables: caregiver's educational status ($p=0.05$), receipt of immunization information during antenatal care ($p=0.01$), labor ($p=0.05$), and perceptions of barriers ($p=0.002$). The second measles vaccination (MR2) exhibited an even more nuanced pattern with strong associations across multiple dimensions. These included cohort groups ($p<0.001$), children's birth order ($p=0.04$), the number of siblings ($p=0.01$), perceptions of barriers ($p=0.003$), and caregiver self-efficacy ($p=0.01$). A study conducted in China reported that households with more than one child were significantly associated with delays in the administration of both doses of the measles-rubella vaccine (41).

As the analysis progressed, bivariate logistic regression provided additional insights. For MR1, only residential blocks demonstrated a strong association. The MR2 analysis, however, revealed a more complex landscape with significant associations across multiple variables: cohort, birth order, number of siblings, and residential blocks. Multivariate logistic regression further refined these findings, ultimately highlighting the significance of cohort and residential blocks in MR2 vaccination delays.

Understanding the methodological nuances underlying these analyses is crucial. Cross-tabulations offer a straightforward view of bivariate associations, presenting raw data patterns between dependent and independent variables. In contrast, logistic

regression provided a more sophisticated approach, not only identifying proportional differences, but also testing their statistical significance while simultaneously adjusting for potential confounding factors. This multi-layered analytical approach underscores the complexity of vaccination uptake, revealing that no single factor operates in isolation. The interplay of sociodemographic variables, caregiver perceptions, and structural factors creates a complex ecosystem that influences vaccination patterns.

5.1.1.1 Age cohort

The cohort of children aged 13-24 months exhibited a significantly higher rate of MR2 vaccination earlier in the study period, as demonstrated by the cross-tabulation analysis. This pattern may be attributed to two primary factors: the proximity of the follow-up date at 15 months to the nine-month vaccination date and the likelihood of caregivers perceiving younger children as more susceptible to measles infection.

Conversely, MR2 vaccination delays became more pronounced in older age groups, specifically those aged 25-36, 37-48, and 49-59 months, indicating that, as children advanced in age, they were less likely to receive MR2 vaccination within the study period. These findings align with those of research conducted in South Africa and Saudi Arabia, suggesting a broader trend in age-related vaccination disparities(14,16).

Notably, while younger children (13-24 months) demonstrated earlier MR2 uptake, the statistical analysis revealed a paradoxical pattern. In the bivariate analysis, children from the 13-24 months cohort exhibited up to four times higher odds of experiencing a delayed MR2 dose. This trend was further corroborated in the multivariate analysis, where the adjusted odds ratio (AOR) was 4.5 times higher compared to the 49-59 months cohort. The observed variations may be attributed to multiple factors,

including potential differences in follow-up procedures, varying levels of caregiver awareness, or lower prioritization of MR2 vaccinations for children in different age brackets. These results underscore the complex nature of vaccination uptake and emphasize the need for targeted interventions to address the age-specific challenges in vaccination programs.

5.1.1.2 Birth order and number of siblings

Cross-tabulation revealed complex patterns of vaccination delays related to birth order and family dynamics, with increased delays in later-born children and among children with more siblings. Previous studies in Jerusalem and Saudi Arabia suggest that a higher birth order correlates with vaccination delays (10, 16). This study presented an unexpected finding: firstborn children had three times the likelihood of delayed MR2 vaccination than later-born children.

Family structure significantly influences vaccination timing. Studies from Malawi, China, and Uganda consistently demonstrated that larger families with multiple young children can experience vaccination delays due to diverted parental attention, increased resource constraints, and competing caregiving responsibilities (8, 9, 12, 16). Caregivers in larger households may encounter difficulties prioritizing timely immunization amidst child-related demands.

Notably, our bivariate analysis indicated that children without siblings had 3.51 times higher odds of experiencing MR2 vaccination delays. This finding underscores the complex relationship between family composition and access to health care. Community-based outreach programs can assist caregivers in managing immunization schedules in diverse family structures. Understanding these intricate dynamics is essential for developing targeted strategies that ensure timely vaccination regardless of family size or birth order.

5.1.1.3 Educational status

The association between vaccination timeliness and maternal educational level is complex. Fisher's exact test in our study revealed a weak correlation with educational status, while bivariate analysis demonstrated no statistical correlation. Cross-tabulation indicated that caregivers with less than a primary school education exhibited greater delays. Similar findings were observed in studies from Malawi and China, suggesting that lower maternal education is correlated with delayed measles vaccination (8, 22). However, this relationship is multifaceted. A contrasting Chinese study revealed that mothers with higher education and employment status were paradoxically associated with vaccination delays, challenging the assumption that education directly improves health-related behaviors (9).

This inconsistency was further elucidated by a Saudi Arabian study that found no significant association between educational status and vaccination delay (16). This variability underscores the multifaceted nature of healthcare decision-making beyond educational attainment. Findings from a study conducted in Pakistan indicated that children who received their most recent vaccination in outreach settings were less likely to receive timely measles vaccination compared to those immunized at fixed health facilities (42). These disparities underscore the need for targeted, community-based educational interventions to promote timely vaccination and improve adherence to the recommended immunization schedule. Such initiatives could simplify vaccination information, emphasize the importance of timely immunization, and provide accessible healthcare guidance that transcends traditional educational barriers.

5.1.1.4 Residential block

In this study, geographic accessibility emerged as a critical factor for vaccination timeliness. Multivariate analysis revealed significant vaccination delays in specific blocks, with qualitative interviews elucidating the challenges faced by caregivers, who must traverse considerable distances from residential areas, predominantly on foot, to access essential preventive services.

Although the type of settlement did not demonstrate a statistically significant association with vaccination delays, the ubiquity of delays across residential areas underscores this systemic issue. The persistent geographic barriers suggest that healthcare access is not uniformly equitable, irrespective of residential context. A systematic review conducted in East Africa on the determinants of second-dose measles vaccination found that greater distance to vaccination sites was a significant barrier to vaccine coverage and was likely to adversely affect the timeliness of vaccination as well (43).

To address these disparities, it is imperative to expand the healthcare infrastructure and implement comprehensive outreach programs. Such strategies can potentially mitigate geographical constraints that impede timely vaccination and ensure more consistent and accessible preventative healthcare across all residential blocks.

