A MULTI-YEAR ANALYSIS OF TRENDS IN VACCINATION COVERAGE, ASSOCIATED FACTORS AND EFFECT ON CHILD GROWTH IN KENYA

BY

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DECLARETION

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DEDICATION

ABSTRACT

Vaccinations are one of the most cost-effective strategies for preventing diseases and achieving universal health coverage. However, incomplete vaccinations pose a significant challenge in Kenya, potentially leading to the resurgence of vaccine-preventable diseases (VPDs) and adverse growth outcomes in children. Key indicators of incomplete vaccination, including non-vaccination, under-vaccination, and Missed Opportunities for Vaccination (MOV), remain areas of concern. Despite the availability of data from the Kenya Demographic and Health Survey (KDHS) on levels and certain determinants of non-vaccination, comprehensive national data on the trends and determinants of non/under-vaccination and MOV are lacking. Addressing this gap in evidence, this study utilized nationally-representative data to analyze multi-year trends in vaccination coverage, associated factors, and their impact on child growth in Kenya from 2003 to 2014. The primary objectives were to examine trends in non-vaccination, under-vaccination, and MOV among children aged 0-23 months, identify demographic and socio-economic factors influencing these trends, explore the role of health system factors, and assess the effects of non-vaccination, under-vaccination, and MOV on child growth rates. Employing an explanatory sequential mixed-methods research design, the study comprised two phases. The first phase involved a quantitative analysis of child immunization datasets from the KDHS cross-sectional surveys conducted in 2003, 2008/09, and 2014. A total of 11,959 children aged 0-23 months were included in the analysis. Study specific data abstraction tools were used to collect children immunization data and their demographic and socio-economic information. Intervening variables such as non/under-vaccination and MOV were evaluated. Child growth outcomes were assessed using indicators of stunting, wasting, and underweight. Data coding and recoding were done using Stata (version 14; College Station, TX: StataCorp LP). Statistical analyses included the Cochrane-Armitage trend test to determine trends in non/under-vaccination and MOV proportions, multivariable logistic regression models to explore the influence of demographic and socio-economic factors, and mixed-effect multi-level linear regression modeling to assess the impact of vaccination status on growth outcomes. The second phase involved qualitative interviews with policymakers at the national and county levels to provide contextual insights. NVIVO software (QSR International Pty Ltd. Version 12, 2018) was used for coding and analysis. Thematic content analysis was employed, and findings were triangulated with quantitative results to identify areas of convergence and divergence. During the study period, non-vaccination decreased by 10%, under-vaccination remained relatively stable, and MOV increased by ~15%.Maternal education, age, marital status, region and family size were identified as significant influencers of vaccination status. Health system challenges such as negative staff attitudes, inadequate staffing, storage facility breakdowns and vaccine stock-outs hindered childhood vaccination services. In the mixed-effect multi-level linear regression modeling, MOV exhibited negative coefficients on Weight for Age Z-score (WAZ) and Weight for Height Z-score (WHZ) in 2003 and 2014, with coefficients of -0.25 ($p < 0.001$) and -0.12 ($p = 0.013$), respectively. Under-vaccination showed negative effects on WAZ in 2008/09 and 2014, as well as on WHZ in all three surveys, with coefficients of -1.61 ($p < 0.001$) for 2003, -0.40 ($p = 0.022$) for 2008/09, and -0.23 ($p < 0.001$) for 2014. Non-vaccination yielded mixed findings, with both significant negative and positive coefficients observed across the years. This comprehensive study contributes valuable insights into the relationship between vaccination status and child growth outcomes, enhancing our understanding of the implications of vaccination programs on public health in Kenya.

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LIST OF ABBREVIATIONS

AOR	–	Adjusted Odds Ratio
ANC	–	Ante-Natal Care
BCG	–	Bacille Calmette-Guérin
CHMT	–	County Health Management teams
CI	–	Confidence Interval
COR	–	Crude Odds Ratio
DHS	–	Demographic and Health Survey
DPT	–	Diphtheria Pertusis and Tetanus
FIC	–	Fully Immunized Children
GCP	–	Good Clinical Practice
GVAP	–	Global Vaccine Action Plan
HDI	–	Human Development Index
ICF	–	Informed Consent Form
KAP	–	Knowledge Attitudes and Practices
KII	–	Key Informant Interview
KePHS	–	Kenya Essential Package of Health
LMIC	–	Low and Middle-Income Countries
MOH	–	Ministry of Health
MOV	–	Missed Opportunity for Vaccination
MUSERC	–	Maseno University Scientific and Ethics Review Committee
NACOSTI	–	National Commission for Science, Technology, and Innovations
NVIP	–	National Vaccines and Immunization Program
OPV	–	Oral Polio Vaccine
PCV	–	Pneumococcal Conjugate Vaccine
SDG	–	Sustainable development goals
sCHMT	–	sub-County Health Management teams
sSA	–	sub-Saharan Africa
UHC	–	Universal Health Coverage
VPD	–	Vaccine-Preventable Diseases
WHO	–	World Health Organization

DEFINITION OF TERMS

Associated factors: Socio-demographic variables such as gender of the child, childbirth order, household size, maternal age, education level, marital status, religion, occupation, wealth quintile, region, and place of delivery that are influential factors associated with non/under-vaccination and MOV.

Immunity: Immunity is a state of resistance of an organism to invading biotic or abiotic pathogens and their harmful effects that prevent the development of infection and maintains an organism's integrity by counteracting, neutralizing, and clearing pathogens (Cabej, 2019).

Herd immunity: This is a condition in which a population is protected from a disease after vaccination which prevents transmits organisms between people. In this way, even people who cannot be vaccinated and are not vaccinated can be protected (OVG, 2016).

Vaccine: These are biological preparations, produced from living organisms, that stimulates the body's immune system to protect the person against subsequent infection or disease.

Vaccination: The process of administering vaccines.

Immunization: Immunization is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine.

Non-vaccination: unvaccinated children with zero doses.

Under-vaccination: Partially vaccinated children.

Fully immunized Child (FIC): A child is considered fully immunized if s/he has received Bacillus Calmette-Guerin (BCG) vaccine against tuberculosis at birth; three doses each of polio and pentavalent (diphtheria-tetanus-pertussis-hepatitis B (Hep), Hemophilus influenza type B (Hib)), pneumococcal conjugate vaccines at 6, 10 and 14 weeks of age; and vaccination against measles-rubella (MR) at 9 months of age.

Missed opportunity for vaccination (MOV): Any contact with a health service that did not result in an eligible child receiving the needed vaccines (WHO, 2020).

Trends: This is the general direction or pattern of change in a variable over a specific period. It shows whether the data points are increasing, decreasing, fluctuating, or remaining stable over time.

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CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

This introductory section delves into the foundational background of the study, explaining the pivotal role of vaccination as a cornerstone in pediatric healthcare. It emphasizes the importance of monitoring and enhancing child growth, recognizing it as a fundamental aspect of pediatric well-being. It also establishes a crucial nexus between non/under-vaccination, missed opportunities for vaccination (MOV), and indicators of malnutrition such as wasting, underweight, and stunting.

This chapter articulates the evolving trajectories of non/under-vaccination and MOV, emphasizing the necessity of conducting a comprehensive multi-year trend analysis. It probes into the intricate interplay of demographic and socio-economic factors, clarifying their influence on non/under-vaccination and MOV among children. Furthermore, it scrutinizes the impact of health system dynamics, including the allocation of resources towards immunization programs in the context of Kenya.

This chapter extends to the ramifications of non/under-vaccination and MOV on child growth rates, delineating their detrimental effects. It lays the groundwork for an age-stratified analysis of vaccination patterns, recognizing the nuanced implications across different developmental stages. Additionally, it examines the burden of vaccine-preventable diseases (VPDs) in the Kenyan context, providing insights into the prevailing epidemiological landscape.

This section concludes by presenting the core research problem, delineating the research objectives, and underscoring the significance of the study. This comprehensive description highlights the intricate interconnections between vaccination practices and child growth outcomes, thereby paving the way for rigorous inquiry and informed interventions.

1.1.1 Background Information on Vaccination Status and Child Growth Outcomes

Vaccines are designed to stimulate the body to fight off antigens they have been primed against (Wang et al., 2019). Most vaccines are safe, immunogenic and efficacious, so it is important to have children fully immunized (Orenstein & Ahmed, 2017). Vaccines have contributed hugely to the eradication of major diseases of public health concern (Greenwood, 2014). It has been

reported that vaccinations are one of the most cost-effective ways of preventing diseases (Anderson, 2014).

Non-vaccinated children are those who have received no age eligible vaccines or also defined as children with zero doses, while under-vaccinated children are those who have been partially vaccinated with age eligible vaccines (Bobo et al., 2022). Further, the World Health Organization (WHO) defines missed opportunity for vaccination (MOV) as a contact with the health services by a child who is eligible for vaccination but does not result in the child receiving all the vaccine doses for which he or she is eligible (WHO, 2017). A systematic review for the period 2001-2011 showed that vaccinations for children averted over 20 million deaths and saved US$ 350 billion in the cost of illness (Ozawa et al., 2017). Immunization programs, therefore, remained a key pillar of the primary health care system, which is the backbone of achieving universal health coverage (GGP, 2019) and a critical driver to the attainment of 14 of the 17 sustainable development goals - SDG (Gavi, 2020).

Child growth failure manifesting as childhood malnutrition is a huge global public health concern and is associated with both morbidity and mortality (Dicker et al., 2018). Malnutrition has been shown to cause immunodeficiency and this may lead to the inability to mount a proper immune response from vaccination (Prendergast, 2015). Children with poor growth outcomes are more likely to experience cognitive, physical, and metabolic developmental impairments with adverse health outcomes (Adair et al., 2013). Poor childhood growth outcomes include stunting, wasting and underweight, and have all been linked with an increased risk of death from common childhood vaccine-preventable diseases (Olofin et al., 2012). Even though there were improvements in child growth in Africa for the period between 2000-2015, heterogeneous differences persisted (Osgood-Zimmerman et al., 2018). These differences posed great challenges to achieving the World Health Organization (WHO) Global Targets 2025 of improving maternal, infant and young child nutrition and the SDG target – to end malnutrition by 2030. These critical malnutrition levels also exist in Kenya with notable differences based on region and socio-economic levels (Osgood-Zimmerman et al., 2018).

1.1.2 Trends of Non/ Under-Vaccination and MOV amongst Children

1.1.2.1 Non/ Under-Vaccination

The modest vaccine coverages reported globally are not enough to prevent disease outbreaks (MacDonald et al., 2018). According to the Global Vaccine Action Plan (GVAP), countries are required to attain ≥90% national coverage and at least 80% in every district or equivalent administrative unit, with three doses of Diphtheria Pertusis and Tetanus (DPT) containing vaccines by 2020(Peck et al., 2019). However, globally, many children remain unvaccinated, under-vaccinated and continue to miss vaccination opportunities meaning that disease outbreaks will still occur (Mantel & Cherian, 2020). Measles outbreaks have been reported in Mozambique (Jani et al., 2008a), South Africa (Jacob & Coetzee, 2015), and Kenya (Manakongtreecheep & Davis, 2017). The same challenge is being witnessed in North America and Europe with the resurgence of measles cases (WHO, 2019b, 2020a).

Non/ under-vaccination represents the inability of a vaccination program to reach eligible children with vaccines. These could be due to various reasons. In Ethiopia, it was established that achieving full immunization was hindered by differences between regions, women's low socio-economic status, not using antenatal care services, and weaker cultural-sensitive media campaigns (Gurmu & Etana, 2016). However, other factors that had been shown to influence achieving full coverage such as religion have not demonstrated consistent results at the global level, necessitating the importance of understanding the local drivers of vaccine confidence in more detail (Larson et al., 2016). Further, a study in Nigeria using data from multiple cluster indicator national surveys reported that reasons for non-vaccination and under-vaccination vary according to the child's immunization status (Sato, 2020). A similar conclusion have been drawn regarding the association between socio-demographic characteristics and under-vaccination (Boyce et al., 2019). In a Nigerian study, most caregivers (45%) with under-vaccinated children thought that their children had already been fully vaccinated (Rainey et al., 2011). Other reasons included the inconvenient location of the service delivery point, and supply issues, e.g. stockouts. For those with non-vaccinated children, low education levels were correlated with more likelihood of trusting the immunization system while poorer households and location of service delivery points were also given as reasons for non-vaccination. Other common reasons for non-vaccination include lack of knowledge, religious taboos, complacency, inconvenience in

accessing vaccines and lack of confidence as key reasons underlying hesitancy (Rainey et al., 2011; Sheikh et al., 2013).

Even though the highlighted studies have documented the factors that drive non/ under-vaccination, they have not shown any evidence on regional and country trends observed over several years. No such evidence has been reported for Kenya. This study is the first one to provides evidence on the trends of non/ under vaccination and factors that deter the achievement of full immunization coverage in Kenya. Similarly, no study has investigated the effects of non/ under-vaccination with stunting, wasting and underweight in Kenya. This study addresses this gap and demonstrates the effects of non/ under-vaccination on child growth outcomes in Kenya.

1.1.2.2 Missed opportunity for vaccination

Missed opportunities for vaccinations represents the inability of the immunization program to retain eligible children and represents a major concern for the immunization programs performance (Sridhar et al., 2014).The MOV may occur during curative or preventive services (e.g. oral rehydration training sessions growth monitoring and nutrition assessments). Reducing MOV is therefore critical in order to attain and sustain the 90% or more immunization coverage goal (Olorunsaiye et al., 2017). The common vaccines being missed are those given at birth and at six weeks of age (BCG,OPV0,OPV1, HBV1 and DTP1) (Ubajaka et al., 2012). Understanding of multi-level determinants that influence non-vaccination, under-vaccination and MOV is important in teasing out both individual and community level characteristics (Isabirye et al., 2020; Joseph et al., 2020).

There have been previous attempts to understand the magnitude and determinants of MOV in Kenya. A meta-analysis reviewing data from low-income countries (Adamu et al., 2019), a study amongst the Maasai nomadic populations (Pertet et al., 2018) and a study among children in a poor urban settlement of Nairobi, Kenya (Mutua et al., 2011) found a MOV prevalence of 42%, 30% and 22%, respectively, with similar drivers documented for MOV as with non/ under-vaccination. However, they all these studies used varying methodologies, hence limitations in their interpretations and generalizability. They also have not used any longitudinal approaches and hence their inability to show trends over time. This study overcomes these limitations and presents multi-year trends of MOV in Kenya.

The WHO planning guide acknowledges that with the increased introduction of new vaccines into the National immunization schedules, the opportunities to vaccinate, as well as the opportunities to catch-up on delayed vaccinations during regular health service also increases. The planning guide further identifies some of the causes of MOV to be failures or inability of health providers to screen for eligibility, perceived contraindications to vaccination on the part of providers and parents, vaccine shortages, rigid clinic schedules that separate curative services from vaccination areas and parental or community resistance to immunizations.

Even though levels in MOV have been published using multi-country Demographic and Health Survey (DHS) data (Ndwandwe et al., 2018), the pathway linking MOVs with growth outcomes were not described across the sub-Saharan African setting. In line with the WHO methodology of MOV assessment where exit interviews with caregivers and Knowledge, Attitudes and Practices (KAP) surveys with health-workers are conducted (WHO, 2017), a recent qualitative study of MOV was conducted in Kenya (Li, Tabu, Shendale, Sergon, et al., 2020). The reported study used exit interviews with caregivers to gain qualitative insights into reasons for missed opportunities for vaccination in Kenyan health facilities.

When conducting MOV assessment using DHS data, it is important to ensure each of the seven contact points the child makes with the health system is taken into consideration as it offers an opportunity for vaccination if the child is eligible. A recent study used five health service contact points to define MOV (Ndwandwe et al., 2018). These include skilled birth attendance, postnatal baby check within two months, received vitamin A dose in first two months after delivery, has health a vaccination card and medical treatment of diarrhoea/ fever/cough) in MOV assessments. Scrutiny of these contacts made reveals that they did not include health facility contacts made during supplementation with iron pills/ syrup given within one week of survey date and intestinal parasites treatment within six months of the survey date. Further, the same study used the presence of an immunization card/ booklet as a point of contact. However, the immunization cards/ booklets are given during Ante-Natal Care (ANC) visits and not necessarily when the child makes the first visit for immunization. It is important to have an exhaustive review of all contact points and understand the effect they have on the potential vaccination status of children. Likewise, it is important to conduct studies on the determinants of MOV from a quantitative

perspective using nationally representative data, a piece of key information which is currently lacking in Kenya.

This study utilized the seven health system contact points captured in Kenya DHS for the years 2003, 2008/09 and 2014 to measure the trends of missed opportunities for vaccination and triangulate this with data from an empirical qualitative study to understand the health system factors that influence missed opportunities for vaccination in Kenyan children. The evidence gained is useful for reducing missed opportunities for vaccination and ensuring all children received their required vaccines on time.

1.1.2.3 Relevance of the Multi-Year Trend Analysis

Understanding the multi-year trends and determinants of non/ under-vaccination and MOV is vital for assessing the efficacy of immunization programs and appreciating the factors influencing vaccination status and access to vaccines. This is the first study in Kenya to utilize DHS data to analyze trends in non/ under-vaccinations and MOV and their impacts on child growth outcomes. The analysis of trends of these vaccination gap over time has been insufficiently explored. Existing studies have primarily focused on overall vaccination coverage rates, overlooking the nuanced effects of policy milestones and the specific gaps in vaccination uptake, including non-vaccination and under-vaccination.

1.1.3 Influence of Demographic and Socio-Economic Factors on Non/ Under-Vaccination and MOV amongst Children

Even though immunization programs aim to reach all children with life-saving vaccines, its success largely depends on vaccination coverage, quality of vaccination reporting and strategies to successfully reach every deserving child with vaccines (Reiss & Weithorn, 2015). Demographic and socio-economic factors have shown to be a major barrier to accessing health and achieving Universal Health Coverage - UHC(Were et al., 2019). Poor households have been shown to suffer catastrophic expenditures when seeking health services and are at more risk of disease burden compared to the richer households (Barasa et al., 2017). In Ethiopia, it was established that achieving full immunization was hindered by differences between regions, women's low socio-economic status, not using antenatal care services, and weaker cultural-sensitive media campaigns (Gurmu & Etana, 2016). Other factors that had been reported to influence achieving full coverage such as religion have not demonstrated consistent results at the

global level, necessitating the importance of understanding the local drivers of vaccine confidence in more detail (Larson et al., 2016).

A similar conclusion was drawn regarding the association between socio-demographic characteristics and under-vaccination. In this Nigerian study, most caregivers (45%) with under-vaccinated children thought that their children had already been fully vaccinated. Other reasons included the inconvenient location of the service delivery point, and supply issues, e.g. stockouts. For those with non-vaccinated children, low education levels were correlated with more likelihood of trusting the immunization system while poorer households and location of service delivery points were also given as reasons for non-vaccination. Other common reasons for non-vaccination include lack of knowledge, religious taboos, complacency, inconvenience in accessing vaccines and lack of confidence as key reasons underlying hesitancy (Rainey et al., 2011; Sheikh et al., 2013).

Reducing socio-economic inequalities is associated with achieving at least four SGD goals such as health for all, reducing poverty, achieved gender and education goals (Niessen et al., 2018). Therefore, a reduction of health inequalities is vital to the promotion of the overall SDG agenda. It is possible to enhance equality in health by sustaining a reduction of general inequalities such as income status, education, and gender within and between countries (Niessen et al., 2018). Herd immunity may be compromised when the poorest children who are at the greatest risk of contracting vaccine-preventable infectious diseases, and unvaccinated children are clustered geographically leading to associated morbidity and mortality (Clouston et al., 2014). Vaccinations can be cost-effective and beneficial but if the gains are skewed towards the most advantaged groups, then UHC will not be achieved (Mantel & Cherian, 2020).

Even though the drivers of non/ under-vaccinations and MOV are known, evidence had been lacking in the Kenyan context on the trends of these factors that drive non/ under-vaccinations and MOV. No studies have been conducted in Kenya using National level data to understand the influence of demographic and socio-economic factors on these immunization coverage gaps. We therefore conducted this study to understand the influence of demographic and socio-economic factors on non/ under-vaccination and MOV amongst children 0-23 months in Kenya for the period 2003-2014.

1.1.4 Influence of health system factors on non/ under-vaccination and MOV amongst children

Effective health systems deliver efficient vaccination services (Sodha & Dietz, 2015). In the US, vaccine safety concerns have led to the under-vaccination of children (Callender, 2016; Gidengil et al., 2019). Studies in Mozambique, Kenya and Somalia showed that health workers who perceive that they are not being supported by the health system may inconsiderately treat mothers leading to under-vaccination of children (Favin et al., 2012). These health system factors include health workers' knowledge, attitude and performance, lack of resources and logistics, false contraindications, fear of side effects and conflicting priorities. In Uganda, vaccine stock-outs was reported to be a major barrier to vaccinations and enhanced non/ under-vaccination and missed opportunities for vaccination (Kamya et al., 2022). To reduce missed opportunities for vaccinations, recommendations have been provided for holding staff discussions on various health programs and aligning childhood vaccination to their core functions, daily vaccination sessions during normal working hours and a part of an integrated outreach, improving vaccine forecasts and management practices and adequate distribution of resources, including staff (Favin, Steinglass, Fields, Banerjee, & Sawhney, 2012).

Most of the reported studies have been conducted with immunization service providers who are frontline health workers. However, few studies have been conducted with immunization services managers such as the current study to understand their insights on the health system factors that influence vaccination, including for MOV. This current study adds to this body of knowledge and provides evidence of the health system factors that impact non/ under-vaccinations and MOV from the immunization services managers' perspective. This is critical in informing evidence-based interventions tailored to overcome immunization barriers and improve child health in Kenya.

1.1.4.1 Funding for the Immunization Program in Kenya

The immunization program in Kenya is largely funded by the Ministry of Health (MOH) and Gavi, the Vaccine Alliance (Gavi, 2020). As with other countries, Gavi provides funding and material support to multilateral agencies (including UNICEF, CDC and WHO) and also to other non-governmental organizations (such as JSI, PATH, CHAI) to support the implementation of

immunization program activities. The Gavi support for the immunization program in Kenya between 2001-2019 is highlighted in Figure 1.1.

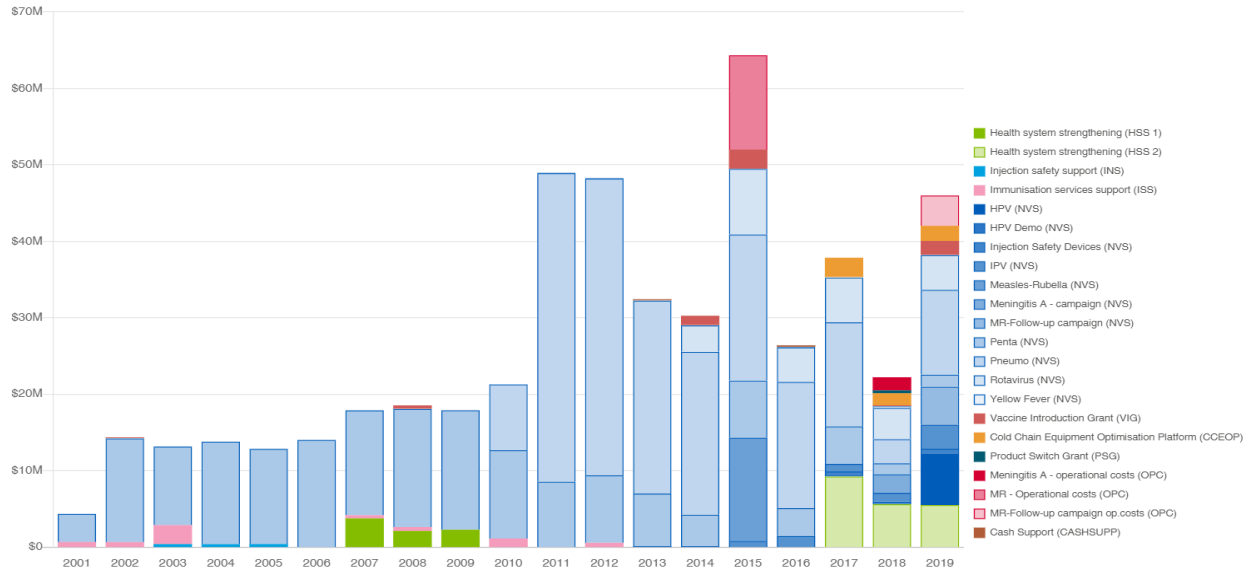

Figure 1.1: Gavi support for the immunization program in Kenya.

These resources in terms of funding and technical support from the various donors are provided to and distributed through the Kenya MOH, which in turn distributes them to the Counties together with other resources. Before the implementation of the Constitution of Kenya 2010, funding for health services, including immunization was managed and implemented from the National Government. However, since 2010, these were fully devolved and are managed by the County Governments(Lwembe, 2019; Okech, 2017). The expectation is that this provides a level ground in terms of resource allocation and distribution across Kenya, hence influencing service delivery and for immunization services. Given the varying levels of funding implementation across the counties and the support provided for immunization system in Kenya, this study provided an opportunity to understand the health system factors that influenced non/ under-vaccination and MOV in Kenya.

1.1.5 Effects of Non/ Under-Vaccination and MOV on the Growth Outcomes Of Children

The worldwide challenge of child under nutrition continues to be significant, as indicated by various measures of child growth faltering, such as stunting, underweight, and wasting (Abarca-Gómez et al., 2017). In 2018, approximately 149 million children, or 21.9%, were estimated to be affected by stunting alone (UNICEF, 2020). Urgent measures are required to achieve

Sustainable Development Goal 2, which aims to eliminate all forms of malnutrition by 2030 (UN, 2020). Accomplishing this goal can also positively impact other objectives related to child survival, educational attainment, and overall health and welfare(Li, Kim, et al., 2020). Malnutrition is an indicator of a child's vaccination status, and a fully immunized child is more likely to be in a good nutritional state (Zewdie & Abebaw, 2013). Likewise, it has been shown that an increasing coverage with childhood vaccination is one of the factors that resulted in reduced stunting (low height-for-age) rates in sub-Saharan Africa (Buisman et al., 2019). There is a higher likelihood of malnutrition and anaemia among children who missed their vaccinations (Semba et al., 2007).

Few recent studies have attempted to bridge the gap in the literature highlighting the relationship between vaccination and child growth outcomes such as underweight, wasting and stunting. A study conducted in Ethiopia revealed that children who received their measles vaccines were less likely to be underweight (Mekonnen & Jones, 2005). Children who were immunized were less likely to be affected by stunting than non-immunized children, and this could be because immunization reduces child morbidity from vaccine-preventable diseases which may lead a child to malnutrition (Galazka et al., 1984). Similar study results have also been observed in Brazil (Sarni et al., 2009). As such, the current study provides evidence to the body of knowledge required to effectively investigate the effects of non-vaccination, under-vaccination, and missed opportunities on the growth rates of children under two years of age in Kenya.

Evidence points to the protective benefits of timely vaccination against malnutrition (Mejia et al., 2018). Children who had not completed their vaccinations were shown to have a higher chance of being underweight and with acute malnutrition (Mejia et al., 2018). Studies have shown that improving childhood vaccination status can reduce malnutrition and improve child growth (Anekwe & Kumar, 2012; Bogler et al., 2019).

1.1.6 Relevance of the Age Stratified Analysis for Vaccination

There have been different age groups used in the evaluation of non/ under-vaccinations. Analysis of full-vaccination, non-vaccination and under-vaccination have used age groups 12-23 months (Asfaw et al., 2016; Asrat & Mesfin, 2017; Bobo et al., 1993; Danis et al., 2010; de Figueiredo et al., 2016; de Figueiredo & Were, 2019; Donfouet et al., 2019). The use of this age group (12-23 months) has been justified while evaluating full immunization. Children at that age are expected

to have received all the vaccinations. The Kenya immunization policy describes a fully immunized child as one who has received all the prescribed antigens and at least one Vitamin A dose under the national immunization schedule before their first birthday.

However, in this study, the age groups 0-23 months was used since the objective also included an assessment of non/ under-vaccination and MOV. The analysis of MOV has often varied by age groups used and ranged from 0-23 months, depending on the definition of contact with health services. In this study, MOV was assessed for 0-23 months of age to cover all possible contacts with the health services from birth up to 2 years old. A child can miss an opportunity for vaccination at one contact with the health system and still present later for the due vaccination. Likewise, a child presenting for a non-vaccination visit can still be vaccinated if the health worker determines that they had missed an opportunity for vaccination in their earlier contacts with the health system. Given that immunizations can still be given past one year of age, in this study, the analysis of non/ under-vaccination and MOV was conducted in children aged 0-23 months. There are studies that have used a similar age categorisation in their analysis of non/ under-vaccination and MOV, and this study followed a similar trend (Adamu et al., 2019; Andersen, 1995; Brown et al., 2018b; Dansereau et al., 2020; Jani, De Schacht, Jani, & Bjune, 2008a; Kaboré et al., 2020; Li, Tabu, Shendale, Okoth, et al., 2020; Mansour et al., 2019; Ndwandwe et al., 2018).

1.1.7 The Burden of Vaccine-Preventable Diseases (VPD) in Kenya

In 2013, the incidence rates of tuberculosis in HIV-exposed children in Kenya was 0.01 (95% CI 0.01-0.03) (Abuogi et al., 2013). An earlier study in 2009 had realized an incidence rate of 0.18 (95% CI 0.16-0.19) (Braitstein et al., 2009). The same studies recorded the prevalence of tuberculosis in HIV-infected children. In 2013, the prevalence of tuberculosis in HIV-exposed children in Kenya was 0.06 (95% CI 0.01-0.10) (Abuogi et al., 2013). An earlier study in 2009 had realized an incidence rate of 0.04 (95% CI 0.03-0.04) (Braitstein et al., 2009).

The incidence of pneumonia among Kenyan infants who were exposed to HIV, but uninfected was 900 (95% CI 800–1000) per 1,000 child-years (Ásbjörnsdóttir et al., 2016). Likewise, the incidence of pneumonia among Kenyan infants who were exposed to HIV, but uninfected was 900 (95% CI 800–1000) per 1,000 child-years (Ásbjörnsdóttir et al., 2016).

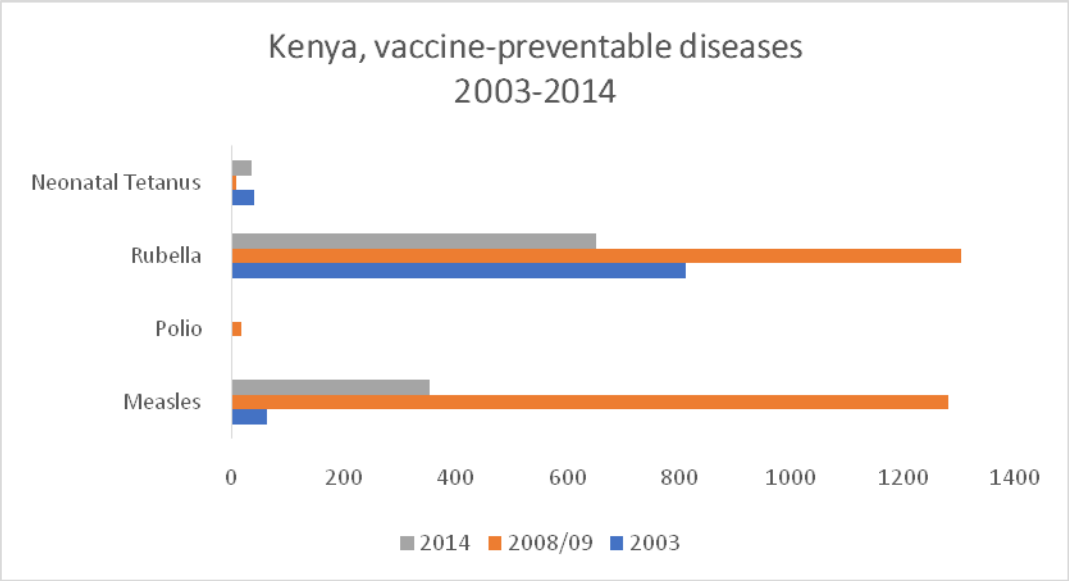

Figure 1.2: The burden of select vaccine-preventable diseases in Kenya between 2003-2014

Data from the WHO vaccine-preventable diseases monitoring system (Figure 1.2) for the period under study shows a variable incidence for at least four VPDs (WHO, 2020b).

Even though these health system factors that influence non/ under-vaccination and missed opportunities have been identified, no study in Kenya, using a nationally representative data has been undertaken to understand any changes in trend and how these changes have influenced Kenya's immunization status gaps. This study has provided critical information on these trends and the results provide opportunities for implementation of any relevant corrective actions.

1.2 Statement of the Problem

Childhood immunization programs are pivotal in preventing vaccine-preventable diseases and reducing child mortality worldwide. However, despite significant advancements in vaccine development and distribution, challenges persist in achieving optimal vaccine coverage, particularly in low- and middle-income countries. Kenya, like many other nations, grapples with issues of non/under-vaccination and MOV, which undermine the effectiveness of immunization efforts.

Non/under-vaccination refers to the failure of vaccination programs to reach eligible children with age-appropriate vaccines, while MOV occurs when eligible children miss opportunities to

receive vaccines during contact with health services. These gaps in immunization status pose substantial public health risks, contributing to outbreaks of preventable diseases such as measles and pertussis. Moreover, they hinder progress towards global health targets, including Sustainable Development Goal 3 - ensuring healthy lives and promoting well-being for all at all ages.

In Kenya, despite efforts to improve vaccination status, disparities persist across regions and socio-economic strata. Factors such as inadequate healthcare infrastructure, vaccine supply issues, and socio-cultural beliefs contribute to the challenges in achieving universal immunization coverage. Understanding the underlying determinants and trends of non/under-vaccination and MOV is crucial for designing targeted interventions to address these gaps and enhance immunization program effectiveness.

Furthermore, the impact of non/under-vaccination and MOV on child health outcomes, particularly on child growth and nutritional status, remains inadequately explored in the Kenyan context. Malnutrition, including stunting, wasting, and underweight, is not only a significant public health concern but also intersects with immunization efforts. Children with poor growth outcomes are more susceptible to vaccine-preventable diseases and may exhibit reduced immune response to vaccinations, exacerbating the vicious cycle of under nutrition and infectious diseases.

Despite previous studies documenting factors influencing non/under-vaccination and MOV, comprehensive national-level analyses of trends and determinants are lacking in Kenya. Additionally, few studies have investigated the association between vaccination status gaps and child growth outcomes. Therefore, there is a critical need for research that examines the multi-year trends of non/under-vaccination and MOV, identifies demographic and socio-economic factors influencing these gaps, and elucidates their impact on child growth rates in Kenya.

This study addresses these knowledge gaps by conducting a comprehensive analysis of vaccination status gaps and their determinants using nationally representative data from the Kenya Demographic and Health Surveys (KDHS) for the years 2003, 2008/09, and 2014. By investigating the trends, determinants, and health system factors influencing non/under-vaccination and MOV, as well as their effects on child growth outcomes, this research informs

evidence-based interventions and policy decisions aimed at improving immunization program performance and child health in Kenya.

1.3 Study Objectives

1.3.1 General Objective

To evaluate multi-year trends in vaccination coverage, associated factors and effect on child growth in Kenya.

1.3.2 Specific Objectives

i. To establish the trends of non-vaccination, under-vaccination and missed opportunities for vaccination (2003-2014) amongst children 0-23 months in Kenya.
ii. To determine the influence of demographic and socio-economic factors on non-vaccination, under-vaccination and missed opportunities for vaccination amongst children 0-23 months in Kenya for the period 2003-2014.
iii. To explore the influence of health system factors on non-vaccination, under-vaccination and missed opportunities for vaccination of children aged 0-23 months in Kenya.
iv. To determine the effects of non-vaccination, under-vaccination and missed opportunities for vaccination on the growth rates of children aged 0-23 months in Kenya for the period 2003-2014.

1.4 Research Questions

Using research questions proved more appropriate for this study as they focus on exploring relationships, trends, and influences, rather than making specific predictions or stating formal hypotheses to be tested. This approach facilitated a more exploratory and descriptive understanding of the research objectives, allowing for a comprehensive exploration of the complex factors involved in vaccination status and its impact on child growth in Kenya. By framing the objectives as research questions, the study was able to delve deeper into various factors such as demographic, socio-economic, and health system influences, providing a nuanced understanding of the dynamics at play. This enabled the research to effectively investigate the multifaceted nature of vaccination patterns and their effects, thereby contributing to a richer and more insightful analysis of the topic. This study answered the following research questions ;

i. What were the trends of non-vaccination, under-vaccination, and missed opportunities for vaccination among children aged 0-23 months in Kenya from 2003 to 2014?
ii. How did demographic and socio-economic factors influence non-vaccination, under-vaccination, and missed opportunities for vaccination among children aged 0-23 months in Kenya from 2003 to 2014?
iii. What was the influence of health system factors on non-vaccination, under-vaccination, and missed opportunities for vaccination among children aged 0-23 months in Kenya?
iv. What were the effects of non-vaccination, under-vaccination, and missed opportunities for vaccination on the growth rates of children aged 0-23 months in Kenya from 2003 to 2014?

1.5 Significance of the Study

Conducting a study on trends and determinants of non-vaccination, under-vaccination, and missed opportunities for vaccination is vital for assessing the efficacy of immunization programs and understanding the factors influencing status and access. This is the first study in Kenya to utilize DHS data to analyze trends in non-vaccination, under-vaccination, and missed opportunities for vaccination and their impacts on child growth outcomes. This study investigated the influence of health system factors on these vaccination status gaps, providing critical insights into vaccination status dynamics. Additionally, this study employed a mixed-methods approach, enhancing the understanding of childhood vaccination status gaps and their impact on child growth in Kenyan children. Insights gained from this study will directly contribute to efforts to strengthen child health interventions and reduce morbidity and mortality associated with vaccine-preventable diseases. These efforts align with Kenya's international commitments and national goals, particularly Sustainable Development Goal (SDG) 3, which aims to improve child health and survival.

Globally, conducting trend analysis requires evaluating data over time to distinguish genuine trends from random fluctuations. This process enables informed decision-making to enhance the efficiency of health interventions. Throughout the ten-year period studied, the introduction of new vaccines into the routine immunization schedule, along with enhancements in the immunization system, likely influenced the coverage of existing antigens. Analyzing data from

repeated national cross-sectional studies facilitated monitoring the influence of demographic, socioeconomic, and health system factors on childhood vaccination status over time.

The study examined vaccination trends in Kenya over a ten-year period using data from the Kenya Demographic and Health Surveys conducted in 2003, 2008/09, and 2014. It found that while non-vaccination decreased, under-vaccination remained stable and MOV increased significantly. The study emphasized the need to prioritize demographic and socio-economic factors in vaccination programs, implement tailored educational campaigns, ensure gender-equal vaccination initiatives, and address region-specific cultural and religious influences. Health system challenges like vaccine stock-outs and transportation barriers were identified as hindrances to vaccination accessibility. Moreover, the study revealed that MOV and under-vaccination negatively impacted child growth indicators, emphasizing the importance of targeted interventions to promote healthy growth trajectories among Kenyan children.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The literature review section delves into the foundational knowledge surrounding the specific objectives of the study, focusing on the intricate relationship between vaccination practices and their impact on child growth outcomes. Central to this review are the trends and underlying factors contributing to non-vaccination, under-vaccination, and missed vaccination opportunities. Through an in-depth analysis, this review explains the complex dynamics shaping these phenomena, shedding light on their prevalence and determinants. Moreover, this section delves into the repercussions of non-vaccination, under-vaccination, and missed opportunities on child growth, unraveling the correlation between vaccination status and child growth outcomes. By examining existing literature, the study offers a comprehensive understanding of how vaccination practices influence the nutritional status and overall well-being of children. Additionally, this review scrutinizes the role of health system factors in shaping vaccination practices, highlighting the diverse mechanisms through which healthcare infrastructure impacts vaccine status. By identifying the key determinants and barriers within the health system, this literature reveals avenues for enhancing vaccination uptake and coverage. Furthermore, this literature review provides insights into the theoretical and conceptual frameworks guiding this study. It contextualizes this research within established theories and frameworks, and strengthens the theoretical underpinnings of the investigation.

This comprehensive review establishes a robust groundwork for the subsequent analysis, offering valuable perspectives on vaccination uptake and its implications for child growth in Kenya. Through synthesizing existing knowledge and theories, this section sets the stage for a rigorous examination of vaccination practices and their impact on child health outcomes.

2.2 Trends Non/ Under-Vaccination and MOV amongst Children

2.2.1 Trends of Non-Vaccination

In 2018, the number of non-vaccinated children was13.5 million infants globally and 5 million in Africa, while in 2010, the number of unvaccinated children was 14.6 million globally and 5 million in Africa (Unicef, 2019; WHO, 2019a). These results show there have not been many changes in the number of non-vaccinated children, creating opportunities for the currently

occurring global vaccine-preventable disease outbreaks (Unicef, 2019).Non-vaccination occurs when an eligible child does not get due to vaccines. Such a child has received zero doses of vaccines and is not protected from any vaccine-preventable disease (Smith et al., 2004). Non-vaccinated children may end up with adverse health outcomes, including impact on growth (Fatima et al., 2020). Non-vaccination can occur due to several reasons, amongst them health system factors such as vaccine stockouts, inaccessible health facilities and lack of health personnel responsible for vaccination.

Un-vaccinated children were characteristically uniquely different from under-vaccinated children and they tended to be clustered geographically, increasing their risk of transmitting vaccine-preventable diseases to other unvaccinated and under-vaccinated children (Smith, Chu, & Barker, 2004). Even though access to vaccines may be a barrier to vaccination in many settings, there are growing numbers of parents who do not let their children get vaccines based on their attitudes (Black & Rappuoli, 2010; Larson et al., 2014). It has also been shown that most outbreaks of vaccine-preventable diseases, especially in developed countries, have been linked to non-vaccinated populations (Atwell et al., 2013; Feikin et al., 2000; Omer et al., 2008). Findings from a systematic review show that as early as 2008, there were already concerns regarding the levels of non-vaccination (Rainey et al., 2011). A study in Malawi highlighted trends in immunization coverage gaps(Munthali, 2007). However, it did not analyse determinants of vaccination gaps which would have helped contextualize their findings.

2.2.2 Trends of Under-Vaccination

In 2018, the number of under-vaccinated children was 5.9 million infants globally and 7.1 million in Africa, while in 2010, the number of unvaccinated children was 2.5 million globally and 2.5 million in Africa(Unicef, 2019; WHO, 2019a). Whereas there was a marginal decrease in the number of unvaccinated children in 2018, a considerable number of unvaccinated still created opportunities for the currently occurring global vaccine-preventable disease outbreaks (Unicef, 2019). In Kenya, based on the National demographic and health survey conducted in 2003 and 2014, the proportion of children aged 12-23 months who were unvaccinated children was 23.4% and 35.5% respectively showing a modest decrease in the proportion of unvaccinated children.

Alongside these, there have been concerns to have an understanding of why children are not vaccinated or do not complete their vaccine schedules (LaFond et al., 2015). One study from Ethiopia revealed that under-vaccination maybe because mothers are not allowed to leave their homes during the first 2-3 weeks after birth, therefore, the children end up missing vaccine doses given in the first few weeks after birth. Further, vaccine shortages and the unwillingness of health workers to open a batch of vaccines when there are not enough children gathered may also discourage mothers from taking their children for immunization, especially if their homes are far from the facility (Yismaw et al., 2019). Under-vaccination has also been related to factors around immunization services and parental knowledge and attitudes. The common factors cited ranged from access to immunization services, health staff attitudes and practices, reliability of services, false contraindications, parents' practical knowledge of vaccination, fear of side effects, conflicting priorities and parental beliefs (Favin, Steinglass, Fields, Banerjee, & Sawhney, 2012).

In Kenya, since the devolution of health care services and the advent of UHC, no study has been conducted using a nationally representative sample to compare the trends of non/ under-vaccination or even explain the health system factors that influence these child vaccination gaps. This study will also offer an opportunity to compare trends of non/ under-vaccination pre/ post-devolution in Kenya and support the implementation of UHC. As vaccination status changes over time, it is important to monitor and track trends of Non/ Under-vaccination and apply relevant interventions to improve vaccination status.

2.2.3 Trends of Missed Opportunities for Vaccination

Given that the global median prevalence of missed opportunities for vaccination stood at 32% in 2014 (Sridhar, Maleq, Guillermet, Colombini, & Gessner, 2014), it is essential to develop and implement strategies for vaccinating all children who make contact with health services to receive other interventions(Restrepo-Méndez et al., 2016). Based on this global prevalence, the WHO has developed the *WHO Planning Guide to Reduce Missed Opportunities for Vaccination (MOV) and Methodology for the Assessment of Missed Opportunities for Vaccination* which are used to assess and act on MOVs globally (WHO, 2017). In Africa, it has been realized that MOV prevalence rates are varied among the poor and non-poor across sub-Saharan Africa - SSA (Ndwandwe et al., 2018), and ranges from 22.5% in Swaziland to 87.1% in Gabon. Amongst the non-poor households, it ranges from 18.4% in Sao Tome and Principe to 93.4% in Gabon. In

Kenya, missed opportunities have been documented in varying proportions, ranging from 33% amongst non-poor and to 53% amongst the poor (Ndwandwe et al., 2018). However, no study has been conducted in Kenya to show trends of these missed opportunities over time.

2.3 The Influence of Demographic and Socio-Economic Factors on Non/ Under-Vaccination and MOV amongst Children

2.3.1 Determinants of Non-Vaccination and Under-Vaccination

Understanding the factors associated with gaps in childhood immunization is essentialin designing strategies for ensuring optimal coverages and policies (LaFond et al., 2015). Of greater use is an understanding of multi-level determinants that influence immunization service utilization(Acharya et al., 2019). These are important in teasing out individual-level characteristics which are often nested within the community level (primary sampling unit level) characteristics. Across Ethiopia, Senegal and DRC, studies have shown that maternal education, socio-economic status, and maternal service utilization during ANC, during delivery, and postnatal care services were associated with childhood immunization(Asfaw, Koye, Demssie, Zeleke, & Gelaw, 2016; Mbengue et al., 2017; Zaidi et al., 2014).

2.3.1.1 Child's Gender

The relationship between gender and vaccination varies across different settings. Gender discrimination and parental investment are both driven by society (Lee & Marwell, 2013). Patriarchal societies tend to favour boys over girls. Women living in such patriarchal societies will prefer having sons than daughters as they are assured some sense of security. In India, after controlling for other variables, girls aged 1-2 years were found to be 5% less likely to be vaccinated than boys (Borooah, 2004). This is in keeping with the global natal inequality where boys receive preferential treatment in access and utilization of services than girls as they grow up. Contrary to this, in Mozambique, there was no evidence of gender influencing whether caretakers availed their children for vaccination, or a child was fully vaccinated or not (Jani, De Schacht, Jani, & Bjune, 2008a). Girls were 5% less likely to have a nutritious diet compared to boys if their mothers were illiterate, but there were no differences in the diets if the mother was literate(Borooah, 2004). In India after three consecutive rounds of surveys undertaken by the Indian National Family Health Survey between 1992 and 2006, gender inequities in immunization coverage were found to be prevalent in some parts of the country(Prusty &

Kumar, 2014). It reported that boys were more likely to have high immunization coverage than girls for the Bacille Calmette-Guérin (BCG), DPT, and measles vaccines across all three surveys.

The hypothesis that not all girls and boys are treated equally was affirmed by evidence of patterns of selective neglect in the case of severe stunting and immunization (Pande, 2003). These findings argue that both girls and boys with only surviving siblings of the opposite sex fare better than do children with no surviving older siblings. Conversely, children with two or more surviving same-sex siblings are worse off in terms of these two health outcomes. The strength of the preference for sons and the low value of girls is evident in that the harmful effect of having surviving older siblings of the same sex alone is harsher for girls than it is for boys.

While looking at the country average, wealth, gender, and regional inequalities in immunization in India, it was reported that gender inequalities persist in most states but seem unrelated to overall immunization or the levels of other inequalities (Pande & Yazbeck, 2003). This report also showed that gender differentials reflect deep-seated societal factors rather than health system issues. Given the variation between a child's gender and its vaccination status, this study sought to determine the trends and determinants of Non/ Under-vaccination for Kenyan children between 2003-2014 and provide relevant context-specific recommendations for improving childhood vaccination status.

2.3.1.2 Maternal Education

Maternal education has been identified as an essential determinant of childhood vaccination (Anand & Bärnighausen, 2007). Maternal and caretakers education levels directly impact their vaccine awareness and attitudes towards vaccination. Those with less awareness and poor attitudes are less likely to have their children vaccinated. Children of mothers having no post-secondary education were more likely to experience immunization delays, hence under-vaccinated or completely miss out on their vaccines (Munthali, 2007). Similarly, in India, the mothers' literacy level was an important factor that contributed to one-third of un/ under-vaccinated children (Lauridsen & Pradhan, 2011). Similarly, there is a positive relationship between maternal education childhood immunization, even after controlling for sociodemographic characteristics and other fixed effects in India (Vikram et al., 2012). This relationship was particularly important when mothers who had primary level education had the essential health knowledge while mothers with secondary level education and above-required

communication skills to advocate for the need for immunization in children (Vikram, Vanneman, & Desai, 2012). Similarly, in Mozambique children of mothers with no education had low vaccine uptake(Jani, De Schacht, Jani, & Bjune, 2008a). However, contrary to other studies, some studies have found no link between maternal education and high immunization uptakes (Kim et al., 2007). In Washington, children born of mothers who were more educated were most likely not to be vaccinated (Bobo, Gale, Thapa, & Wassilak, 1993). Even though maternal education has been identified as an essential determinant for childhood vaccinations, it is essential to identify the trends of the impact of maternal education on un/ under-vaccination in children as well as on missed opportunities for vaccination. This study fills that gap.

2.3.1.3 Household Income

Household income and financial capacities have been reported to be barriers in the distribution of other health services and thus, a barrier to achieving universal health coverage and sustainable development goals(Were et al., 2019). Given conflicting household demands, children in poor and low income household are less likely to access health services, including vaccination.The socio-economic status of mothers or caretakers directly impacts their ability to finance health requirements (Phillips et al., 2017a). There is evidence indicating that children belonging to poor households were most likely to have fewer interactions with immunization services leading to un/ under-vaccination and increased likelihood of having missed opportunities for vaccination (Ndwandwe et al., 2018). When evaluating factors that contributed to delayed immunization in American families, it was realized that the status of family income was a significant determinant of completing childhood immunizations on schedule (Bobo, Gale, Thapa, & Wassilak, 1993). Similarly, economic factors were found to be significant determinants of up to date immunization status of children (Kim, Frimpong, Rivers, & Kronenfeld, 2007). Other similar findings have been realized out of demographic health survey done in Kenya, Ghana and Côte d'Ivoire which showed persistence in the inequality in immunization coverage in the three countries and majorly favoured the most-advantaged households (Donfouet, Agesa, & Mutua, 2019). However, in Kenya similar to other countries, there are no studies that have been conducted using multi-year, longitudinal data to assess the trend of wealth status as a determinant of un/ under-vaccination and missed opportunities for vaccination.

2.3.1.4 Maternal Marital Status

A mother's marital status directly impacts on mothers ability to spare time to bring an eligible child to a vaccinating site (Phillips, Dieleman, Lim, & Shearer, 2017a). Single mothers have conflicting demands on their time and are less likely to bring their children for vaccination especially if the child is well. Several studies in different contexts have documented the influence maternal marital status have on the vaccination status of their children (Nozaki et al., 2019a; Pertet et al., 2018; Rossi, 2015). However, similar results have not been noted with missed opportunities for vaccinations where fewer studies have been conducted. Children of unmarried mothers were at increased likelihood of experiencing immunization delays, un/ under-vaccinations and marital status were found to be a significant predictor of failure to immunize on schedule (Bobo, Gale, Thapa, & Wassilak, 1993). The marital status also continues to play a significant role in delay or non-immunization. Examining the effects of maternal characteristics on the up-to-date immunization status of children revealed a lower completion of immunization rates to be associated with single motherhood (Kim, Frimpong, Rivers, & Kronenfeld, 2007). Given the mixed findings on the influence of a mother's marital status on their child's vaccination status, using a multi-year cross-sectional data, this study provides an opportunity to understand its influence on the vaccination status of Kenyan children over the years.

2.3.1.5 Maternal Age

Maternal age has been positively associated with vaccination. Children born to women in the older age category had a less likelihood of their children being un/ under-vaccinated (Breiman et al., 2004). This is likely explained by the possibility of the older mothers having experienced the benefits of immunization for their children than the younger mothers, especially if they have other children. Amongst the African-American preschoolers in the United States, children with mother in the age category25 and 34 years had an increased odds of under-vaccination than children with mothers aged ≥35 (Daniels et al., 2001). In Greece, maternal age was also found to be a positive predictor of completing vaccination (Danis, Georgakopoulou, Stavrou, Laggas, & Panagiotopoulos, 2010) with younger mothers having a higher likelihood of their children being un/ under-vaccination. In Africa, a study in Malawi also established maternal age as associated with un/ under-vaccination among children (Ntenda, 2019). This study offers an important opportunity for understanding the influence of trends of maternal age on the vaccination status of children.

2.3.1.6 Birth Order

The number of siblings in a family directly impacts the mother's ability to spare time to bring another sibling to the health facility for vaccination (Phillips, Dieleman, Lim, & Shearer, 2017a). The love and attachment given to children in the first order is higher compared to those of subsequent children. This includes for seeking preventive health services. Parents and caregivers are more likely to seek preventive health services for their first children compared to subsequent ones. The presence of other siblings was determined to be an independent predictor for un/ under-vaccination (Danis, Georgakopoulou, Stavrou, Laggas, & Panagiotopoulos, 2010). Children who were not in the first birth order were more likely to be non/ under-vaccinated (Bobo, Gale, Thapa, & Wassilak, 1993). Similar findings were also reported in Bangladesh, where children born of families with threeor more siblings had a reduced probability of being vaccinated (Perry et al., 1998). However, a study in Ethiopia has found no association between birth order and the vaccination status of children (Asrat & Mesfin, 2017). This study offers an opportunity to understand the influence of trends of birth order on the vaccination status of children in Kenya.

2.3.1.7 Place of Birth

A global time-series analysis conducted over 30 years has emphasized the link between out-of-hospital birth and un/ under-vaccination in countries with medium or low Human Development Index (HDI) scores (de Figueiredo et al., 2016).Children born in hospitals are more likely to get their first vaccine doses before they are discharged than those born at home. Childhood vaccination is part of the care package offered post natal and mothers who deliver in health facilities are more likely to have their children vaccinated.

Since there have been mixed findings on what factors determine a child's vaccination status, and the effects of these factors on Non/ Under-vaccination, this study offers an opportunity to use nationally representative data collected over ten years and mixed with a qualitative assessment to explain these determinants within the Kenyan context.

2.3.2 Determinants of Missed Opportunities for Vaccination

2.3.2.1 Wealth Status

There is evidence to show that there is a relationship between wealth and missed opportunities (Sridhar, Maleq, Guillermet, Colombini, & Gessner, 2014). In cases where the health facility is

experiencing vaccine stock outs or missing antigens, children from poorer households are less likely to be brought back to the facility for vaccination than those from wealthy households. This maybe occasioned by the unavailability of extra resources required for transport to the health facility and conflicting financial demands within the households. While reviewing data from multiple countries in a meta-analysis, they found out that children from poor households had illiterate mothers who had a higher risk of missing their vaccinations, ranging from 4.2% in the Democratic Republic of Congo to 20.1% in Kenya. Further, the risk of missed opportunities for vaccination in sub-Saharan Africa was found to be influenced by the family's financial capacity(Uthman et al., 2018).

2.3.2.2 Place of Birth

In sub-Saharan Africa, cases of missed opportunities mainly arise in two instances – during home births (Yismaw, Assimamaw, Bayu, & Mekonen, 2019) and as the children get older (Ogbuanu et al., 2019a). A home birth conducted by a skilled birth attendant or health worker that does not end up with vaccination is a missed opportunity for vaccination. Similarly, the risk of missed opportunities for vaccination in sub-Saharan Africa was also found to be influenced by place of birth (Uthman et al., 2018). In Northwest Ethiopia, traditional birth attendants are not equipped to provide the BCG and Oral Polio vaccines at birth, and since some communities do not allow new mothers to leave the house for the first 2-3 weeks, they miss the window for these vaccines (Yismaw, Assimamaw, Bayu, & Mekonen, 2019). Further, the risk of not completing a vaccination program is 2.27 times higher among children born at home than those delivered in health facilities (Jani, De Schacht, Jani, & Bjune, 2008a). In this case, equipping community health workers to provide/ refer for such services would be hugely beneficial in increasing childhood vaccination status.

2.3.2.3 Maternal Age

Children born to middle aged mothers are more likely to end up with missed opportunities for vaccination than those of younger mothers. This is due to the fact that middle aged mothers have conflicting financial priorities and familial responsibilities and demands of their time compared to the younger ones. They are less likely to spend their time in catching up the vaccination status of their children compared to their younger counterparts. Across sub-Saharan Africa, children of middle aged mothers were identified as having an increased odd of missed opportunity for

vaccination (Uthman et al., 2018). Amongst the African-American preschoolers in the United States, children with mother in the age category25 and 34 years had an increased odds of missed opportunities for vaccination than children with mothers aged ≥35 (Daniels, Jiles, Klevens, & Herrera, 2001).

2.3.2.4 Health System Issues

MOVs occur at the health system level either during visits for immunization and other preventive services or during visits for curative services (WHO, 2017). Health system issues may include stock-outs, lack of coordination of services and poor dissemination of information. Vaccine stock-outs discourage caregivers from taking their children to health facilities for vaccination, especially when the facilities are far from home (Mutua, Kimani-Murage, & Ettarh, 2011). Health system structuring also plays a vital role on when children get vaccinated, that is, children may present to facilities for other reasons when they are due for vaccines but fail to be vaccinated because the department they presented to does not carry out vaccination or does not have their vaccination records(Gibson et al., 2023; Shearer et al., 2023). Streamlining vaccination and referral systems by keeping accurate records in the health facilities may, therefore, be key in eliminating this challenge (Brown et al., 2018a; Ogbuanu et al., 2019b).

There is also lack of clarity on policies regarding providing vaccines when caregivers do not have the vaccination book on hand as well as children who are past the age when the vaccine is recommended (Ogbuanu et al., 2019a; Sadr-Azodi, 2019). Health promotion campaigns should be carried out to ensure caregivers always carry their children's record books for every hospital visit; regardless of whether it is time for vaccination or not (Hanson et al., 2018). Furthermore, health workers should always be encouraged to check the records and ensure vaccination status is up to date during every visit, if not they should ensure the children are given vaccines as required (Brown et al., 2018b; Ogbuanu et al., 2019a). This is supported by evidence that home-based records and parents recall fare better facility records and serological tests in determining children's vaccination status in LMICs; dependent on study setting, child age, dosage, type of antigen and level of coverage (Dansereau, Brown, Stashko, & Danovaro-Holliday, 2020; Kaboré et al., 2020; Mansour et al., 2019). However, outdated and non-standard home-based records is a crucial challenge to this claim (Kaboré et al., 2020; Mansour et al., 2019).

One of the critical factors leading to missed opportunities for vaccination is lack of confidence by health workers to administer two or more vaccines at the same time for fear of contraindications (Li et al., 2019; Mutua, Kimani-Murage, & Ettarh, 2011). In some instances, health workers have stated a lack of training and guidance on different categories presenting at the facilities, for example, over aged and overdue children, and adverse effects related to immunization (Li et al., 2019). This shows a need for governments to carry out training not just for programmatic staff but also frontline health workers in the community and health facilities which will, in turn, spill over to the community.

As the children get into their second year of life, health workers should ensure they check vaccination records in every instance children present at health facilities providing booster doses and vaccines missed in the first year of life thereby improving vaccination status and protecting children (Hanson et al., 2018; Sadr-Azodi, 2019). Working with the private sector (private hospitals, clinics, pharmacies) and non-formal health care providers to streamline services should also improve vaccination status as caregivers seek them out for health care in places where public hospitals are not readily available, or there is no confidence in access to services in public facilities (Hanson et al., 2018; Mutua, Kimani-Murage, & Ettarh, 2011). Further, identifying ways of vaccinating children in special population groups such as refugees and internally displaced persons, people living in slums and nomads and transient communities is also key to addressing missed opportunities for vaccination gaps(Pertet et al., 2018; Sadr-Azodi, 2019). In a study of Kenyan nomadic communities, about one-third of the children had been taken to a health facility for curative services and had failed to be vaccinated; placing the prevalence of MOV at within this group to be 30% (Pertet et al., 2018). They concluded that finding a solution to address vaccination issues in these particular groups is essential for the protection of these children from vaccine-preventable diseases. This study evaluated the trends of these determinants of missed opportunities for vaccination and their effects on these vaccination gaps. Further, it offers an opportunity to use nationally representative data collected over a decade, mixed with a qualitative assessment to explain these determinants within the Kenyan context.

2.4 Effects of Non/ Under-Vaccination and MOV on the Growth Rates of Children

Child growth failure is expressed as either stunting, wasting, and underweight in children under five years of age (0–59 months), and is a precise subcategory of under nutrition exemplified by

insufficient height or weight against age-specific growth reference standards (WHO, 2009). Undernourished children would end up with cognitive, physical, and metabolic developmental impairments which later may cause cardiovascular diseases, impair their intellectual capacities, poor school performances and later in adulthood, reduce their economic productivity (Victora et al., 2008).

The WHO defines prevalence of stunting, wasting, or underweight in children under five as the proportion of children with a height-for-age, weight-for-height, or weight-for-age z-score, respectively, with more than two standard deviations below the World Health Organization's median growth reference standards for a healthy population (WHO, 2006). Many low- and middle-income countries are still struggling with the ambitious WHO global nutrition targets of reducing stunting by 40% and wasting to less than 5% by 2025 with significant disparities in prevalence and progress exist across and within countries (Ausloos & Collaborators, 2020).

Vaccines, particularly the live-attenuated ones like measles vaccine and BCG, provide more protection to children other than those they are designed explicitly for (Berendsen et al., 2016; Steiniche et al., 2020). There is increasing evidence that vaccines provide non-specific effects which alter the susceptibility to non-targeted infectious diseases(Benn et al., 2013; Higgins et al., 2016)thereby increasing survival and child growth. Improved vaccination status has been shown to have likely led to improvements in nutrition, reduced child growth failures and child mortality as they can break the cycle of metabolic compromise leading to child growth failures (Osgood-Zimmerman et al., 2018). Under nutrition is one of the factors that compromise a child's growth. It is well established that infectious diseases compromise children's nutrition, and since vaccines avert infectious diseases, they may promote children's growth(Domingo et al., 2019).

2.4.1 Wasting

A study in Nigeria that found evidence linking non-vaccination to increased incidence of wasting (Ukwuani & Suchindran, 2003). Similarly, another study in Nigeria also confirmed that a child's immunization status was a key determinant of wasting amongst children under 5, with children who were not vaccinated at a higher risk of wasting (Ojofeitimi et al., 2003). In Western Kenya, under-vaccinated children had more likely to be wasted than those who were fully vaccinated (Bloss et al., 2004). This was consistent with a similar finding in Ethiopia, where under-vaccination was a be risk factors for wasting (Akombi et al., 2017; Getaneh et al., 1998).

2.4.2 Stunting

Non-vaccination has been associated with increased odds of stunting, and the odds remain higher even if the vaccination delayed and given later in infancy (Berendsen, Smits, Netea, & van der Ven, 2016). A Nigerian study found evidence linking non-vaccination to increased incidences of stunting (Ukwuani & Suchindran, 2003). Likewise, during the same duration, another study in Nigeria also confirmed that a child's non-vaccination status was a key determinant of stunting amongst children under 5 (Ojofeitimi, Owolabi, Aderonmu, Esimai, & Olasanmi, 2003). While evaluating the prevalence and Predictors of Underweight, Stunting, and Wasting among children under 5 in Western Kenya, it was realized that children who were under-vaccinated being twice more likely to be stunted than those who were fully vaccinated (Bloss, Wainaina, & Bailey, 2004). Similarly, in Ethiopia, under-vaccination was a risk factor for stunting (Akombi et al., 2017; Getaneh, Assefa, & Tadesse, 1998).

2.4.3 Underweight

In Ethiopia, under-vaccination was found to be a risk factor for underweight (Akombi et al., 2017; Getaneh, Assefa, & Tadesse, 1998). In Kenya, a study has looked at the trends of childhood under nutrition, taking into consideration under-weight, stunting and wasting (Matanda et al., 2014). However, no link has been made with the gaps in immunization such as non-vaccination, under-vaccination and missed opportunities for vaccination.

No study has used similar longitudinal nationally representative data or qualitative assessments to explain the effect of these vaccination gaps on child growth. This study evaluated the trends of these vaccination gaps and their effects on these under nutrition statuses (wasting, stunting and underweight).

2.5 Health System Factors Influencing Non/Under-Vaccination and MOV

Health system factors such as facility opening times, availability of vaccinators, location of facility and availability of vaccines and related supplies influence access and utilization of immunization services (Akwataghibe et al., 2019; Bangura et al., 2020a; Malande et al., 2019). In the United States, these health system factors have also been identified as barriers to vaccination, leading to missed opportunities for vaccination (Anderson, 2014). Similarly, in Greece, perceived long distance to the immunization site was identified as a barrier to completing vaccinations and led to delayed or un/ under-vaccination status (Danis,

Georgakopoulou, Stavrou, Laggas, & Panagiotopoulos, 2010). A cross-sectional study in Mozambique found out that every 10 km increase from the nearest health facility resulted in 36% reduced odds of a child being fully immunized (Shellese A. Shemwell et al., 2017). The distance from a household to a health facility directly impacts on their transport time and costs and leading them to decide to balance this against childhood vaccination (Phillips, Dieleman, Lim, & Shearer, 2017a). Health workers density and availability has been identified as an important determinant for vaccination status, and an important factor in reducing both un/ under-vaccination (Anand & Bärnighausen, 2007).

Compliance with national immunization policies and guidelines, such as those calling for vaccination on all days, mapping out and reaching all children including those in hard to reach areas, having vaccination sites closer to populations, ensuring the availability of vaccinators, vaccines and related supplies would reduce the numbers of children not vaccinated, under-vaccinated. Those are missing out on opportunities for vaccination (Mell et al., 2005). Whereas studies have been done on these health system factors and it is well understood how they generally impact on immunization services, it is also essential to conduct studies to understand the trends these factors take and monitor their impacts on un/ under-vaccinations and miss opportunities for vaccinations.

In Kenya, missed opportunities for vaccinations were influenced by lack of standardizing vaccination checks during health facility visits(Brown et al., 2018a). Further, health workers and key informants expressed that lack of training for all staff members on immunization, significant understaffing in immunization sites, and the persistent challenge of stock-outs of vaccines and vaccination-related supplies may have increased opportunities for children missing their vaccinations.

Apart from the Kenyan study, the rest of the studies described above were not designed to establish specific health system factors that influence non-vaccination, under-vaccination and missed opportunities for vaccination. They were conducted as part of a broader study on the determinants of childhood immunization. The Kenyan study, on the other hand, was designed to determine the reasons for missed opportunities for vaccination individually and did not report on children who were non-vaccinated and under-vaccinated. The results from this study offers a

better understanding of the factors that influence these three gaps for vaccination amongst Kenyan children.

2.6 Theoretical Frameworks

In this section, the theoretical framework underpinning the utilization of health services is reviewed. A review of factors and determinants that underly decisions to access and utilize immunization services is made.

2.6.1 Theory of Reasoned Action and Planned Behaviour

A framework integrating three existing theoretical frameworks has been used to describe an optimal framework on factors leading to optimal vaccination (Phillips, Dieleman, Lim, & Shearer, 2017a). These three frameworks include 1) a health belief model which describes perceived costs compared to expected benefits as the determinant of vaccine utilization, 2) vaccine perceptions, accountability and adherence model which places additional emphasis on cultural and economic drivers while similarly recognizing the critical place of barriers and structural factors. This framework places emphasis on perception-related decision making rather than strictly economic choices and 3) community engagement and institutional commitment framework which placing a heavy focus on community engagement, awareness, and commitment from high-level institutions, both in government and development institutions.

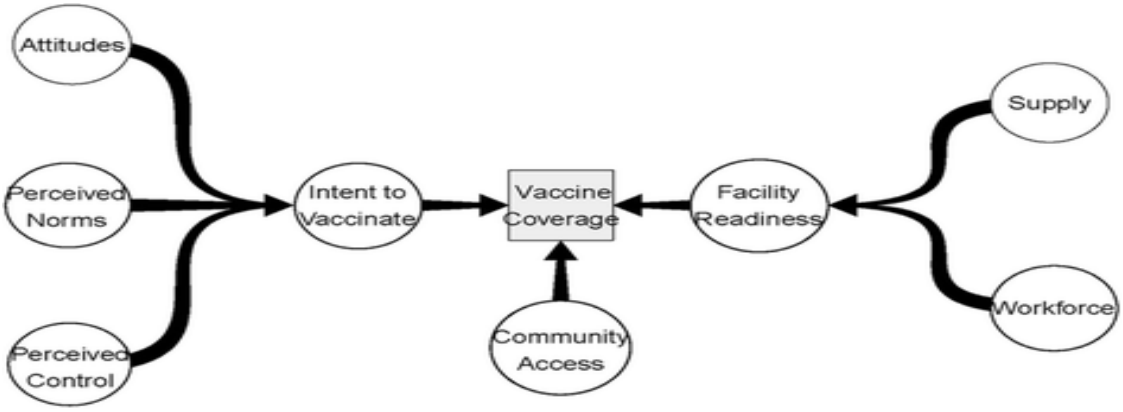

Figure 2.1: Theory of reasoned action and planned behaviour

This framework as highlighted in Figure 2.1 and hypothesizes three principal determinants of vaccine utilization:

- Intent to Vaccinate - Demand for vaccines on the part of the mother that would result in vaccination in the absence of other barriers.
- Facility Readiness - Supply (by the health system) of vaccine services to adequately meet demand. Incorporates supplies (vials, syringes, etc.), human resources and the consistency of their availability.
- Community Access - The ability (or inability) to successfully carry out the transaction of vaccine utilization, i.e. barriers and facilitators between Intent and Readiness.

Each principal determinant is also influenced by contributing factors, such as attitudes, norms, and perceptions for intent to vaccinate, and supply and workforce for facility readiness. Where these three principal determinants and their several contributing factors are not optimally at play, then utilization of immunization services is compromised, leading to either non-vaccination, under-vaccination or a missed opportunities for vaccinations.

The predisposing characteristics consist of demographic factors, a social structure such as educational attainment, occupation and health beliefs which involve health-related knowledge and behaviours. Enabling resources are related to individuals' personal and community support which enables them to use health services, reflected by income level, insurance vaccination status and other factors that could affect one's access to health services. Lastly, the external environment incorporates wider social and environmental determinants of health. This model has been used to understand why families use health services, and to define and measure equitable access to health care.

This theoretical framework provides the basis for identifying and categorizing various indicators that will be analyzed in this study. Through the framework, we have been able to identify which indicators are independent and which ones are the outcome variable for this study. The framework also provide for an understanding of how these indicators are interrelated and how they influence each other. Through the implementation of this study, we have been able to confirm these interrelationships, their influences and provide suggestions on improvements that should be made in reducing vaccination gaps in Kenya.

2.7 Conceptual Framework

The relationship between the variables used in this study has been summarized in Figure 2.2 which shows the interaction between the different variables. This conceptual framework, illustrates the complex interactions between various factors influencing vaccination status and child growth outcomes.

Here, the independent variables are the primary drivers of vaccination status gaps and are categorized into socio-demographic and health system factors.

1. **Socio-demographic factors:**
    - Gender: Gender biases may influence vaccination rates, with girls sometimes having lower vaccination rates than boys in certain cultures.
    - Child birth order: Firstborn children might receive more attention and healthcare, including vaccinations, compared to later-born children.
    - Number of children in a household: Larger households may face more logistical and financial challenges in ensuring all children are vaccinated.
    - Religion: Certain religious beliefs might affect attitudes toward vaccination, leading to differences in vaccination rates.
    - Occupation: Parental occupation can influence income and time availability, affecting access to healthcare services.
    - Wealth quintile: Wealthier families are more likely to have better access to healthcare, including vaccinations, due to financial resources.
    - Region: Geographical disparities can lead to differences in vaccination status due to varying healthcare infrastructure and outreach programs.
    - Place of delivery: Children born in healthcare facilities might have better immediate access to vaccinations compared to those born at home.

2. **Health system factors:**
    - Stock outs: Availability of vaccines is critical; stock outs can lead to missed vaccinations.
    - Health workers' attitude: Positive attitudes and proactive engagement by healthcare workers can improve vaccination rates, whereas negative attitudes can deter parents.

- Clinic closure times: Accessibility of clinics, including their operational hours, affects whether parents can bring their children for vaccinations.

The proximate variables were considered as those factors that bridge the independent variables and the dependent outcomes.

- Non-vaccination: This refers to children who have not received any required vaccines thereby are not protected against vaccine preventable diseases.
- Under-vaccination: Refers to children who do not receive all required vaccines, reducing their protection against preventable diseases.
- Missed opportunities for vaccination (MOV): This occurs when a child interacts with the healthcare system but does not receive a vaccine for which they are eligible. This can happen due to various reasons, such as clinic inefficiencies, stock outs, or lack of awareness among parents and healthcare providers.

The dependent variables in this study were the child growth outcomes influenced by the independent and proximate variables:

- Underweight: This indicates insufficient weight for age and can result from chronic or acute malnutrition.
- Stunting: This is a measure of chronic malnutrition, where a child is too short for their age, indicating long-term nutritional deficiencies.
- Wasting: This refers to acute malnutrition, where a child has a low weight for their height, often due to recent and severe weight loss.

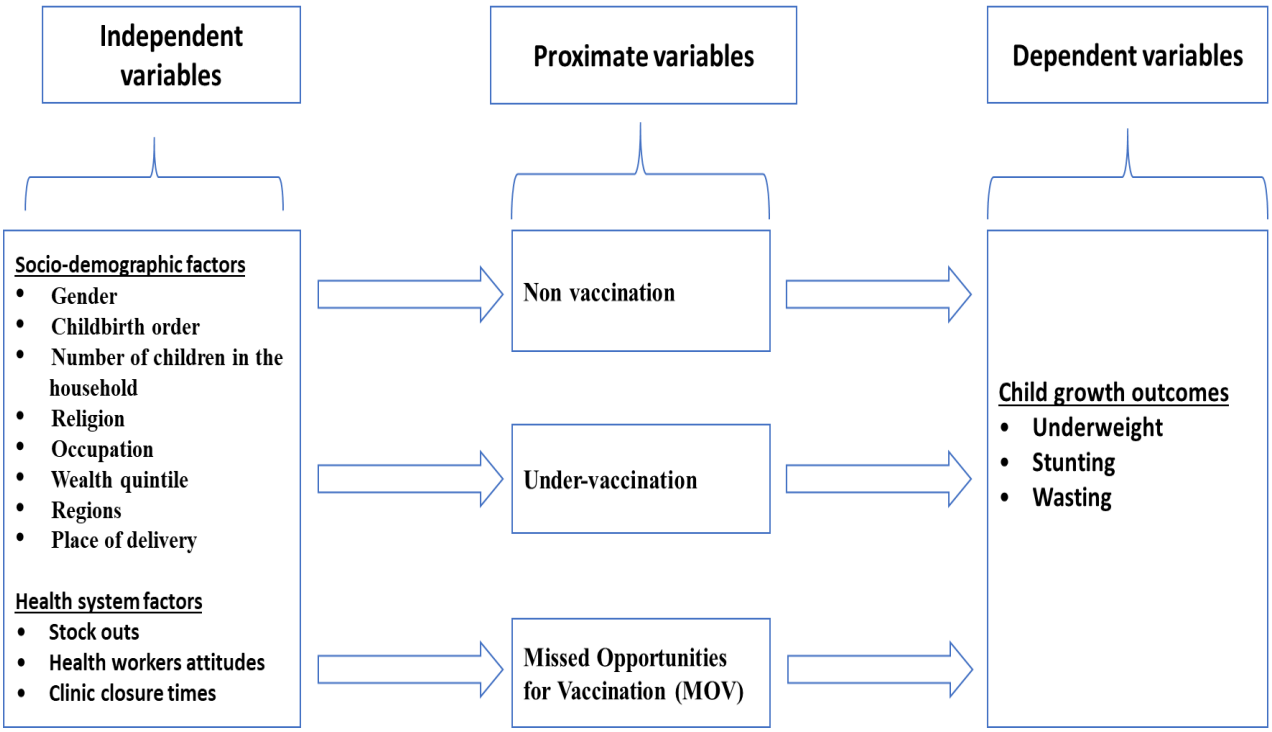

Figure 2.2: A conceptual framework for pathways of non/ under vaccination and MOV.