5.1.1.5 Health Belief Model

Perceptions of barriers

The study revealed a complex landscape of vaccination barriers, wherein respondents' perceptions diverged from the potential underlying challenges. Most participants disagreed with the proposed barriers, which may indicate a tendency towards socially desirable responses rather than a candid disclosure of difficulties.

Moreover, unacknowledged obstacles, such as extended wait times, inconvenient facility hours, and transportation challenges, could significantly impact vaccination timeliness. Comparative research has provided several noteworthy insights. A Chinese study demonstrated that strong opinions regarding vaccination obstacles correlated with reduced immunization adherence (22), a pattern echoed in a Saudi Arabian investigation (16).

Comprehensive community dialogues and thorough evaluations are essential to bridge the gap between perceived and actual barriers. Such approaches can help elucidate the complex realities impeding timely vaccination, moving beyond surface-level responses to understand the genuine challenges caregivers face.

Perceptions of self-efficacy

Caregivers exhibited high self-efficacy regarding MR2 vaccination, indicating strong motivation despite previous delays in children receiving their second measles-rubella dose. While self-efficacy has emerged as a critical predictor of vaccination behavior, various studies have elucidated its complex role, with Saudi Arabian research correlating high self-efficacy to improved adherence (21), and Chinese findings suggesting that perception challenges can contribute to vaccination delays (22). To leverage caregivers' confidence, immunization programs must concurrently address structural barriers and ensure systemic support, which translates motivation into timely vaccine completion.

5.1.1.6 Information on immunization at ANC and labor

Antenatal care (ANC) has emerged as a significant factor for improving the timeliness of MR vaccination. In our study, a lower frequency of ANC visits and missed opportunities for immunization education was significantly associated with delayed vaccination. Research conducted in Ethiopia demonstrates how maternal health

education and facility-based delivery can substantially enhance vaccination compliance, with hospital-born children exhibiting markedly higher rates of timely immunization (14, 15). A study conducted in China demonstrated a statistically significant association between births occurring at home and the delayed administration of the second dose of the measles-containing vaccine (41). Healthcare professionals emphasize the importance of integrating immunization counselling into ANC sessions, recognizing these interactions as critical opportunities to inform, motivate, and empower caregivers. By strategically enhancing ANC coverage, hospital-based deliveries, and targeted health education programs, these interactions can be transformed into effective mechanisms to ensure the timely vaccination of children.

5.1.1.7 Inefficient service delivery

Service delivery inefficiencies have emerged as a significant barrier to timely measles-rubella vaccination, with extended waiting times and resource limitations substantially affecting immunization rates. Research from China has emphasized that personnel shortages and suboptimal service quality can reduce vaccination timeliness (22). A comprehensive approach is essential to address these challenges: strategically expanding healthcare resources, implementing digital communication platforms, and optimizing facility hours to accommodate caregivers' requirements. Conducting regular satisfaction surveys can provide actionable insights, enabling healthcare systems to systematically identify and resolve service-delivery constraints. By prioritizing accessibility, communication, and responsive healthcare design, programs can effectively mitigate barriers that contribute to vaccination delays.

5.1.1.8 Other reasons for delayed measles vaccination

Child health and logistical challenges significantly contribute to delays in MR vaccination. Healthcare professionals and caregivers consistently reported child illness as a primary impediment, a finding corroborated by studies in China (9) and Saudi Arabia (16). Exacerbating this issue are practical barriers, such as multidose vial constraints, where insufficient numbers of children to open a vial can disrupt immunization schedules. Caregivers frequently cited appointment oversight as another critical factor, highlighting the need for enhanced communication and reminder systems. The current practice of deferring vaccination due to multidose vial limitations risks further compromising the immunization timeliness. Potential interventions, such as procuring five-dose MR vials, could simultaneously address concerns regarding vaccine wastage and improve timely immunization rates. By acknowledging these complex, interconnected challenges, healthcare systems can develop more adaptable, patient-centered vaccination strategies.

5.2 CHAPTER SUMMARY

Chapter 5 presents the findings of this study with reference to the literature. This study demonstrated that multiple independent variables influenced the outcomes of timely MR vaccination. Several factors were found to affect age-appropriate MR vaccination timeliness, including the educational status of the caregiver and insufficient immunization information during ANC and labor. Belonging to the 13-24 month cohort, being firstborn, being an only child, and residing in specific residential blocks increases the probability of delayed MR vaccination administration. Moreover, certain perceptions and service delivery aspects, such as extended waiting times, further contribute to delayed MR vaccination. The subsequent chapter concludes the study, addresses its limitations, and proposes recommendations based on the findings.

CHAPTER 6: CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

The findings of both the quantitative and qualitative phases have been discussed in the preceding section. This final chapter presents the conclusions derived from the study's findings, including the limitations encountered during the research period and recommendations. In addition, areas for future study were delineated.

6.1 SUMMARY OF FINDINGS

This investigation demonstrated that timeliness for MR1 and MR2 is indeed a concern in Rehoboth Urban, with between 25% and 56% of children receiving delayed MR1 and MR2 vaccinations. Multiple factors were identified to affect the timeliness of age-appropriate MR vaccination, including the educational status of the caregiver and insufficient immunization information during ANC and labor. Being in the 13-24 month cohort, being firstborn, being an only child, and residing in residential blocks B, D, E, and F increased the probability of delayed MR vaccination dose administration. Furthermore, certain perceptions and inefficient service delivery, exacerbated by extended waiting times, reluctance to open multi-dose MR vials, child illness on the day of vaccination, and caregiver forgetfulness, contribute significantly to untimely MR vaccination.

6.2 CONCLUSION

In conclusion, this study established the magnitude of the age-appropriate timing for measles vaccination and identified various factors that serve as barriers. Consequently, it is imperative to address the barriers that could have the most significant impact, such as implementing vaccination outreach programs in residential areas, reducing waiting times, enhancing immunization-related health education, and emphasizing the

importance of timely vaccination. Furthermore, investigating the utilization of reminder systems to encourage caregivers to present their children with timely MR vaccination is a crucial endeavor. Addressing these barriers has the potential to prevent measles outbreaks and to enhance herd immunity.