The relationships between these variables are interconnected either;

1. Through the direct influence of independent variables: Socio-demographic and health system factors directly affect vaccination status. For instance, wealthier families (socio-demographic factor) are more likely to ensure their children are vaccinated due to better access to healthcare services. Similarly, positive health worker attitudes (health system factor) can directly encourage parents to vaccinate their children.
2. Indirect influence through the proximate variables: Independent variables also influence child growth outcomes indirectly through non/under-vaccination and MOV. For example, a household with more children (socio-demographic factor) might struggle to vaccinate all children on time, leading to under-vaccination, which in turn can increase the risk of infectious diseases, impacting child growth outcomes like underweight or stunting.
3. Direct impact on growth outcomes: Proximate variables such as non/under-vaccination and MOV have a direct impact on growth outcomes. Non-vaccinated children are more susceptible to infections, which can hinder their growth and development, leading to underweight, stunting, or wasting.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter provides a detailed overview of the methodology utilized in the research, covering key aspects essential for understanding how the study was conducted and what results were anticipated. It begins by introducing the study area, outlining its scope and importance, before moving on to explain the chosen study design. The methods employed, including the procedures for data collection, ethical considerations, and the potential real-world applications of the findings, are discussed in depth.

The process of identifying the study population and the sampling techniques employed are described to ensure transparency in the research methodology. Furthermore, the reasoning behind determining the study sample size is explained to underscore the reliability of the study's statistical analysis. The acquisition of data from both primary and secondary sources is also detailed, shedding light on the methods used for data collection and the sources consulted.

Additionally, this chapter offers insights into the statistical and qualitative analyses conducted to uncover patterns, trends, and relationships within the dataset. By providing a thorough explanation of the methodology, this chapter lays the groundwork for understanding the research framework and sets the stage for subsequent sections of the thesis.

3.2 Study Design

This research adopted an explanatory sequential mixed-methods approach, comprising two distinct phases that integrate both quantitative and qualitative components. This methodological choice was made to facilitate a comprehensive exploration of vaccination status gaps, associated factors, and their impact on the growth outcomes of Kenyan children. The sequential design involves gathering qualitative data subsequent to a quantitative phase, thereby allowing for a deeper understanding and elaboration of the quantitative findings (Creswell & Clark, 2017; Morse, 1991).

The initial phase constituted a quantitative study, which included longitudinal repeated annual surveys conducted as part of national cross-sectional surveys. Specifically, the quantitative component involved an analytical secondary analysis of datasets obtained from the Kenya DHS

conducted in 2003, 2008/09, and 2014. The Kenya DHS, as nationally representative household surveys conducted every five years, serve to assess the demographic and health landscape of the population. The inclusion of a 10-year trend analysis was deemed essential to capture pivotal changes in child health indicators and vaccination-related policies over the preceding years, thereby offering valuable insights into potential trends in vaccination status over time. Subsequently, the second phase comprised a qualitative explanatory study, engaging decision-makers at both National and County levels. This qualitative inquiry aimed to elucidate and expand upon the initial quantitative findings, providing deeper insights into the underlying factors shaping vaccination status and its implications at various administrative levels.

3.3 Study Area

This study encompassed all 47 counties within Kenya, a prominent nation in East Africa. Geographically, Kenya lies between 5 degrees north and 5 degrees south latitude, and spans 24 to 31 degrees east longitude. With a landmass covering approximately 580,367 square kilometers, Kenya's varied terrain is bordered by the Indian Ocean and Somalia to the East, Ethiopia and South Sudan to the North, Uganda to the West, and Tanzania to the South.

Originally, the Kenya DHS were conducted nationwide, covering all eight regions of Kenya until 2010. However, in 2014, the survey ambitiously expanded its scope to include data collection from all 47 counties within the country. Consequently, these counties collectively serve as the study area for both the quantitative and qualitative investigations undertaken in this research endeavor.

During the final analysis, data from the counties is all aggregated at the former Province level and the administrative unit employed is the Province. This aggregation facilitated a broader understanding of trends and patterns within each province, offering insights into regional variations and enabling comparisons across administrative boundaries. Consolidating data at the provincial level enhanced the depth of analysis and allowed for the exploration of broader trends that may not be apparent when examining individual counties in isolation.

3.4 Political and Governance Structure in Kenya

Administratively, Kenya is divided into 47 counties, which are further divided into 303 sub-counties, and 1,450 wards. The ward forms the smallest political-administrative unit. In 2010,

Kenya promulgated a new constitution, which laid the basis for political devolution, stemming national-level political conflict and addressing regional disparities and historic marginalization (Silas et al., 2018). More public resources have been channeled under devolution to the formerly marginalized areas of the country, including investments in the infrastructure and resources (Silas, Wawire, & Okelo, 2018).

3.4.1 Study Population

All children under 5 years of age are eligible for vaccination(MoH, 2023). As per the 2009 population census, the total population of children under 5 years was 5939306 of which 2938867 were females and 3000439 were males(KNBS, 2009). The Kenya DHS children datasets are reported for children under 5 years and allows abstraction of data for the various age categories within. The quantitative study phase was restricted to children 0-23 months of age. Concentrating on children within the 0-23 month age bracket ensured that the study captured data during a critical period when the majority of routine vaccinations are administered. This age group is particularly susceptible to vaccine-preventable diseases, underscoring the importance of assessing vaccination status and effectiveness. Furthermore, honing in on children in the first two years of life allowed for the evaluation of vaccination impact during the most formative stages of development. Timely vaccination during infancy significantly diminishes the risk of childhood illnesses and their subsequent complications, thus contributing to improved long-term health outcomes. Additionally, restricting the study to children aged 0-23 months enhanced the accuracy and reliability of vaccination data. Children within this age range are more likely to possess complete vaccination records, given the intensified immunization efforts during infancy. The meticulous data abstraction ensured the quality of data obtained and facilitated a more comprehensive analysis of vaccination status and compliance. By targeting this specific age group, the study aimed to provide valuable insights into vaccination practices, identify potential areas for improvement, and ultimately contribute to the enhancement of immunization efforts.

The study population for the qualitative phase comprised immunization services managers at the National and County level. These will include 1) health services managers in all the 47 counties, including; the County Director of Health, County Public Health Nurse, County Community Focal person and 2) the National level staff in charge of vaccine logistics and safety surveillance, monitoring and evaluation, advocacy, communication and social mobilization, training and

capacity building and the National Manager at the National Vaccines and Immunization Program. These are individuals who are deemed to possess intricate knowledge of managing the immunization program within the country. They have firsthand experience and understanding of the challenges encountered within the system. Additionally, they are well-versed in the various health system factors that either hinder or promote vaccination both nationally and within the individual counties. Their roles grant them a comprehensive understanding of the operational challenges and nuances within the system. By including these key stakeholders in the study population, the research aimed to gather rich, contextual data that can inform strategies for improving vaccination status and effectiveness at both the national and local levels. Their expertise and perspectives are essential for gaining a holistic understanding of the factors influencing immunization outcomes, thus lending credibility and depth to the research findings.

3.4.2 Socio-Economic Characteristics of the Kenyan Population

In a bid to promote social-economic growth, lower poverty and income inequality and ensure stable regional growth amongst Counties, the Kenya government has established economic decentralization and continued empowerment to the County governments over the years (Silas, Wawire, & Okelo, 2018). However, poverty levels remain high raising the need for county governments to have adequate own-source revenue to finance their expenditure, including for health services and immunization, as opposed to relying on intergovernmental transfers from the National government (Silas, Wawire, & Okelo, 2018).

Even though there was wavering economic growth in Kenya in the last three decades, the living standards and incomes for most Kenyans have improved (Babijes, 2016). These improvements, however, are parallelled by overall population increases and an increased number of people in urban areas (Owuor, 2018). These population increases lead to an enhanced proportion of individuals in urban areas which then forms the basis for the many challenges faced by Kenyans.

Despite considerable health gains achieved, there are widespread regional and socio-economic disparities observed including in the access and use of maternal and child health care service in Kenya with most services, concentrated in the urban Counties of Nairobi, Mombasa, Eldoret and Kisumu (Wong et al., 2017). These socio-economic inequalities and inequities largely favour the rich particularly in preventive and inpatient care services (Ilinca et al., 2019). The regional socio-economic disparities have also been documented in immunization with the regions in the North-

Eastern part of the Country performing dismally (Egondi et al., 2015). Even within counties, for poorer sub-Counties like Mbita in former Nyanza Province of Kenya, health care services including immunization and vaccination are largely concentrated in the relatively urban areas with less utilization and coverage compared to a richer County Kiambu in the Central part of Kenya (Wandera et al., 2017). These high levels of disparities in health and access to services led to the development, introduction and implementation of a Universal Health Coverage plan initially piloted in four Kenyan counties and its later scale-up (Ilinca, Di Giorgio, Salari, & Chuma, 2019).

3.4.3 Health Services in Kenya

Health service delivery in the country is devolved to its 47 counties. MoH at the national level provides policy direction and guidelines for service delivery as well as overseeing referral health services. The country is focused on accelerating progress toward universal health coverage guided by the Kenya Health Sector Strategic and Investment Plan 2013–2017. In line with this, the Kenya Essential Package of Health (KEPH) defines a six-tiered system made up of community health services, primary healthcare (PHC) facilities (levels II and III), county hospitals, regional hospitals and national referral hospitals (MOH, 2014). These tiers are differentiated by infrastructure, equipment, human resource investment levels, and the catchment population served.

Immunization services in Kenya are coordinated by the MoH through the National Vaccines and Immunization Program (NVIP). The program supports more than 5,874 public and private health facilities to provide immunization services at no cost to the client. This is done in collaboration with County Health Management teams (CHMTs), sub-County Health Management Teams (sCHMTs), health facility teams, and key stakeholders, including opinion and community leaders, religious leaders, and community health volunteers. Over the past four years, the Country has witnessed a drop in immunization coverage for most antigens, which has consistently remained below the target of 90%. The decline has largely been attributed to challenges related to the transition to the devolved system of governance and instability among the health workforce due to industrial strikes (Gavi, 2017).

3.5 Sampling technique

For the quantitative study, the Kenya DHS used a two-level, multi-stage and stratified technique with households as the sampling unit. The two-level or multistage sampling techniques is a form of cluster sampling technique involving two or more stages of random sample selection (Sedgwick, 2015). Multi-stage sampling is more appropriate for community-based or large scale surveys (Omair, 2014). Large populations are divided into smaller clusters into several stages to make primary data collection more manageable. It is relatively more cost and time effective and allows for a high level of flexibility in terms of data collection.

In this type of sampling technique, initially, smaller groups are successively selected from the larger populations. In the case of the Kenya DHS studies, the first level involved a random selection of the enumeration areas (clusters) from the Kenya national master sample frame. The second level involved a random selection of households in each of the selected enumeration areas. The relevant study tools are then administered in randomly selected households. This technique has been consistently used for each of the Kenya DHS surveys, both locally and internationally.

The interviewers visited only the preselected households, and no replacement of the preselected households was allowed during data collection. The Kenya DHS questionnaires included a mother questionnaire that has both mother and child information. The Household Questionnaire and the Woman's Questionnaire were administered in all households. Because of the non-proportional allocation to the sampling strata and the fixed sample size per cluster, the survey was not self-weighting. Sampling weights were created to account for the uneven distribution of sampling probabilities and non-responses rates.

Sampling weights were formulated to rectify variations in the likelihood of selecting sampling units, households, and individuals, while accounting for the response rate per stratum, which encompassed counties and enumeration areas. The household weight for a specific household was computed as the reciprocal of its household selection probability, multiplied by the reciprocal of the household response rate within the stratum. Subsequently, the individual weight was derived by multiplying the household weight by the reciprocal of the individual response rate within the same stratum. Given the pivotal concept of response rate for groups in the Kenya DHS, households and individuals were categorized into sample strata to calculate response rates.

This approach ensured that the analysis encompassed a representative sample of the population, and upheld the statistical integrity of the findings. These allowed for a weighted analysis to account for full population generalizability. The resulting data were weighted to be representative at the national, regional, and county levels. In this analysis, the child datasets for children aged 0-23 months were abstracted and analysed for year 2003, 2008/9 and 2014.

In the qualitative study, a purposive sampling strategy was used to select 1) health services managers in all the 47 counties, including; the County Director of Health, County Public Health Nurse, County Community Focal person and 2) the National level staff in charge of vaccine logistics and safety surveillance, monitoring and evaluation, advocacy, communication and social mobilization, training and capacity building and the National Manager at the National Vaccines and Immunization Program.

3.6 Sample Size Determination

3.6.1 Phase one: Quantitative Study

The quantitative study used the Kenya DHS sample size estimation process, which aimed to estimate the minimum number of women aged 15-49 years, number of households, number of children under five years and 12-23 months. In this process, the sample size was estimated for each indicator, with varying standard error estimates, level of coverage and estimated response rates(ICF, 2012).The sample size for full immunization coverage of children aged 12-23 months was used in the determination of non/ under-vaccination.

The detailed sample size assumptions for various vaccination and growth indicators based on data from the Kenya Demographic and Health Survey (KDHS) conducted in 2003, 2008/09 and 2014 are presented in tables 3.1, 3.2 and 3.3 respectively. In the tables, each row corresponds to a specific indicator, numbered from 1 to 11, with descriptions provided for each indicator. For instance, Indicator 1 pertains to "Sought medical treatment for diarrhoea." The table also includes metrics such as the proportion (R) of the population assumed to possess the indicator, the associated standard error (SE), total sample size (N), weighted sample size (WN) accounting for survey design, design effect (DEFT) adjusting for survey complexity, relative standard error (RSE) indicating precision relative to the proportion estimate, and lower and upper bounds of the 95% confidence interval for the proportion estimate (R-2SE and R+2SE).

These metrics offer insights into the methodology and precision of estimation for each indicator, aiding in the interpretation of KDHS 2014 data related to vaccination and growth indicators in Kenya as applied in the current study.

Table 3.1:Sample size assumptions for vaccination and growth indicators, KDHS 2014

No.	Indicators	R	SE	N	WN	DEFT	RSE	R-2SE	R+2SE
1	Sought medical treatment for diarrhoea	0.576	0.013	2,953	2,844	1.375	0.023	0.55	0.603
2	A vaccination card is seen	0.747	0.011	4,052	3,777	1.482	0.014	0.726	0.768
3	Received BCG vaccination	0.967	0.004	4,052	3,777	1.34	0.004	0.959	0.974
4	Received DPT vaccination (3 doses)	0.899	0.007	4,052	3,777	1.384	0.008	0.885	0.913
5	Received polio vaccination (3 doses)	0.899	0.007	4,052	3,777	1.343	0.007	0.885	0.912
6	Received measles vaccination	0.871	0.007	4,052	3,777	1.218	0.008	0.857	0.884
7	Fully vaccinated	0.792	0.009	4,052	3,777	1.282	0.011	0.775	0.809
8	Vitamin A supplementation in the last 6 months	0.987	0.001	18,256	17,008	1.36	0.001	0.985	0.99
9	Height-for-age (-2SD)	0.260	0.005	20524	18986	1.459	0.019	0.25	0.27
10	Weight-for-height (-2SD)	0.040	0.002	20524	18986	1.527	0.056	0.036	0.045
11	Weight-for-age (-2SD)	0.110	0.004	20524	18986	1.535	0.034	0.102	0.117

Where :

R – Value of the statistics (Proportion)

SE – Standard error

N – Unweighted cases

WN – Weighted cases

RSE – Relative standard error

R-2SE – Lowe 95% confidence limit of R

R+2SE – Upper 95% confidence limits of R

Table 3.2: Sample size assumptions for vaccination and growth indicators, KDHS 2008/09

No.	Indicators	R	SE	N	WN	DEFT	RSE	R-2SE	R+2SE
Sought medical treatment for diarrhoea	Sought medical treatment for diarrhoea	0.166	0.009	5706	5481	1.79	0.057	0.147	0.185
Received DPT vaccination (3 doses)	Received DPT vaccination (3 doses)	0.864	0.015	1119	1096	1.441	0.017	0.834	0.894
Fully vaccinated	Fully vaccinated	0.683	0.02	1119	1096	1.391	0.029	0.644	0.722
Vitamin A supplementation in last 6 months	Vitamin A supplementation in last 6 months	0.303	0.012	5111	4946	1.616	0.038	0.28	0.326
Height-for-age (-2SD)	Height-for-age (-2SD)	0.353	0.011	5563	5470	1.539	0.03	0.332	0.374
Weight-for-height (-2SD)	Weight-for-height (-2SD)	0.067	0.005	5563	5470	1.408	0.074	0.057	0.077
Weight-for-age (-2SD)	Weight-for-age (-2SD)	0.161	0.01	5563	5470	1.853	0.063	0.141	0.181

Table 3.3: Sample size assumptions for vaccination and growth indicators, KDHS 2003

No.	Indicators	R	SE	N	WN	DEFT	RSE	R-2SE	R+2SE
1	Sought medical treatment for diarrhoea	0.297	0.02	866	888	1.219	0.067	0.258	0.337
2	Vaccination card seen	0.599	0.02	1,099	1,131	1.343	0.033	0.56	0.639
3	Received BCG vaccination	0.873	0.014	1,099	1,131	1.368	0.016	0.846	0.9
4	Received DPT vaccination (3 doses)	0.722	0.018	1099	1131	1.311	0.025	0.686	0.757
5	Received polio vaccination (3 doses)	0.725	0.017	1099	1131	1.276	0.024	0.691	0.759
6	Received measles vaccination	0.725	0.017	1099	1131	1.281	0.024	0.691	0.76
7	Fully vaccinated	0.568	0.019	1099	1131	1.292	0.034	0.53	0.606
8	Height-for-age (-2SD)	0.303	0.009	5071	5307	1.371	0.03	0.285	0.322
9	Weight-for-height (-2SD)	0.056	0.005	5071	5307	1.487	0.089	0.046	0.066
10	Weight-for-age (-2SD)	0.199	0.008	5071	5307	1.315	0.039	0.183	0.214
11	Sought medical treatment for diarrhoea	0.297	0.02	866	888	1.219	0.067	0.258	0.337

The sample size forfull immunization coverage of children aged 0-23 months in 2014 was determined as follows;

$$n = Deft^2 \frac{(\frac{1}{p} - 1)}{\alpha^2} / (R_i \, _X R_h \, _X \, d)$$

where ;

n – The sample size in households;

Deft –The design effectof 1.800

P –The estimated proportion (0.792)

α – the desired relative standard error;(SE=0.011)

R_i– the individual response rate;92.6% (0.926)

R_h– the household gross response rate;98% (0.98)

d – the number of eligible individuals per household.1.05

$$n = 1.800^2 \frac{\left(\frac{1}{0.792} - 1\right)}{0.011^2} / (0.98_X \, 0.926_X \, 1.05)$$

$$n = 3.24 \frac{\left(\frac{1}{0.792} - 1\right)}{0.000121} / (0.952854)$$

$$n = 7032/0.952854$$

n=7380

The sample size for full immunization coverage of children aged 0-23 months in 2008/09 was determined as follows;

$$n = Deft^2 \frac{(\frac{1}{p} - 1)}{\alpha^2} / (R_i \, _X R_h \, _X \, d)$$

where ;

n – The sample size in households;

Deft – The design effect of 1.391

P – The estimated proportion (0.88)

α – the desired relative standard error;(SE=0.011)

R_i – the individual response rate; 90.8% (0.9086)

R_h – the household gross response rate; 99% (0.99)

d – the number of eligible individuals per household; 1.04

$$n = 1.391^2 \frac{\left(\frac{1}{0.88} - 1\right)}{0.011^2} / (0.9086_X \, 0.99_X \, 1.05)$$

$$n = 1.935 \frac{\left(\frac{1}{0.88} - 1\right)}{0.000121} / (0.93549)$$

$$n = 2077.894336/0.93549$$

n=2221

The sample size for full immunization coverage of children aged 0-23 months in 2003 was determined as follows;

$$n = Deft^2 \frac{\left(\frac{1}{p} - 1\right)}{\alpha^2} / (R_{i\,X} R_{h\,X} \, d)$$

where ;

n – The sample size in households

Deft – The design effect of 1.292

P – The estimated proportion (0.8)

α – the desired relative standard error; (SE=0.011)

R_i – the individual response rate; 90.9% (0.9086)

R_h – the household gross response rate; 99% (0.99)

d – the number of eligible individuals per household; 1.05

$$n = 1.292^2 \frac{\left(\frac{1}{0.8} - 1\right)}{0.011^2} / (0.9086_X \, 0.99_X \, 1.05)$$

$$n = 1.669264 \frac{\left(\frac{1}{0.8} - 1\right)}{0.000121} / (0.94449)$$

$$n = 2227.159424/(0.94449)$$

$$n = 2358.05581$$

n=2358

The sample size for each year for children aged 0-23 months at the time of the three surveys are 2003, n=2358; 2008, n=2221 2014, n=7380, yielding a final sample size of11,959 children aged 0-23 months for this study.

3.6.2 Phase Two: Qualitative Study

The qualitative study was based on the purposive sampling methodology. Based on purposive sampling methodology, the study aimed to conduct key informant interviews(KII) with 5 national level immunization program managers and 188 health services managers in the 47 counties, leading to a total of 203 interviews with health services managers at the National and County levels. These 293 KII were pead across the country. The sample size estimates for the key informants is presented in sub-section 3.4.

Table 3.4: Summary of key informant interviews to be conducted in the qualitative study

Study population	Sampling method	Sample size
National level immunization program managers	Purposive sampling	5
Health services managers in the 47 counties	Purposive sampling	188
Total		203

3.7 Data Collection

3.7.1 Phase one: Quantitative Study

For the quantitative study, appropriate datasets were abstracted from the Kenya DHS conducted in 2003, 2008/09 and 2014. These datasets contained information on children aged 0-23 months from the three surveys and were obtained from the public DHS repository. To facilitate data abstraction from these datasets, specialized tools (see Appendix 1) were developed.

Prior to their use, the data abstraction tools underwent a rigorous pretesting phase on Kenya DHS datasets from 1998. This pretesting was conducted to ensure the tools' reliability and validity in extracting the required information accurately.

The data abstraction tools were designed to collect information on various aspects, including the demographic characteristics of mothers and children, socio-economic variables, and adherence to the child vaccination schedule as per national guidelines. These tools played a crucial role in systematically extracting relevant data from the Kenya DHS datasets, ensuring consistency and

accuracy in the analysis process. The immunization schedule employed during the analysis period was utilized for data abstraction.

- Birth; BCG, Oral Polio Vaccine (OPV)
- Six weeks; OPV1, Pentavalent 1, Pneumococcal vaccine 1 (PCV1), Rotavirus vaccine 1
- Ten weeks; OPV2, Pentavalent 2, Pneumococcal vaccine 2 (PCV2), Rotavirus vaccine 2
- 14 weeks; OPV3, Pentavalent 3, Pneumococcal vaccine 3 (PCV3), Rotavirus vaccine 3
- Nine-months; Measles

To establish missed opportunities for vaccination, the following seven possible child contact points with the health system were used, including with possible eligible vaccination time;

- Health facility delivery
- Post-natal check within 2 months
- Treatment of fever/ cough in a facility 2 weeks before the survey date
- Diarrhoea treated within 2 weeks at a health facility
- Iron pills, syrup given within 1 week of the survey date
- Intestinal parasites treated within 6 months of the survey date
- Vitamin A was given within 6 months of the survey date

Table 3.5 illustrates various scenarios outlining potential interactions between children and the healthcare system, detailing the timing, reasons for contact, and eligible vaccinations at each stage. Scenario 1 (Birth or $\leq$ 5 weeks) involves child contact with the facility within the first five weeks of life, primarily during birth or shortly after. Reasons for contact include facility-based delivery, postnatal check-ups within two months, and the administration of vitamin A supplements. Vaccinations eligible for administration at this stage include BCG and Oral Polio Vaccine (OPV). Scenario 2 (6 - 9 weeks) involves child contact with healthcare facilities occurring between 6 and 9 weeks of age. Common reasons for visits include treatment for fever or cough, management of diarrhea, postnatal check-ups, and vitamin A supplementation. Eligible vaccinations encompass BCG, OPV, Pentavalent, Pneumococcal, and Rotavirus vaccines. Scenario 3 (10 - 13 weeks) involves child contact with healthcare facilities takes place between 10 and 13 weeks of age, with similar reasons for visits as in Scenario 2. Vaccinations administered during this stage include BCG, OPV, Pentavalent, Pneumococcal, and Rotavirus

vaccines, with additional doses where applicable. Scenario 4 (14 weeks - 8 months) involves child contact occurs between 14 weeks and 8 months of age, with common reasons for visits and eligible vaccinations similar to those in previous scenarios. However, additional doses of OPV, Pentavalent, Pneumococcal, and Rotavirus vaccines are administered during this period. Scenario 5 (> = 9 months) involves child contact with the healthcare system at or after 9 months of age. The reasons for visits remain consistent with previous scenarios, with the addition of iron supplementation and treatment for intestinal parasites. Eligible vaccinations at this stage include those administered in previous scenarios, alongside the measles vaccine.

Table 3.5: Summary of possible child contacts with the health system

Scenario	Timing of contact with health facility	Reason for contact with health facility	Eligible vaccination at the time of contact with health facility
1	Birth or <=5weeks	Facility delivery Baby postnatal check within two months Given vitamin A1 Given vitamin A2	BCG Oral Polio Vaccine(OPV)
2	6-9 weeks	Fever/cough treatment Diarrhoea treatment Baby postnatal check within two months Given vitamin A1 Given vitamin A2	BCG; OPV0,1, Pentavalent 1, Pneumococcal1 Rotavirus1
3	10-13 weeks	Fever/cough treatment Diarrhoea treatment Given vitamin A1 Given vitamin A2	BCG; OPV 0,1 and 2; Pentavalent 1,2; Pneumococcal 1,2; Rotavirus 1,2
4	14weeks-8 months	Fever/cough treatment Diarrhoea treatment Given vitamin A1 Given vitamin A2	BCG; OPV 0,1,2 and 3; Pentavalent 1,2,3; Pneumococcal 1,2,3; Rotavirus 1,2
5	>=9 months	Fever/cough treatment Diarrhoea treatment Given vitamin A1 Given vitamin A2 Given iron pills/syrup Given drugs for intestinal parasites	BCG; OPV 0,1,2 and 3; Pentavalent 1,2,3; Pneumococcal 1,2,3; Rotavirus 1,2 Measles

Other indicators that were used include wealth quintiles and signs such as weight, height, age of the child, date of birth, mid-upper arm circumference. These were used to estimate child growth indicators.

3.7.2 Phase two: Qualitative Study

Data collection for the qualitative aspect of the study employed a key informant interview guide, conducted either face-to-face or via telephone interviews. Interviews were documented using tablets whenever possible, or manually recorded in notebooks during the sessions.

To ensure the reliability and validity of the interview guide, a pre-testing phase was conducted with immunization program managers at the sub-county level. It's important to note that these managers were not participants in the main study. Kisumu East sub-county served as the pre-test site for the key informant interview tools. For reference, the key informant interview guide is attached as Appendix2.

3.8 Data Management and Storage

3.8.1 Phase one: Quantitative Data

DHS data is publicly available and was obtained from the DHS program webpage (DHSProgram, 2014) for the period 2003, 2008/9, and 2014. The relevant datasets regarding the children's information (Kids recode [KR]) were used. The STATA format were extracted and analyzed. All analysis datasets and all reports generated from this data are stored in an access-controlled google drive, only accessible to the investigator. All coding and recordings were done using Stata (version 14; College Station, TX: StataCorp LP).

3.8.2 Phase two: Qualitative Data

The audio recording of all KIIs were downloaded onto a computer daily. Each audio was given a unique name and identity. The audio were stored in audio format .mp3 or .mp4. Each audio was transcribed into Microsoft office word version. The transcript was named as per the audio identities. The transcripts were uploaded on NVIVO (QSR International Pty Ltd. Version 12, 2018) for coding purposes. A master codebook was developed with themes, sub-themes and nodes generated from the KII guides and emerging from the responses. All transcripts were coded and stored in NVIVO with relevant memos, case classifications and descriptions before analysis was conducted.

3.9 Data Analysis

The following operational definitions were used in the analysis in phase one:

1. **Trends**: This is the general direction or pattern of change in a variable over a specific period. It shows whether the data points are increasing, decreasing, fluctuating, or remaining stable over time.
2. **Non-vaccination:** Defined as a child who had zero doses of vaccinations (for a child aged 0-23 months).
3. **Under-vaccination:** Child not receiving all vaccines they are eligible by the specific age.
4. **Missed opportunity for Vaccination (MOV):** Any contact with health services by an unvaccinated or under-vaccinated child aged 0-23 months who were eligible for vaccination and free from contraindication but which did not result in vaccination. Refer to table 3.6 for possible contacts a child aged 0-23 months could have with the health system based on the KDHS tools.
5. **Child growth outcomes:** Stunting (Height-for-Age, HAZ <-**2)**, wasting (Weight-for-Height, WHZ <-**2)**, and underweight (weight-for-Age, WAZ <-2).
6. **Associated factors:** Socio-demographic variables such as gender of the child, childbirth order, household size, maternal age, education level, marital status, religion, occupation, wealth quintile, region, and place of delivery that are influential factors associated with non/under-vaccination and MOV.

Objective 1:To establish the trends of non/ under-vaccination and MOV (2003-2014) amongst children 0-23 months in Kenya

The analysis to establish trends in non-vaccination, under-vaccination, and missed vaccination opportunities among children aged 0-23 months was conducted in several stages. Initially, the levels of non/under-vaccination were determined as proportions using weighted descriptive analysis. The results were presented as proportions along with 95% Confidence Intervals (CI) for each year. Subsequently, missed opportunities for vaccination (MOV) were defined using a specific algorithm based on characteristics outlined in Table 3.6. The outcome variable was categorized as MOV=1 or 0 otherwise, representing a binary variable. Based on this outcome, the levels of MOV were also subsequently determined as proportions using weighted descriptive analysis. The results were presented as proportions along with 95% Confidence Intervals (CI) for

each year. To assess trends over time, the proportions of non/under-vaccination and MOV were compared between the years 2003, 2008/09, and 2014 using the Cochrane-Armitage trend test. A trend test *P*-value of ≤0.05 was considered indicative of significant results.

Objective 2: To determine the influence of demographic and socio-economic factors on non/ under-vaccination and MOV amongst children 0-23 months in Kenya for the period 2003-2014

The analysis of how demographic and socio-economic factors influence non/under-vaccination and MOV was conducted systematically.

Initially, given the binary nature of the dependent variables and the need to address survey weighting due to the stratified sampling method employed in the DHS, a binary logistic regression model was utilized. The model used was of the form;

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots + x_n \beta_n$$

Where y was the outcome of interest (binary categorical outcome). The independent variables ($x_{i \quad i=1\ to\ n}$) of interest included the demographic and soci-economic factors as indicated in the conceptual framework. These were sex of the child, childbirth order, number of children in the household, parity, mothers' age category, mothers education level, marital status, religion, occupation, wealth quintile, regions, and place of delivery. β are the effect of independent variables represented by odds ratios.

This allowed for the computation of crude odds ratios (COR) along with their corresponding 95% confidence intervals (CI). Each independent variable was initially examined individually against the outcomes. Subsequently, a two-step process was undertaken. Firstly, all independent variables with P-values <0.2 were identified for potential inclusion in the multivariable logistic regression. These independent variables included factors such as the sex of the child, childbirth order, household size, maternal age, education level, marital status, religion, occupation, wealth quintile, region, and place of delivery. This step, employing backward selection criteria, aimed to ensure a comprehensive consideration of potential confounding factors. The child's gender may impact access to vaccinations due to cultural or social norms. Urban or rural residence can affect healthcare accessibility, potentially influencing vaccination rates. The mother's age and marital status may also play roles; younger mothers or those who are single might face more barriers to

accessing vaccination services. Religious beliefs within the family could influence attitudes toward vaccination. Socioeconomic factors, such as maternal education and household wealth, often correlate with vaccination rates, with higher levels of education and wealth typically associated with better access to healthcare services. Regional differences in healthcare infrastructure and cultural practices can also significantly impact vaccination status. Additionally, family dynamics, including birth order and the number of children in the household, may influence vaccination decisions, as could the place of delivery, with home births potentially leading to missed vaccination opportunities. Maternal occupation adds another layer, as the demands of work may affect a mother's ability to seek healthcare for her child.

Following the backward selection criteria, separate regression models were developed for each dependent variable, applying the same criteria to incorporate independent variables in the final regression models. In the conclusive multivariable model, statistically significant variables were those with P-values <0.05, with odds ratios and their corresponding 95% CI reported. The effect of independent variables in the multivariable logistic regression was depicted as Adjusted Odds Ratio (AOR) along with 95% CI. Results achieving *P*-values <0.05 were considered statistically significant.

Objective 3: To explore the influence of health system factors on non/ under-vaccination and MOVin children aged 0-23 months in Kenya

The analysis of qualitative data was conducted on three levels;

- Stage 1: **Descriptive analysis** included exploring the transcripts, case classification, most frequent words and word clouds. A descriptive code sheet was developed and summarized by sources, nodes and sub-nodes. In this stage, content analysis was used.
- Stage 2: **Thematic analysis**. This involved the identification of *priori* themes from the interview guides. Subsequent themes or nodes were generated from the data through responses of the respondents. A hierarchical theme was developed to show the level of codes emanating from the transcripts.
- Stage 3: **Analytic,** which involved comparing themes and triangulation of the data. This included identifying concurrence and divergence between quantitative and qualitative results. The analysis aimed to identify the relationship between the deductive themes and the pre-existing theories guiding this study.

The main themes developed inductively included;

Knowledge, attitudes, experiences and understanding of **health service managers on;**

- Childhood vaccination services, gaps and methods of improvement
- Vaccination compliance with EPI schedule
- Causes of non-vaccination, under vaccination and missed opportunities
- Ways of mitigation non-vaccination, under vaccination and missed opportunities
- Relationship between non-vaccination under vaccination missed opportunities and occurrence of childhood diseases
- The effects of non-vaccination under vaccination missed opportunities on the growth of children
- Trends and policy changes in Kenya from 2003 to 2014 including decentralization of governance structures and how this has contributed to vaccination status, adherence, compliance and child health
- Role of health systems factors on non-vaccination, non-vaccination and missed-opportunities

The results were summarized in tabular form and some text cited verbatim for emphasis. The analysis was done using NVIVO version 12.

Objective 4: To determine the effects of non/ under-vaccination and MOV on the growth rates between 2003-2014 amongst children 0-23 months in Kenya

The analysis of the effect of non/ under-vaccination and MOV on growth outcomes begun by identifying the growth outcome measurements. These were defined as weight for age (underweight), height for age (stunting), and weight for age (wasting)according to WHO 2006 technical report on child growth standards. In the DHS, the Z-scores have been generated as continuous variables and also categorized as stunting (Height-for-Age, HAZ <-2), wasting (Weight-for-Height, WHZ <-2), and underweight (Weight-for-Age, WAZ <-2).

Subsequently, the association between non/ under-vaccination, MOV, and growth outcomes was assessed. Three steps were involved. First, a binary logistic regression analysis was used to compare the independent variables (non-vaccination, under-vaccination, MOV) and the

dependent variables(underweight, stunting, and wasting) while controlling for the proximate factors (socio-demographic characteristics) identified in the conceptual framework. Both COR and AOR with 95% CI were reported. The analysis was repeated for each of the three survey years.

Next, growth curves were developed for each of the growth outcomes (HAZ, WAZ and WHZ), with the Z-scores for height, weight, or weight-for-height are on the y-axis against the age of the child (0 to 23 months) in the x-axis. These child growth curves models were classified by non/ under-vaccination and MOV.

Following these, the effects of non-vaccinations, MOV, under-vaccination on growth outcomes over the lifetime of a child 0-23 months were evaluated using mixed effect multi-level linear regression model. In this model, the dependent variable was growth outcome represented as continuous variables measured by Z scores. The model equation was as follows;

$$y = \beta_0 + \beta_1 x_1 + \beta_1 {x_1}^2 + \beta_2 x_2 + \beta_3 x_3 + \ldots\ldots + x_n \beta_n$$

Where;

- x_1 is the age of the child (all children 0-23 months)
- ${x_1}^2$ is the square of the age of the child to include a quadratic function for the growth curve
- x_2 is the primary predictor outcome (Non/ under-vaccination or MOV)
- x_3 to x_n other confounding factors likely to affect the growth of a child over time, e.g., maternal education
- β are effects of the independent variables represented by coefficients. These coefficients are interpreted, e.g., At any given age, what is the net impact on a unit change in HAZ, or WAZ or WHZ if the child had MOV or not?Is this effect significant and what would be if the effect of MOV other con-founding factors are included?

The effects of the independent variables have been reported as coefficients along with 95% CI. Both positive or negative coefficients achieving *P*-values <0.05 were considered statistically significant.

3.10 Ethical Considerations

An initial proposal review and approval was granted by the Maseno University School of Graduate Studies (SGS) (Appendix 3). Ethical review and approval were sought from the Maseno University Scientific and Ethics Review Committee (MUSERC) before the commencement of any study procedures (Appendix 4). Additionally, a research permit was obtained from the National Commission for Science, Technology, and Innovations (NACOSTI)(Appendix 5).The DHS data utilized in this study were publicly available on the DHS Program website (https://dhsprogram.com) and did not require individual permissions for use. However, all key informants involved in the qualitative aspect of the study were required to provide informed consent prior to their participation. Informed consent was obtained from all participants in the qualitative study through the administration of an Informed Consent Form (ICF) (Appendix 6). This form comprehensively outlined the purpose of the study, potential risks and benefits, voluntary participation, confidentiality measures, and the rights of the participants. Participants' right to privacy and confidentiality was strictly upheld, and all information provided was handled exclusively by the study team. Study data were stored on access-controlled computers, with access limited to authorized study team members. To ensure compliance with ethical requirements, all study team members underwent Good Clinical Practice (GCP) training. Furthermore, all data collected were anonymized, and no identifiable information of participants was used in any study reports, presentations, or publications. Participants had the right to withdraw from the study at any time, without any impact on their access to vaccinations or other health services. Their decision to withdraw was respected and did not affect their ongoing healthcare.