6.3 LIMITATIONS

The following limitations of this study should be considered:

- The study was conducted exclusively in Rehoboth Urban; consequently, the findings cannot be generalized to other settings.
- No key informant interviews or focus group discussions were conducted with the caregivers.
- Children without vaccination cards were excluded from the study to mitigate recall bias. This exclusion could have resulted in a different outcome; hence, the findings cannot be generalized, as those with a vaccination card might not be representative of the general population. Furthermore, there may have been data recording errors on some vaccination cards.
- The number of children per household per block was not available; therefore, the researcher used the number of households per block.

6.4 RECOMMENDATIONS

To mitigate the untimely administration of MR1 and MR2 vaccinations in children, the following recommendations were proposed:

The National Level

1. The Primary Health Care (PHC) Directorate to initiate national awareness campaigns emphasizing the significance of vaccination records and their content.

2. Jointly, the PHC Directorate, Finance, and Human Resource Divisions should revise staffing structures for nurses and community health workers to enhance community-based preventive services, including immunization and family planning.
3. The PHC Directorate to collaborate with the Ministry of Education, Arts, and Culture to implement the mandatory verification of vaccination records upon children's enrollment.

The Regional Level

1. The Regional Management Team (RMT) to advocate for additional nursing personnel particularly at the Rehoboth Clinic, as it is a high-volume healthcare facility serving the primary informal settlement population.
2. The RMT to ensure timely recruitment of staff for vacant healthcare positions to maintain continuous service delivery.

The District and Health Facility Level

1. The District Coordinating Committee (DMT) to conduct comprehensive research on the factors contributing to delays in MR2 vaccination, as well as the reasons for the significant dropout rate between MR1 and MR2.
2. Nursing staff at the health facility level to develop and enhance reminder systems.
3. Nursing staff at the health facility level to devise targeted interventions for age groups with the highest vaccination delay rates.
4. DMT in collaboration with facility in-charges to implement operational improvements, such as establishing a dedicated immunization room and conducting community-based immunization activities, including outreach programs with community health workers.

5. Nursing staff at the health facility level to strengthen health education and health promotion regarding the importance of immunization, timeliness, and proper maintenance of vaccination records from ANC, maternity, and PNC.
6. Nursing staff at the health facility level to monitor and address Adverse Events Following Immunization (AEFIs) to alleviate parental concerns.
7. In-charges at the health facility level to provide continuous refresher training on immunization-related activities for healthcare workers.
8. Campaign coordinators and social mobilization teams to enhance communication strategies during campaigns.
    a. Emphasize that national mass campaigns are supplementary and do not replace routine doses.
    b. Emphasize that routine campaigns, such as the African Vaccination Week and Maternal and Child Health Days, augment routine immunization.
9. Healthcare workers at the healthcare facility level to offer vaccination scheduling that accommodates caregiver availability.
10. Healthcare workers at the health facility level to ensure clear communication regarding vaccine availability.

The Community Level

1. Caregivers to keep vaccination records safe and adhere to follow-up dates as indicated.
2. Caregivers to communicate any challenges in ensuring timely MR immunization to the health facility level to allow joint problem-solving.

6.5 AREAS FOR FUTURE STUDY

Conduct a qualitative investigation using focus group discussions with caregivers to elucidate the factors contributing to enhanced MR1 compliance and identify barriers associated with MR2 completion.

6.6 SUMMARY

This chapter presents the conclusions and limitations of this study. In addition, recommendations derived from the study findings are delineated in this chapter.

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APPENDICES

APPENDIX A: ETHICAL CLEARANCE CERTIFICATE FROM UNAM

UNAM
UNIVERSITY OF NAMIBIA

ETHICAL CLEARANCE CERTIFICATE

Ethical Clearance Reference Number: DEC OSH 0108 **Date: 12/12/2023**

This Ethical Clearance Certificate is issued by the University of Namibia Ethics Committee (REC) in accordance with the University of Namibia's Research Ethics Policy and Guidelines. Ethical approval is given in respect of undertakings contained in the Research Project outlined below. This Certificate is issued on the recommendations of the ethical evaluation done by the ethics committee.

Title of Project: BARRIERS TO AGE-APPROPRIATE TIMELINESS OF MEASLES VACCINATION AMONG CHILDREN IN REHOBOTH URBAN, HARDAP REGION, NAMIBIA

Principal researcher: GERTRUIDA FRANSINA BURGER

Staff Number/ Student number: 9967435

Remarks: Low Risk and Approved

Centre for Research Services

Take note of the following:

1. Any significant changes in the conditions or undertakings outlined in the approved Proposal must be communicated to the ethics committee. An application to make amendments may be necessary.
2. Any breaches of ethical undertakings or practices that have an impact on ethical conduct of the research must be reported to the ethics committee.
3. The Principal Researcher must report issues of ethical compliance to the ethics committee (through the Chairperson) at the end of the Project or as may be requested by the ethics committee.
4. The ethics committee retains the right to:
   i) Withdraw or amend this Ethical Clearance if any unethical practices (as outlined in the Research Ethics Policy) have been detected or suspected,
   ii) Request for an ethical compliance report at any point during the course of the research.

The ethics committee wishes you the best in your research.

Prof Hans J Amukugo (Oshakati Campus Chairperson Decentralized Ethics Committee)

Prof. Davis Mumbengegwi (Head, Multidisciplinary Research)

APPENDIX B: PERMISSION TO CONDUCT THE STUDY – MOHSS

REPUBLIC OF NAMIBIA

MINISTRY OF HEALTH AND SOCIAL SERVICES

Ministerial Building
Harvey Street
Private Bag 13198, Windhoek

OFFICE OF THE EXECUTIVE DIRECTOR

Tel: No: 061 -203 2507
Fax No: 061-222 558
Andreas.Shipanga@mhss.gov.na

Ref: 22/3/1/2
Date: 16 February 2024

Enquiries: Mr. A. Shipanga

Ms. Gertruida Burger
P.O. Box 3713
Rehoboth

Dear Ms. Burger

Title: Barriers to age appropriate timeliness of measles vaccination among children in Rehoboth Urban, Hardap Region, Namibia.