3.11 Risks and Benefits

In the first phase of this study, which utilized secondary data, there were no anticipated risks to human subjects or participants. As the study solely relied on pre-existing de-identified and anonymized data, there was no potential risk of breaching confidentiality or privacy. This secondary data analysis aimed to provide insights into the burden of non/ under-vaccination, and MOV within the Kenyan population.

Participation in the key informant interviews, however, carried some associated risks, primarily related to the potential loss of anonymity and confidentiality. Nevertheless, the study team took steps to mitigate these risks by providing training to the research team, implementing strict data storage procedures, and limiting access to study information to only those team members who required it. Contingency measures had been defined for any breaches of confidentiality or privacy, which were to be promptly reported to the MUSERC and addressed according to MUSERC guidelines.

On the other hand, participation in this study offered numerous benefits. The information provided by key informants has enabled the researcher to generate recommendations aimed at improving immunization and child health programming. With this understanding, appropriate measures would be designed and implemented to ensure that all eligible children in Kenya benefitted equitably from routine immunization and other child health services.

3.12 Conflict of Interest

There was no conflict of interest because the researcher is not an employee of MoH or County governments.

CHAPTER FOUR
RESULTS

4.1 Introduction

This chapter presents the findings of the study, encompassing both quantitative and qualitative data. The results are organized according to the specific objectives outlined in the study. Quantitative findings are displayed in tables and figures, with detailed descriptions provided for each. Significance is emphasized for all pertinent findings.

Each table and figure is meticulously described to ensure clarity and comprehension. Qualitative results are presented alongside verbatim quotes to provide context and richness to the findings. Through this comprehensive approach, the study outcomes are thoroughly elucidated, offering insights into both the numerical trends and the qualitative nuances of the research.

4.2 Socio-demographic characteristics of children aged 0-23 months in Kenya;2003,2008/09 and 2014

Table 4.1 presents the socio-demographic characteristics of children aged 0-23 months in Kenya as reported in the Kenya Demographic Health Surveys (KDHS) conducted in 2003, 2008/09, and 2014. The table provides data on various variables including sex of child, residence, mother's age, marital status, religion, education, wealth quintile, province, child's birth order, parity, number of children in the household, place of delivery, and occupation. For each variable, the table displays the number of children (n) and the percentage (%) for each survey year.

The data shows a nearly equal distribution of male and female children across all three years, with males slightly outnumbering females in 2003 (49.9% male, 50.1% female) and 2014 (50.9% male, 49.1% female). There was an increase in urban residence from 2003 to 2014, with a corresponding decrease in rural residence. In 2003, 18.8% of children lived in urban areas, which rose to 35.2% in 2014, while rural residence decreased from 81.2% to 64.8% over the same period. The majority of mothers were within the 20-29 age range, with slight variations observed over the years. In 2014, 29.3% of mothers were aged 20-24, and 29.1% were aged 25-29. The data further indicates that the majority of mothers were married or living together across all three years, with proportions remaining relatively stable. In 2014, 83.3% of mothers were married or living together. The largest religious group among respondents was Protestant/other Christian, though there was a slight decrease in this group by 2014. In 2014, 70.4% of respondents

identified as Protestant/other Christian. There was an improvement in maternal education levels over the years, with an increasing proportion of mothers attaining secondary education or higher. In 2014, 33.7% of mothers had completed secondary education or higher, compared to 20.8% in 2003. Wealth distribution remained relatively stable over the years, with minor fluctuations in proportions across quintiles. In 2014, 25.2% of respondents were in the lowest wealth quintile, compared to 24.8% in 2003. The Rift Valley consistently had the highest proportion of respondents, followed by Nyanza and Coast, with slight variations in proportions over the years. In 2014, Rift Valley accounted for 29.5% of respondents. The proportion of first-born children increased from 24% in 2003 to 26.6% in 2014, while the proportions of children with birth orders 2-4 and 5+ showed slight declines. Parity remained relatively stable over the years, with the majority of respondents falling within the 2-4 range. In 2014, 53.2% of respondents had a parity of 2-4. There was a decrease in the proportion of households with 0-1 children and an increase in households with 2-4 children over the years. In 2014, 41.6% of households had 0-1 children, compared to 35.8% in 2003. There was an increase in deliveries taking place in public facilities over the years, accompanied by a decrease in home deliveries. In 2014, 49.7% of deliveries occurred in public facilities, compared to 61.3% in 2003. The proportion of employed mothers showed slight fluctuations over the years, indicating changes in employment rates among mothers. In 2014, 63.2% of mothers were employed, compared to 61.5% in 2003.

Table 4.1: Socio-demographic characteristics of caregivers of children 0-23months; KDHS 2003, 2008/09 and 2014

Variable	2003		2008		2014	
Sex of child	**n (2380)**	**%**	**n (2237)**	**%**	**n (7380)**	**%**
Male	1187	49.9	1157	51.7	3757	50.9
Female	1193	50.1	1081	48.3	3623	49.1
Residence						
Urban	447	18.8	449	20.1	2597	35.2
Rural	1934	81.2	1788	79.9	4783	64.8
Mother's Age						
15-19	283	11.9	211	9.4	706	9.6
20-24	742	31.1	719	32.1	2159	29.3
25-29	597	25.1	590	26.4	2150	29.1
30-34	413	17.4	423	18.9	1297	17.6
35-39	235	9.9	195	8.7	764	10.4
40-44	94	3.9	83	3.7	263	3.6
45-49	16	0.7	16	0.7	40	0.5
Marital Status						
Never Married	187	7.9	223	10.0	675	9.2
Married/ living together	2020	84.9	1854	82.9	6147	83.3
Divorced/separated/widowed	173	7.3	161	7.2	558	7.6
Religion						
Roman catholic	604	25.5	460	20.7	1338	18.2
Protestant/other Christian	1491	62.9	1495	67.1	5174	70.4
Muslim	209	8.8	198	8.7	627	8.5
No religion	66	2.8	75	3.4	209	2.8
Education						
No Education	359	15.1	276	12.3	850	11.5
Primary Incomplete	869	36.5	727	32.5	2054	27.8
Primary Complete	657	27.6	686	30.6	1989	27.0
Secondary +	495	20.8	549	24.5	2487	33.7
Wealth Quintile						
Lowest	589	24.8	543	24.3	1856	25.2
Second	493	20.7	443	19.8	1466	19.8

Middle	445	18.7	398	17.8	1333	18.1
Fourth	407	17.1	417	18.6	1267	17.2
Highest	446	18.7	437	19.5	1458	19.7
Province						
Nairobi	146	6.1	127	5.7	740	10.0
Central	250	10.5	159	7.1	669	9.1
Coast	211	8.9	213	9.5	806	10.9
Eastern	379	15.9	331	14.8	881	11.9
Nyanza	355	14.9	442	19.7	1030	14.0
Rift Valley	667	28.1	653	29.2	2180	29.5
Western	308	13.0	249	11.2	841	11.4
North Eastern	63	2.6	64	2.9	233	3.2
Child's Birth Order						
1	571	24	523	23.4	1964	26.6
2-4	1151	48.3	1111	49.7	3810	51.6
5 +	658	27.7	603	26.9	1607	21.8
Parity						
0-1	586	24.6	533	23.8	2006	27.2
2-4	1234	51.9	1185	53.0	3925	53.2
5 +	560	23.5	519	23.2	1448	19.6
Number of children in household						
0-1	852	35.8	763	34.1	3074	41.6
2-4	1508	63.4	1430	63.9	4247	57.6
5 +	21	0.8	44.1	2.0	59	0.8
Place of delivery						
Home	1429	61.3	1185	53.9	2495	34.2
Public	572	24.6	767	34.9	3633	49.7
Private	329	14.1	245	11.2	1173	16.1
Occupation						
Unemployed	915	38.5	954	42.7	1303	36.8
Employed	1463	61.5	1278	57.3	2239	63.2

4.3 Trends of non/ under-vaccination and MOV (2003-2014) amongst children 0-23 months in Kenya.

4.3.1 Trends of under-vaccination among children aged 0-23 months in Kenya from 2003 to 2014

Table 4.2 presents the trend of non-vaccination among children aged 0-23 months in Kenya based on the Kenya Demographic Health Surveys (KDHS) conducted in 2003, 2008/09, and 2014. The table includes data on the percentage of non-vaccinated children along with their 95% confidence intervals (CI) for each survey year, as well as the p-values calculated from the Cochrane-Armitage trend test.

In the three surveys, the percentage of children who were non-vaccinated decreased significantly from 13.2% (2003) to 6.1% (2008/09) to 3.2% (2014); $P<0.0001$. In terms of residence, a notable decrease in non-vaccination trends was observed among children from the rural areas with a decrease from 14.7% (2003) to 6.6% (2008/09) to 4.0% (2014); $P<0.0001$. This pattern was observed for all the significant results across all the factors except for women who were divorced/ separated or widowed 12.0% (2003) to 3.2% (2008/09) and 3.9% (2014); $P=0.0001$ and for women residing in Nairobi Province 4.6% (2003) to 6.1% (2008/09) and 1.0% (2014); $P=0.0015$, respectively.

Table 4.2: Trend of non-vaccination among children aged 0-23 months in Kenya; KDHS 2003, 2008/09 and 2014

	2003 (n=2380) % (95% CI)	2008/09 (n=2237) % (95% CI)	2014 (n=7380) % (95% CI)	*P*-value[a]
Sex of child				
Male	13.5(11.7-15.6)	6.8(5.4-8.3)	2.7(2.1-3.2)	**<0.0001**
Female	12.9(11.1-14.9)	5.5(4.3-7.0)	3.8(3.2-4.5)	**<0.0001**
Residence				
Urban	6.9(4.9-9.7)	4.4(2.8-6.7)	1.8(1.3-2.4)	**<0.0001**
Rural	14.7(13.1-16.3)	6.6(5.5-7.8)	4.0(3.5-4.6)	**<0.0001**
Mother's Age				
15-19	12.1(8.8-16.5)	6.3(3.7-10.5)	3.7(2.5-5.4)	**<0.0001**
20-24	13.1(10.8-15.7)	5.0(3.6-6.9)	2.5(1.9-3.2)	**<0.0001**
25-29	11.7(9.3-14.5)	5.8(4.1-8.0)	2.9(2.3-3.7)	**<0.0001**
30-34	13.0 (10.1-16.6)	7.2(5.1-10.1)	2.6(1.9-3.6)	**<0.0001**
35-39	17.4(13.0-22.8)	9.7(6.3-14.7)	3.6(2.5-5.1)	**<0.0001**
40-44	13.3(7.8-21.8)	4.5(1.6-11.8)	12.7(9.2-17.3)	0.8814
45-49	38.2(17.9-63.7)	4.0(0.3-34.9)	3.5(0.65-16.8)	**0.0006**
Marital Status				
Never Married	9.5(6.0-14.6)	5.8(3.4-9.7)	2.5(1.5-4.0)	**<0.0001**
Married/ living together	13.7(12.2-15.2)	6.4(5.4-7.7)	3.2(2.8-3.7)	**<0.0001**
Divorced/ separated/ widowed	12.0(7.9-17.8)	3.2(1.4-7.4)	3.9(2.6-5.9)	**0.0001**
Religion				
Roman catholic	12.4(10.0-15.2)	5.8(4.0-8.3)	2.0(1.3-2.9)	**<0.0001**
Protestant/ other Christian	11.6(10.1-13.4)	5.2(4.1-6.4)	3.0(2.6-3.5)	**<0.0001**
Muslim	23.1(17.8-29.3)	10.9(7.2-16.0)	7.1(5.3-9.4)	**<0.0001**
No religion	22.7(14.1-34.4)	13.7(7.5-23.6)	4.8(2.6-8.8)	**<0.0001**
Birth Order				
1	10.2(7.9-12.9)	4.0(2.6-6.1)	2.3(1.7-3.1)	**<0.0001**
2-4	10.9(9.2-12.8)	4.6(3.5-6.0)	2.4(1.9-2.9)	**<0.0001**
5 +	19.9(17.0-23.1)	10.8(8.5-13.5)	6.4(5.3-7.7)	**<0.0001**
Parity				
0-1	11.5(9.2-14.3)	4.0(2.6-6.0)	2.1(1.6-2.9)	**<0.0001**
2-4	10.4(8.8-12.2)	5.0(3.9-6.4)	2.5(2.1-3.1)	**<0.0001**

5 +	21.2(18.0-24.8)	10.9(8.5-13.9)	6.7(5.5-8.1)	**<0.0001**
Number of Children in Household				
0-1	11.3(9.3-13.6)	3.0(2.0-4.3)	1.9(1.5-2.5)	**<0.0001**
2-4	14.3(12.6-16.2)	7.9(6.6-9.4)	4.2(3.6-4.8)	**<0.0001**
5 +	10.9(2.9-33.7)	4.9(1.3-17.1)	1.8(2.8-11.3)	0.0738
Education				
No Education	29.6(25.1-34.6)	11.3(8.1-15.6)	8.9(7.1-11.0)	**<0.0001**
Primary Incomplete	15.0(12.7-17.5)	6.6(5.0-8.7)	3.6(2.9-4.5)	**<0.0001**
Primary Complete	7.8(5.9-10.1)	5.5(4.0-7.4)	2.3(1.7-3.0)	**<0.0001**
Secondary +	5.5(3.8-7.8)	3.8(2.5-5.8)	1.7(1.3-2.3)	**<0.0001**
Wealth Quintile				
Lowest	25.0(21.6-28.6)	11.2(8.8-14.2)	6.6(5.5-7.8)	**<0.0001**
Second	12.3(9.7-15.5)	4.3(2.8-6.7)	2.5(1.8-3.5)	**<0.0001**
Middle	11.0(8.4-14.2)	7.5(5.3-10.5)	3.5(2.7-4.7)	**<0.0001**
Fourth	6.9(4.8-9.8)	3.4(2.0-5.7)	1.4(0.8-2.2)	**<0.0001**
Highest	6.6(4.6-9.3)	3.0(1.8-5.1)	1.0(0.6-1.6)	**<0.0001**
Occupation				
Unemployed	14.7(12.5-17.1)	7.2(5.7-9.0)	3.7(2.8-4.8)	**<0.0001**
Employed	12.3(10.7-14.1)	5.4(4.3-6.8)	2.1(1.6-2.8)	**<0.0001**
Province				
Nairobi	4.6(2.2-9.4)	6.1(3.1-11.9)	1.0(0.4-2.0)	**0.0015**
Central	6.3(3.9-10.1)	6.1(3.3-11.1)	0.4(0.1-1.4)	**<0.0001**
Coast	9.2(6.0-13.9)	5.2(2.9-9.1)	2.3(1.4-3.5)	**<0.0001**
Eastern	676.4(4.3-9.4)	4.1(2.3-6.8)	1.1(0.5-2.0)	**<0.0001**
Nyanza	25.0(20.7-29.7)	7.2(5.1-10.0)	2.6(1.8-3.8)	**<0.0001**
Rift Valley	11.9(9.8-14.6)	4.8(3.3-6.7)	4.7(3.9-5.7)	**<0.0001**
Western	14.3(10.8-18.7)	7.5(4.8-11.5)	4.2(3.0-5.7)	**<0.0001**
North Eastern	56.7(44.2-68.4)	21.9(13.4-33.7)	15.2(11.1-20.4)	**<0.0001**
Place of delivery				
Home	18.1(16.2-20.2)	8.5(7.1-10.3)	6.6(5.7-7.7)	**<0.0001**
Public	5.5(3.8-7.6)	2.9(1.9-4.3)	1.5(1.1-1.9)	**<0.0001**
Private	6.4(4.2-9.6)	5.1(2.9-8.6)	1.1(0.7-1.9)	**<0.0001**
Total	13.2(11.9-14.6)	6.1(5.2-7.2)	3.2(2.8-3.6)	**<0.0001**

KDHS = Kenya Demographic Health Survey

[a] *P*-values were calculated form the Cochrane-Armitage trend test

4.3.2 Trends of under-vaccination among children aged 0-23 months in Kenya from 2003 to 2014

Table 4.3presents the trend of under-vaccination among children aged 0-23 months in Kenya based on the Kenya Demographic Health Surveys (KDHS) conducted in 2003, 2008/09, and 2014. The table includes data on the percentage of under-vaccinated children along with their 95% confidence intervals (CI) for each survey year, as well as the p-values calculated from the Cochrane-Armitage trend test.

The trend of under-vaccination from 2003 to 2008/09 to 2014 showed varied results as displayed in Table 4.3. It decreased from 54.3% (2003) to 50.0% (2008/09) to 51.3% (2014); *P*=0.0109. Among female children, under-vaccination decreased from 54.7% (2003) to 48.3% (2008/09) then increased to 50.8% (2014); *P*=0.0194. For those residing in the urban areas, under-vaccination decreased from 58.3% (2003) to 43.3% (2008/09) and then increased to 49.4% (2014); *P*=0.0005. The percentages of children born to mothers aged 25-29 years was highest in 2003 (54.3%) then 2008/09 (51.6%) to 2014 (48.1%); *P*=0.0073, and for women who were divorced/ separated/ widowed 2003 (58.2%), 2008/09 (56.8%) and 2014 (46.6%); *P*=0.0077.

In terms of birth order and parity, under-vaccination among children who were second to forth born decreased from 55.9% (2003) to 51.1% (2008/09) to 51.0% (2014); *P*=0.0035 and 56.5% (2003) to 51.5% (2008/09) and 50.7% (2014); *P*=0.0004 respectively. Under-vaccination amongst women having zero or one child living in a household decreased from 51.7% (2003) to 42.1% (2008/09) then increased to 46.7% (2014); *P*=0.0097. For children born to mothers in the lowest wealth quintile it was 52.0% (2003) to 52.6% (2008/09) and then increased to 57.1% (2014); *P*= 0.0299). Amongst those in second level wealth quintile, under-vaccination decreased from 59.1% (2003) to 55.2% (2008/09) and to 52.1% (2014); *P*=0.0070). In those within the fourth level of wealth quintile, under-vaccination decreased from 56.1% (2003) to 49.3% (2008/09) and then to 47.2% (2014); *P*=0.0036. Amongst those in the highest wealth quantile, under-vaccination was 54.7% (2003) then reduced to 43.1% (2008/09) and then rose to 47.2% (2014); *P*=0.0056.

In terms of occupation, trends in under-vaccination among children whose mothers were employed decreased from 53.6% (2003) to 49.5% (2008/09) and then increased to 50.1% (2014); *P*=0.0372. In the Provinces, the trend of under-vaccination was also varied as shown in Western

and North-Eastern Provinces (NEP). In Western, under-vaccination was 56.6% (2003), 51.9% (2008/09) and 49.9% (2014); *P*=0.0441 while in NEP, it was 36.5% (2003), 49.7% (2008/09) and 50.6%; *P*=0.0468). Additionally, trends in under-vaccination among children who were delivered in private sectors decreased from 54.9% (2003) to 51.6% (2008/09) and to 45.2% (2014); *P*=0.0011.

Table 4.3: Trends of Under-vaccination among children aged 0-23 months in Kenya; KDHS 2003, 2008/09 and 2014

	2003 (n=2380) % (95% CI)	2008/09 (n=2237) % (95% CI)	2014 (n=7380) % (95% CI)	*P*-value[a]
Sex of child				
Male	53.9(51.0-56.7)	51.6(48.7-54.5)	51.8(51.8-53.4)	0.2067
Female	54.7(54.3-57.5)	48.3(45.3-51.3)	50.8(49.2-52.5)	**0.0194**
Residence				
Urban	58.3(53.7-62.8)	43.3(38.8-47.9)	49.4(47.5-51.3)	**0.0005**
Rural	53.4(51.1-55.6)	51.7(49.4-54.0)	52.3(50.9-53.7)	0.4136
Mother's Age				
15-19	62.1(56.3-67.6)	54.4(47.6-61.0)	60.6(56.9-64.1)	0.6620
20-24	53.7(50.1-57.2)	53.9(50.2-57.5)	51.6(49.5-53.7)	0.3232
25-29	54.3(52.7-58.2)	51.6(47.6-55.6)	48.1(46.0-50.2)	**0.0073**
30-34	54.0(49.1-58.7)	41.2(36.6-45.9)	49.9(47.1-52.6)	0.1466
35-39	50.2(43.8-56.4)	45.2(38.3-52.3)	55.0(51.5-58.5)	0.1968
40-44	49.1(39.1-59.2)	51.4(40.6-61.9)	47.3(41.3-53.4)	0.7643
45-49	44.6(22.5-69.1)	46.9(24.4-70.7)	42.5(28.1-58.3)	0.8860
Marital Status				
Never Married	55.2(48.0-62.2)	52.7(46.1-59.2)	54.2(50.4-57.9)	0.8080
Married/living together	53.9(51.7-56.0)	49.1(46.8-51.4)	51.4(50.2-52.7)	0.0510
Divorced/separated/widowed	58.2(53.2-65.4)	56.8(49.0-64.3)	46.6(42.4-50.7)	**0.0077**
Religion				
Roman catholic	55.6(51.6-59.5)	53.3(48.8-57.9)	51.0(48.3-53.6)	0.0602
Protestant/other Christian	54.2(51.6-56.7)	49.1(46.6-51.7)	51.5(50.1-52.9)	0.0660
Muslim	51.9(45.1-58.6)	52.9(45.7-59.7)	50.3(46.3-54.2)	0.6887
No religion	55.9(43.7-67.4)	42.9(32.1-54.4)	48.2(41.5-55.0)	0.2754
Birth Order				
1	52.2(48.1-56.3)	46.4(42.2-50.7)	48.4(46.2-50.6)	0.1099
2-4	55.9(53.0-58.8)	51.1(48.2-54.1)	51.0(49.5-52.6)	**0.0035**
5 +	53.3(49.4-57.1)	51.2(47.2-55.1)	55.5(53.1-57.9)	0.3395
Parity				
0-1	52.3(48.2-56.3)	47.0(42.8-51.2)	49.2(47.0-51.4)	0.1867
2-4	56.5(53.7-59.2)	51.5(48.6-54.3)	50.7(49.2-52.3)	**0.0004**
5 +	51.6(47.5-55.7)	49.9(45.6-54.2)	55.8(53.2-58.3)	0.0900

Number of children in Household				
0-1	51.7(50.6-54.9)	42.1(38.6-45.6)	46.7(44.9-48.4)	**0.0097**
2-4	55.8(53.3-58.3)	54.0(51.4-56.6)	54.6(53.1-56.1)	0.4211
5 +	56.6(34.8-76.1)	58.5(43.4-72.1)	55.8(43.0-68.0)	0.9494
Education				
No Education	52.0(46.8-57.1)	54.5(48.6-60.3)	57.2(53.9-60.5)	0.0963
Primary Incomplete	56.6(53.3-59.9)	51.5(47.9-55.1)	54.5(52.3-56.6)	0.2968
Primary Complete	54.3(50.5-58.1)	48.7(45.0-52.5)	50.1(47.9-52.3)	0.0619
Secondary +	51.8(47.4-56.2)	47.5(43.3-51.7)	47.7(45.7-49.6)	0.0955
Wealth Quintile				
Lowest	52.0(47.9-56.0)	52.6(48.4-56.8)	57.1(54.8-59.3)	**0.0299**
Second	59.1(57.4-63.4)	55.2(50.5-59.8)	52.1(49.5-54.7)	**0.0070**
Middle	50.0(45.3-54.6)	49.1(44.2-54.0)	50.2(47.5-52.9)	0.9418
Fourth	56.1(51.2-60.8)	49.3(44.4-54.0)	47.8(45.0-50.5)	**0.0036**
Highest	54.7(50.1-59.3)	43.1(38.5-47.8)	47.2(44.7-49.8)	**0.0056**
Occupation				
Unemployed	55.5(52.2-58.7)	50.7(47.6-53.9)	52.5(49.8-55.2)	0.1630
Employed	53.6(53.6-56.1)	49.5(46.7-52.2)	50.1(48.0-52.1)	**0.0372**
Province				
Nairobi	57.0(48.8-64.8)	52.3(43.6-60.9)	49.6(46.0-53.2)	0.1021
Central	47.4(41.3-53.7)	46.0(38.4-53.8)	43.4(39.7-47.2)	0.2775
Coast	53.4(46.6-60.0)	52.7(45.9-59.3)	52.7(49.2-56.1)	0.8561
Eastern	55.2(50.1-60.1)	51.0(45.6-56.4)	50.7(47.4-54.0)	0.1426
Nyanza	56.2(51.0-61.3)	58.3(53.6-62.8)	52.2(49.1-55.2)	0.1923
Rift Valley	55.6(51.8-59.4)	42.9(39.2-46.7)	54.3(52.2-56.4)	0.5547
Western	56.6(56.1-62.0)	51.9(45.7-58.0)	49.9(46.5-55.2)	**0.0441**
North Eastern	36.5(25.5-49.1)	49.7(37.6-61.8)	50.6(50.7-56.9)	**0.0468**
Place of delivery				
Home	55.4(52.8-58.0)	50.7(47.9-53.5)	52.8(50.8-54.7)	0.1160
Public	51.1(47.0-55.1)	48.1(44.5-51.6)	52.1(50.5-53.7)	0.6559
Private	54.9(49.5-60.2)	51.6(45.3-57.8)	45.2(42.4-48.1)	**0.0011**
Total	54.3(54.9-56.3)	50.0(48.0-52.1)	51.3(50.2-52.4)	**0.0109**

KDHS = Kenya Demographic Health Survey

[a] *P*-values were calculated form the Cochrane-Armitage trend test

4.3.3 Trends of MOV among children aged 0-23 months in Kenya 2003 to 2014

Table 4.4presents the trend of MOV among children aged 0-23 months in Kenya based on the Kenya Demographic Health Surveys (KDHS) conducted in 2003, 2008/09, and 2014. The table includes data on the percentage of MOV among children along with their 95% confidence intervals (CI) for each survey year, as well as the p-values calculated from the Cochrane-Armitage trend test.

The results presented in Table 4.4 indicate a statistically significant increase in the percentage of children who experienced MOV from 22.7% in 2003 to 31.9% in 2008/09 and further to 37.6% in 2014 ($P<0.0001$). This trend was observed across all significant factors except for those residing in urban areas (24.5% in 2003 to 24.4% in 2008/09 to 32.5% in 2014; $P=0.0008$), children with mothers who were Muslims (19.3% in 2003 to 35.5% in 2008/09 to 28.5% in 2014; $P=0.0088$), those who had no religion (27.5% in 2003 to 35.2% in 2008/09 to 42.2% in 2014; $P=0.0325$), children who belonged to the highest wealth quintile (24.8% in 2003 to 23.4% in 2008/09 to 31% in 2014; $P=0.0120$), and those living in Nyanza Province (34.3% in 2008 to 39.9% in 2008/09 to 42.1% in 2014; $P=0.0096$).

Table 4.4: Trends of MOV among children aged 0-23 months in Kenya; KDHS 2003, 2008/09 and 2014

	2003 (n=2380) % (95% CI)	2008/09 (n=2237) % (95% CI)	2014 (n=7380) % (95% CI)	*P*-value[a]
Sex of child				
Male	23.9(21.5-26.4)	33.3(30.6-36.0)	39.1(37.5-40.7)	**<0.0001**
Female	21.5(19.3-23.9)	30.4(27.7-33.2)	36.0(34.5-37.6)	**<0.0001**
Residence				
Urban	24.5(20.7-28.7)	24.4(20.6-28.6)	32.5(30.7-34.3)	**0.0008**
Rural	22.3(20.5-24.2)	33.8(31.6-36.0)	40.4(39.0-41.8)	**<0.0001**
Mother's Age				
15-19	26.3(21.5-31.7)	31.0(25.1-37.6)	41.7(38.1-45.4)	**<0.0001**
20-24	23.8(20.9-27.0)	34.5(31.1-38.1)	39.0(37.0-41.1)	**<0.0001**
25-29	22.2(19.0-25.7)	29.4(25.8-33.2)	36.9(34.9-39.0)	**<0.0001**
30-34	22.3(18.6-26.6)	31.7(27.4-36.3)	35.4(32.9-38.1)	**<0.0001**
35-39	19.7(15.1-25.3)	29.5(23.5-36.3)	34.8(31.5-38.2)	**<0.0001**
40-44	15.2(9.2-24.0)	36.4(26.8-47.3)	39.7(34.0-45.8)	**<0.0001**
45-49	20.0(6.6-47.1)	31.1(13.2-57.1)	32.3(19.5-48.3)	0.3584
Marital Status				
Never Married	21.6(16.3-28.1)	22.9(17.8-28.9)	36.7(33.1-40.4)	**0.0001**
Married/ living together	23.1(21.3-25.0)	32.5(30.4-34.7)	37.9(36.7-39.1)	**<0.0001**
Divorced/ separated/ widowed	19.3(14.1-25.9)	37.2(30.0-44.9)	35.0(31.2-39.1)	**0.0001**
Religion				
Roman catholic	24.8(21.5-28.4)	31.2(27.1-35.6)	36.3(33.8-38.9)	**<0.0001**
Protestant/ other Christian	21.8(19.8-24.0)	31.3(29.0-33.7)	38.9(37.6-40.2)	**<0.0001**
Muslim	19.3(14.5-25.3)	35.5(29.1-42.4)	28.5(26.4-32.2)	**0.0088**
No religion	27.5(18.0-39.5)	35.2(25.2-46.7)	42.2(41.1-49.0)	**0.0325**
Birth Order				
1	24.6(21.2-28.3)	27.7(24.0-31.7)	39.8(37.6-42.0)	**<0.0001**
2-4	23.2(20.9-25.8)	29.2(26.6-31.9)	35.6(34.0-37.1)	**<0.0001**
5 +	20.1(17.2-23.3)	40.6(36.7-44.5)	39.7(37.3-42.1)	**<0.0001**
Parity				
0-1	25.4(22.1-29.1)	27.9(24.2-31.8)	40.2(38.0-42.3)	**<0.0001**
2-4	22.3(20.0-24.7)	30.6(28.0-33.3)	35.6(34.1-37.1)	**<0.0001**
5 +	20.7(17.5-24.2)	39.0(34.8-43.2)	39.5(37.0-42.0)	**<0.0001**

Number of children in Household				
0-1	25.0(22.2-28.0)	25.9(22.9-29.1)	36.1(34.4-37.8)	**<0.0001**
2-4	21.4(19.4-23.6)	34.2(31.8-36.7)	38.8(37.3-40.2)	**<0.0001**
5 +	18.5(6.8-41.5)	62.4(47.3-75.5)	31.5(20.9-44.4)	0.2550
Education				
No Education	18.3(14.6-22.7)	43.6(37.9-49.6)	33.2(30.1-36.4)	**<0.0001**
Primary Incomplete	25.3(22.6-28.3)	35.5(32.1-39.0)	41.4(39.3-43.6)	**<0.0001**
Primary Complete	21.5(18.5-24.8)	30.3(27.0-33.8)	36.6(34.5-38.7)	**<0.0001**
Secondary +	22.8(19.3-26.7)	23.2(19.9-27.0)	36.7(34.8-38.6)	**<0.0001**
Wealth Quintile				
Lowest	21.5(18.4-25.1)	38.5(34.5-42.7)	39.1(36.9-41.4)	**<0.0001**
Second	26.3(22.6-30.4)	35.2(30.8-39.7)	41.8(39.2-44.3)	**<0.0001**
Middle	20.2(16.7-24.2)	32.3(27.8-37.0)	38.6(36.1-41.3)	**<0.0001**
Fourth	20.3(16.6-24.5)	28.3(24.2-32.8)	37.0(34.4-39.7)	**<0.0001**
Highest	24.8(21.0-29.0)	23.4(19.7-27.6)	31.0(30.1-33.4)	**0.0120**
Occupation				
Unemployed	19.5(17.0-22.2)	32.5(29.6-35.5)	40.6(37.9-43.3)	**<0.0001**
Employed	24.7(22.6-27.0)	31.5(29.0-34.1)	45.9(43.8-48.0)	**<0.0001**
Province				
Nairobi	22.8(16.7-30.3)	30.8(23.3-39.4)	27.9(24.8-31.2)	0.2049
Central	16.2(12.1-21.3)	19.7(14.2-26.7)	33.2(29.7-36.8)	**<0.0001**
Coast	18.1(13.5-23.9)	37.4(31.1-44.1)	37.5(34.3-40.9)	**<0.0001**
Eastern	17.3(13.8-21.4)	21.7(17.5-26.4)	38.9(35.7-42.1)	**<0.0001**
Nyanza	34.3(29.5-39.4)	39.9(22.9-29.7)	42.1(41.1-45.2)	**0.0096**
Rift Valley	20.2(17.3-23.4)	26.2(42.7-55.2)	38.1(36.1-40.2)	**<0.0001**
Western	32.0(27.0-37.4)	49.0(42.9-55.2)	46.5(43.1-49.8)	**<0.0001**
North Eastern	10.9(5.2-21.4)	35.0(24.3-47.4)	19.2(14.6-24.8)	0.1234
Place of delivery				
Home	18.7(16.8-20.8)	39.0(36.2-41.8)	34.6(32.5-36.2)	**<0.0001**
Public	26.9(23.4-30.7)	22.9(20.0-26.0)	40.0(38.4-41.6)	**<0.0001**
Private	34.1(29.2-39.4)	26.9(21.7-32.8)	37.3(34.5-40.1)	0.0575
Total	22.7(21.0-24.4)	31.9(30.0-33.9)	37.6(36.5-38.7)	**<0.0001**

KDHS = Kenya Demographic Health Survey

[a] *P*-values were calculated form the Cochrane-Armitage trend test

Figure 4.1 depicts the vaccination trends among children aged 0-23 months in Kenya, as observed in the Kenya DHS conducted in 2003, 2008/09, and 2014. Trends in proportion of non-vaccination among children aged 0-23 months in Kenya was 13.2%, 6.1% and 3.2% in 2003, 2008/09 and 2014, respectively. Trends in proportion of under-vaccination among children aged 0-23 months in Kenya was 54.3%, 50% and 51.3% in 2003, 2008/09 and 2014, respectively. The trends in proportion of children who experienced MOV was 22.7% in 2003, 31.9% in 2008/09 and 37.6% in 2014. In the study duration, non-vaccination decreased by 10%, under-vaccination remained relatively stable, and MOV increased by ~15%.

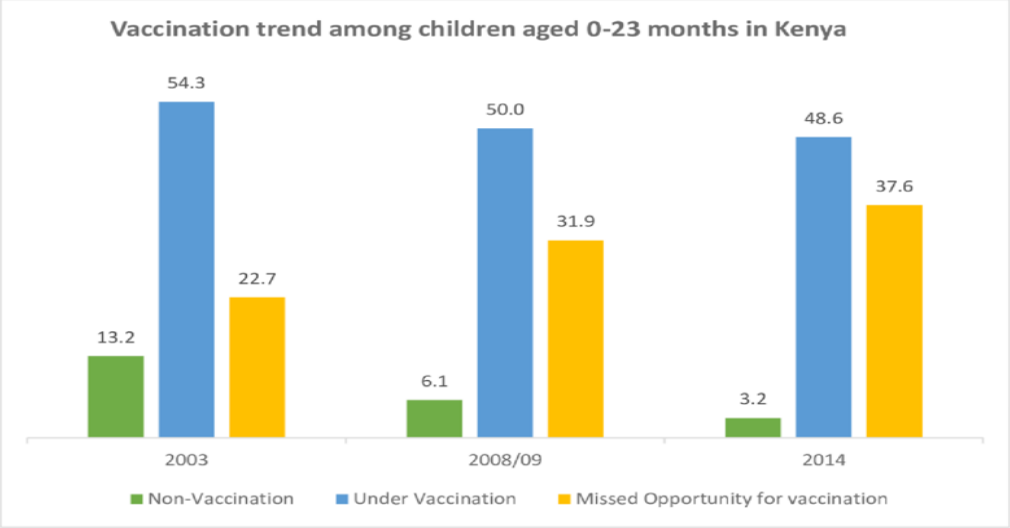

Figure 4.1: Vaccination trends among children aged 0-23 months in Kenya

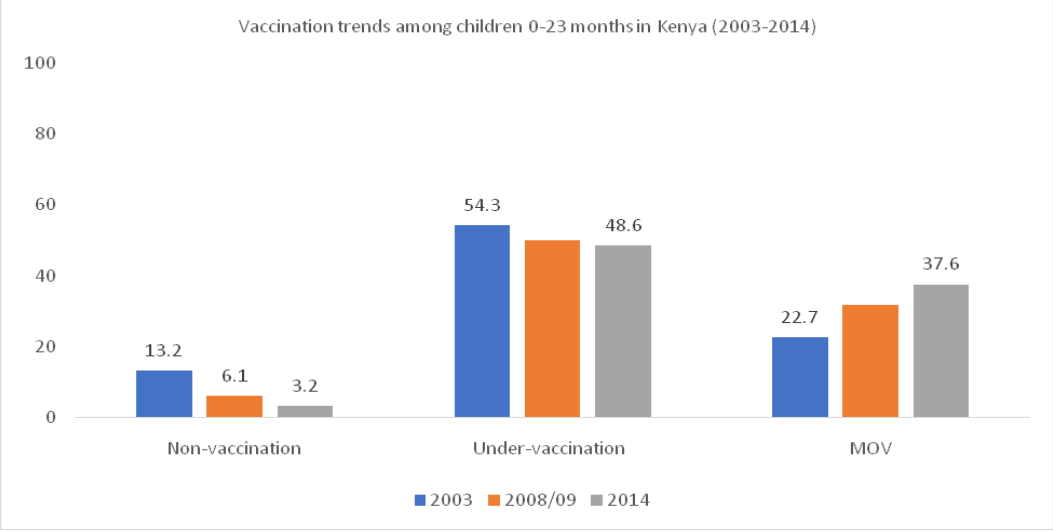

Figure 4.2: Vaccination trends among children aged 0-23 months in Kenya

4.4 The influence of demographic and socio-economic factors on non/ under-vaccination and MOV amongst children 0-23 months in Kenya for the period 2003-2014.

4.4.1 Demographic and socio-economic determinants of non-vaccination amongst children 0-23 months in Kenya 2003 to 2014

Table 4.5 presents the findings on the demographic and socio-economic determinants of non-vaccination amongst children 0-23 months in Kenya 2003 to 2014, utilizing data from the Kenya DHS conducted in 2003, 2008/09, and 2014. Each row of the table corresponds to a specific variable, including the child's sex, residence (urban or rural), mother's age, marital status, religion, education level, wealth quintile, province, child's birth order, parity, number of children in the household, place of delivery, and maternal occupation. The results are presented in terms of Crude Odds Ratios (COR) and Adjusted Odds Ratios (AOR) along with their 95% confidence intervals. The COR indicates the association between each variable and non-vaccination without accounting for other factors, while the AOR adjusts for potential confounders through multivariable logistic regression.