1. Reference is made to your application to conduct the above study.
2. The proposal has been evaluated and found to have merit.
3. **Kindly be informed that permission to conduct the study has been granted under the following conditions:**
   - 3.1 The data to be collected must only be used for academic purposes;
   - 3.2 No other data should be collected other than the data stated in the proposal;
   - 3.3 No any specimen should be collected from Human Subjects;
   - 3.4 Stipulated ethical considerations in the protocol related to the protection of Human Subjects' information should be observed and adhered to; any violation thereof will lead to termination of the study at any stage;
   - 3.5 A quarterly report to be submitted to the Ministry's Research Unit;
   - 3.6 Preliminary findings to be submitted upon completion of the study;
   - 3.7 Final report to be submitted upon completion of the study;
   - 3.8 Separate permission should be sought from the Ministry for the publication of the findings.
4. All the cost implications that will result from this study will be the responsibility of the applicant and **not** of the MoHSS.

Yours sincerely,

EXECUTIVE DIRECTOR
MINISTRY OF HEALTH AND SOCIAL SERVICES

BEN NANGOMBE
EXECUTIVE DIRECTOR

All official correspondence must be addressed to the Executive Director.

My NAMIBIA
MY COUNTRY, MY PRIDE

APPENDIX C: CONSENT FORM FOR CAREGIVERS

UREC Annex 5C: Informed Parental Consent for Quantitative Studies

INFORMED PARENTAL CONSENT FORM

Informed Consent for parents/caregivers who I/we are inviting to participate in research titled **barriers to age-appropriate timeliness of measles vaccination among children aged 9 to 59 months in Rehoboth urban, Hardap region, Namibia**

Name of Principal Investigator:	Gertruida Fransina Burger
Name of Sponsor:	None

This Informed Consent Form has two parts:

- Information Sheet (this section, to share information about the study with you)
- Certificate of Consent (for signatures if you choose to participate)

You will be given a copy of the full Informed Consent Form.

PART I: INFORMATION SHEET

Introduction

I am Gertruida Fransina Burger, a student at the University of Namibia studying towards a Master's Degree in Applied Field Epidemiology and Laboratory Training under the supervision of Dr. Anna Shilunga. I am conducting research to understand the **barriers to age-appropriate timeliness of measles vaccination among children aged 9 to 59 months in Rehoboth urban, Hardap region, Namibia.** You do not have to decide today whether or not your child will participate in the research. Before you decide, you can talk to anyone you feel comfortable with about the research. This consent form may contain words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions, you can ask them and I will clarify.

Purpose of the Research

To assess the reasons why children (9-59 months) are receiving the 9 months and 15 months measles rubella vaccine later than indicated in the health passport in Rehoboth urban. The information we collect will help in identifying the barriers that contribute to children being vaccinated late in Rehoboth urban and will assist the government to plan health services. I/we will need to verify the vaccination status of your child by viewing the health passport or vaccination card.

Type of Research Intervention

This research will involve your participation in filling out the questionnaire. It will take about 25 minutes to complete.

Participant Selection

You have been selected to participate in this study because you fall in the required population group for the study as you are a parent/caregiver of a child 9-59 months and your participation may add value to the study. Kindly note that about 316 respondents have been selected randomly to participate in this study from the community.

Voluntary Participation

Taking part in this study is entirely voluntary, therefore, kindly note that it is up to you to decide whether or not to take part. Even after you have decided to participate, you are still free to withdraw at any time without providing reasons.

Procedures

The study will involve the manual completion of this consent form and a questionnaire.

The study will be conducted in Rehoboth urban from March to April 2024.

The questionnaire will be read aloud either by Gertruida Burger or …… and you can give us the answer which you want me to write down.

If you wish not to answer some of the questions included in the questionnaire, you may skip them and move on to the next question. The information recorded is confidential, and no one else except Dr. Shilunga will have access to her questionnaire. The questionnaires will be destroyed after five years.

Duration

It will take about 25 minutes to complete the questionnaire.

Risks

You may need time to complete the questionnaire, otherwise, no risk is expected since all information will be kept confidential and no names will be used in this study. In case you have any concerns, feel free to communicate with a researcher and supervisor.

Benefits

There will be no immediate and direct benefit to you, but your participation is likely to help us determine the needs of the community in terms of vaccination services and help the ministry in improving healthcare services in the future.

Reimbursements

You will not be provided with any payment to take part in the research.

Confidentiality

Because something out of the ordinary is being done through research in your community, it will draw attention. If you participate, you may be asked questions by other people in the community. We will not be sharing information about you outside of the research team. The information that we collect from this research project will be kept confidential. Information about your child that will be collected from the research will be put away and no one but the researchers will be able to see it. Any information about your child will have a number on it instead of his/her name. Only the researchers will know what his/her number is and we will lock that information up with a lock and key. It will not be shared with or given to anyone except Dr. Shilunga who is my supervisor.

Sharing the Results

The results of this study will be shared in a copy that is filed with the University of Namibia and the resource centre for the Ministry of Health and Social Services in Windhoek. This will happen once the Degree is awarded and the thesis is published.

Right to Refuse or Withdraw

Choosing to participate or not will not affect either your own or your child's future treatment at the health facility in any way. You and your child will still have all the benefits that would

otherwise be available at the health facility. You may stop participating in completing the questionnaire at any time that you wish without losing any of your rights here.

Who to Contact

If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact me, Gertruida Fransina Burger, at +264 81 2528774 or bgertruida@yahoo.com or my supervisor Dr. Anna Shilunga at +264 81 391 5767 or ashilunga@unam.na (Main Supervisor)0

This research has been reviewed and approved by the relevant Ethics Review Committee at the University of Namibia, which is a committee whose task it is to make sure that research participants are protected from harm. The committee reports to the University's Centre for Research Services. If you wish to contact this Centre, please call +264 61 206 4673 or send an e-mail to research@unam.na.

PART II: CERTIFICATE OF CONSENT

I have been invited to participate in research about the barriers to age-appropriate timeliness of measles vaccination among children aged 9-59 months in Rehoboth urban. I confirm that the person asking my consent to partake in this study has explained to me the purpose, procedure, risks, confidentiality and benefits of the study. I have had the opportunity to ask questions about it and any questions I have been asked, have been answered to my satisfaction. I consent voluntarily for both me and my child to be participants in this study.

…… ……

Name of Parent/Guardian (print) Signature of Parent/Guardian

……

Date (day/month/year)

If illiterate

[*A literate witness must sign. (If possible, this person should be selected by the participant and should have no connection to the research team.) Participants who are illiterate should include their thumbprint as well.*]

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

……

Name of Witness (print)

Thumbprint of Participant

……

Signature of Witness

……

Date (day/month/year)

Statement by the Researcher/Person taking Consent

I have accurately read out the information sheet to the parent/caregiver, and to the best of my ability made sure that the participant understands that the questionnaire will be filled with the help of the researcher.

I confirm that the parent was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

…… ……

Name of Researcher/Person taking Consent (print) Signature

……

Date (day/month/year)

If Assisted by an Interpreter: Statement by Interpreter

I have accurately interpreted the information sheet to the parent/caregiver of the potential participant in …… (insert name of target language), and to the best of my ability made sure that they understand that the questionnaire will be filled with the help of the researcher.

I confirm that the parent/caregiver was given an opportunity to ask questions about the study, and all the questions asked by the parent/caregiver have been interpreted correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

I declare that I will not divulge any information that I interpret during this research intervention to a third party outside this study.

…… ……

Name of Interpreter (print) Signature

……

Date (day/month/year)

APPENDIX D: CONSENT FORM FOR HEALTHCARE WORKERS

JREC Annex 5F: Informed Consent for Qualitative Studies

INFORMED CONSENT FORM

UNAM
UNIVERSITY OF NAMIBIA

Informed Consent for healthcare workers whom I/we are inviting to participate in research titled **barriers to age-appropriate timeliness of measles vaccination among children aged 9 to 59 months in Rehoboth urban, Hardap Region, Namibia.**

Name of Principal Investigator:	Gertruida Fransina Burger
Name of Sponsor:	None

This Informed Consent Form has two parts:
- **Information Sheet (this section, to share information about the study with you)**
- **Certificate of Consent (for signatures if you choose to participate)**

You will be given a copy of the full Informed Consent Form.

PART I: INFORMATION SHEET

Introduction

I am Gertruida Fransina Burger, a student at the University of Namibia studying towards a Master's Degree in Applied Field Epidemiology and Laboratory Training under the supervision of Dr. Anna Shilunga. I am conducting research to understand the **barriers to age-appropriate timeliness of measles vaccination among children aged 9 to 59 months in Rehoboth urban, Hardap Region, Namibia.**

This consent form may contain words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions, you can ask them and I will clarify.

Purpose of the Research

To assess the reasons why so many children (9-59 months) are receiving the 9 months and 15 months measles-rubella vaccine later than indicated in the health passport in Rehoboth urban. The information we collect will help in identifying the barriers that contribute to children being vaccinated late in Rehoboth urban and will assist the government in planning health services.

Type of Research Intervention

This research will involve your participation in a key informant interview. It will take about 40 minutes to complete.

Participant Selection

You have been selected to participate in this study because you fall in the required population group for the study as you are a healthcare worker providing immunization services to children 9-59 months or dealing with vaccines and your participation may add value to the study.

Voluntary Participation

Taking part in this study is entirely voluntary, therefore, kindly note that it is up to you to decide whether or not to take part. Even after you have decided to participate, you are still free to withdraw at any time without providing reasons. The choice that you make will have no bearing on your job or on work-related evaluations or reports.

Procedures

The study will involve an interview in a comfortable place at the health facility where you are working. No one else but me will be present unless you want someone else to be there. The information recorded is confidential and no one else except Dr. Shilunga who is my supervisor will have access to the information documented during your interview. The entire interview will be recorded, but no one will be identified by name in the recording. The recording will be kept safe in a lockable cabinet and destroyed after transcribing. The written notes will be destroyed after five years.

Duration

The interview will take about 40 minutes to complete.

Risks

There is a risk that you may share some personal opinions by chance or that you may feel uncomfortable talking about some of the topics. However, we do not wish for this to happen. You do not have to answer any question if it makes you feel uncomfortable. You may need time to think about your response before sharing it with me. I would like to assure you that all information will be kept confidential and no names will be used in this study. In case you have any concerns, feel free to communicate with the researcher and supervisor.

Benefits

There will be no immediate and direct benefit to you, but your participation is likely to help us determine the needs of the community in terms of vaccination services and help the ministry in improving healthcare services in the future.

Reimbursements

You will not be provided with any payment to take part in the research.

Confidentiality

Because something out of the ordinary is being done through research in the health facility, it will draw attention. If you participate, you may be asked questions by other colleagues and patients. We will not be sharing information about you outside of the research team. The information that we collect from this research project will be kept confidential and no one but the researchers will be able to see it. It will not be shared with or given to anyone except Dr. Shilunga who is my supervisor.

Sharing the Results

The results of this study will be shared in a copy that is filed with the University of Namibia and the resource centre for the Ministry of Health and Social Services in Windhoek. This will happen once the Degree is awarded and the thesis is published.

Right to Refuse or Withdraw

Choosing to participate or not will not affect your future treatment in the health facility in any way. You will still have all the benefits that would otherwise be available at the health facility. You may stop participating in the interview at any time without your job being affected. I will share the transcribed notes with you to allow you to modify or remove portions of those if you do not agree with my notes or if I did not understand you correctly.

Who to Contact

If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact me, Gertruida Fransina Burger, at +264 81 2528774 or bgertruida@yahoo.com

Dr. Anna Shilunga at +264 81 391 5767 or ashilunga@unam.na (Main Supervisor)

This research has been reviewed and approved by the relevant Ethics Review Committee at the University of Namibia, which is a committee whose task it is to make sure that research participants are protected from harm. The committee reports to the University's

Centre for Research Services. If you wish to contact this Centre, please call +264 61 206 4673 or send an e-mail to research@unam.na.