In 2003, the mothers' education and Province were statistically significant. When compared to mothers with no education, the probability of non-vaccination was 0.55 times (AOR=0.55, 95% CI=0.37-0.81) among mothers who didn't complete primary education, 0.34 times (AOR=0.34, 95% CI=0.21-0.56) for mothers with complete primary education and 0.26 times (AOR=0.26, 95% CI=0.14-0.50) for mothers with secondary education or higher. Compared to children in Coast Province, the odds of non-vaccination were 6.04 times in Nyanza Province (AOR=6.04, 95% CI=2.80-13.02) and 8.60 times in North Eastern Provinces (AOR=8.60, 95% CI=3.36-19.18).

In 2008/09 marital status, religion, wealth quintile and Province were statistically significant for non-vaccination. Compared to mothers who have never been married, children of divorced/separated/widowed women were 0.22 times (AOR=0.22, 95% CI=0.07-0.65) likely to be non-vaccinated. Compared to children of women with no religion, those of Protestant/other Christian were 0.37 times (AOR=0.37, 95% CI=0.17-0.81) likely to be non-vaccinated. Compared to the highest wealth quintile, children of the lowest quintile were 7.3 times (AOR=7.30, 95% CI=2.11-25.24) and middle quintiles 4.96 (AOR=4.96, 95% CI=1.59-15.46) times likely to be non-vaccinated, respectively. Within the provinces, non-vaccination was 4.43

times (AOR=4.43, 95% CI=1.24-15.85) in Central province and 2.99 times (AOR=2.99, 95% CI=1.32-6.75) in North-Eastern compared to the Coast province.

In 2014, mothers age, province, birth order and place of delivery were statistically significant for non-vaccination. Non-vaccination was 12.53 times (AOR=12.53, 95% CI=1.59-98.73) in children whose mothers age ranged between 15-19 years compared to those aged 45-49 years. It was 7.15 times (AOR=7.15, 95% CI=2.02-25.30) in north-Eastern compared to Coast and 4.19 times (AOR=4.19, 95% CI=1.09-16.18) times in families with more than 5 children compared to those with one child. Non-vaccination was also 4.47 times (AOR=4.47, 95% CI=1.32-15.17) likely in children born at home compared to those born in a private facility.

Table 4.5: Demographic and socio-economic determinants of non-vaccination amongst children 0-23 months in Kenya; KDHS 2003, 2008/09 and 2014

	2003 (n=2380)		2008/09 (n=2237)		2014 (n=7380)	
	COR (95% CI)	AOR‡ (95% CI)	COR (95% CI)	AOR‡ (95% CI)	COR (95% CI)	AOR‡ (95% CI)
Sex of child						
Male	1	1	1	1	1	1
Female	0.95(0.72-1.26)	0.98(0.73-1.330	0.80(0.54-1.19)	0.82(0.56-1.21)	**1.46(1.01-2.11)** *	1.27(0.79-2.02)
Residence						
Urban	**0.43(0.27-0.68)** *	0.87(0.46-1.66)	0.65(0.32-1.32)	2.57(0.98-6.72)	**0.44(0.27-0.70)** *	1.24(0.62-2.47)
Rural	1	1	1	1	1	1
Mother's Age						
15-19	**0.22(0.06-0.82)** *	0.54(0.11-2.69)	1.62(0.19-13.96)	5.34(0.49-58.24)	1.05(0.22-5.16)	**12.53(1.59-98.73)***
20-24	**0.24(0.07-0.89)** *	0.70(0.15-3.23)	1.28(0.15-10.51)	3.22(0.30-34.69)	0.70(0.14-3.37)	5.96(0.84-42.35)
25-29	**0.21(0.06-0.76)** *	0.59(0.14-2.47)	1.47(0.18-12.20)	2.80(0.28-28.18)	0.82(0.17-3.98)	6.41(0.97-42.23)
30-34	**0.24(0.07-0.89)** *	0.42(0.10-1.74)	1.88(0.23-15.47)	3.09(0.36-26.94)	0.74(0.15-3.55)	3.74(0.60-23.30)
35-39	0.34(0.08-1.39)	0.62(0.38-2.78)	2.59(0.30-22.25)	3.06(0.34-27.85)	1.02(0.21-4.93)	4.51(0.69-29.45)
40-44	0.25(0.06-1.00)	0.30(0.06-1.42)	1.14(0.30-12.61)	1.43(0.13-16.11)	4.00(0.67-23.75)	7.44(0.90-61.28)
45-49	1	1	1	1	1	1
Marital Status						
Never Married	1	1	1	1	1	1
Married/ living together	1.51(0.86-2.66)	1.01(0.51-1.99)	1.12(0.52-2.41)	0.73(0.45-1.54)	1.29(0.66-2.51)	0.88(0.40-1.96)
Divorced/separated/widowed	1.30(0.60-2.84)	0.92(0.37-2.30)	0.54(0.18-1.65)	**0.22(0.07-0.65)** *	1.58(0.71-3.56)	1.44(0.49-4.21)
Religion						
Roman catholic	0.48(0.22-1.07)	0.53(0.25-1.12)	**0.39(0.16-0.94)** *	0.46(0.20-1.05)	**0.39(0.19-0.82)** *	1.20(0.39-3.70)
Protestant/other Christian	**0.45(0.20-0.98)** *	0.53(0.26-1.08)	**0.34(0.13-0.90)** *	**0.37(0.17-0.81)** *	0.61(0.28-1.33)	1.21(0.36-4.02)
Muslim	1.02(0.43-2.44)	0.40(0.15-1.07)	0.77(0.27-2.21)	0.47(0.18-1.24)	1.49(0.69-3.25)	0.98(0.26-3.70)
No religion	1	1	1	1	1	1
Education						
No Education	1	1	1	1	1	1
Primary Incomplete	**0.42(0.30-0.58)** *	**0.55(0.37-0.81)** *	0.56(0.28-1.08)	0.96(0.44-2.09)	**0.38(0.27-0.54)** *	0.85(0.44-1.64)
Primary Complete	**0.20(0.13-0.31)** *	**0.34(0.21-0.56)** *	**0.45(0.22-0.92)** *	1.32(0.57-3.07)	**0.24(0.12-0.48)** *	0.88(0.37-2.08)
Secondary +	**0.14(0.08-0.23)** *	**0.26(0.14-0.50)** *	**0.31(0.14-0.69)** *	1.14(0.47-2.76)	**0.18(0.11-0.30)** *	0.55(0.18-1.69)
Wealth Quintile						
Lowest	**4.70(2.78-7.95)** *	1.31(0.56-3.04)	**4.08(1.72-9.68)** *	**7.30(2.11-25.24)** *	**7.19(2.45-21.16)** *	1.42(0.31-6.53)
Second	**1.98(1.13-3.46)** *	0.80(0.34-1.86)	1.46(0.57-3.75)	2.75(0.83-9.08)	2.66(0.87-8.20)	0.67(0.144-3.11)
Middle	1.74(0.96-3.15)	0.95(0.40-2.27)	**2.61(1.04-6.59)** *	**4.96(1.59-15.46)** *	**3.74(1.08-12.98)** *	0.79(0.18-3.43)
Fourth	1.05(0.57-1.92)	0.68(0.30-1.58)	1.13(0.41-3.12)	2.10(0.73-6.06)	1.39(0.41-4.70)	0.99(0.23-4.28)
Highest	1	1	1	1	1	1
Province						
Nairobi	0.48(0.21-1.06)	1.42(0.51-4.00)	1.20(0.33-4.37)	4.26(0.88-20.70)	0.42(0.06-3.23)	NA

Central	0.67(0.32-1.38)	1.81(0.72-4.55)	1.20(0.45-3.17)	**4.43(1.24-15.85)** *	**0.19(0.06-0.63)** *	0.92(0.14-6.01)
Coast	1	1	1	1	1	1
Eastern	0.68(0.34-1.36)	1.10(0.47-2.55)	0.78(0.32-1.86)	1.03(0.39-2.75)	0.47(0.17-1.31)	1.08(0.28-4.19)
Nyanza	**3.28(1.72-6.27)** *	**6.04(2.80-13.02)** *	1.42(0.70-2.89)	2.37(0.95-5.90)	1.17(0.54-2.52)	1.63(0.41-6.56)
Rift Valley	1.34(0.71-2.52)	1.67(0.84-3.36)	0.91(0.39-2.13)	0.99(0.40-2.41)	**2.15(1.10-4.18)** *	2.62(0.80-8.55)
Western	1.65(0.90-3.03)	2.49(1.22-5.05)	1.48(0.57-3.88)	2.18(0.68-6.91)	1.89(0.73-4.88)	1.68(0.43-6.54)
North Eastern	**12.95(6.69-25.07)** *	**8.60(3.86-19.18)** *	**5.13(2.30-11.45)** *	**2.99(1.32-6.75)** *	**7.76(3.80-15.84)** *	**7.15(2.02-25.30)***
Child's Birth Order						
1	1	1	1	1	1	1
2-4	1.08(0.74-1.57)	1.66(0.67-4.11)	1.16(0.64-2.09)	1.12(0.50-2.49)	1.03(0.64-1.65)	1.36(0.56-3.27)
5 +	**2.19(1.55-3.10)** *	1.60(0.47-5.42)	**2.86(1.48-5.54)** *	1.61(0.49-5.28)	**2.89(1.66-5.01)** *	**4.19(1.09-16.18)** *
Parity						
0-1	1	1	1	1	1	1
2-4	0.89(0.63-1.26)	0.46(0.18-1.17)	1.28(0.72-2.29)	1.10(0.48-2.51)	1.19(0.73-1.94)	0.48(0.21-1.08)
5 +	**2.07(1.47-2.90)** *	0.95(0.30-3.04)	**2.95(1.49-5.87)** *	1.97(0.56-6.98)	**3.29(1.85-5.83)** *	0.36(0.99-1.34)
Number of children in household						
0-1	1	1	1	1	1	1
2-4	1.31(0.98-1.76)	1.09(0.75-1.56)	**2.77(1.72-4.44)***	**1.98(1.07-3.69)***	**2.21(1.47-3.33)***	1.43(0.74-2.74)
5 +	0.96(0.29-3.26)	1.16(0.37-3.64)	1.67(0.33-8.45)	1.40(0.28-7.01)	0.95(0.18-5.01)	NA
Place of delivery						
Home	**3.24(1.74-6.03)** *	1.85(0.99-3.47)	1.75(0.63-4.84)	1.21(0.29-5.10)	**6.26(1.98-19.87)***	**4.47(1.32-15.17)***
Public	0.84(0.40-1.76)	0.92(0.44-1.92)	0.55(0.19-1.58)	0.50(0.13-2.03)	1.35(0.40-4.52)	1.17(0.33-4.14)
Private	1	1	1	1	1	1
Occupation						
Unemployed	1	1	1	1	1	1
Employed	0.82(0.60-1.12)	0.78(0.57-1.05)	0.73(0.48-1.13)	0.79 (0.49-1.26)	**0.57(0.38-0.85)***	0.88(0.57-1.36)

***P-value <0.05**

‡ **Adjusted Odds Ratio (AOR):** All variables from the bivariable logistic regression were included in the multivariable logistic regression model using the enter method selection criteria

N/A- fewer observations hence omitted in the regression model

4.4.2 Demographic and socio-economic determinants of under-vaccination amongst children 0-23 months in Kenya 2003 to 2014

Table 4.6 presents the findings on the demographic and socio-economic determinants of under-vaccination amongst children 0-23 months in Kenya 2003 to 2014, utilizing data from the Kenya DHS conducted in 2003, 2008/09, and 2014. Each row of the table corresponds to a specific variable, including the child's sex, residence (urban or rural), mother's age, marital status, religion, education level, wealth quintile, province, child's birth order, parity, number of children in the household, place of delivery, and maternal occupation. The results are presented in terms of Crude Odds Ratios (COR) and Adjusted Odds Ratios (AOR) along with their 95% confidence intervals. The COR indicates the association between each variable and under-vaccination without accounting for other factors, while the AOR adjusts for potential confounders through multivariable logistic regression.

In 2003, children from the Rift Valley were 0.45 times (AOR=0.45,95% CI=0.25-0.82) likely to be under-vaccinated compared to children from the Coast province. In 2008/2009, religion, Province and birth order were statistically significant. Compared to mothers with no religion children, mothers who were Roman Catholic, Protestant/Other Christian and Muslims were 2.51 (AOR=2.51,95%=1.41-4.48), 2.34 (AOR=2.34,95% CI=1.37-3.99) and 1.99(AOR=1.99,95% CI=1.07-3.69) times likely to have their children under-vaccinated, respectively. Likewise, compared to children from the Coast Province, those from Rift Valley were 0.55 times (AOR=0.55,95% CI=0.36-0.86) likely to be under-vaccinated. Households with between 2-4 children were 1.42 times (AOR=1.42,95% CI=1.04-1.93) likely to be under-vaccinated compared to households with 0 to 1 child.

In 2014, gender, mothers age and number of children in a household were statistically significant. Female children were 0.83 times (AOR=0.83,95% CI=0.71-0.98) likely to be under-vaccinated compared to their male counterparts. Mothers aged 15-19 years were 3.27 times (AOR=3.27,95% CI=1.14-9.36) likely to have under-vaccinated children compared to those aged 45-49 years. Likewise, households with between 2 to 4 children were 1.38 times (AOR=1.38, 95% CI=1.11-1.73) likely to be under-vaccinated compared to households with 0 to 1 child.

Table 4.6: Demographic and socio-economic determinants of under vaccination among children 0-23 months in Kenya; KDHS 2003, 2008/09 and 2014

	2003 (n=2380)		2008/09 (n=2237)		2014 (n=7380)	
Variables	**COR (95% CI)**	**AOR‡ (95% CI)**	**COR (95% CI)**	**AOR‡ (95% CI)**	**COR (95% CI)**	**AOR‡ (95% CI)**
Sex of child						
Male	1	1	1	1	1	1
Female	1.03(0.85-1.25)	1.02(0.83-1.25)	0.88(0.68-1.13)	0.89(0.69-1.16)	0.96(0.85-1.09)	**0.83(0.71-0.98)** *
Residence						
Urban	1.22(0.94-1.58)	1.52(0.93-2.47)	0.71(0.48-1.05)	0.72(0.46-1.13)	0.89(0.78-1.01)	1.07(0.86-1.33)
Rural	1	1	1	1	1	1
Mother's Age						
15-19	2.03(0.54-7.67)	2.08(0.48-9.02)	1.35(0.47-3.88)	1.78(0.57-5.62)	**2.08(1.02-4.24)** *	**3.27(1.14-9.36)** *
20-24	1.44(0.38-5.41)	1.26(0.29-5.47)	1.32(0.47-3.70)	1.48(0.50-4.43)	1.44(0.72-2.90)	2.05(0.78-5.42)
25-29	1.47(0.39-5.54)	1.15(0.27-4.93)	1.21(0.42-3.44)	1.18(0.41-3.42)	1.25(0.63-2.51)	1.66(0.64-4.36)
30-34	1.46(0.38-5.57)	1.09(0.25-4.67)	0.79(0.27-2.33)	0.67(0.23-2.00)	1.35(0.67-2.70)	1.85(0.71-4.77)
35-39	1.25(0.32-4.83)	0.97(0.23-4.13)	0.94(0.32-2.74)	0.75(0.25-2.28)	1.66(0.81-3.37)	1.93(0.73-5.05)
40-44	1.20(0.29-4.88)	0.95(0.22-4.17)	1.20(0.37-3.91)	0.99(0.31-3.15)	1.21(0.55-2.68)	2.04(0.74-5.64)
45-49	1	1	1	1	1	1
Marital Status						
Never Married	1	1	1	1	1	1
Married/living together	0.95(0.69-1.30)	0.95(0.65-1.38)	0.86(0.61-1.23)	0.85(0.55-1.32)	0.90(0.73-1.10)	1.04(0.75-1.44)
Divorced/separated/widowed	1.13(0.72-1.77)	1.10(0.68-1.79)	1.18(0.73-1.91)	1.15(0.65-2.02)	0.74(0.54-1.00)	0.79(0.49-1.27)
Religion						
Roman catholic	0.99(0.59-1.66)	0.97(0.56-1.69)	1.52(0.98-2.35)	**2.51(1.41-4.48)** *	1.12(0.80-1.55)	1.22(0.77-1.92)
Protestant/other Christian	0.93(0.56-1.56)	0.96(0.55-1.69)	1.29(0.82-2.01)	**2.34(1.37-3.99)** *	1.14(0.84-1.56)	1.23(0.79-1.92)
Muslim	0.85(0.48-1.52)	1.17(0.60-2.29)	1.49(0.90-2.48)	**1.99(1.07-3.69)** *	1.09(0.77-1.54)	0.10(0.66-1.84)
No religion	1	1	1	1	1	1
Education						
No Education	1	1	1	1	1	1
Primary Incomplete	1.20(0.95-1.53)	0.96(071-1.31)	0.89(0.57-1.38)	0.66(0.37-1.16)	0.89(0.74-1.07)	0.89(0.66-1.21)
Primary Complete	1.10(0.86-1.40)	0.94(0.69-1.29)	0.79(0.53-1.20)	0.63(0.37-1.05)	**0.75(0.62-0.91)** *	0.85(0.62-1.18)
Secondary+	0.99(0.75-1.31)	0.90(0.62-1.32)	0.75(0.49-1.17)	0.72(0.43-1.22)	**0.68(0.57-0.82)** *	0.92(0.66-1.29)
Wealth Quintile						
Lowest	0.90(0.68-1.19)	1.07(0.65-1.75)	1.46(0.94-2.28)	1.27(0.78-2.07)	**1.49(1.20-1.84)***	1.39(0.92-2.09)
Second	1.20(0.90-1.60)	1.36(0.84-2.21)	**1.63(1.05-2.53)***	1.37(0.84-2.24)	1.22(0.98-1.51)	0.98(0.67-1.44)
Middle	0.83(0.62-1.10)	0.98(0.61-1.58)	1.27(0.79-2.04)	1.13(0.68-1.86)	1.13(0.89-1.43)	1.12(0.77-1.64)
Fourth	1.06(0.78-1.43)	1.28(0.80-2.06)	1.28(0.80-2.04)	1.09(0.69-1.73)	1.02(0.79-1.33)	1.07(0.73-1.57)
Highest	1	1	1	1	1	1
Province						

Nairobi	1.16(0.82-1.62)	1.23(0.76-1.97)	0.99(0.66-1.48)	1.35(0.78-2.35)	0.88(0.64-1.22)	0.94(0.56-1.59)
Central	0.79(0.57-1.09)	1.09(0.73-1.64)	0.77(0.48-1.23)	0,73(0.43-1.25)	0.69(0.53-0.90)	0.90(0.57-1.44)
Coast	1	1	1	1	1	1
Eastern	1.08(0.80-1.44)	1.36(0.91-2.04)	0.94(0.67-1.31)	0.74(0.47-1.17)	0.92(0.73-1.17)	1.12(0.75-1.66)
Nyanza	1.12(0.80-1.57)	1.34(0.87-2.06)	1.26(0.92-1.71)	0.96(0.63-1.47)	0.98(0.80-1.20)	1.15(0.78-1.71)
Rift Valley	1.10(0.80-1.50)	1.31(0.89-1.93)	**0.67(0.47-0.98)** *	**0.55(0.36-0.86)** *	1.07(0.89-1.28)	1.16(0.82-1.63)
Western	1.14(0.82-1.59)	1.33(0.90-1.97)	0.97(0.63-1.50)	0.80(0.47-1.39)	0.89(0.72-1.11)	0.96(0.65-1.43)
North Eastern	0.50(0.30-0.83)	**0.45(0.25-0.82)** *	0.89(0.55-1.44)	0.59(0.29-1.22)	0.92(0.69-1.23)	0.95(0.60-1.51)
Child's Birth Order						
1	1	1	1	1	1	1
2-4	1.16(0.93-1.45)	1.28(0.68-2.02)	1.21(0.94-1.55)	1.65(0.74-3.69)	1.11(0.96-1.29)	0.77(0.38-1.55)
5+	1.04(0.81-1.34)	1.80(0.81-4.04)	1.21(0.89-1.64)	2.52(0.87-7.39)	**1.33(1.11-1.60)***	0.98(0.40-2.36)
Parity						
0-1	1	1	1	1	1	1
2-4	1.18(0.96-1.46)	1.06(0.56-2.02)	1.20(0.93-1.54)	0.81(0.35-1.89)	1.06(0.91-1.23)	1.32(0.64-2.72)
5+	0.97(0.74-1.27)	0.72(0.30-1.72)	1.12(0.82-1.54)	0.68(0.22-2.06)	**1.30(1.08-1.56)***	1.37(0.55-3.38)
Number of children in household						
0-1	1	1	1	1	1	1
2-4	1.19(0.98-1.43)	1.17(0.93-1.48)	**1.61(1.22-2.14)** *	**1.42(1.04-1.93)** *	**1.37(1.21-1.56)***	**1.38(1.11-1.73)***
5+	1.23(0.61-2.48)	1.42(0.66-3.08)	1.94(0.88-4.25)	1.37(0.65-2.84)	1.44(0.87-2.40)	0.74(0.43-1.27)
Place of delivery						
Home	1.02(0.76-1.37)	1.02(0.73-1.41)	0.97(0.65-1.44)	0.77(0.49-1.21)	**1.35(1.10-1.67)** *	1.20(0.87-1.65)
Public	0.86(0.61-1.20)	0.85(0.59-1.20)	0.87(0.56-1.34)	0.72(0.44-1.16)	**1.32(1.08-1.61)** *	1.37(0.71-1.49)
Private	1	1	1	1	1	1
Occupation						
Unemployed	1	1	1	1	1	1
Employed	0.93(0.77-1.11)	0.95(0.77-1.16)	0.95(0.78-1.16)	0.97(0.77-1.23)	0.91(0.76-1.08)	1.00(0.81-1.22)

***P-value <0.05**

‡ **Adjusted Odds Ratio (AOR):** All variables from the bivariable logistic regression were included in the multivariable logistic regression model using the enter method selection criteria

N/A- fewer observations hence omitted in the regression model

4.4.3 Demographic and socio-economic determinants of MOV amongst children 0-23 months in Kenya

Table 4.7 presents the findings on the demographic and socio-economic determinants of MOV amongst children 0-23 months in Kenya 2003 to 2014, utilizing data from the Kenya DHS conducted in 2003, 2008/09, and 2014. Each row of the table corresponds to a specific variable, including the child's sex, residence (urban or rural), mother's age, marital status, religion, education level, wealth quintile, province, child's birth order, parity, number of children in the household, place of delivery, and maternal occupation. The results are presented in terms of Crude Odds Ratios (COR) and Adjusted Odds Ratios (AOR) along with their 95% confidence intervals. The COR indicates the association between each variable and MOV without accounting for other factors, while the AOR adjusts for potential confounders through multivariable logistic regression.

In 2003, religion, Province and place of delivery were significant. Mothers who were Protestant/Other Christians were 0.46 times (AOR=0.46, 95% CI=0.26-0.83) likely to have children with MOV compared to those with no religion. Children living in Nyanza and Western Provinces were 2.81 (AOR=2.81,95% I=1.65-4.80) and 2.62 (AOR=2.62, 95% CI=1.62-4.26) times likely to have MOV compared to children from the Coast Province. Similarly, children delivered at home were 0.35 times (AOR=0.35, 95% CI=0.24-0.51) likely to have MOV compared to children born at private health facility.

In 2008/09, marital status, education, Province and birth order were statistically significant. When analysed within the marital status category, and compared to single women, the likelihood of MOV in children of those who were Married/living together and the divorced/separated/widowed was 1.64 times (AOR=1.64, 95% CI=1.02-2.65) and 2.01 (AOR=2.01,95% CI=1.03-3.92), respectively. Similarly, within education category, when compared to mothers with no education, the likelihood of MOV among those with incomplete primary education was 0.57 (AOR=0.57, 95% CI=0.38-0.84), 0.57 (AOR=0.57, 95% CI=0.36-0.90) amongst those with complete primary education and 0.47 (AOR=0.47, 95% CI=0.28-0.79) amongst mothers with secondary education and above. When compared to children from Coast Province, the likelihood of MOV amongst children from Eastern Province was 0.39 (AOR=0.39, 95% CI=0.22-0.69) and 0.45 (AOR=0.45, 95% CI=0.25-0.80) in Rift-Valley Province. Children

in the 5+ birth order were 2.82 times (AOR=2.82, 95% CI=1.17-6.84) likely to experience MOV compared to first-borns.

In 2014, wealth quintile and Province were statistically significant. Similarly, as compared to Coast Province, children from Western and North-Eastern Provinces were 1.67 times (AOR=1.67, 95% CI=1.04-2.67) and 0.54 times (AOR=0.54, 95% CI=0.31-0.93) likely to have MOV.

Table 4.7: Demographic and socio-economic determinants of MOV amongst children 0-23 months in Kenya; KDHS 2003, 2008/09 and 2014

	2003 (n=2380)		2008/09 (n=2237)		2014 (n=7380)	
Variable	**COR (95% CI)**	**AOR‡ (95% CI)**	**COR (95% CI)**	**AOR‡ (95% CI)**	**COR (95% CI)**	**AOR‡ (95% CI)**
Sex of child						
Male	1	1	1	1	1	1
Female	0.87(0.70-1.08)	0.85(0.68-1.07)	0.88(0.69-1.11)	0.90(0.71-1.15)	**0.88(0.78-0.99)***	1.00(0.84-1.18)
Residence						
Urban	1.13(0.87-1.47)	1.17(0.75-1.83)	**0.63(0.42-0.95)** *	0.62(0.36-1.07)	**0.71(0.61-0.82)** *	0.88(0.70-1.10)
Rural	1	1	1	1	1	1
Mother's Age						
15-19	1.42(0.17-11.81)	0.78(0.08-7.00)	1.00(0.31-3.22)	3.32(0.97-11.39)	1.50(0.73-3.08)	1.11(0.38-3.29)
20-24	1.25(0.15-10.06)	0.71(0.08-6.03)	1.17(0.37-3.68)	3.33(1.03-10.78)	1.34(0.68-2.66)	1.20(0.45-3.19)
25-29	1.14(0.14-9.10)	0.75(0.09-6.19)	0.92(0.30-2.88)	2.32(0.73-7.34)	1.23(0.61-2.46)	1.08(0.41-2.82)
30-34	1.15(0.14-9.26)	0.68(0.08-5.52)	1.03(0.31-3.39)	2.19(0.69-6.91)	1.15(0.58-2.30)	1.06(0.42-2.68)
35-39	0.98(0.12-8.08)	0.69(0.09-5.47)	0.93(0.26-3.35)	1.55(0.47-5.14)	1.12(0.55-2.27)	1.10(0.43-2.84)
40-44	0.71(0.08-6.71)	0.56(0.06-5.29)	1.27(0.35-4.60)	2.06(0.61-6.99)	1.38(0.66-2.90)	1.35(0.49-3.75)
45-49	1	1	1	1	1	1
Marital Status						
Never Married	1	1	1	1	1	1
Married/living together	1.09(0.72-1.64)	1.20(0.78-1.84)	**1.63(1.11-2.39)** *	**1.64(1.02-2.65)** *	1.05(0.86-1.29)	1.33(0.95-1.86)
Divorced/separated/widowed	0.87(0.50-1.53)	1.08(0.58-2.01)	**2.00(1.13-3.52)** *	**2.01(1.03-3.92)** *	0.93(0.70-1.24)	1.08(0.69-1.69)
Religion						
Roman catholic	0.87(0.47-1.62)	0.58(0.31-1.08)	0.84(0.47-1.50)	2.23(1.20-4.16)	0.78(0.53-1.15)	0.98(0.57-1.69)
Protestant/other Christian	0.74(0.41-1.33)	**0.46(0.26-0.83)** *	0.84(0.49-1.43)	2.05(1.12-3.73)	0.87(0.62-1.23)	1.11(0.68-1.80)
Muslim	0.63(0.33-1.21)	0.70(0.37-1.33)	1.01(0.59-1.75)	1.55(0.84-2.85)	0.55(0.37-0.81)	1.18(0.62-2.25)
No religion	1	1	1	1	1	1
Education						
No Education	1	1	1	1	1	1
Primary Incomplete	**1.51(1.08-2.13)***	1.06(0.68-1.65)	**0.71(0.53-0.95)***	**0.57(0.38-0.84)** *	**1.43(1.15-1.77)** *	1.07(0.75-1.520
Primary Complete	1.22(0.83-1.79)	0.87(0.53-1.42)	**0.56(0.40-0.78)** *	**0.57(0.36-0.90)** *	1.16(0.93-1.44)	1.04(0.70-1.53)
Secondary+	1.31(0.90-1.91)	0.73(0.44-1.22)	**0.39(0.28-0.56)** *	**0.47(0.28-0.79)** *	1.17(0.95-1.45)	1.01(0.68-1.51)
Wealth Quintile						
Lowest	0.83(0.60-1.16)	0.99(0.56-1.72)	**2.05(1.33-3.16)** *	1.07(0.54-2.15)	**1.43(1.15-1.78)** *	1.65(1.12-2.43)
Second	1.09(0.77-1.53)	1.23(0.71-2.15)	**1.78(1.07-2.94)** *	0.99(0.50-1.97)	**1.60(1.28-1.99)** *	1.30(0.90-1.88)
Middle	0.77(0.53-1.11)	0.92(0.54-1.58)	1.56(0.97-2.51)	0.96(0.49-1.88)	**1.40(1.11-1.77)** *	1.13(0.79-1.61)
Fourth	0.77(0.54-1.11)	0.94(0.57-1.55)	1.29(0.80-2.10)	0.96(0.52-1.76)	**1.31(1.02-1.68)** *	1.30(0.92-1.85)
Highest	1	1	1	1	1	1
Province						
Nairobi	1.34(0.87-2.05)	1.05(0.62-1.80)	0.75(0.45-1.25)	1.40(0.73-2.68)	0.64(0.43-95)	1.04(0.59-1.82)
Central	0.88(0.57-1.34)	0.82(0.48-1.41)	**0.41(0.23-0.73)** *	0.53(0.26-1.08)	0.83(0.61-1.12)	1.14(0.70-1.84)
Coast	1	1	1	1	1	1
Eastern	0.95(0.61-1.46)	1.09(0.65-1.83)	0.46(0.30-0.72) *	**0.39(0.22-0.69)***	1.06(0.81-1.37)	1.47(0.94-2.30)

Nyanza	**2.36(1.53-3.62)***	**2.81(1.65-4.80)***	1.11(0.75-1.65)	1.03(0.60-1.78)	1.21(0.96-1.52)	1.30(0.85-2.00)
Rift Valley	1.14(0.81-1.62)	1.25(0.80-1.96)	0.59(0.35-1.00)	**0.45(0.25-0.80)***	1.02(0.82-1.28)	1.48(0.99-2.23)
Western	**2.13(1.46-3.10)***	**2.62(1.62-4.26)***	**1.61(1.04-2.50)***	1.46(0.80-2.66)	**1.44(1.12-1.87)***	**1.67(1.04-2.67)***
North Eastern	0.55(0.28-1.10)	0.63(0.30-1.30)	0.90(0.52-1.57)	0.50(0.25-1.00)	**0.39(0.30-0.53)***	**0.54(0.31-0.93)***
Child's Birth Order						
1	1	1	1	1	1	1
2_4	0.93(0.71-1.22)	1.42(0.75-2.70)	1.08(0.80-1.45)	1.18(0.63-2.22)	**0.83(0.73-0.96)***	1.02(0.52-2.00)
5+	0.77(0.54-1.09)	1.06(0.44-2.53)	**1.78(1.24-2.57)***	**2.82(1.17-6.84)***	1.00(0.84-1.18)	1.38(0.59-3.20)
Parity						
0-1	1	1	1	1	1	1
2_4	0.84(0.64-1.10)	0.72(0.37-1.39)	1.14(0.85-1.53)	0.76(0.41-1.41)	**0.82(0.72-0.95)***	0.80(0.40-1.58)
5+	0.76(0.54-1.08)	0.98(0.40-2.37)	**1.65(1.11-2.46)***	0.59(0.24-1.46)	0.97(0.82-1.15)	0.58(0.25-1.36)
Number of children in household						
0-1	1	1	1	1	1	1
2-4	0.82(0.65-1.02)	0.90(0.68-1.20)	**1.49(1.12-1.98)***	1.05(0.78-1.41)	1.12(0.99-1.26)	1.10(0.88-1.38)
5+	0.68(0.24-1.96)	0.70.0.22-2.30)	**4.77(1.78-12.79)***	2.14(0.78-1.41)	0.81(0.38-1.73)	0.46(0.16-1.132)
Place of delivery						
Private	1	1	1	1	1	1
Public	0.71(0.51-1.00)	0.75(0.53-1.07)	0.81(0.52-1.25)	0.74(0.45-1.21)	1.12(0.92-1.36)	1.03(0.75-1.41)
Home	**0.45(0.32-0.62)***	**0.35(0.24-0.51)***	**1.74(1.14-2.65)***	1.37(0.84-2.25)	0.88(0.72-1.08)	0.78(0.54-1.12)
Occupation						
Unemployed	1	1	1	1	1	1
Employed	**1.36(1.08-1.72)***	1.22(0.94-1.59)	0.96(0.78-1.18)	0.98(0.77-1.26)	**1.24(1.04-1.48)***	1.19(0.98-1.45)

***P-value <0.05**

‡ **Adjusted Odds Ratio (AOR):** All variables from the bivariable logistic regression were included in the multivariable logistic regression model using the enter method selection criteria

N/A- fewer observations hence omitted in the regression model

4.5 The Influence of Health System factors on Non/ Under-Vaccination and MOVin Children aged 0-23 Months in Kenya.

4.5.1 Health System Factors Influencing Non/ Under-vaccination and MOV

Out of 204 potential respondents spread across the country, 152 respondents spread across the 47 Counties were interviewed due to logistical challenges, perceived time burden and time constraint. The Key Informant Interviews were conducted in regard to exploring the health system factors influencing non-vaccination, under-vaccination and missed opportunities in Kenya. Six key thematic areas were identified including; Paediatric health challenges in the community, child health protective measures, community attitude towards child vaccination, childhood vaccination services, vaccine compliance and missed opportunities. The thematic analysis seeks to provide deeper understanding of the research question and draw conclusions based on the data collected.

4.5.2 Socio-Demographic Characteristics

Depending on their availability, the key informant interviewers included a wide range of experts in the medical field ranging from Public Health Officers, Nursing Officers in-charge of immunization, County Directors of Health, County Immunization Logisticians, and Immunization Program Officers at the National Level.

The longest serving key informant had working experience of 28 years while the shortest had served for one month in the working station. The mean age of the participants was 40.22 years; with the eldest being 58 years and youngest being 27 years old. Majority of the key respondents had received a tertiary level of education 114(75%), with 29(19.23%) holding a master's degree while9(6.12%) had a PhD degree. Regarding marital status 114(75%) were married, 35(23.08%) were single and 3(1.92%) were divorced. Out of all the respondents 123(80.77%) were female and 29(19.23%) were male. See the detailed results in table 4.8.

Table 4.8: Socio-demographic characteristics of the key informant interviewers

Variable	Category	Proportion	Frequency
Gender	Male	19.23	29
	Female	80.77	123
Level of Education	Tertiary	75	114
	Master's Degree	19.23	29
	PhD	6.12	9
Marital Status	Single	23.08	35
	Married	75	114
	Divorced	1.92	3

a) Paediatric health challenges

A word cloud analysis was conducted to explore the prevalent paediatric health challenges, revealing that diseases, infections, malaria, and pneumonia were the most frequently cited concerns affecting children, as depicted in Figure 4.3. Malnutrition emerged prominently among the highlighted issues, with many children brought to health facilities found to be malnourished and suffering conditions such as worm infestations or jiggers. Respondents attributed malnutrition to inadequate parental care, leading to a cascade of problems including accidents, diseases, and missing their vaccinations as part of their preventive health care.

Furthermore, diseases like measles, polio, diabetes, and non-communicable diseases were reported to impact children, along with environmental factors exacerbating conditions such as typhoid, malaria, rotavirus, pneumonia, and meningitis. Upper respiratory tract infections were particularly prevalent among children under five, as indicated by respondents. Additionally, skin infections, fungal infections, and ringworm diseases were highlighted as notable concerns.

Figure 4.3: A word cloud query on paediatric health challenges in Kenya

These challenges were linked to various factors, including single parenthood, with respondents noting that children raised by teenage single mothers often faced difficulties in receiving necessary vaccinations due to oversight. The following quotes were provided by the respondents:

"So one of the health.. we have got malnutrition, malnutrition especially for the under-five's and then we have got warm infestation. And then aah those are some of the major forms of...forms of what..." (KII_BUSIA_01).

" I think majorly we have like cases of malnutrition." ...(KII_BUSIA_01).

"Number one problem for children I think, for now, is lack of proper parental care. Parents are busy people; caregivers are also busy. So, you find with very minimal time for the child, there are a lot of problems that now will arise, like accidents, diseases like malnutrition, lack of proper preventive measures, vaccination, assessments and all that." ...(KII_BUSIA_02).

"Some, health problems that affect children in this community are mostly Malnutrition and Diarrhea." ...(KII_BUSIA_02).

"Upper respiratory tract infections come is also common." ...(KII _EMBU_01).

"Then the other problem could be maybe the issue of children, we have some children who are shown by single mothers, especially the teenagers. So, when it comes to their upbringing, is not well taken care of. So at least there is a high tendency of them maybe defaulting to receive all the required vaccines." ...(KII_BUSIA_02).

b) Child Health protective measures

These are the measures implemented to address and mitigate the health challenges faced by children in the community. According to the participants, community health workers sensitize the community on caring for their children by ensuring they receive immunizations, early treatment, and necessary education support. Paralegals at the community level also work to protect children from abuse.

"community health workers who sensitize the community on how to care for their children to ensure taking them for immunization, early treatment, and ensuring that they receive the needs that they require for education." …(KII_SIAYA_01).

Efforts in continuous education have been initiated to address various health challenges. One such initiative promotes crop cultivation during the short rainy season to ensure a balanced diet for children, aiming to combat malnutrition and instill healthy eating habits. Concurrently, advocacy for mosquito net usage, clearing of vegetation around households, stagnant water removal to eradicate mosquito breeding sites, and administering malaria vaccinations and sprays to children under five is actively underway.