PART II: CERTIFICATE OF CONSENT

I have been invited to participate in research about the barriers to age-appropriate timeliness of measles vaccination among children aged 9-59 months in Rehoboth urban, Hardap Region, Namibia. I confirm that the person asking my consent to partake in this study has explained to me the study's purpose, procedure, risks, confidentiality and benefits. I have had the opportunity to ask questions about it and any questions I have been asked, have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

…… ……

Name of Participant (print) Signature of Participant

……

Date (day/month/year)

Statement by the Researcher

I have accurately read out the information sheet to the participant, and to the best of my ability made sure that the participant understood that the interview will take about 40 minutes to conduct and be recorded.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the participant has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

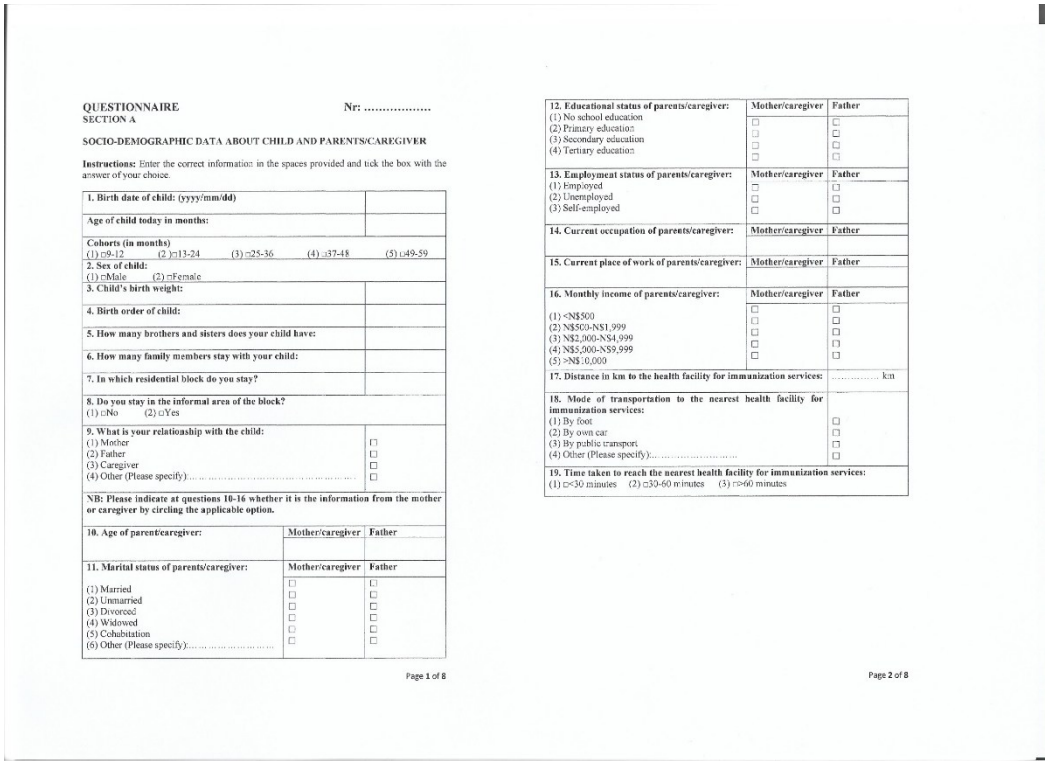
…… ……

Name of Researcher (print) Signeture of researcher

……

Date (day/month/year)

APPENDIX E: QUANTITATIVE QUESTIONNAIRE – CAREGIVERS



QUESTIONNAIRE Nr: .....
SECTION A

SOCIO-DEMOGRAPHIC DATA ABOUT CHILD AND PARENTS/CAREGIVER

Instructions: Enter the correct information in the spaces provided and tick the box with the answer of your choice.

1. Birth date of child: (yyyy/mm/dd)	
Age of child today in months:	
Cohorts (in months) (1) □9-12 (2) □13-24 (3) □25-36 (4) □37-48 (5) □49-59	
2. Sex of child: (1) □Male (2) □Female	
3. Child's birth weight:	
4. Birth order of child:	
5. How many brothers and sisters does your child have:	
6. How many family members stay with your child:	
7. In which residential block do you stay?	
8. Do you stay in the informal area of the block? (1) □No (2) □Yes	
9. What is your relationship with the child: (1) Mother (2) Father (3) Caregiver (4) Other (Please specify).....	□ □ □ □

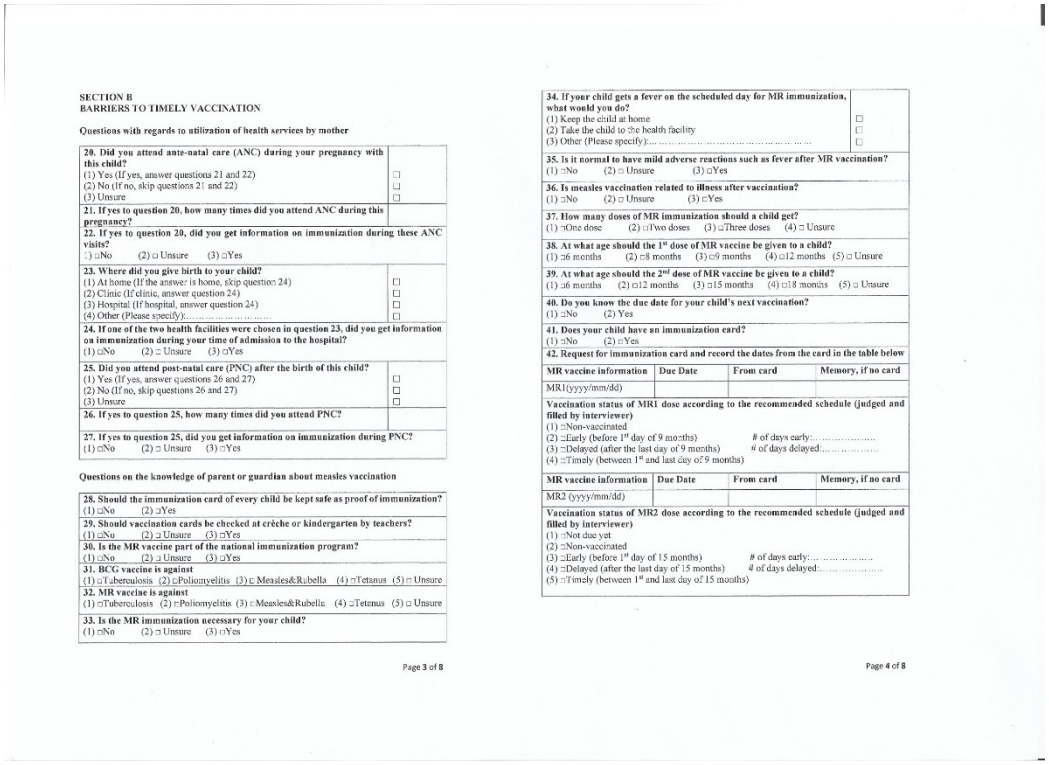
NB: Please indicate at questions 10-16 whether it is the information from the mother or caregiver by circling the applicable option.