School feeding programs and the encouragement of parents to establish kitchen gardens for enhanced food security have also been introduced. Moreover, deworming tablets are distributed during vaccination visits, and educational sessions on nutrition and hygiene, including preventative measures against skin ailments like scabies, are provided.

"They come to the facility to be vaccinated against the diseases that they have not received the vaccine." …(KII_BUSIA_01.)

"We have continuous health education in the communities eh to to help them to continue growing various crops that are short... short-rained ones so that they may be, you may have a stable food there." …(KII_BUSIA_02)

Mothers are particularly supported in managing diarrhea, with emphasis on using boiled drinking water and adhering to the immunization schedule for their babies. At the facility level, health education sessions are conducted every morning for parents and guardians attending facilities for services. Additionally, through the community health strategies, community health promoters are assigned to households to provide health education and promotion, focusing on hygiene, nutrition, health-seeking behaviors, and primary prevention through vaccination and hand washing. These efforts highlight the importance of secondary prevention measures.

"...we encourage the children to get vaccines to prevent such and even reduce the severity of the infection." ...(KII_TAITA_TAVETA_02).

c) Community attitude towards children vaccination

This theme delves deeply into the perspectives and sentiments surrounding childhood vaccination within the community. Among the expressed views, respondents highlighted a generally positive reception of child vaccination. Many affirmed that the community wholeheartedly embraces childhood immunization, with vaccination status currently reaching approximately eighty-two percent. Notably, one participant shared their experience of witnessing tangible benefits from malaria vaccination, leading to a positive shift in attitude due to a noticeable reduction in malaria cases.

"Community members are positive about childhood vaccinations." ...(KII_NAKURU_01).

"They are positive, according to me." ...(KII_EMBU_01).

"Mothers are attended to fast by friendly health workers and they, and they come out satisfied." ...(KII_KISUMU_02).

Additional findings from this study also revealed that religion plays a significant role in shaping attitudes towards children's immunization. Participants noted a noticeable contrast between counties in the northern region, predominantly Muslim, and those with a Christian majority. In the former, there exists a considerable disparity in perception, knowledge, and attitude towards immunization, largely influenced by religious beliefs. Despite this, routine vaccination has generally garnered acceptance, albeit occasional instances of dropouts. Notably, community members consistently bring their children in substantial numbers for vaccinations, reflecting a positive attitude towards children's health, as highlighted by one respondent. Moreover, there's a widespread acknowledgment of the efficacy of vaccines in safeguarding children against various diseases.

However, it's worth noting that certain Asian communities harbor suspicions and exhibit less receptiveness towards child vaccinations. These observations are supported by quotes provided by respondents, underscoring the complexities and nuances surrounding attitudes towards childhood immunization.

"They are positive about childhood vaccinations they bring their children for vaccination in large numbers [short pause] that implies they have positive attitude." ...(KII_NAKURU_02).

"Then we have other communities in the Asian region. They do not, they're not receptive at all. They will be suspicious. They love rumors. They love myths. You will have to take a lot of work to convince them on vaccination." ...(KII_NATIONAL_04).

"It has been well accepted though we have aah small issues of dropout rates. Children dropping out while still going through their vaccine... routine vaccination but it has been well accepted." ...(KII_NATIONAL_03).

d) Childhood Vaccination services

This theme encompasses the strategies and methodologies employed in delivering vaccination services for children within healthcare facilities. Sub-themes include the level of satisfaction, challenges encountered in vaccination services, reasons underlying satisfaction or dissatisfaction, and suggestions for enhancing vaccination services. Respondents highlighted their efforts in community sensitization regarding vaccination, particularly emphasizing the benefits of malaria vaccination and its role in preventing severe malaria cases. They expressed satisfaction in the availability of vaccines within healthcare facilities, accessible across all sub-locations, thereby facilitating ease of access. Additionally, respondents noted that health education emphasizing the importance of vaccination and immunization commences during antenatal clinics.

The respondents reported that the effectiveness of vaccination services is evident, with an average of 50 children visiting for vaccination monthly. However, despite the availability of services, some of them pointed out that universal accessibility is hindered by nomadic lifestyles. Nonetheless, the majority of respondents indicated high vaccination uptake, estimated at about 80%.

"Child vaccination aah uptake is very good, it's high. Most aah more than 80% of the community take their children for vaccination. And the compression rate is also very good for the under ones." ...(KII_MERU_01).

"Most of the kids are brought for vaccinations from the community." ...(KII_VIHIGA_02).

"Basically, it is more of health education and trying to explain to them the importance of immunization. This is done once the mother starts ante-natal visits." ...(KII_EMBU_02).

4.5.3 Levels of Satisfaction

The sub-theme covers the satisfaction level of the community with vaccination services. Majority of the people preferred places with no stressors like prolonged waiting time and would therefore choose the private over public facilities. In general, the majority of respondents expressed satisfaction with the services. Some participants rated their satisfaction with

vaccination services at eight out of ten, and this rating was dependent on the location and facility where they receive the services. Others noted that the service is conveniently timed and fast, with reduced queues, leaving mothers very satisfied. Furthermore, vaccination services are provided free of charge in public hospitals. Another participant mentioned that they haven't received any complaints, and vaccination services are available five days a week. Below were some of the mentioned comments.

"They are satisfied with the services because we have not had any complain. the services are offered 5 days in a week." ...(KII_NAIROBI_02).

"Most of them are more satisfied." ...(KII_SIAYA_04).

"Not 100% But if I was to grade them, you know, one to ten, I'd go to eight." ...(KII_KAKAMEGA_01).

4.5.4 Challenges in Vaccination Services

The sub-theme covers the challenges faced in vaccination of children at the facility level. The respondents reported poverty among people such that they cannot even afford transport to access the services. In some facilities, EPI logistician experienced challenges on stock-outs, inaccessibility to the health facility due to floods and distance covered to the health facilities. Another participant mentioned that planning for an outreach becomes challenging when there is only one staff available in a level two facility dispensary. Consequently, it becomes difficult for that individual to organize and conduct outreach activities in hard-to-reach areas. Additionally, the inconsistent supply of certain antigen commodities and vaccines, such as the Rota vaccine, leads to inconsistencies, causing parents to give up. Moreover, there are sects within the community that oppose vaccination due to their beliefs. Furthermore, participants noted that the education level of caregivers and their socio-economic status affect immunization rates and access to healthcare. Some of the statements are listed below.

"...some of the people comingfar away from the health facilities. So, it becomes cumbersome for them to afford to get fare to take their children for vaccination." ...(KII_MARSABIT_02).

"...you can plan for an outreach but you have got one staff in a dispensary that is a level two facility. So, it comes very hard for that particular person to organize and be able to carry out an outreach to the hard-to-reach areas." ...(KII_GARISA_01).

"We have some sects in the community who are not for, who their beliefs is against any medicine." ...(KII__KILIFI_ 01).

"education level of other caregivers also affects immunization as well as the social economic status, which of course would affect access to health care." …(KII_NATIONAL_01).

4.5.5 Reasons for Satisfaction and Dissatisfaction

The sub-theme covers some of the reasons why respondents at the community level are dissatisfied or satisfied with the vaccination services. Firstly, a significant cause of satisfaction since the emergence of malaria vaccine was a decline in malaria-related deaths compared to previous years. Additionally, vaccinations and immunization activities are conducted in outpatient settings, allowing caregivers to avoid mixing with other patients and saving time. Furthermore, the availability of vaccinations free of charge and consistently stocked contributes to satisfaction among caregivers.

"…it's in a form of an outpatient setup, so they don't really get to mix with other clients. when you go to, it's a design, actually it's a design within the Ministry of Health. The vaccination services are never mixed with other services. So, you find this, just a designated place where it's purely immunization." …(KII_NATIONAL_02).

"…first of all, are given free of charge, meaning people do not have to pay for the actual antigen. Secondly, it's very rare to see stock outs for vaccines, except recently when we had the typhoid, the DCV vaccine shortage which has now been sorted, but it was because of the change in formulation." …(KII_NATIONAL_01).

However, some express dissatisfaction with long queues and unfriendly staff behavior towards babies. Dissatisfaction could be due to an increase in the number of vaccines currently being administered to children. Some parents may have a tendency to fear bringing their kids to be vaccinated because their child may need to receive around five injections in one day. Nonetheless, satisfaction is strengthened by witnessing the effectiveness of vaccines, receiving knowledge from healthcare officers, and recognizing the competence, knowledge, and information provided by caregivers administering the services. The following quotes were provided by the respondents:

"Some claim that queues are long in public hospitals [short pause] they also claim that there are no baby friendly health care workers in public hospitals." …(KII_NAKURU_02).

"The main dissatisfaction could maybe be the, there is the high increased number of vaccines currently that we are still administering. So, you find that some of the parents, they have a tendency of that fear of bringing their kids to be vaccinated because now maybe the child comes and has to get like around five jabs in a day." …(KII_BUSIA_02).

4.5.6 Suggestions for Improving Vaccination Services

These are the opinions on what the stakeholders believe can be done to enhance the vaccination services in the community. As mentioned by some respondents, some of the ways to improve vaccinations is offering the services during outreaches accompanied with continuous education and giving them the correct information about the vaccinations through the community health promoters on the importance of vaccinating children. Another suggested approach is to ensure that vaccines are consistently available in the facility. Funds should also be provided to ensure timely accessibility of these vaccines to various stores. Additionally, it was proposed that cold chain equipment for vaccine storage should be provided, as they are currently inadequate in the facilities. Constant updates on policies are necessary to support the work of healthcare workers. It was also recommended that services be brought closer to the community for improved accessibility. Increasing the number of staff in health facilities to enhance service delivery was also mentioned. Furthermore, some suggested conducting more outreaches targeting hard-to-reach areas to reduce transportation costs for community members. Lastly, it was suggested that staff be motivated through training programs. A sample of what was said by the respondents is as shown below.

"Then lastly, we motivate now the staff by training them and giving them updates." ...(KII_WEST POKOT_03).

"We can be given funds at least to enable accessibility of these vaccines to our different store on time." ...(KII_BUSIA_01).

"Another thing is of course is constant updates to the service providers and also constant updates also to the policy makers. Because once you bring in the policy makers, they'll ensure that our work is good." ...(KII_KISUMU_01).

"I think it will have been better, gotten services being brought closer to where they areliving." ...(KII_WEST_POKOT_02).

"We advocate for maybe increasing the number of the staffs in health facilities to be able to assist in service delivery." ...(KII_MIGORI_01).

"...uhm to conduct outreaches so that to target those hard-to-reach areas so that they don't use transport to these facilities most of them feel that the hospital is far." ...(KII_HOMABAY_02)

e) Vaccine Compliance

Vaccine compliance entails the consistent adherence to immunization and vaccination schedules. Sub-themes within this topic include enhancing vaccination programs, identifying barriers to

timely vaccination, and implementing vaccination schedule programs. However, a significant challenge arises from the lack of adequate understanding among most parents or caregivers regarding vaccination programs.

Participants highlighted various obstacles to achieving 100% compliance, including caregiver defaults, lifestyle constraints, disparities in literacy levels, and occasional forgetfulness regarding vaccination dates, often stemming from ignorance or oversight. Additionally, challenges may arise from sporadic availability of antigens, leading to missed opportunities for vaccination among women. Nevertheless, some respondents acknowledged the presence of immunization schedules and demonstrated excellent compliance with them. Here are some statements provided by participants:

"…Parents or the caregivers are not well conversant to them so that is the, where it is giving us a little bit of challenge." …(KII_KIAMBU_01).

"…yes, we do have, the immunization schedule." …(KII_EMBU_02).

"…The turn-up, there are many who come. So, they comply positively." …(KII_MAKUENI_01).

"They complied. Actually, they liked it and they came in numbers. Because we had outreaches plus in the station. They used to come." …(KII_MAKUENI_02).

"Compliance is not 100% because of the lifestyle, people move from one place to another. Additionally, you may go for outreach and find that the community had emigrated. Because of illiteracy levels, sometimes they forget the dates that have been indicated. Sometimes it is because of ignorance, they just assume. There are also a few times maybe availability of the antigens is a problem and as a result women miss to get the antigen." …(KII_MARSABIT_01).

4.5.6.1 Vaccination Schedule Compliance

This sub-theme delves into the extent to which caregivers adhere to vaccination and immunization programs. Participants highlighted that the community is well-informed, thanks to extensive community engagement efforts. Consequently, there is a general awareness of the vaccination schedule, although there may be gaps in knowledge regarding new vaccines, efforts are underway to ensure their widespread dissemination.

According to some participants, compliance with the vaccination schedule is generally satisfactory, although challenges arise with updates such as the introduction of vaccines for measles and rubella. Notably, strict adherence is observed for certain antigens during the child's early years, such as the first, second, and third doses of the Pentavalent vaccine, as mentioned by another respondent.

"… that it is okay apart from the updates where we have got some updates like the vaccines like the measles and rubella." …(KII_BUSIA_02).

"The compliance is like let me say like 80%." …(KII_BUSIA_01).

However, there are instances of non-compliance among some caregivers, particularly concerning certain antigens. Once a child reaches a certain age and has presumably received the necessary vaccinations, adherence may falter. These are also linked to the other childhood preventive treatments intended for children up to 59 months old such as observed for deworming with Albendazole and vitamin A. Caregivers residing in hard-to-reach areas often encounter difficulties in adhering to the vaccination schedule due to transportation challenges.

Additionally, it is worth noting that some healthcare providers discourage adhering strictly to the vaccination schedule, opting to administer vaccines only when readily available and ceasing vaccination once their stock runs out. Furthermore, challenges in implementing the schedule are evident, attributed to capacity gaps, workload issues, and various other factors. Below are some responses provided by participants:

"It is difficult. It is one of the things that has been a challenge in the program because you will set a schedule, but the person who is supposed to implement the schedule, in a way, maybe capacity, capacity gaps, maybe workload, maybe all other things, they will affect what the policy says they should do." …(KII_NAIROBI_04).

"But there are some antigens whereby they don't comply once the child has reached one and a half years." …(KII_SIAYA_02).

"Yeah, not all as I said those hard-to-reach areas they don't comply because of the transport." …(KII_WEST_POKOT_02).

"So, we usually discourage, actually we don't schedule; we don't schedule vaccines. We give and once the stocks run out, that is it." …(KII_EMBU_02).

4.5.6.2 Barriers to Timely Vaccination

The sub-theme covers some of the reasons and causes that hinder compliance and timely vaccinations. Some reported barriers by participants were, caregivers spend a long time at the facility, negatively impacting them by demoralizing some from bringing their children on the appointment dates. Another barrier reported is inadequate supply of vaccines, which leads to non-vaccination of scheduled vaccines. Others mentioned that distance as a barrier, as they live far from facilities and wait for outreach, resulting in non-adherence and untimely vaccination. This is due to shortages of staff to conduct outreach programs, causing children to miss their vaccinations. Participants also noted that due to funding of vaccines, some may not be able to afford them, resulting in children missing out on vaccination. Additionally, myths and misconceptions contribute significantly. For instance, some caregivers believe that children shouldn't receive vaccination while sick. Cultural and religious beliefs among some communities like keeping new-borns indoors for a period before allowing them to interact with others contributed to untimely vaccination. Capacity gaps among healthcare workers, Community Health Promoters (CHPs), and the community itself, stemming from a lack of understanding of vaccines, also contribute to stock fallouts.

"They take a long time a long time at the facility so they … it impacts negatively on them it's somehow it demoralizes some of the parents to bring their children on the appointment dates and lastly another thing that would make them maybe it's inadequate supply of vaccines the stock outs especially when they come and they find that we don't have that particular antigen so that would make them not get the vaccine as scheduled." …(KII_KILIFI_01).

Others because of the distance they are far so they just wait for that outreach and in the hospital we have that eeh we have short shortages or we don't have that facility maybe it's facilitator to go for an outreaches maybe monthly so you find that that month that child can miss the vaccine." …(KII_GARISA_02).

"…now because of the funding we might not be able to go because we don't have that fare, lunches so we miss then maybe we go after like three months." …(KII_WEST_POKOT_01).

"…misconceptions. Because you realize that we have got a lot of myths especially whenever a child is sick. They say that once a child is sick then they are not supposed to receive a vaccination. We have got things like cultural and religious beliefs especially in our county whereby you find that we have got those regions that believe that probably after a child has been born then this child is supposed to be contained in the house for some time before they are taken outside to interact with people." …(KII_MARSABIT_02).

"…Number one, like we say, capacity gaps. In this case, healthcare workers, CHPs, the community itself, people have gaps. They do not understand. And then lack of knowledge of...about the vaccines and how many losses should one take to achieve the recommended immunity or anything. Then another thing could be sometimes we fall out of stock, stock outs, but stock outs of lead have not been there unless it's now an issue with the manufacturers and all that." …(KII_NATIONAL_03).

4.5.6.3 Improving Vaccination Adherence

The sub-theme discusses measures and activities aimed at improving adherence to vaccination practices. Scaling up motivation within the support team is seen as crucial to ensure thorough sensitization of every caregiver on the importance of vaccinations and to facilitate follow-up activities at the community level. Participants proposed increasing staffing levels at healthcare facilities to mitigate disruptions in service provision caused by staff absences. Enhancing the availability of vaccine supplies emerged as another key recommendation to ensure consistent access for clients.

Moreover, respondents emphasized the importance of health education initiatives targeting caregivers to address misconceptions about vaccination, particularly regarding perceived barriers like illness. Suggestions were made to include individuals residing far from facilities in vaccination sessions, potentially through regular outreach programs funded on a monthly basis. Some participants proposed the implementation of a data synchronization system to notify healthcare workers about children due for vaccination, alongside digitizing tools in facilities for improved communication and record-keeping.

Furthermore, establishing a managerial position to oversee vaccination records, especially for nursery children, was recommended to ensure comprehensive coverage. Policy formulations mandating vaccination for pre-primary school enrollment were also suggested. Additionally, leveraging the media for health messaging targeting relevant age groups was seen as a valuable strategy to increase outreach efforts and public awareness. Below are some pieces of evidence supporting these recommendations.

"…First is just continue health education to ah to learn or tell the caregivers that sickness is not a contraindication to vaccination then aah ah we should encourage those that are far to come for vaccines or just we have to be to sustain the outreaches if funds are allow are allowed at least we go monthly on a monthly basis so that we cannot skip." …(KII_NAIROBI_01).

"…if at all probably if a child is born the we could have something like synchronizing the data so that incase probably a child is due for a vaccine, then the healthcare worker is informed. We could digitalize the what the tools that we have so that there's an alert to the healthcare workers and there is also an alert to the parents. Another thing probably integrating this aah what do we call them, the pre-primary, how is it called the "Chekechea" what is it called the nursery schools. When we probably synchronize that information, even during enrollment, then at least, aah someone from the immunization program is incorporated, just to make sure that aah to confirm whether these children have received any form of vaccination. Because we have got these children who are enrolled in baby class who are at about one month…one year. So those schools if at all we could have people they enroll then we could have someone taking the data just to ensure that our children have been vaccinated then that one will be a big plus especially for the program. Because it will ensure that everyone is covered with vaccination. Another thing aah probably as we look at that is the policy formulation. That we make vaccination to be a requirement for a child to join in the pre-primary school." …(KII_BUSIA_02).

"…also, the media can also play a very big role. If they can keep on advertising or giving health messages that are a key message concerning vaccination, which will be a great help to us to focus in on that and also increasing the outreaches." …(KII_KILIFI-02).

f) Missed Opportunities

This theme revolves around the problem of missed chances for vaccination, covering issues like why healthcare workers might not give vaccines, why caregivers might not follow through, and how we can get more people vaccinated. Comments collected shed light on why these opportunities are missed.

One big problem is that healthcare workers sometimes get worn out, especially when they have to work weekends. This can make it harder for people to come back for vaccines because they're not used to going to the doctor on weekends. Sometimes, vaccines aren't available when needed, which makes things even tougher.

Another issue is when sick children can't get their vaccines because they're too unwell. And sometimes, healthcare workers don't give all the recommended vaccines when they should, which means some children miss out. Below are some of the mentioned comments.

"Sometimes, when the child is sick, very sick, the child cannot receive the antigen when they are very ill. And sometimes, maybe the availability of the antigen, when the antigen is not present." …(KII_MARSABIT_01).

"Some health workers will not be willing to fulfill children all the recommended vaccines on time when they visit the hospital." …(KII_MARSABIT_02).

"The staff might be exhausted, may end up writing even on a weekend. So, this will even make clients not to come back. Because when a client comes, it's beingadvised to come on a weekend,

and we don't usually have services up to the weekend. We just do Monday to Friday. So that one can also make a client not to come because of the date.On a weekend or a public holiday." …(KII_ELGEYO_01).

i. Barriers to vaccination provision by Health care workers

A respondent stated that there are still some cases of negative attitudes, as they feel that when clients arrive late, vaccines cannot be administered, contributing to clients not receiving their vaccines at the required time. Some healthcare workers also feel overwhelmed by the workload, staff shortages, and a lack of knowledge among the caregivers. A significant gap between the staff working in the mother-child clinic and those in the general wards was reported. Participants said the training sessions primarily focused on the mother-child clinic personnel, leaving other staff members out, resulting in a knowledge gap, particularly regarding how to check the mother-child booklet and familiarity with the vaccine schedule. Also, many caregivers were unaware of the vaccine schedule and were harassed by the healthcare workers. Another issue mentioned was the breakdown of storage facilities such as fridges. Another concern raised was the issue of Vaccine Vial Monitors (VVM), where a client may present with vaccines, but the VVM has already changed to stage 4, rendering the vaccine unusable. Statements to prove the comments are mentioned below;

"I think the main problem there is usually workload." …(KII_BUSIA_02).

"I would still say that there are still some cases of a negative attitude. Somebody feels, ahh, you came late. Now we can't give the vaccines. So that is another reason why that can make these clients not get their vaccines at the required time." …(KII_KISUMU_01).

"…there was a very big gap between the staff who are working in the mother child clinic versus the ones who are working in the general wards. Because you realize that aah whenever we conduct things like trainings and the rest of the things, we normally concentrate in the mother child, the personnel who work in the MCHs and we normally leave out the rest of the staff. So, we realized that there was a knowledge gap because most of these staff did not really know how even to check the mother child booklet. And they saw that that was just the role that was supposed to be played by the staff in the mother child clinics. So, we could find that most of them have a knowledge gap, most of them did not even do not even know some of them do not even know the schedule, the vaccine schedule aah for the various antigens that we have. So out of that you know aah if you lack knowledge then you'll not be able to act." …(KII_BUSIA_01).

"…the other reason could be maybe they break down of the storage facilities like the fridges." …(MIGORI).

"…So, another one is the issue of VVM, as I told you earlier. A client may come and I have the vaccine, yes, with me. But the VVM has already changed to stage 4. Stage 4 is when you cannot use it completely." …(KII_ELGEYO_01).

ii. Barriers to caregiver compliance

Within this sub-theme, it was noted that certain caregivers face challenges in accessing vaccination services promptly due to the considerable distance to health facilities. Furthermore, concerns about potential side effects, such as irritability or fever in children following antigen administration, may dissuade caregivers from returning for subsequent vaccinations. Notably, respondents highlighted concerns regarding the side effects of the newly introduced malaria vaccine, with caregivers attributing any subsequent illness in their child to the vaccination.

Additionally, vaccine stock outs were identified as a significant barrier, as administering only partial doses when stock is available is deemed unacceptable. Furthermore, the risk of severe side effects, such as abscess formation due to improper injection technique, particularly with vaccines like Penta, underscores the importance of correct administration techniques and instills fear in caregivers.

Moreover, religious and cultural beliefs pose additional barriers, as reported by healthcare workers. Ignorance and misconceptions among caregivers, such as the belief that a single vaccine suffices or that vaccines are harmful, were also highlighted. Forgetfulness and concerns about healthcare workers' attitudes further compound the challenges, contributing to delayed or missed vaccinations. The following comments reflect some of the respondents thoughts.

"…Because some of them don't come at the right time because of the distance. Someone will say I will not go today because it is far let me just go tomorrow." …(KII_BUNGOMA_01).

"…Number one we look at probably the side effects aah because aah you find that aah at times you find that a child probably has received one antigen and probably the child becomes irritable, they have aah side effects. So, you find that sometimes they tend to shy away from bringing back and I think that is among the major things that are really disturbing us." …(KII_KILIFI_02).

"…for example, malaria vaccine was newly introduced. Malaria vaccine has side effects of fever. So, if someone hears that my child got sick, they use it to say they got sick. My child got sick after getting the malaria vaccine." …(KII_KISUMU_01).

"So technically a lot of it is hinged on the religious beliefs as well as some of the cultural beliefs." …(KII_MACHAKOS_04).

iii. Enhancing vaccination uptake

This sub-theme explores a range of strategies aimed at boosting vaccination uptake within communities. Insights gathered underscore the importance of optimizing staff availability at Maternal and Child Health (MCH) facilities during designated hours. Additionally, a collaborative approach among healthcare workers is advocated to ensure comprehensive screening of all children visiting these facilities.

Participants highlighted the effectiveness of sending vaccination reminders to caregivers and educating them about the significance of bringing the mother-child booklet to healthcare facilities. It was also suggested that healthcare workers conduct thorough screenings upon arrival to identify any missed antigens, thereby enhancing vaccination status. To mitigate stock outs, participants recommended that health facilities ensure they order a sufficient number of vaccines. Moreover, there was a proposal to digitalize a system that links children to a database based on their birthplace, thus facilitating the tracking of vaccination status. This would address the challenges posed by the current manual tracking system.

Education emerged as a key aspect, with emphasis placed on raising awareness among communities and policymakers about the importance of immunization. Participants highlighted immunization as a significant breakthrough in healthcare and stressed the need for prioritizing it accordingly. Furthermore, addressing staff attitudes and organizing frequent outreach programs were identified as crucial steps, particularly in reaching immunization in hard-to-reach areas. Suggestions such as home visitations and establishing a defaulting tracking mechanism were put forth to ensure enhanced uptake by effectively following up on vaccine defaulters. These reflections are highlighted in the following comment.

"Ensuring that we have always staff at the right working hours at the MCH, we would also use a collaborative approach so that all the healthcare workers are aware that we need to screen all these children once they appear at the facility." …(KII__KILIFI_01).

"I think we also have to send for them reminder messages." …(KII_NAIROBI_02).

"…educate the caregivers that when child that when they bring the child in the hospital, they should carry a mother-child booklet. Secondly when reaching the hospital, the health care worker is able to screen to go to the mother-child booklet and see which antigen the child has not gotten. Third you, aah health facility or us health facility we should ensure that we order this adequate number of vaccines dose that can sustain us to avoid stock-outs." …(KII_KIAMBU_03).

"Then staff attitude, to change attitude." …(KII_BUSIA _02).

"…And then to that education especially to the communities, education to the communities, education to the…the policy makers aah for them to ensure that immunization is really taken into consideration. Then that one will really help us because when you look at immunization eh it is among the breakthrough discoveries." …(KII_BUNGOMA_01).

"…to those hard-to-reach areas if you are able to organize outreaches, frequent outreaches you will actually get to immunize these babies fully" (KII_EMBU_01).

4.7 The effects of Non/Under-Vaccination and MOV on the Growth Rates of Children Aged 0-23 Months in Kenya for the period 2003-2014

a) Descriptive analysis of characteristics of children and mothers

The nutritional analysis used a de jure approach. This approach considers individuals who are usual residents of the household, regardless of whether they are present at the time of the survey. De jure measures are preferred when studying chronic malnutrition or when the research aims to understand the long-term nutritional status of a population, irrespective of their current presence(Corsi et al., 2017; Croft et al., 2018).Given these considerations, the sample size used in the estimation of nutritional indices for children 0-23 months of age was 2003 (n=2321), 2008/09 (n=1521) and 2014 (n=5799), leading to a total sample size of 9641.

2. Underweight

Table 4.9 provides a detailed analysis of the prevalence of underweight among children with MOV in Kenya across various demographic and socio-economic factors, spanning three survey years: 2003, 2008/09, and 2014. Each row of the table represents a specific characteristic or variable under investigation, while the columns detail the prevalence of underweight among children with MOV as a percentage along with the corresponding 95% CI for each survey year. The key variables examined include the child's vaccination (under-vaccinated, non-vaccinated and MOV), the child's sex, residence (urban or rural), maternal education level, maternal marital status, and household wealth status. The prevalence of underweight is reported for each variable across the survey years, allowing for comparisons over time and across different groups. Additionally, the sample sizes (n) for each survey year are provided, offering insights into the robustness of the estimates. Trends over time can be observed within each variable, helping to identify patterns and potential disparities in underweight prevalence among children in Kenya.

With regards to MOV, the prevalence of underweight children declined from 15.43% in 2003 to 11.83% in 2014. Among the under-vaccinated children, there was a decreasing trend in underweight prevalence from 2003 to 2014, with prevalence dropping from 13.39% to 10.28%. There was a notable decrease in underweight prevalence in non-vaccinated children from 2003 to 2008/09 (14.74% to 9.52%), followed by an increase to 13.30% in 2014. Male children consistently exhibited a higher prevalence of underweight (16.48%, 95% CI: 14.44-18.74 in 2003, 14.29%, 95% CI: 12.00-16.92 in 2008/09 and 12.79%, 95% CI: 11.63-14.05 in 2014) compared to females (11.16%, 95% CI: 9.48-13.09 in 2003, 10.72%, 95% CI: 8.68-13.17 in 2008/09 and 9.62%, 95% CI: 8.59-10.76 in 2014). Both sexes experienced a decline in prevalence over the study period. Rural areas consistently displayed higher prevalence rates compared to urban areas. While both rural and urban areas witnessed a decrease in prevalence over time, the decline was more pronounced in rural areas (15.73%, 95% CI: 14.09-17.53 in 2003, 13.31%, 95% CI: 11.47-15.39 in 2008/09 and 12.41%, 95% CI: 11.42-13.46 in 2014). Children whose mothers had no education showed a higher prevalence of underweight compared to those with primary education and above. However, prevalence decreased in both groups over the study period, with higher decline observed among children whose mothers had no education (21.25%, 95% CI: 17.70-25.29 in 2003, 18.42%, 95% CI: 14.45-23.19 in 2008/09 and 17.31%, 95% CI: 15.40-19.39 in 2014. There seems to be no clear pattern in underweight prevalence based on maternal marital status. Whereas, the prevalence of underweight was higher in 2003 and 2008/09 amongst non-married women (14.33%, 95% CI = 11.03 - 18.41 and 14.29%, 95% CI = 14.29 - 21.12 respectively), in 2014 children of married women had a higher prevalence 11.23%, 95% CI = 10.41 - 12.11) compared to those not married. Prevalence fluctuated over the years but generally decreased slightly. Children from poorer households consistently exhibited higher prevalence rates compared to those from wealthier households. Notably, there was a decrease in prevalence among children from poor households ranging from 16.63%, 95% CI: 14.79-18.65 in 2003 to 14.96%, 95% CI: 12.83-17.36) in 2008/09 to 13.11%, 95% CI: 12.14-14.15 in 2014.

Table 4.9: Prevalence of underweight over children and mothers' characteristics

Variable	Underweight Prevalence % (95%CI)		
	2003(n=2321)	2008/09(n=1521)	2014(n=5799)
MOV			
Yes	15.43(12.55-18.83)	14.43(11.59-17.82)	11.83 (10.53-13.26)
No	13.32(11.83-14.97)	11.66(9.84-13.77)	10.87 (9.90-11.92)
Under-vaccinated			
Yes	13.39(11.60-15.41)	11.40(9.35-13.82)	10.28 (9.25-11.42)
No	14.23(12.28-16.44)	13.78(11.48-16.46)	12.24(11.08-13.51)
Non-vaccinated			
Yes	14.74(11.36-18.94)	9.52(5.20-16.81)	13.3 (9.40-18.49)
No	13.62(12.18-15.21)	12.78(11.14-14.63)	11.14(10.35-12.00)
Sex			
Male	16.48(14.44-18.74)	14.29(12.00-16.92)	12.79(11.63-14.05)
Female	11.16(9.48-13.09)	10.72(8.68-13.17)	9.62(8.59-10.76)
Residence			
Rural	15.73(14.09-17.53)	13.31(11.47-15.39)	12.41(11.42-13.46)
Urban	8.11(6.16-10.60)	10.16(7.45-13.72)	8.55(7.34-9.95)
Maternal education			
No education	21.25(17.70-25.290)	18.42(14.45-23.19)	17.31(15.40-19.39)
Primary and above	12.01(10.61-13.56)	11.09(9.45-12.99)	9.33(8.50-10.22)
Maternal marital status			
Married	13.69(12.24-15.28)	12.38(10.75-14.23)	11.23(10.41-12.11)
Not married	14.33(11.03-18.41)	14.29(9.40-21.12)	11.15(8.72-14.16)
Wealth status			
Poor	16.63(14.79-18.65)	14.96(12.83-17.36)	13.11(12.14-14.15)
Not poor	9.16(7.43-11.25)	8.50(6.46-11.10)	5.58 (4.51-6.89)

3. Wasting

Table 4.10 provides a detailed analysis of the prevalence of wasting among children with MOV in Kenya across various demographic and socio-economic factors, spanning three survey years: 2003, 2008/09, and 2014. Each row of the table represents a specific characteristic or variable under investigation, while the columns detail the prevalence of wasting among children with MOV as a percentage along with the corresponding 95% CI for each survey year. The key variables examined include the child's vaccination (under-vaccinated, non-vaccinated and MOV), the child's sex, residence (urban or rural), maternal education level, maternal marital status, and household wealth status. The prevalence of wasting is reported for each variable across the survey years, allowing for comparisons over time and across different groups. Additionally, the sample sizes (n) for each survey year are provided, offering insights into the robustness of the estimates. Trends over time can be observed within each variable, helping to identify patterns and potential disparities in underweight prevalence among children in Kenya.

The results as provided in Table 4.10 outlines the prevalence of wasting among children, stratified across various factors and years. Children with MOV generally showed higher prevalence of wasting that also fluctuated over time. There was a lower prevalence observed in 2014 (6.73%, 95% CI: 5.74-7.86) compared to 2008/09 (13.21%, 95% CI: 10.49-16.50). Under-vaccinated children and consistently exhibited higher prevalence rates (9.74%, 95% CI: 8.20-11.53 in 2003, 10.24%, 95% CI: 8.30-12.58 in 2008/09 and 7.09%, 95% CI: 6.22-8.06 in 2014) compared to those not under-vaccinated (9.55%, 95% CI: 7.94-11.45 in 2003,8.51%, 95% CI: 6.71-10.75 in 2008/09 and 6.05%, 95% CI: 5.22-7.00 in 2014). The prevalence of underweight was equally higher in those who were non-vaccinated (13.27%, 95% CI: 10.06-17.32 in 2003, 14.29%, 95% CI: 8.80-22.36 in 2008/09 and 9.17%, 95% CI: 5.99-13.79 in 2014) compared to those who were vaccinated (9.03%, 95% CI: 7.85-10.38 in 2003, 9.04%, 95% CI: 7.65-10.65 in 2008/09 and 6.49%, 95% CI: 5.87-7.16 in 2014). Males generally showed a higher prevalence of wasting (10.72%, 95% CI: 9.06-12.65 in 2003, 10.33%, 95% CI: 8.39-12.67 in 2008/09 and 7.45%, 95% CI: 6.55-8.46 in 2014) compared to females (8.60%, 95% CI: 7.13-10.35 in 2003, 8.41%, 95% CI: 6.61-10.65 in 2008/09 and 5.70%, 95% CI: 4.91-6.61) across all three years. Both males and females experienced a decrease in prevalence over time, with females consistently exhibiting lower prevalence rates. Rural areas generally had higher prevalence rates (10.24%, 95% CI: 8.89-11.76 in 2003, 9.59%, 95% CI: 8.02-11.43 in 2008/09 and 6.99%, 95%

CI: 6.24-7.82) compared to urban areas (7.94%, 95% CI: 6.02-10.41 in 2003, 8.79%, 95% CI: 6.28-12.17 in 2008/09 and 5.68%, 95% CI: 4.70-6.86) across all three years. The prevalence decreased over time for both rural and urban areas, with a larger decrease observed in rural areas. Children whose mothers had no education consistently exhibited higher prevalence rates (16.33%, 95% CI: 13.18-20.05 in 2003, 17.43%, 95% CI: 13.57-22.12 in 2008/09 and 11.80%, 95% CI: 10.20-13.61 in 2014) compared to those whose mothers had primary education and above (8.06%, 95% CI: 6.91-9.38 in 2003, 7.40%, 95% CI: 6.05-9.01 in 2008/09 and 4.96%, 95% CI: 4.35-5.64 in 2014). The prevalence decreased over time for both groups, with a larger decrease observed among children whose mothers had primary education and above. The wasting prevalence analysis based on maternal marital status indicates relatively stable rates over time, with children of married mothers showing prevalence rates of 9.89% (95% CI: 8.65-11.29), 9.49% (95% CI: 8.05-11.15), and 6.48% (95% CI: 5.85-7.18) in 2003, 2008/09, and 2014, respectively. Conversely, children of unmarried mothers exhibited prevalence rates of 8.31% (95% CI: 5.83-11.70), 8.57% (95% CI: 4.93-14.49), and 7.69% (95% CI: 5.69-10.32) during the same periods, indicating a comparatively smaller reduction in wasting prevalence by 2014. In contrast, the analysis based on wealth status demonstrates a consistent trend of higher wasting prevalence among children from poorer households, with prevalence rates of 11.27% (95% CI: 9.74-13.02), 10.46% (95% CI: 8.67-12.57), and 7.31% (95% CI: 6.58-8.13) for poor households and 7.01% (95% CI: 5.51-8.90), 7.61% (95% CI: 5.69-10.11), and 4.41% (95% CI: 3.47-5.60) for non-poor households in 2003, 2008/09, and 2014, respectively.

Table 4.10: Prevalence of wasting over children and mothers' characteristics

Variable	Wasting Prevalence % (95%CI)		
	2003(n=2321)	2008/09 (n=1521)	2014(n=5799)
MOV			
Yes	10.35(7.99-13.30)	13.21(10.49-16.50)	6.73(5.74-7.86)
No	9.45(8.19-10.89)	7.58(6.11-9.37)	6.51(5.75-7.35)
Under-vaccinated			
Yes	9.74(8.20-11.53)	10.24(8.30-12.58)	7.09 (6.22-8.06)
No	9.55(7.94-11.45)	8.51(6.71-10.75)	6.05(5.22-7.00)
Non-vaccinated			
Yes	13.27(10.06-17.32)	14.29(8.80-22.36)	9.17(5.99-13.79)
No	9.03(7.85-10.38)	9.04(7.65-10.65)	6.49(5.87-7.16)
Sex			
Male	10.72(9.06-12.65)	10.33(8.39-12.67)	7.45(6.55-8.46)
Female	8.60(7.13-10.35)	8.41(6.61-10.65)	5.70(4.91-6.61)
Residence			
Rural	10.24(8.89-11.76)	9.59(8.02-11.43)	6.99(6.24-7.82)
urban	7.94(6.02-10.41)	8.79(6.28-12.17)	5.68(4.70-6.86)
Maternal education			
no education	16.33(13.18-20.05)	17.43(13.57-22.12)	11.80(10.20-13.61)
primary and above	8.06(6.91-9.38)	7.40(6.05-9.01)	4.96(4.35-5.64)
Maternal marital status			
Married	9.89(8.65-11.29)	9.49(8.05-11.15)	6.48(5.85-7.18)
Not married	8.31(5.83-11.70)	8.57(4.93-14.49)	7.69(5.69-10.32)
Wealth status			
Poor	11.27(9.74-13.02)	10.46(8.67-12.57)	7.31(6.58-8.13)
Not poor	7.01(5.51-8.90)	7.61(5.69-10.11)	4.41 (3.47-5.60)

4. Stunting

Table 4.11 provides a detailed analysis of the prevalence of stunting among children with MOV in Kenya across various demographic and socio-economic factors, spanning three survey years: 2003, 2008/09, and 2014. Each row of the table represents a specific characteristic or variable under investigation, while the columns detail the prevalence of stunting among children with MOV as a percentage along with the corresponding 95% CI for each survey year. The key variables examined include the child's vaccination (under-vaccinated, non-vaccinated and MOV), the child's sex, residence (urban or rural), maternal education level, maternal marital status, and household wealth status. The prevalence of stunting is reported for each variable across the survey years, allowing for comparisons over time and across different groups. Additionally, the sample sizes (n) for each survey year are provided, offering insights into the robustness of the estimates. Trends over time can be observed within each variable, helping to identify patterns and potential disparities in underweight prevalence among children in Kenya.

Children experiencing MOV demonstrated slightly lower prevalence rates of stunting compared to those without missed opportunities, with rates ranging from 26.37% (95% CI = 22.73-30.36) to 23.01% (95% CI = 21.28-24.83) between 2003 and 2014, respectively. Conversely, under-vaccinated children exhibited higher prevalence rates of stunting, ranging from 23.70% (95% CI = 21.41-26.16) to 18.04% (95% CI = 16.70-19.45) across the years. Non-vaccinated children displayed varying rates of stunting, showing no clear trend over the studied period with lower rates in 2003; 25.66% (95% CI=21.29-30.58), in 2008/09; 23.82% (95% CI=16.62-32.88) and higher rates in 2014; 25.69% (95% CI= 20.32-31.90) compared vaccinated children.

Male children consistently exhibited higher rates of stunting compared to females across all years, with prevalence rates ranging from 31.12% (95% CI = 28.51-33.87) to 26.77% (95% CI = 25.20-28.40). Children residing in rural areas had higher rates, ranging from 29.55% (95% CI=27.45-31.75) in 2003 to 24.47% (95% CI=23.16-25.82) in 2014. Similarly, children from households with poor wealth status had higher prevalence rates of stunting across the years compared to those from wealthier families, with rates ranging from 30.06% (95% CI=27.75-32.49) to 24.98% (95% CI=23.71-26.29).

Children born to mothers with no education exhibited slightly lower rates of stunting, ranging from 26.17% (95% CI = 22.31-30.45) to 24.76% (95% CI = 22.56-27.11) compared to those whose mothers have attained primary education and above, where prevalence rates range from 27.37% (95% CI = 25.40-29.44) in 2003 to 22.27% (95% CI = 21.07-23.52) in 2014. Moreover, maternal marital status is another influential factor, with children born to mothers in marriage showing slightly higher prevalence rates of stunting in 2003; 27.69% (95% CI=25,76-29.71), in 2008/09; 31.79% (95% CI=29.38-34.30) and lower rates in 2014; 22.85% (95% CI=21.75-24.00) compared to those born by unmarried.

Table 4.11: Prevalence of stunting over children and mothers' characteristics

Variable	Stunting Prevalence % (95%CI)		
	2003(n=2321)	2008(n=1521)	2014(n=5799)
MOV			
Yes	26.37(22.73-30.36)	29.67(25.80-33.87)	23.01(21.28-24.83)
No	27.36(25.36-29.47)	32.17(29.38-35.09)	22.78(21.45-24.17)
Under-vaccinated			
Yes	23.70(21.41-26.16)	24.71(21.81-27.86)	18.04 (16.70-19.45)
No	31.04(28.36-33.85)	38.38(34.94-41.94)	28.06(26.42-29.76)
Non-vaccinated			
Yes	25.66(21.29-30.58)	23.81(16.62-32.88)	25.69 (20.32-31.90)
No	27.40(25.48-29.40)	31.92(29.54-34.40)	22.76(21.67-23.87)
Sex			
Male	31.12(28.51-33.87)	34.82(31.56-38.23)	26.77(25.20-28.40)
Female	23.25(20.92-25.76)	27.68(24.57-31.03)	18.85(17.46-20.33)
Residence			
Rural	29.55(27.45-31.75)	31.37(28.76-34.11)	24.47(23.16-25.82)
urban	20.10(17.06-23.53)	31.32(26.76-36.27)	19.25(17.48-21.15)
Maternal education			
no education	26.17(2.31-30.45)	30.92(25.98-36.35)	24.76(22.56-27.11)
primary and above	27.37(25.40-29.44)	31.47(28.92-34.14)	22.27(21.07-23.52)
Maternal marital status			
Married	27.69(25.76-29.71)	31.79(29.38-34.30)	22.85(21.73-24.00)
Not married	24.07(19.87-28.84)	27.14(20.42-35.10)	23.08(19.65-26.90)
Wealth status			
Poor	30.06(27.75-32.49)	33.16(30.24-36.21)	24.98(23.71-26.29)
Not poor	22.40(19.77-25.27)	28.32(24.75-32.18)	16.54 (14.72-18.54)

b) Mixed effect multi-level linear regression model of effect of non/under-vaccination and MOV on WAZ

1. Missed opportunity for Vaccination

Table 4.12 presents results from a mixed effect multi-level linear regression model examining the effect of MOV on WAZ among children in Kenya across three survey years (2003, 2008/09, and 2014), with respective sample sizes indicated. Each row delineates a specific variable, including MOV, age, sex, residence (rural), maternal education level, maternal marital status, and wealth status, with coefficients, 95% Confidence Intervals (CI), and *P*- value values provided. Negative coefficients suggest a negative association with WAZ, while positive coefficients indicate a positive association. The table contrasts unadjusted and adjusted coefficients for MOV, enabling comparisons before and after considering other variables. It offers insights into the impact of MOV on WAZ, alongside the influence of demographic and socio-economic factors on child nutritional status in Kenya over the period.

This analysis revealed that MOV exhibited varied associations with WAZ across the study years. In the unadjusted model, MOV was negatively associated with WAZ in 2003 (Coeff = -0.24, 95% CI [-0.38, -0.09], P=0.001), insignificantly associated in 2008/09 (Coeff = 0.01, 95% CI [-0.29, 0.32], P= 0.948), and marginally insignificant in 2014 (Coeff = -0.07, 95% CI [-0.16, 0.03], P= 0.162). After adjusting for covariates, the negative association between MOV and WAZ persisted in 2003 (Coeff = -0.25, 95% CI [-0.39, -0.113], P< 0.001) and 2014 (Coeff = -0.071, 95% CI [-0.167, 0.023], P= 0.140), while remaining statistically insignificant in 2008/09 (Coeff = 0.09, 95% CI [-0.21, 0.40], P= 0.554).

Several demographic and socioeconomic factors also demonstrated significant associations with WAZ. Age exhibited a negative association with WAZ, with statistically significant coefficients for both linear and squared terms across all study years (P< 0.001). Female sex was positively associated with WAZ across all study years (P< 0.05). Maternal education level and wealth status were negatively associated with WAZ in 2003 and 2014 (P< 0.001), indicating that higher maternal education and wealth were associated with higher child WAZ.

Table 4.12: Mixed effect multi-level linear regression model of the effect of MOV on WAZ

Variable	2003 (n=2,321)			2008/09 (n =1,521)			2014 (n = 5,799)		
	Coeff	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**
MOV (Un-adjusted)	-0.24	-0.38, -0.09	**0.001**	0.01	-0.29, 0.32	0.948	-0.07	-0.16, 0.03	0.162
MOV (Adjusted)	-0.25	-0.39, -0.11	**<0.001**	0.09	-0.21, 0.40	0.554	-0.07	-0.17, 0.02	0.140
Age	-0.08	-0.12, -0.05	**<0.001**	-0.23	-0.31, -0.14	**<0.001**	-0.13	-0.15, -0.10	**<0.001**
Age squared	0.00*	0.00* , 0.00*	**0.045**	0.00*	0.00*, 0.01	**<0.001**	0.00*	0.00*, 0.00*	**<0.001**
Sex (female)	0.24	0.12, 0.35	**<0.001**	0.35	0.07, 0.63	**0.016**	0.11	0.02, 0.20	**0.016**
Residence (Rural)	-0.27	-0.43, -0.10	**0.001**	-0.35	-0.78, 0.09	0.116	-0.03	-0.15, 0.08	0.565
Maternal education (No-education)	-0.44	-0.60, -0.28	**<0.001**	-0.32	-0.69, 0.05	0.085	-0.20	-0.31, -0.09	**<0.001**
Maternal marital status (Marrried)	-0.04	-0.19, 0 .11	0.602	0.31	-0.18, 0.81	0.208	0.10	-0.06 , 0.26	0.220
Wealth status (Poor)	-0.29	-0.44, -0.14	**<0.001**	-0.24	-0.63, 0.16	0.238	-0.37	-0.49, -0.25	**<0.001**

*Truncated at 2 decimal points

2. Under-vaccination

Table 4.13 presents results from a mixed effect multi-level linear regression model examining the effect of under-vaccination on Weight-for-Age Z-score (WAZ) among children in Kenya across three survey years (2003, 2008/09, and 2014), with respective sample sizes indicated. Each row delineates a specific variable, including under-vaccination, age, sex, residence (rural), maternal education level, maternal marital status, and wealth status, with coefficients, 95% Confidence Intervals (CI), and p-values provided. Negative coefficients suggest a negative association with WAZ, while positive coefficients indicate a positive association. The table contrasts unadjusted and adjusted coefficients for under-vaccination, enabling comparisons before and after considering other variables. It offers insights into the impact of under-vaccination on WAZ, alongside the influence of demographic and socio-economic factors on child nutritional status in Kenya over the period

Under-vaccination status demonstrated varying associations with WAZ across the study years. In the unadjusted model, under-vaccination showed a non-significant association with WAZ in 2003 (Coeff = -0.06, 95% CI [-0.19, 0.07], P= 0.380). However, in 2008/09 and 2014, under-vaccination was significantly associated with lower WAZ scores (Coeff = -0.49, 95% CI [-0.82, -0.16], P= 0.004; Coeff = -0.23, 95% CI [-0.34, -0.12], P< 0.001, respectively). After adjusting for covariates, under-vaccination remained significantly associated with lower WAZ scores in 2008/09 (Coeff = -0.45, 95% CI [-0.78, -0.13], P= 0.007) and 2014 (Coeff = -0.20, 95% CI [-0.30, -0.09], P< 0.001), although the association in 2003 remained non-significant (Coeff = -0.08, 95% CI [-0.21, 0.04], P= 0.220).

Several demographic and socioeconomic factors also exhibited significant associations with WAZ. Age showed a consistent negative association with WAZ across all study years (P<0.001). Female sex was positively associated with WAZ across all study years (P< 0.05). Maternal education level and wealth status were negatively associated with WAZ in 2003 and 2014 (P< 0.001), indicating that higher maternal education and wealth were associated with higher child WAZ.

Table 4.13: Mixed effect multi-level linear regression model of the effect of under-vaccination on WAZ

Variable	2003 (n=2,321)			2008/09 (n =1,521)			2014 (n = 5,799)		
	Coeff	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**
Under-vaccination (un-adjusted)	-0.06	-0.19, 0.07	0.380	-0.49	-0.82, -0.16	**0.004**	-0.23	-0.34, -0.12	**<0.001**
Under-vaccination (Adjusted)	-0.08	-0.21, 0.04	0.220	-0.45	-0.78, -0.13	**0.007**	-0.20	-0.30 -0.09	**<0.001**
Age	-0.09	-0.12, -0.05	**<0.001**	-0.24	-0.33 -0.16	**<0.001**	-0.14	-0.17, -0.11	**<0.001**
Age squared	0.00*	0.00*, 0.00*	0.034	0.007	0.00* , 0.01	**<0.001**	0.00*	0.00*, 0.00*	**<0.001**
Sex (Female)	0.24	0.12, 0 .36	**<0.001**	0.34	0.06, 0.63	**0.017**	0.11	0.02, 0.20	**0.016**
Residence (Rural)	-0.26	-0.42, -0.10	**0.002**	-0.34	-0.77, 0.09	0.118	-0.04	-0.15, 0.08	0.529
Maternal education (No education)	-0.43	-0.59, -0.28	**<0.001**	-0.30	-0.67, 0.07	0.110	-0.18	-0.29, -0.07	**0.001**
Maternal marital status (Married)	-0.03	-0.19, 0.12	0.668	0.31	-0.18, 0.80	0.210	0.10	-0.06, 0.26	0.215
Wealth status (Poor)	-0.30	-0.45, -0.15	**<0.001**	-0.22	-0.61, 0.17	0.274	-0.36	-0.48, -0.24	**<0.001**

*Truncated at 2 decimal points

3. Non-vaccination

Table 4.14 presents results from a mixed effect multi-level linear regression model examining the effect of non-vaccination on Weight-for-Age Z-score (WAZ) among children in Kenya across three survey years (2003, 2008/09, and 2014), with respective sample sizes indicated. Each row delineates a specific variable, including non-vaccination, age, sex, residence (rural), maternal education level, maternal marital status, and wealth status, with coefficients, 95% Confidence Intervals (CI), and *P*-values provided. Negative coefficients suggest a negative association with WAZ, while positive coefficients indicate a positive association. The table contrasts unadjusted and adjusted coefficients for non-vaccination, enabling comparisons before and after considering other variables. It offers insights into the impact of non-vaccination on WAZ, alongside the influence of demographic and socio-economic factors on child nutritional status in Kenya over the period.

Non-vaccination status exhibited a significant association with WAZ across the study years. In the unadjusted model, non-vaccination was negatively associated with WAZ in 2003 (Coeff = -0.43, 95% CI [-0.61, -0.25], $P< 0.001$) and positively associated in 2008 (Coeff = 0.85, 95% CI [0.28, 1.43], $P= 0.004$). However, by 2014, the association became statistically insignificant (Coeff = 0.12, 95% CI [-0.12, 0.37], $P= 0.325$). After adjusting for covariates, the association between non-vaccination and WAZ remained significant throughout the study period. Specifically, the adjusted model revealed a positive association in 2003 (Coeff = 2.16, 95% CI [0.95, 3.37], $P<0.001$) and 2008 (Coeff = 1.00, 95% CI [0.39, 1.61], $P= 0.001$), while in 2014, the association remained positive but attenuated (Coeff = 0.30, 95% CI [0.06, 0.56], $P= 0.017$).

Other demographic and socioeconomic factors also demonstrated significant associations with WAZ. Age exhibited a negative association with WAZ, with statistically significant coefficients for both linear and squared terms in both 2003 and 2014 ($P< 0.001$). Female sex was associated with higher WAZ in 2003 (Coeff = 0.08, 95% CI [-0.69, 0.85], $P= 0.835$) and 2008 (Coeff = 0.29, 95% CI [-0.01, 0.58], $P= 0.055$), whereas in 2014, the association became statistically significant (Coeff = 0.11, 95% CI [0.02, 0.20], $P= 0.015$). Maternal education level, marital status, and wealth status also demonstrated significant associations with WAZ in 2008 and 2014.

Table 4.14: Mixed effect multi-level linear regression model of the effect of Non-vaccination on WAZ

Variable	2003 (n=2,321)			2008 (n =1,521)			2014 (n = 5,799)		
	Coeff	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**
Non-vaccination (unadjusted)	-0.43	-0.61, -0.25	**<0.001**	0.85	0.28, 1.43	**0.004**	0.12	-0.12, 0.37	0.325
Non-vaccination (Adjusted)	2.16	0.95, 3.37	**<0.001**	1.00	0.39, 1.61	**0.001**	0.30	0.06, 0.56	0.017
Age	-0.70	-0.93, -0.47	**<0.001**	-0.10	-019, -0.01	**0.024**	-0.12	-0.15, -0.09	**<0.001**
Age squared	0.02	0.02 , 0.03	**<0.001**	0.00*	0.00*, 0.01	**0.045**	0.00*	0.00*, 0.00*	**<0.001**
Sex (Female)	0.08	-0.69, 0.85	0.835	0.29	-0.01, 0.58	0.055	0.11	0.02, 0.20	**0.015**
Residence (Rural)	0.50	-0.59 , 1.58	0.368	-0.21	-0.66, 0.24	0.363	-0.04	-0.15, 0.08	0.513
Maternal education (No education)	-0.17	-1.23, 0 .88	0.746	-0.59	-0.97, -0.20	**0.003**	-0.21	-0.33, -0.10	**<0.001**
Maternal marital status (Married)	0.36	-0.63, 1.36	0.473	0.32	-0.19, 0.83	0.219	0.10	-0.06, 0.26	0.223
Wealth status (Poor)	-0.41	-1.40, 0.58	0.419	-0.21	-0.62, 0.20	0.318	-0.38	-0.50, -0.26	**<0.001**

*Truncated at 2 decimal points

c) Mixed effect multi-level linear regression model of the effect ofnon/ under-vaccination and MOV on HAZ

1. Missed opportunity for Vaccination

Table 4.15 presents results from a mixed effect multi-level linear regression model examining the effect of MOV on Height-for-Age Z-score (HAZ) among children in Kenya across three survey years (2003, 2008/09, and 2014), with respective sample sizes indicated. Each row delineates a specific variable, including MOV, age, sex, residence (rural), maternal education level, maternal marital status, and wealth status, with coefficients, 95% Confidence Intervals (CI), and *P*-values provided. Negative coefficients suggest a negative association with HAZ, while positive coefficients indicate a positive association. The table contrasts unadjusted and adjusted coefficients for MOV, enabling comparisons before and after considering other variables. It offers insights into the impact of MOV on HAZ, alongside the influence of demographic and socio-economic factors on child nutritional status in Kenya over the period.

The unadjusted model revealed non-significant associations between MOV and HAZ across all study years. In 2003, MOV showed a coefficient of -0.14 (95% CI [-0.40, 0.12], $P= 0.298$), in 2008, a coefficient of 0.21 (95% CI [-0.12, 0.54], $P=0.220$), and in 2014, a coefficient of 0.02 (95% CI [-0.09, 0.12], $P= 0.774$). After adjusting for covariates, the association between MOV and HAZ remained non-significant in 2003 (Coeff = -0.13, 95% CI [-0.39, 0.13], $P= 0.324$), in 2014 (Coeff = 0.05, 95% CI [-0.06, 0.15], $P= 0.369$)and 2014(Coeff = 0.28, 95% CI [-0.06, 0.61], $P= 0.104$).

Several demographic and socioeconomic factors exhibited significant associations with HAZ. Age showed a consistent negative association with HAZ across all study years ($P< 0.001$). Female sex was positively associated with HAZ across all study years ($P< 0.05$). Residence in rural areas was negatively associated with HAZ in 2003 and 2008 ($P< 0.05$), but not in 2014. Maternal education level was positively associated with HAZ in 2003 and 2014 ($P< 0.05$), while wealth status exhibited a negative association with HAZ across all study years ($P< 0.001$).

Table 4.15: Mixed effect multi-level linear regression model of the effect of MOV on HAZ

Variables	2003 (2,321)			2008 (n =1,521)			2014 (n = 5,799)		
	Coeff	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**
MOV (unadjusted)	-0.14	-0.40, 0.12	0.298	0.21	-0.12, 0.54	0.220	0.02	-0.09, 0.12	0.774
MOV (Adjusted)	-0.13	-0.39, 0.13	0.324	0.28	-0.06, 0.61	0.104	0.05	-0.06, 0.15	0.369
Age	-0.08	-0.14, -0.02	**0.015**	-0.29	-0.38, -0.20	**<0.001**	-0.09	-0.12, -0.06	**<0.001**
Age squared	-0.00*	-.00*, 0.00*	0.361	0.01	0.00*, 0.02	**<0.001**	0.00*	-0.00*, 0.00*	0.211
Sex (Female)	0.32	0.11, 0.54	**0.004**	0.35	0.04, 0.65	**0.027**	0.22	0.12, 0.32	**<0.001**
Residence (Rural)	-0.46	-0.77, -0.15	**0.004**	-0.46	-0.92, 0.01	0.056	-0.10	-0.22, 0.03	0.124
Maternal education (No education)	0.30	0.01, 0.59	0.045	0.04	-0.36, 0.45	0.828	0.23	0.11, 0.36	**<0.001**
Maternal marital status (Married)	0.13	-0.15, 0.41	0.368	0.16	-0.37, 0.69	0.553	0.06	-0.11, 0.24	0.472
Wealth status (Poor)	-0.06	-0.34, 0.22	0.66	-0.25	-0.67, 0.18	0.253	-0.36	-0.50, -0.23	**<0.001**

*Truncated at 2 decimal points

2. Under-vaccination

Table 4.16 presents results from a mixed effect multi-level linear regression model examining the effect of under-vaccination on Height-for-Age Z-score (HAZ) among children in Kenya across three survey years (2003, 2008/09, and 2014), with respective sample sizes indicated. Each row delineates a specific variable, including under-vaccination, age, sex, residence (rural), maternal education level, maternal marital status, and wealth status, with coefficients, 95% Confidence Intervals (CI), and *P*-values provided. Negative coefficients suggest a negative association with HAZ, while positive coefficients indicate a positive association. The table contrasts unadjusted and adjusted coefficients for under-vaccination, enabling comparisons before and after considering other variables. It offers insights into the impact of under-vaccination on HAZ, alongside the influence of demographic and socio-economic factors on child nutritional status in Kenya over the period.

In the unadjusted model, under-vaccination status did not show a significant association with HAZ across all study years. In 2003, the coefficient for under-vaccination was -0.01 (95% CI [-0.24, 0.23], $P = 0.961$), in 2008, the coefficient was -0.37 (95% CI [-0.72, -0.01], $P = 0.045$), and in 2014, the coefficient was -0.08 (95% CI [-0.20, 0.04], $P = 0.219$). After adjusting for covariates, the association between under-vaccination and HAZ remained non-significant in all study years. The adjusted coefficients were -0.00 (95% CI [-0.24, 0.23], $P = 0.987$) for 2003, -0.35 (95% CI [-0.70, 0.01], $P = 0.057$) for 2008, and -0.06 (95% CI [-0.18, 0.06], $P = 0.356$) for 2014.

Several demographic and socioeconomic factors demonstrated significant associations with HAZ. Age exhibited a consistent negative association with HAZ across all study years ($P < 0.001$). Female sex was positively associated with HAZ across all study years ($P < 0.001$). Residence in rural areas showed a negative association with HAZ in 2003 and 2008 ($P < 0.05$), but not in 2014. Maternal education level was positively associated with HAZ in 2003 and 2014 ($P < 0.05$), while wealth status exhibited a negative association with HAZ across all study years ($P < 0.001$).

Table 4.16: Mixed effect multi-level linear regression model of the effect of Under-vaccination on HAZ

Variables	2003 (2,321)			2008 (n =1,521)			2014 (n = 5,799)		
	Coeff	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**
Under-vaccination (unadjusted)	-0.01	-0.24, 0.23	0.961	-0.37	-0.72, -0.01	**0.045**	-0.08	-0.20, 0.04	0.219
Under-vaccination (Adjusted)	-0.00	-0.24, 0.23	0.987	-0.35	-0.70, 0.01	0.057	-0.06	-0.18, 0.06	0.356
Age	-0.08	-0.14, -0.02	**0.013**	-0.30	-0.40, -0.21	**<0.001**	-0.09	-0.12, -0.06	**<0.001**
Age squared	-0.00*	-0.00*, 0.00*	0.396	0.01	0.00*, 0.01	**<0.001**	0.00*	0.00*, 0.00*	0.222
Sex (Female)	0.33	0.11, 0.54	**0.003**	0.34	0.04, 0.65	**0.028**	0.21	0.11, 0.31	**<0.001**
Residence (Rural)	-0.45	-0.76, -0.14	**0.004**	-0.45	-0.92, 0.02	0.059	-0.10	-0.22, 0.03	0.127
Education (No education)	0.30	0.01, 0.60	**0.041**	0.07	-0.33, 0.48	0.717	0.23	0.23, 0.35	**<0.001**
Maternal marital status (Marrried)	0.13	-0.15, 0.41	0.364	0.16	-0.37, 0.69	0.551	0.06	-0.11, 0.24	0.472
Wealth status (Poor)	-0.07	-0.35, 0.21	0.637	-0.21	-0.64, 0.21	0.325	-0.36	-0.50, -0.22	**<0.001**

*Truncated at 2 decimal points

3. Non-vaccination

Table 4.17 presents results from a mixed effect multi-level linear regression model examining the effect of non-vaccination on Height-for-Age Z-score (HAZ) among children in Kenya across three survey years (2003, 2008/09, and 2014), with respective sample sizes indicated. Each row delineates a specific variable, including non-vaccination, age, sex, residence (rural), maternal education level, maternal marital status, and wealth status, with coefficients, 95% Confidence Intervals (CI), and *P*- values provided. Negative coefficients suggest a negative association with HAZ, while positive coefficients indicate a positive association. The table contrasts unadjusted and adjusted coefficients for non-vaccination, enabling comparisons before and after considering other variables. It offers insights into the impact of non-vaccination on HAZ, alongside the influence of demographic and socio-economic factors on child nutritional status in Kenya over the period.

In the unadjusted model, non-vaccination status exhibited significant associations with HAZ in 2003 and 2008. Specifically, in 2003, non-vaccination was associated with a decrease in HAZ with a coefficient of -0.43 (95% CI [-0.76, -0.10], $P = 0.012$), while in 2008, it was associated with an increase in HAZ with a coefficient of 0.81 (95% CI [0.18, 1.44], $P = 0.011$). However, in 2014, non-vaccination did not show a significant association with HAZ (Coeff = 0.08, 95% CI [-0.19, 0.35], $P=0.571$).After adjusting for covariates, the association between non-vaccination and HAZ remained significant in 2003 and 2008. In 2003, the adjusted coefficient was -0.49 (95% CI [-0.84, -0.15], $P = 0.005$), and in 2008, it was 0.91 (95% CI [0.28, 1.55], $P = 0.004$). However, similar to the unadjusted model, no significant association was observed in 2014 (Coeff = 0.08, 95% CI [-0.20, 0.36], $P = 0.56$).

Several demographic and socioeconomic factors showed significant associations with HAZ. Age exhibited a consistent negative association with HAZ across all study years ($P < 0.001$). Female sex was positively associated with HAZ across all study years ($P<0.05$). Residence in rural areas showed a negative association with HAZ in 2003 and 2008 ($P < 0.05$), but not in 2014. Maternal education level was positively associated with HAZ in 2003 and 2014 ($P < 0.05$), while wealth status exhibited a negative association with HAZ across all study years ($P < 0.001$).

Table 4.17: Mixed effect multi-level linear regression model of the effect of Non-Vaccination on HAZ

Variables	2003 (2,321)			2008 (n =1,521)			2014 (n = 5,799)		
	Coeff	95%CI	*P*-value	Coeff	95%CI	*P*-value	Coeff	95%CI	*P*-value
Non-vaccination (unadjusted)	-0.43	-0.76, -0.10	**0.012**	0.81	0.18, 1.44	**0.011**	0.08	-0.19, 0.35	0.571
Non-vaccination (Adjusted)	-0.49	-0.84, -0.15	**0.005**	0.91	0.28, 1.55	**0.004**	0.08	-0.20, 0.36	0.56
Age	-0.10	-0.17, -0.04	**0.002**	-0.26	-0.35, -0.17	**<0.001**	-0.09	-0.12, -0.06	**<0.001**
Age squared	-0.00*	-0.00*, 0.00*	0.785	0.01	0.00*, 0.01	**0.001**	0.00*	-0.00*, 0.00*	0.302
Sex (Female)	0.33	0 .11, 0.54	**<0.001**	0.34	0.03, 0.65	**0.031**	0.21	0.11, 0.31	**<0.001**
Residence (Rural)	-0.45	-0.75, -0.14	**0.004**	-0.44	-0.91, 0.02	0.062	-0.10	-0.22,0.03	0.126
Education (No education)	0.41	0.11, 0.70	**0.008**	-0.00	-0.40, 0.40	0.995	0.22	0.10, 0.35	**<0.001**
Maternal marital status (Marrried)	0.13	-0.15, 0.41	0.367	0.17	-0.37, 0.70	0.539	0.06	-0.11, 0.24	0.476
Wealth status (Poor)	-0.03	-0.31, 0.25	0.808	-0.27	-0.69, 0.16	0.218	-0.36	-0.50, -0.23	**<0.001**

*Truncated at 2 decimal points

d) Mixed effect multi-level linear regression model of the effect of non/ under-vaccination and MOV on WHZ

1. Missed opportunities for vaccination

Table 4.18 presents results from a mixed effect multi-level linear regression model examining the effect of MOV on Weight-for-Height Z-score (WHZ) among children in Kenya across three survey years (2003, 2008/09, and 2014), with respective sample sizes indicated. Each row delineates a specific variable, including MOV, age, sex, residence (rural), maternal education level, maternal marital status, and wealth status, with coefficients, 95% Confidence Intervals (CI), and *P*- values provided. Negative coefficients suggest a negative association with WHZ, while positive coefficients indicate a positive association. The table contrasts unadjusted and adjusted coefficients for MOV, enabling comparisons before and after considering other variables. It offers insights into the impact of MOV on WHZ, alongside the influence of demographic and socio-economic factors on child nutritional status in Kenya over the period.

In the unadjusted model, MOV did not show a significant association with WHZ across all study years. Specifically, in 2003, the coefficient was 0.10 (95% CI [-0.83, 1.02], $P = 0.837$), in 2008, it was -0.05 (95% CI [-0.37, 0.26], $P = 0.737$), and in 2014, it was -0.10 (95% CI [-0.20, 0.00], $P = 0.054$).After adjusting for covariates, MOV exhibited a significant negative association with WHZ in 2014. The adjusted coefficient was -0.12 (95% CI [-0.22, -0.03], $P = 0.013$), indicating that higher levels of MOV were associated with lower WHZ scores in 2014. However, no significant associations were observed in 2003 and 2008 after adjustment.

Several demographic and socioeconomic factors showed significant associations with WHZ. Age exhibited a consistent negative association with WHZ across all study years ($P < 0.001$), with higher coefficients indicating a decrease in WHZ with increasing age. Female sex showed a significant positive association with WHZ in 2008 ($P = 0.048$), while maternal education level was negatively associated with WHZ in 2008 and 2014 ($P < 0.01$). Wealth status also exhibited a negative association with WHZ across all study years ($P < 0.001$).

Table 4.18: Mixed effect multi-level linear regression model of the effect of MOV on WHZ

Variables	2003 (2,321)			2008 (n =1,521)			2014 (n = 5,799)		
	Coeff	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**
MOV (Unadjusted)	0.10	-0.83, 1.02	0.837	-0.05	-0.37, 0.26	0.737	-0.10	-0.20, 0.00	0.054
MOV (Adjusted)	0.13	-0.80, 1.06	0.783	0.02	-0.30, 0.34	0.905	-0.12	-0.22, -0.03	**0.013**
Age	-0.80	-1-02, -0,57	**<0.001**	-0.14	-0.22, -0.05	**0.003**	-0.15	-0.18, -0.13	**< 0.001**
Age squared	0.03	0.02, 0.04	**<0.001**	0.01	0.00*, 0.01	**0.009**	0.01	0.00*, 0.01	**< 0.001**
Sex (Female)	0.08	-0.69, 0.85	0.839	0.30	0.00, 0.59	**0.048**	-0.01	-0.11, 0.08	0.811
Residence (Rural)	0.53	-0.56, 1.61	0.342	-0.22	-0.67, 0.23	0.348	0.05	-0.07, 0.16	0.426
Education (No education)	0.27	-0.76, 1.30	0.605	-0.52	-0.91, -0.13	**0.009**	-0.42	-0.53, -0.30	**< 0.001**
Maternal marital status (Married)	0.36	-0.64, 1.36	0.482	0.32	-0.20, 0.83	0.225	0.09	-0.07, 0.26	0.282
Wealth status (Poor)	-0.27	-1.26, 0.07	0.592	-0.16	-0.57, 0.25	0.446	-0.23	-0.36, -0.1	**< 0.001**

*Truncated at 2 decimal points

2. Under-vaccination

Table 4.19 presents results from a mixed effect multi-level linear regression model examining the effect of under-vaccination on Weight-for-Height Z-score (WHZ) among children in Kenya across three survey years (2003, 2008/09, and 2014), with respective sample sizes indicated. Each row delineates a specific variable, including under-vaccination, age, sex, residence (rural), maternal education level, maternal marital status, and wealth status, with coefficients, 95% Confidence Intervals (CI), and *P*- values provided. Negative coefficients suggest a negative association with WHZ, while positive coefficients indicate a positive association. The table contrasts unadjusted and adjusted coefficients for under-vaccination, enabling comparisons before and after considering other variables. It offers insights into the impact of under-vaccination on WHZ, alongside the influence of demographic and socio-economic factors on child nutritional status in Kenya over the period.

In the unadjusted model, under-vaccination demonstrated a significant negative association with WHZ across all study years. Specifically, in 2003, under-vaccination was associated with a decrease in WHZ with a coefficient of -1.61 (95% CI [-2.43, -0.78], $P< 0.001$). Similarly, in 2008, the coefficient was -0.43 (95% CI [-0.78, -0.09], $P= 0.013$), and in 2014, it was -0.27 (95% CI [-0.38, -0.15], $P<0.001$).After adjusting for covariates, under-vaccination remained significantly associated with WHZ in all study years. The adjusted coefficients for under-vaccination were -1.61 (95% CI [-2.43, -0.79], $P< 0.001$) in 2003, -0.40 (95% CI [-0.74, -0.06], $P= 0.022$) in 2008, and -0.23 (95% CI [-0.34, -0.12], $P< 0.001$) in 2014.

Additionally, several demographic and socioeconomic factors showed significant associations with WHZ. Age exhibited a consistent negative association with WHZ across all study years ($P< 0.001$), while female sex showed a marginal association with WHZ in 2008 ($P= 0.051$). Maternal education level demonstrated a negative association with WHZ in 2008 and 2014 ($P< 0.05$), while wealth status exhibited a negative association with WHZ in all study years ($P< 0.001$).

Table 4.19: Mixed effect multi-level linear regression model of the effect of under-vaccination on WHZ

Variables	2003 (2,321)			2008 (n =1,521)			2014 (n = 5,799)		
	Coeff	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**
Under-vaccination (Unadjusted)	**-1.61**	-2.43, -0.78	**<0.001**	-0.43	-0.78, -0.09	**0.013**	-0.27	-0.38, -0.15	**<0.001**
Under-vaccination (Adjusted)	**-1.61**	-2.43, -0.79	**<0.001**	-0.40	-0.74, -0.06	**0.022**	-0.23	-0.34, -0.12	**< 0.001**
Age	-0.81	-1.04, -0.59	**<0.001**	-0.15	-0.24, -0.06	**0.001**	-0.17	-0.20, -0.14	**< 0.001**
Age squared	0.03	0.02, 0.04	**<0.001**	0.01	0.00*, 0.01	**0.009**	0.01	0.00*, 0.01	**< 0.001**
Sex (female)	0.07	-0.69, 0.84	0.853	0.29	-0.00*, 0.59	0.051	-0.01	-0.10, 0.08	0.840
Residence (Rural)	0.49	-0.59, 1.58	0.37	-0.21	-0.66, 0.24	0.35	0.04	-0.07, 0.16	0.470
Education (No education)	0.17	-0.86, 1.20	0.744	-0.50	-0.89, -0.12	**0.011**	-0.40	-0.51, -0.28	**< 0.001**
Maternal marital status (Married)	0.45	-0.55, 1.44	0.377	0.32	-0.20, 0.83	0.228	0.09	-0.07, 0.26	0.274
Wealth status (Poor)	-0.23	-1.22, 0.75	0.641	-0.15	-0.56, 0.26	0.474	-0.22	--0.35, -0.10	**0.001**

*Truncated at 2 decimal points

3. Non-vaccination

Table 4.20 presents results from a mixed effect multi-level linear regression model examining the effect of non-vaccination on WHZ among children in Kenya across three survey years (2003, 2008/09, and 2014), with respective sample sizes indicated. Each row delineates a specific variable, including non-vaccination, age, sex, residence (rural), maternal education level, maternal marital status, and wealth status, with coefficients, 95% Confidence Intervals (CI), and *P*- values provided. Negative coefficients suggest a negative association with WHZ, while positive coefficients indicate a positive association. The table contrasts unadjusted and adjusted coefficients for non-vaccination, enabling comparisons before and after considering other variables. It offers insights into the impact of non-vaccination on WHZ, alongside the influence of demographic and socio-economic factors on child nutritional status in Kenya over the period.

In the unadjusted model, non-vaccination showed a significant positive association with WHZ across all study years. Specifically, in 2003, non-vaccination was associated with an increase in WHZ with a coefficient of 2.08 (95% CI [0.93, 3.47], $P< 0.001$). Similarly, in 2008, the coefficient was 0.81 (95% CI [0.20, 1.41], $P= 0.009$), and in 2014, it was 0.25 (95% CI [-0.01, 0.50], $P= 0.059$).After adjusting for covariates, non-vaccination remained significantly associated with WHZ in all study years. The adjusted coefficients for non-vaccination were 2.16 (95% CI [0.95, 3.37], $P< 0.001$) in 2003, 1.00 (95% CI [0.39, 1.61], $P=0.001$) in 2008, and 0.48 (95% CI [0.23, 0.74], $P< 0.001$) in 2014.