10. Age of parent/caregiver:	**Mother/caregiver**	**Father**
11. Marital status of parents/caregiver:	**Mother/caregiver**	**Father**
(1) Married (2) Unmarried (3) Divorced (4) Widowed (5) Cohabitation (6) Other (Please specify).....	□ □ □ □ □ □	□ □ □ □ □ □

Page 1 of 8

12. Educational status of parents/caregiver: (1) No school education (2) Primary education (3) Secondary education (4) Tertiary education	**Mother/caregiver** □ □ □ □	**Father** □ □ □ □
13. Employment status of parents/caregiver: (1) Employed (2) Unemployed (3) Self-employed	**Mother/caregiver** □ □ □	**Father** □ □ □
14. Current occupation of parents/caregiver:	**Mother/caregiver**	**Father**
15. Current place of work of parents/caregiver:	**Mother/caregiver**	**Father**
16. Monthly income of parents/caregiver: (1) <N$500 (2) N$500-N$1,999 (3) N$2,000-N$4,999 (4) N$5,000-N$9,999 (5) >N$10,000	**Mother/caregiver** □ □ □ □ □	**Father** □ □ □ □ □
17. Distance in km to the health facility for immunization services: ..... km		
18. Mode of transportation to the nearest health facility for immunization services: (1) By foot (2) By own car (3) By public transport (4) Other (Please specify).....		□ □ □ □
19. Time taken to reach the nearest health facility for immunization services: (1) □<30 minutes (2) □30-60 minutes (3) □>60 minutes		

Page 2 of 8



SECTION B
BARRIERS TO TIMELY VACCINATION

Questions with regards to utilization of health services by mother

20. Did you attend ante-natal care (ANC) during your pregnancy with this child? (1) Yes (If yes, answer questions 21 and 22) (2) No (If no, skip questions 21 and 22) (3) Unsure	□ □ □
21. If yes to question 20, how many times did you attend ANC during this pregnancy?	
22. If yes to question 20, did you get information on immunization during these ANC visits? (1) □No (2) □ Unsure (3) □Yes	
23. Where did you give birth to your child? (1) At home (If the answer is home, skip question 24) (2) Clinic (If clinic, answer question 24) (3) Hospital (If hospital, answer question 24) (4) Other (Please specify).....	□ □ □ □
24. If one of the two health facilities were chosen in question 23, did you get information on immunization during your time of admission to the hospital? (1) □No (2) □ Unsure (3) □Yes	
25. Did you attend post-natal care (PNC) after the birth of this child? (1) Yes (If yes, answer questions 26 and 27) (2) No (If no, skip questions 26 and 27) (3) Unsure	□ □ □
26. If yes to question 25, how many times did you attend PNC?	
27. If yes to question 25, did you get information on immunization during PNC? (1) □No (2) □ Unsure (3) □Yes	

Questions on the knowledge of parent or guardian about measles vaccination

28. Should the immunization card of every child be kept safe as proof of immunization? (1) □No (2) □Yes
29. Should vaccination cards be checked at crèche or kindergarten by teachers? (1) □No (2) □ Unsure (3) □Yes
30. Is the MR vaccine part of the national immunization program? (1) □No (2) □ Unsure (3) □Yes
31. BCG vaccine is against (1) □Tuberculosis (2) □Poliomyelitis (3) □ Measles&Rubella (4) □Tetanus (5) □ Unsure
32. MR vaccine is against (1) □Tuberculosis (2) □Poliomyelitis (3) □Measles&Rubella (4) □Tetanus (5) □ Unsure
33. Is the MR immunization necessary for your child? (1) □No (2) □ Unsure (3) □Yes

Page 3 of 8

34. If your child gets a fever on the scheduled day for MR immunization, what would you do? (1) Keep the child at home (2) Take the child to the health facility (3) Other (Please specify).....			□ □ □
35. Is it normal to have mild adverse reactions such as fever after MR vaccination? (1) □No (2) □ Unsure (3) □Yes			
36. Is measles vaccination related to illness after vaccination? (1) □No (2) □ Unsure (3) □Yes			
37. How many doses of MR immunization should a child get? (1) □One dose (2) □Two doses (3) □Three doses (4) □ Unsure			
38. At what age should the 1st dose of MR vaccine be given to a child? (1) □6 months (2) □8 months (3) □9 months (4) □12 months (5) □ Unsure			
39. At what age should the 2nd dose of MR vaccine be given to a child? (1) □6 months (2) □12 months (3) □15 months (4) □18 months (5) □ Unsure			
40. Do you know the due date for your child's next vaccination? (1) □No (2) Yes			
41. Does your child have an immunization card? (1) □No (2) □Yes			
42. Request for immunization card and record the dates from the card in the table below			
MR vaccine information	**Due Date**	**From card**	**Memory, if no card**
MR1(yyyy/mm/dd)			
Vaccination status of MR1 dose according to the recommended schedule (judged and filled by interviewer) (1) □Non-vaccinated (2) □Early (before 1st day of 9 months) # of days early:..... (3) □Delayed (after the last day of 9 months) # of days delayed:..... (4) □Timely (between 1st and last day of 9 months)			
MR vaccine information	**Due Date**	**From card**	**Memory, if no card**
MR2 (yyyy/mm/dd)			
Vaccination status of MR2 dose according to the recommended schedule (judged and filled by interviewer) (1) □Not due yet (2) □Non-vaccinated (3) □Early (before 1st day of 15 months) # of days early:..... (4) □Delayed (after the last day of 15 months) # of days delayed:..... (5) □Timely (between 1st and last day of 15 months)			

Page 4 of 8

Questions regarding parent/guardian's attitude and health beliefs towards measles vaccination

Perception of susceptibility to measles

43. Measles is infectious, and children are more likely to get measles than adults (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
44. Without vaccination, it is likely that children will get measles (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
45. Without timely vaccination, children are more likely to get measles (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
46. Without completing two doses of measles vaccines within two years, children are more likely to get measles (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
47. Without timely and complete measles vaccination, children are more likely to get complications of measles, e.g. pneumonia (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree

Perception of the severity of measles

48. Measles is a serious illness (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
49. Measles is one of the major causes of death among children (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
50. Measles can weaken the child's immune system (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
51. If my child contracts measles, the disease could spread to other family members in the house (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree

Perception of benefit from measles vaccination

52. MR vaccination will protect my child against measles (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
53. MR vaccination will alleviate symptoms of measles (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
54. MR vaccination will stop the transmission of measles among children (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
55. MR vaccines are safe for children (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree

Perception of barriers to measles vaccination

56. Two doses of MR vaccine are unnecessary, my child should only get one measles dose (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
57. It is better to get natural immunity by getting measles rather than through immunization (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
58. MR immunizations are unsafe and have serious side effects (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
59. Time and transportation to the health facility make it difficult to take my child for vaccination (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
60. A child can still get measles despite vaccination (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
61. I do not know when my child needs to get vaccinated (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
62. My child is allergic to vaccines or eggs (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
63. There is no information available about the safety of MR vaccines (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree

Perception of cues to action (factors that could motivate parents to get children vaccinated with MR immunization)

64. If MR vaccination is recommended by healthcare workers, I would let my child be vaccinated (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
65. If MR vaccination is suggested by relatives, I would let my child be vaccinated (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
66. If there is information available about the safety of MR vaccines, I would let my child be vaccinated (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
67. If MR vaccine is available and accessible, I would let my child be vaccinated (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree
68. If I am aware of the vaccination dates on my child's vaccination card, I would let my child be vaccinated (1)□Strongly disagree (2)□Disagree (3)□ Unsure (4) □Agree (5)□Strongly agree

Perception of self-efficacy

69. Are you willing to let your child completely participate in the national immunization program? (1)□Strongly unwilling (2)□Unwilling (3)□Unsure (4)□Willing (5)□Strongly willing
70. Are you willing to let your child be vaccinated on time? (1)□Strongly unwilling (2)□Unwilling (3)□Unsure (4)□Willing (5)□Strongly willing

Questions related to health services

71. Are vaccines offered free of charge at the health facility you visit? (1)□No (2)□Unsure (3)□Yes
72. Which health facility do you usually visit for immunization services? (1) Rehoboth Clinic (2) Rehoboth Health Centre (3) Other (Please specify)…… □□□
73. Do you know the working hours of this health facility? (1)□No (2)□ Unsure (3)□Yes
74. Is the working hours of the health facility convenient for you? (1)□No (2)□ Unsure (3)□Yes
75. How long do you wait for immunization service at the health facility that you visit? (1) □Less than 30 minutes (2) □Between 30 minutes to an hour (3) □ Between one and three hours (4) □More than three hours
76. How satisfied are you with the immunization services at the health facility? (1) □Very unsatisfied (2) □ Unsatisfied (3) □Neutral (4) □Satisfied (5) □Very satisfied
77. If this child was immunized late with MR, what were the reasons that your child was immunized late? (Please specify below)
(1)
(2)
(3)
(4)

The end

Thank you for your time and participation!

HREC-NH Annex 5B: Questionnaire

QUESTIONNAIRE

UNAM
UNIVERSITY OF NAMIBIA

Dear Participant

My name is Gertruida Frissina Burger, student number 9967455. I am studying towards a Masters degree in Science in Field Epidemiology and Laboratory Training at the University of Namibia (UNAM), and I am conducting a survey about **the barriers to age-appropriate timeliness of measles vaccination among children in Rehoboth urban, Hardap Region, Namibia.**

1. I have selected you to participate in my study, because you belong to the study population and also because you possess knowledge that could contribute greatly with regards to timely vaccination among children. I would therefore like to invite you to complete this questionnaire.
2. The UNAM Research Ethics Committee has approved the research I am conducting. I would appreciate it very much if you would complete this questionnaire, and I would like to assure you of the following:
   a. You are under no obligation to complete this questionnaire if you do not want to.
   b. Once you have decided to take part in the study, you can stop completing the questionnaire at any time you want, and there will be no negative consequences for you.
   c. Your participation is completely anonymous. This means that, even if I ask for information that might identify you or if I know you, I am not allowed to make your identity known to anyone. When I report on my questionnaires' data and results, I will not mention any personal information about participants that might identify them.
   d. All completed questionnaires and data will be stored in a safe and secure place and only authorized University officials, my supervisor and I will have access to it. After five years, all the questionnaires and data will be destroyed in an environmentally friendly way.
3. If you have any questions about this questionnaire, or if you do not understand anything, please feel free to ask me, and I will be happy to explain it to you.
4. If you want to know more about the research I am doing, please feel free to ask me, and I will be happy to tell you more.
5. It should take about 25 minutes for you to complete the questionnaire.
6. You can contact me on my cell phone at +264 81 25 28774, or send an e-mail to bgertruida@yahoo.com
7. If you want to contact the UNAM Centre for Research Services for more information or if you want to lay a complaint or make any comment regarding the research or about me, please call (+ 264 61) 206 4673, or send an e-mail to research@unam.na. Please provide specific information.
8. Thank you very much for your willingness to participate in this research!

Please detach this page and keep it.

Please turn over to complete the questionnaire.

APPENDIX F: INTERVIEW GUIDE HEALTHCARE WORKERS

INTERVIEW GUIDE

University of Namibia, School of Nursing and Public Health

Title of the research: Barriers to age-appropriate timeliness of measles vaccination among children in Rehoboth urban, Hardap Region, Namibia

The following items will be required: Research proposal, a blue or black pen, a tape recorder, a writing pad and a comfortable place.

Introduction

Greet the respondents and introduce yourself by name and surname, workplace, clearly explain the purpose of the study and emphasize that it is voluntary, obtain written consent from the participant him/herself, and explain to the respondent that the results of the study will strictly be used for the stated purpose. With the semi-structured interview, the researcher will ask open-ended questions and if necessary, probe focusing on the objectives of the study.

Indicate the following information of the respondent:

Age of respondent	Gender of respondent	Cadre of respondent

Question to Nurses/Community Health Workers/Pharmacist Assistants

Tell me about the barriers to age-appropriate timeliness of measles vaccination among children in Rehoboth urban

Probe on the following areas: Patient-related barriers, healthcare worker-related barriers, health facility barriers, healthcare system barriers, and other barriers

The end

Thank you for your time and participation!