Additionally, several demographic and socioeconomic factors showed significant associations with WHZ. Age exhibited a consistent negative association with WHZ across all study years ($P< 0.001$). Maternal education level demonstrated a negative association with WHZ in 2008 and 2014 ($P< 0.05$), while wealth status exhibited a negative association with WHZ in all study years ($P< 0.001$).

Table 4.20: Mixed effect multi-level linear regression model of the effect of non-vaccination on WHZ

Variables	2003 (2,321)			2008 (n =1,521)			2014 (n = 5,799)		
	Coeff	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**	**Coeff**	**95%CI**	***P*-value**
Non-vaccination (unadjusted)	2.08	-0.93, -0.47	**<0.001**	0.81	0.20, 1.41	**0.009**	0.25	-0.01, 0.50	0.059
Non-vaccination (Adjusted)	2.16	0.95, 3.37	**<0.001**	1.00	0.39, 1.61	**0.001**	0.48	0.23, 0.74	**< 0.001**
Age	-0.70	-0.93, -0.47	**<0.001**	-0.10	-0.19, -0.01	**0.024**	-0.15	-0.18, -0.12	**< 0.001**
Age squared	0.02	0.02, 0.03	**<0.001**	0.00*	0.00*, 0.01	**0.045**	0.01	0.00*, 0.01	**< 0.001**
Sex (Female)	0.08	-0.69, 0.85	0.835	0.29	-0.01, 0.58	0.055	-0.01	-0.10, 0.09	0.860
Residence (Rural)	0.50	-0.59, 1.58	0.368	-0.21	-0.66, 0.24	0.363	0.04	-0.08, 0.16	0.501
Education (Noeducation)	-0.17	-1.23, 0.88	0.746	-0.59	-0.97, -0.20	**0.003**	-0.44	-0.56, -0.33	**< 0.001**
Maternal marital status (Married)	0.36	-0.63, 1.36	0.473	0.32	-0.19, -0.83	0.219	0.09	-0.08, 0.25	0.288
Wealth status (Poor)	-0.41	-1.40, 0.58	0.419	-0.21	-0.62, 0.20	0.318	-0.25	-0.37, -0.12	**< 0.001**

*Truncated at 2 decimal points

CHAPTER FIVE
DISCUSSION

5.1 Trends in Non/Under-Vaccination and MOV among Children Aged 0-23 Months in Kenya from 2003 to 2014

The study has established that over the 10-year period, there was a consistent decline in the trend of non-vaccination among children aged 0-23 months in Kenya, across most of the study variables except for women who were divorced/ separated or widowed and for women residing in Nairobi Province. This consistent decline is aligned with the reported findings in the East Africa region and in Africa in general (Hanifin et al., 2007; Ozawa et al., 2016; Peck et al., 2019; Tesema et al., 2020).

Non-vaccination is indicative of children within the immunization age not being in contact with immunization services and represents vulnerable group being left behind by multiple vaccination services and interventions (Santos et al., 2021). The declining trend of non-vaccination in Kenya may be suggestive of improvement in immunization services in the country. These improvements may be attributed to increased advocacy, communication and social mobilization (ACSM) efforts by the immunization program and its partners (Manakongtreecheep & Davis, 2017).

As seen in other settings, these improvements in non-immunization trends could also possibly be explained by improvements in the maternal-child health programs in the country, increased investments in the health sector, increased investments in the vaccination and immunization programs in Kenya by the Ministry of health, immunization implementing partners and the County Governments (Bangura et al., 2020b; Nolna et al., 2018; Ozawa et al., 2016; Sakas et al., 2022).

The immunization program in Kenya is largely funded by the government of Kenya, supported by immunization partners such as Gavi, the Vaccine Alliance (Haakenstad et al., 2016). The flow of support (funding and technical) from donors to the Government of Kenya, for public health programs, is through the MOH, which in turn distributes them to the counties alongside other resources (Muli, 2016). Assumedly, this provides a level ground in terms of resource allocation and distribution across the country. With this support, the Kenya MOH could have implemented immunization program activities that could have led to the observed improvements in terms of

reductions in non-immunized children. The reducing trend in non-vaccination across the variables in this study need to be sustained in order to have better immunization outcomes at the population and health system level.

There were varied outcomes in terms of trends of under-vaccination among children aged 0-23 months in Kenya. Under-vaccination is indicative of the inability of the immunization system to attract and retain eligible children till they complete their immunization schedule. This inability could be due to several immunization system related factors. These factors could be related to availability, accessibility and affordability of these immunization services to the populations that need them most.

Over the study period, the levels of under-vaccination are lower than those seen around East Africa where about 69% of children received their required vaccines (Tesema, Tessema, Tamirat, & Teshale, 2020). There were gender differences observed from this study with more males than females being vaccinated. However, different studies have reported a varying influence of gender on immunization with others reporting girls to be less likely to be vaccinated than boys (Borooah, 2004). In this study, more children in rural areas were vaccinated than those in urban areas. These differences in utilization of immunization services have been described before and may be due to proximity to service delivery points and possible higher travel costs (Sibeudu et al., 2019).

A significant increasing trend was observed for those in the lowest wealth quintile and those living in NEP. Living in remote areas and urban poor populations have been documented as known inequity determinants for under-vaccination (Ozawa et al., 2016). There is a significantly large number of refugees and nomadic populations amongst the inhabitants of the NEP (Masters et al., 2019). Even within the NEP, there have been persistent disparities in vaccinations, with Somali children more likely to be vaccinated compared to non-Somalis (Masters et al., 2019).

A significant declining trend in under-vaccination was noticed in children of women aged 25-29, children of divorced/separated/widowed parents, children in 2-4 birth order and parity, second and fourth wealth quintiles, children living in the former Western Province and those born in private health facilities.

A significant mixed trend in under-vaccination was seen in families with one child at home, children living in the highest wealth quintiles where only close to half of their children were vaccinated. Studies in Kenya have shown full and timely vaccination to be higher amongst children of the rich and wealthy individuals with the hazard for being fully immunized being 10% more likely among children of the wealthiest compared to those of the poorest children (Mutua et al., 2020). A similar trend was also observed in the Democratic Republic of the Congo (DRC) where the proportion of fully immunized children were found to be higher in upper wealth quintiles (Acharya et al., 2018). A similar mixed trend in under-vaccination was seen amongst children with unemployed parents. However, a different study in Ethiopia using the DHS found the husband's employment status to significantly influence the full vaccination status of their children with the odds of full vaccination higher in children of mothers with employed husbands (Kinfe et al., 2019).

Over the 10-year period, the trends of MOV among children aged 0-23 months in Kenya has generally increased across most variables. The MOV is indicative of the inability of the immunization system to provide children when they are free of contraindications their required immunization whenever they make contact with the health system (Nnaji et al., 2023). In other words, the system is not able to utilize all opportunities to provide immunization services to deserving children (Anderson, 2014). This inability could be due to several factors such as health workers not checking vaccination status of children making contact with the health system, limited integration of vaccination services with other health services at the service delivery points, human resource shortages, poor retention of vaccination cards, and stock-outs of vaccines or related supplies (Gibson, Zameer, Alban, & Kouwanou, 2023; Shearer et al., 2023).

A meta-analysis reviewing data from low-income countries (Adamu et al., 2019), another study amongst the Maasai nomadic populations (Pertet et al., 2018) and another one amongst children in a poor urban settlement of Nairobi, Kenya (Mutua, Kimani-Murage, & Ettarh, 2011) found a MOV prevalence of 42%, 30% and 22%, respectively. The findings from this trend analysis has shown consistent significant rising trend and also aligns with regional trends of MOV in the region. However, there were non-significant trends of MOV that were observed amongst children with mothers aged 45-49, children in households with more than five children, those living in Nairobi and North-Eastern Provinces and those children born in private health facilities.

5.2 Influence of Demographic and Socio-Economic Factors on Non/ Under-Vaccination and MOV among Children Aged 0-23 Months in Kenya between 2003 and 2014

The results of the analysis we conducted on the influence of demographic and socio-economic determinants of non-vaccination, under-vaccination and MOV amongst children 0-23 months in Kenya from 2003 to 2014 showed varied trends.

With regards to non-vaccination, in 2003, education, province of residence, and place of delivery were significant factors, while in 2008/09, marital status, religion, wealth quintile, and child birth order played a crucial role. In 2003, the mothers' education, Province and place of delivery were statistically significant.

Maternal education stands out as a crucial factor influencing childhood vaccination (Anand & Bärnighausen, 2007). This is attributed to its direct impact on vaccine awareness and attitudes toward vaccination. Studies have reported that mothers lacking post-secondary education are more prone to overlooking their children's vaccination schedules (Munthali, 2007). Furthermore, a positive correlation exists between maternal education and childhood immunization (Vikram, Vanneman, & Desai, 2012). This connection becomes particularly significant as mothers with primary education possess essential health knowledge, while those with secondary education and beyond exhibit the necessary communication skills to advocate for child immunization (Vikram, Vanneman, & Desai, 2012). Likewise, in Mozambique, children of uneducated mothers demonstrate lower vaccine uptake (Jani, De Schacht, Jani, & Bjune, 2008a).

In this study, across the 3 surveys, regional disparities have been noted for non-vaccination. Regional clustering and variations in non-vaccinations have been observed in other studies (Uthman et al., 2021). It is therefore important to identify factors that influence these regional differences. The differences could be due to individual, contextual and systematic factors including socioeconomic inequalities in vaccine uptake in these regions (Gilbert et al., 2017). These have also been described for Kenyan communities, especially those living in the refugee communities (Masters et al., 2019). In Nyanza and Western Provinces, there are cultural and religious practises and beliefs that have been identified to influence non-vaccination. These include religious sects that don't believe in vaccination as well as cultural practises that prohibit vaccination and access to general health care (Friedman et al., 2014).

Maternal age and family dynamics play pivotal roles in determining the likelihood of non-vaccination among children. Specifically, children born to mothers aged 15-19 years and those within larger families encountered significantly elevated odds of remaining unvaccinated. Additionally, children born to younger mothers and those in the 5+ birth order were prone to non-vaccination compared to their counterparts, particularly when contrasted with first-born children. This trend has been reported in other settings (Ntenda, 2019) and could be related to the complacency and lack of focus that comes with maternal experience as well as having many children. Some reasons may be related to women being fully engaged with domestic work, and hence they tend to forget their children's vaccination timing (Sheikh et al., 2018).

The socio-economic status of mothers or caretakers directly impacts on their ability to finance health requirements (Phillips, Dieleman, Lim, & Shearer, 2017a). In our study, when we compared to the highest wealth quintile, children of the lowest quintile and middle quintiles were likely to be non-vaccinated. There is evidence indicating that children belonging to poor households were most likely to have fewer interactions with immunization services leading to non-vaccination (Ndwandwe et al., 2018).

The birthing environment also influenced non-vaccination. Children born at home were more likely to be non-vaccinated as compared to those born in private facilities. This is aligned with studies in other settings that reported significant advantages conferred to children born in health facilities, including vaccination (Sheikh et al., 2018).

Regarding under-vaccination, there were varied demographic and socio-economic determinants reported amongst children 0-23 months in Kenya from 2003 to 2014. In 2003, the Province was a statistically significant factor in determining a child's under-vaccination status. Progressing to 2008/2009, the study findings were that religion, Province, and birth order were statistically significant factors linked to a child's under-vaccination status. In 2014, gender, the mother's age, and the number of children in a household were the statistically significant factors influencing a child's under-vaccination status.

The number of children in a household influenced a child's under-vaccination status. Our study findings have shown that in 2008/09 period, households with between 2-4 children were likely to be under-vaccinated compared to households with 0 to 1 child. Similarly, in 2014, households with between 2 to 4 children were likely to be under-vaccinated compared to households with 0 to 1 child. Studies have found that the number of siblings in a family directly impacts on the mother's ability to spare time to bring another sibling to the health facility for vaccination (Phillips, Dieleman, Lim, & Shearer, 2017a). The presence of other siblings was determined to be an independent predictor for under-vaccination (Danis, Georgakopoulou, Stavrou, Laggas, & Panagiotopoulos, 2010). Similar findings were also reported in Bangladesh, where children born of families with three or more siblings had a reduced probability of being vaccinated (Perry, Weierbach, Hossain, & Islam, 1998).

There is a global natal inequality where boys receive preferential treatment in access and utilization of services than girls as they grow up. In our study, in 2014, the female children were likely to be under-vaccinated compared to their male counterparts. Similar findings have been reported in other parts of the world where girls are less likely to be vaccinated than boys (Borooah, 2004). Similar gender inequities in immunization coverage were found to be prevalent even for individual level vaccine antigens (Prusty & Kumar, 2014).

Province had a significant influence on under-vaccination in Kenya. In 2003 and 2008/09, children from the Rift-Valley were likely to be under-vaccinated compared to children from the coast. The Rift-Valley is such an expansive region with sparsely populated areas and infrastructural difficulties related to access to immunization services. It has been reported that less than 50% of the total population living less than one-hour to a health facility (Ray & Okiro, 2020). This is most likely to influence immunization decisions taken by mothers and ultimately impact in under-vaccination status.

In our study, mothers aged 15-19 years were likely to have under-vaccinated children compared to those aged 45-49 years. Other studies have reported that older women (35 years and above) were more likely to take their children for basic vaccination (Nozaki et al., 2019b).

Our findings are that religion, similarly, significantly affected under-vaccination. Compared to mothers with no religion, children whose mothers were Roman Catholic, Protestant/Other Christian and Muslims were likely to have their children under-vaccinated. This is similar to study findings in the region which have reported that children belonging to Roman catholic mothers were less likely to vaccinate their children as compared to those belonging to orthodox churches (Kinfe, Gebre, & Bekele, 2019).

The demographic and socio-economic determinants of missed opportunity for vaccination amongst children 0-23 months in Kenya showed varied trends over the 10-year period. In 2003, our research identified the significance of religion, province, and place of delivery; in 2008/09, it revealed the statistical significance of marital status, education, province, and birth order; and in 2014, highlighted the importance of wealth quintile and province as influential factors shaping MOV.

Our findings conflict those reported in region where studies found that the mothers marital status has no influence on the child's MOV status (Jani et al., 2008b; Pertet et al., 2018). Single mothers seem to be having their children fully vaccinated than those who are married or in relationships. This could be explained by the fact that they are fully focused on their children and are not distracted by other chores brought about by marriages and commitments expected in relationship.

There is evidence to show that there is a relationship between wealth and missed opportunities (Sridhar, Maleq, Guillermet, Colombini, & Gessner, 2014). In 2014, the study revealed that women in the lowest wealth quintile were more likely to have their children missing opportunity for vaccination as compared to those in the highest wealth quintile. This may be explained by differences in priorities, where women in the lowest wealth quintile may have different priorities from those of those in the highest quintile given their socio-economic needs. Vaccination for their children, given they are not manifesting any signs or symptoms of illness, may rank lower to them compared to fending for their daily needs. Similarly, for the same reasons, households with more than five children were more likely to have MOV compared to those with 1 child.

In our study, children delivered at home were likely to have MOV compared to children born at private health facility. Similar findings have been reported in other studies (Ntenda, 2019; Odiit & Amuge, 2003) where children born in health facilities were significantly more likely to be vaccinated and up to date with their vaccine schedules as compared to children born at home. The findings in this study also contrasted the results of Kagoné et al. (2017) who found no association between place of birth and MOV.

Children living in Nyanza and Western Provinces were likely to have MOV compared to children from the Coast Province in 2003. These regional differences could also be due to individual, contextual and systematic factors including socioeconomic inequalities in vaccine uptake (Gilbert, Gilmour, Wilson, & Cantin, 2017). Similar to those noted for non-vaccination above, these factors have also been described for Kenyan communities, especially those of the Somali community and living in the refugee communities (Masters et al., 2019). Cultural and religious practices and beliefs in Western Province may influence non-vaccination. These include religious sects that don't believe in vaccination as well as cultural practices that prohibit vaccination and access to general health care (Friedman et al., 2014).

5.3 Health System Factors Impact Non/ Under-Vaccination and MOV among Children Aged 0-23 Months in Kenya

The literature suggests that health system factors such as facility opening times, availability of vaccinators, location of facilities, and vaccine supply influence vaccination access and utilization (Anderson, 2014; Li, Tabu, Shendale, Okoth, et al., 2020). Findings from the study echo this sentiment, indicating challenges such as long distances to health facilities, stock-outs of vaccines and supplies, and understaffing, which can contribute to missed opportunities for vaccination. Longer distances lead to reduced odds of children being fully immunized, emphasizing the importance of proximity to vaccination sites in ensuring access. Consistent with the literature, the study reported the significant impact of distance from health facilities on vaccination status(Phillips et al., 2017b; Shellese A Shemwell et al., 2017).These findings put into context and explain the levels of non-vaccination, under-vaccinations and MOV observed in the rift valley and North Eastern Provinces where vast distances covered to reach the nearest immunizing health facilities. Parents in these areas may struggles to bring their children for vaccination especially given that vaccinations are provided for healthy children. These parents

may not have sufficient motivation to cover these vast distances to bring their children for vaccination. Similarly, stock-outs of vaccines and supplies, and inadequate staff may pose sufficient barriers for health workers to be motivated to provide vaccinations. Parents may also not be inspired to bring their children to the health facilities for vaccination if they are not confident in these capacities in the health facilities. This finding aligns with similar literature which highlights the importance of health worker density in improving vaccination status(Anand & Bärnighausen, 2007).

Both the literature and study findings emphasized the influence of community attitudes towards vaccination on vaccination uptake (Mell et al., 2005). As reported, positive attitudes towards childhood vaccination, can contribute to higher vaccination status, while negative attitudes, particularly influenced by religious beliefs, can act as barriers to vaccination.

The study findings also reflect the importance of accessible vaccination services, aligning with the literature and emphasizing the need for vaccination sites closer to populations and ensuring the availability of vaccinators and vaccines (Mell et al., 2005).

Both literature and study findings indicated that caregivers' compliance with vaccination schedules can be influenced by various factors such as knowledge, awareness, and convenience (Li, Tabu, Shendale, Okoth, et al., 2020). Similar to the literature, the study identifies challenges in maintaining compliance, including forgetfulness, misconceptions about vaccines, and barriers related to distance and transportation (Danis, Georgakopoulou, Stavrou, Laggas, & Panagiotopoulos, 2010; Phillips, Dieleman, Lim, & Shearer, 2017b). These findings underscore the importance of ongoing education and outreach efforts to improve adherence to vaccination schedules.

Several barriers to timely vaccination, including long waiting times at health facilities, vaccine stock outs, and side effects leading to vaccine hesitancy were reported in the findings. (Shellese A Shemwell et al., 2017). These barriers are consistent with literature highlighting logistical challenges and healthcare system inadequacies as significant impediments to timely vaccination (Mell et al., 2005). Addressing these barriers requires improvements in healthcare infrastructure, vaccine supply management, and caregiver education.

Based on the findings, various strategies to enhance vaccination uptake, such as improving staffing levels, utilizing reminder messages, and conducting frequent outreach programs were reported. These recommendations align with literature emphasizing the importance of accessible and well-staffed healthcare facilities, proactive communication with caregivers, and community engagement to promote vaccination (Anderson, 2014). By implementing these strategies, healthcare systems can better reach underserved populations and improve vaccination status.

While negative attitudes among some healthcare workers is identified as a barrier to vaccination provision in the findings, this aspect is not extensively covered in the literature provided. However, literature on vaccine hesitancy acknowledges the role of healthcare providers' attitudes and behaviours in influencing caregiver decision-making regarding vaccination (Cooper et al., 2019; Larson, Jarrett, Eckersberger, Smith, & Paterson, 2014).This highlights the need in addressing negative attitudes and improving provider communication skills are crucial for fostering trust and confidence in vaccination programs.

The study suggests digitalizing vaccination records to improve tracking and monitoring of vaccination status, which is not explicitly discussed in the literature provided. However, leveraging technology for vaccine tracking and surveillance has been proposed as a promising approach to enhance vaccination status and accountability (Kumar et al. 2014). Digital solutions can streamline data management, facilitate tracking of vaccine doses, and improve communication between healthcare providers and caregivers.

5.4 Effects of Non/ Under-Vaccination and MOV on the Growth Rates Of Children Aged 0-23 Months in Kenya from 2003 to 2014

The findings of this study provide valuable insights into the effects of non-vaccination, under-vaccination, and missed opportunities for vaccination (MOV) on the growth rates of children aged 0-23 months in Kenya over the period 2003-2014. The discussion focus on the prevalence of underweight, wasting, and stunting among children in relation to vaccination status, as well as the results of the mixed-effect multi-level linear regression models assessing the association between vaccination status and anthropometric indicators, while considering demographic and socioeconomic factors.

The prevalence of underweight, wasting, and stunting among children varied across different vaccination statuses over the study period. Generally, children with missed vaccination opportunities demonstrated higher prevalence rates of underweight and wasting compared to those without missed opportunities. However, the prevalence of stunting was slightly lower among children with missed vaccination opportunities. This variation suggests a complex interplay between vaccination status and nutritional outcomes, influenced by various socioeconomic and demographic factors. It is possible that children who have missed vaccination opportunities may also face challenges in accessing regular healthcare services, including nutritional support. Limited access to healthcare could result in underweight and wasting due to inadequate monitoring of growth and nutritional needs. Likewise, families with limited financial resources may struggle to prioritize both vaccination and nutrition for their children. They may face difficulties affording nutritious food, leading to underweight and wasting. Additionally, some families who miss vaccination opportunities may also lack knowledge about proper nutrition and feeding practices. Health education, particularly on nutritional aspects are provided as part of integrated services with immunization. Missing out on this health talks may have negative consequences on their children's nutritional requirements, contributing to underweight and wasting among their children. On the other hand, it is also possible that some families might prioritize nutrition over vaccination, leading to better stunting outcomes despite missed vaccination opportunities.

Some regions in Kenya, particularly in the North Eastern and parts of the Rift Valley, with inadequate healthcare infrastructure, vaccination campaigns may be sporadic or less effective, leading to missed opportunities for vaccination. This same lack of infrastructure could also impact access to nutritional resources, exacerbating underweight and wasting. On the same breath, regions with high rates of malnutrition may also experience higher rates of vaccine-preventable diseases. Children who miss vaccination opportunities due to various factors may be more susceptible to these diseases, which could contribute to underweight and wasting.

The higher prevalence of underweight and wasting among under-vaccinated children underscores the importance of timely and complete vaccination in promoting overall child health and growth. Furthermore, the consistently higher prevalence of underweight, wasting, and stunting among children from rural areas, poorer households, and with mothers lacking formal education

highlights the significant role of socioeconomic factors in shaping nutritional outcomes. Addressing these disparities requires comprehensive strategies that go beyond vaccination programs to encompass broader social and economic interventions. The findings of our study highlight significant associations between vaccination status and growth indicators among children aged 0-23 months in Kenya from 2003 to 2014. Specifically, there were varying patterns in underweight, wasting, and stunting prevalence rates across different vaccination statuses, including non/ under-vaccination, and MOV.

The prevalence of underweight children displayed a fluctuating trend over the study period, with notable differences observed based on vaccination status. Non-vaccinated children showed a concerning increase in underweight prevalence from 2008/09 to 2014, contrasting with the decreasing trend seen in under-vaccinated children. This divergence suggests a potential protective effect of vaccination against underweight status. Similarly, children with missed opportunities for vaccination exhibited a decline in underweight prevalence, albeit not as pronounced as under-vaccinated children. These findings align with previous studies indicating the role of vaccination in improving child health outcomes beyond the prevention of specific diseases (Gausman et al., 2022; Ghazy et al., 2024; Katz et al., 2020; Martorell, 2017). Vaccination programs provide a holistic approach to child health by bolstering overall immunity, reducing susceptibility to infections, and indirectly contributing to nutritional status through improved health and well-being.

The prevalence of wasting among children also demonstrated differential patterns based on vaccination status. Under-vaccinated children consistently exhibited higher wasting prevalence rates compared to fully vaccinated children across all study years. Moreover, the prevalence of wasting among non-vaccinated children showed fluctuating trends, indicating a potential association between incomplete vaccination and nutritional status. These findings underscore the multifaceted impact of vaccination on child growth and nutrition (Christian et al., 2015; Prendergast, 2015). Vaccination not only prevents specific diseases but also plays a role in reducing the overall burden of illness, thereby indirectly mitigating factors contributing to malnutrition and wasting.

Stunting prevalence rates varied across vaccination statuses, with under-vaccinated children consistently showing higher rates compared to fully vaccinated children. Interestingly, children with missed opportunities for vaccination exhibited slightly lower stunting prevalence rates than those without such missed opportunities. While the reasons behind this observation require further exploration, it suggests potential avenues for targeted interventions to address stunting in under-vaccinated populations. These findings highlight the importance of vaccination as a cornerstone of comprehensive child health interventions. By reducing the incidence and severity of infectious diseases, vaccination programs contribute to improved nutritional outcomes and reduced stunting prevalence, thereby promoting healthy growth and development in early childhood (Prendergast, 2015).

5.5 Limitations of the Study

Although the study utilized nationally-representative data from the Kenya DHS, the availability and completeness of certain variables pertinent to vaccination status and child growth were constrained. Factors such as the adequacy of vaccination records and the accuracy of anthropometric measurements could affect the robustness of the analysis. Despite efforts to ensure data integrity during analysis, the quality of the original data collected in the Kenya DHS surveys may be subject to variability. Variations in data collection methods, interviewer bias, and respondent recall accuracy could introduce potential errors or inconsistencies, impacting the reliability of the study findings. In order to overcome these, this study utilized the Cochrane-Armitage trend test to analyze trends over time, which is well-suited for categorical data with an ordered response variable, like vaccination or nutritional status categories. This statistical tool allowed us to quantify and evaluate trends in these variables across multiple time points, providing valuable insights into longitudinal changes in vaccination status and child growth indicators. Additionally, in our multivariable analysis, we accounted for potential confounding factors to ensure the robustness of our findings. Finally, the study sample size was robust enough to ensue this limitation does not affect the quality of the results.

The study period spanning from 2003 to 2014 encompasses significant temporal changes in vaccination policies, healthcare infrastructure, and socio-economic conditions in Kenya. However, the analysis may not fully capture more recent developments in vaccination programs, limiting the relevance of the findings to the current landscape of immunization services in the

country. To mitigate this limitation, the current study integrated a qualitative approach in its second phase. By triangulating the data gathered from Key Informant Interviews (KIIs), the study delved deeper into the contextual factors shaping vaccination policies, healthcare infrastructure, and socio-economic conditions in Kenya. This approach facilitated the complementing of quantitative trends observed in vaccination status and child growth indicators with qualitative insights into the underlying reasons for these trends. Through the integration of both quantitative and qualitative data, this current study bolstered the relevance and reliability of its findings, resulting in a more comprehensive understanding of the dynamic landscape of immunization services in Kenya.

While the Kenya DHS surveys employed rigorous sampling techniques to ensure national representativeness, inherent limitations such as non-response bias or underrepresentation of certain demographic groups may affect the generalizability of the findings. Furthermore, the study's focus on children aged 0-23 months may not fully capture vaccination status among older age groups or specific vulnerable populations. While the study provides insights specific to Kenya's vaccination programs and child growth outcomes, caution should be exercised when extrapolating the findings to other settings or populations with distinct socio-economic, cultural, or healthcare contexts. Variations in healthcare infrastructure, vaccination policies, and socio-cultural norms may influence vaccination practices and child health outcomes differently across diverse regions or countries.

Although qualitative interviews were conducted with policymakers to provide contextual insights, the perspectives obtained may not fully represent the breadth of stakeholder viewpoints involved in vaccination programs. Additionally, qualitative data interpretation is subject to researcher bias and may not capture the full complexity of factors influencing vaccination status and child growth outcomes. To mitigate this limitation, proactive steps were taken to address potential limitations in qualitative interviews. This included ensuring representation from various perspectives within vaccination programs by deploying a diverse pool of data collectors. Moreover, the study respondents were carefully selected from a broad spectrum of immunization services managers at both the national and county levels, ensuring a comprehensive range of insights. Furthermore, the study deployed a mixed-methods approach through triangulation of quantitative data with qualitative insights. To mitigate researcher bias in qualitative data

interpretation, there was implementation of rigorous measures such as deploying multiple coders and conducting checks. These efforts bolstered the credibility and trustworthiness of the findings, enhancing the robustness of this study.

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Findings

This study offers a comprehensive analysis spanning a decade to evaluate trends in non/under-vaccination and MOV. Understanding these immunization gaps and their determinants is pivotal for informing vaccination programs and policymaking, facilitating the design of evidence-based interventions, and ensuring effective resource allocation.

Key findings from the study underscore several significant points. Firstly, while the incidence of non-vaccination saw a notable decrease, under-vaccination remained relatively stable, and instances of missed opportunities for vaccination significantly increased. Secondly, the study identified various demographic and socio-economic determinants influencing non/under-vaccination and MOV among children aged 0-23 months in Kenya. These included the child's gender, maternal age, marital status, religion, maternal education, wealth index, province, child birth order, number of children in the household, and place of delivery.

Furthermore, logistical challenges such as inadequate vaccine supply, distance to healthcare facilities, and cultural beliefs were recognized as contributing factors to non/under-vaccination and MOV. Additionally, the study revealed that missed vaccination opportunities and under-vaccination negatively impacted child growth indicators, particularly Weight for Age (WAZ) and Weight for Height (WHZ). The relationship between non-vaccination and child growth outcomes yielded mixed results, with significant negative and positive coefficients observed over the years, highlighting the intricate nature of this relationship.

These findings underscore the significance of implementing targeted interventions to address malnutrition and foster healthy growth trajectories among children in Kenya.

6.2 Conclusions

6.2.1 Trends in non/ under-vaccination and MOV among children aged 0-23 months in Kenya from 2003 to 2014

The overall trend of full vaccination was low among children aged 0-23 months in Kenya. Even though the benefits of most childhood vaccinations are scientifically unquestionable, vaccination status rates are far from 100% in many regions in the country and show substantial variations**.**

The results show a significant decrease in the percentage of non-vaccinated children in Kenya from 2003 to 2014. However, some demographic groups, such as children in rural areas and those with higher birth orders or parities, still have higher non-vaccination rates than others. Overall, the results show that under-vaccination rates decreased in Kenya between 2003 and 2014. However, some groups, such as children in urban areas and those born to older mothers, still had high under-vaccination rates in 2014. Within the same study period, there was an increase in the proportion of missed opportunities for vaccination among children in Kenya, and there are significant differences in missed opportunities by various factors, including sex of child, residence, mother's age, marital status, religion, birth order, and parity.

6.2.1 Influence of Demographic and Socio-Economic Factors on Non/ Under-Vaccination and MOV among Children Aged 0-23 Months in Kenya between 2003 and 2014

Non-vaccination was influenced by factors such as education, province, and place of delivery in 2003, while marital status, religion, wealth quintile, and birth order played a pivotal role in 2008/09. Maternal education emerged as a crucial factor affecting childhood vaccination, with regional disparities indicating the impact of cultural and religious practices. Maternal age and family dynamics were identified as significant contributors to non-vaccination risk. The socio-economic status of mothers, reflected in wealth quintile, directly affected vaccination outcomes.

Under-vaccination determinants varied over the years, involving factors such as province, religion, gender, mother's age, and household size. Regional differences, particularly in Nyanza and Western Provinces, highlighted the influence of cultural and religious beliefs on under-vaccination. The global gender inequality observed with access to health services was observed, with female children less likely to be under-vaccinated.

Missed opportunities for vaccination (MOV) exhibited varied determinants, including marital status, education, province, birth order, wealth quintile, and place of delivery. Unique findings included single mothers having fully vaccinated children, contrary to previous studies. Wealth disparities and larger households were associated with increased MOV risk, while home births were linked to a higher likelihood of missed opportunities. Regional differences persisted, especially in Nyanza and Western Provinces.

6.2.2 Health System Factors Impact Non/ Under-Vaccination and MOV among Children Aged 0-23 Months in Kenya

The community faces various paediatric health challenges, including diseases like malnutrition, malaria, pneumonia, and infections, which are aggravated by factors such as single parenthood and lack of proper parental care. These challenges evidently contribute to defaults in vaccinations, implying the need for comprehensive interventions. Efforts to mitigate the paediatric health challenges include community health worker sensitization, continuous education initiatives, and promotion of preventive measures like mosquito net usage and proper nutrition. While the community generally has positive attitudes towards childhood vaccinations, variations exist due to factors such as religious beliefs and cultural misconceptions.

Vaccination services are generally satisfactory, with high uptake rates observed, but challenges such as stock-outs, long queues, and transportation barriers in hard-to-reach areas hinder universal accessibility of the services. Moreover, barriers to timely vaccination, including logistical challenges, inadequate vaccine supply, distance to healthcare facilities, and cultural beliefs, resulted to either non-vaccination, under-vaccination or MOV.

6.2.3 Effects of Non/ Under-Vaccination and MOV on the Growth Rates of Children Aged 0-23 months in Kenya from 2003 to 2014

Our findings emphasize the importance of vaccination as a cornerstone of comprehensive child health interventions, not only in preventing specific diseases but also in promoting healthy growth and development by reducing the overall burden of illness and indirectly contributing to improved nutritional status. Timely and complete vaccination is critical in promoting overall child health and growth. Particularly, under-vaccinated children demonstrated consistently higher prevalence rates of underweight and wasting compared to fully vaccinated children, highlighting the protective effect of vaccination against these nutritional deficiencies. Additionally, the observed fluctuating trends in underweight prevalence among non-vaccinated children suggest a potential association between incomplete vaccination and nutritional status.

Furthermore, vaccination status showed varying impacts on stunting prevalence rates, with under-vaccinated children consistently displaying higher rates compared to fully vaccinated children. Intriguingly, children with missed opportunities for vaccination exhibited slightly lower stunting prevalence rates, indicating potential avenues for targeted interventions in under-

vaccinated populations. Our study also underscores the influence of socioeconomic factors on nutritional outcomes, with children from rural areas, poorer households, and with mothers lacking formal education experiencing consistently higher prevalence rates of underweight, wasting, and stunting.

6.3 Recommendations from the Current Study

6.3.1 Trends in Non/ Under-Vaccination and MOV among Children Aged 0-23 Months in Kenya from 2003 to 2014

On the trends objective, this study identified high proportions of under-vaccination and an increasing proportion of MOV. A recommendation is therefore made to County Governments to implement adaptable and community friendly vaccination programs that can reduce under-vaccination and MOV.

The County governments need to develop and deploy tailored interventions to increase access to vaccination services and improve awareness in areas where children are not being vaccinated in Kenya. These interventions need to be tailored to target especially children in rural areas and those with higher birth orders or parities, women in urban areas such as Nairobi and those who are divorced/ separated or widowed.

In order to address the challenge of under-vaccination which has shown a varying trend across most study variables, the NVIP needs to invest in immunization system related factors that would ensure children are retained in the immunization program for the period they are within the immunization schedule. These factors include those related to availability, accessibility and affordability and where possible, to ensure sustainability, strengthen their integration within routine childhood services offered in the same period.

6.3.2 Influence of Demographic and Socio-Economic Factors on Non/Under-Vaccination and MOV among Children Aged 0-23 Months in Kenya between 2003 and 2014

On the influence of socio-demographic factors on vaccination status, this study identified maternal education, age, marital status, region and family size as significant influencers of vaccination status. A recommendation is therefore made to County Governments to target their programmatic support towards positively influencing these vaccination status determinants.

In order to improve childhood vaccination in Kenya, it will be important to tailored educational campaigns by implementing targeted maternal education programs to raise awareness about the importance of childhood vaccination. The focus should be on dispelling myths and addressing concerns to improve overall vaccine acceptance.

Region-specific interventions are critical in the development and implementation of strategies to address cultural and religious influences on vaccination decisions. Interventions should be tailored to the unique challenges observed in provinces like Nyanza and Western Provinces.

There is value in evaluating the implementation of economic support for vulnerable families by providing targeted support and subsidies for families in lower wealth quintiles to ensure equitable access to vaccines. This could involve making vaccines more affordable and accessible for economically disadvantaged families.

Gender-equal vaccination initiatives should be implemented to ensure equal access to vaccination for both male and female children. Awareness campaigns should specifically target communities where gender disparities in vaccination status exist.

Integrated Missed Opportunities Interventions should be developed and implemented. Comprehensive interventions should target factors associated with missed opportunities for vaccination, including marital status, education, wealth quintile, and place of delivery. Healthcare facilities should be strengthened to capitalize on every interaction for vaccination promotion and administration. To accurately assess the magnitude of Missed Opportunities for Vaccination (MOV), a process to verify home-based vaccination records used in surveys should be considered during data collection. This can help identify any discrepancies and provide more reliable data for future analyses.

6.3.3 Health System Factors Impact Non/ Under-Vaccination, and MOV among Children Aged 0-23 Months in Kenya

On health system factors influencing vaccination status, this study found that challenges like vaccine stock-outs and transportation barriers among others were important influencers of vaccination status. A recommendation is made to County Governments to optimize immunization services through appropriate initiatives such as mobile vaccination clinics.

Additionally, investments in health infrastructure should be prioritized, including ensuring adequate staffing levels, improving storage facilities for vaccines, and addressing logistical challenges such as transportation barriers.

Policies at both National and County levels should be implemented to provide comprehensive training and support for all healthcare workers involved in vaccination programs. The training should not only focus on technical skills but also on fostering positive attitudes towards vaccination and addressing knowledge gaps. Researchers can assess the effectiveness of different training programs and identify best practices for health worker education.

Community education initiatives aimed at increasing awareness of the importance of vaccination and addressing misconceptions and cultural barriers should be prioritised.

Efforts should be made so as to strengthen vaccine supply chains and prevent stock outs at healthcare facilities. This can be achieved by improving forecasting methods, enhancing vaccine distribution networks, and implementing better inventory management practices.

Use of digital health technologies such as electronic immunization registries and mobile health applications for reminders should be explored to improve vaccine tracking and monitoring. These technologies can help identify missed opportunities for vaccination and facilitate follow-up with vaccine defaulters.

Implementing targeted interventions to reach underserved populations and providing financial incentives or subsidies for vaccination. To address socioeconomic barriers to vaccination, such as poverty, lack of education, and access to healthcare.

6.3.4 Effects of Non/ Under-Vaccination, and MOV on the growth rates of Children Aged 0-23 Months in Kenya from 2003 to 2014

On effects of vaccination status on child growth outcomes, this study found a correlation between non-vaccination and under-vaccination and poor child growth outcomes. A recommendation is made to NVIP to strengthen policies on integrated nutrition and child vaccination, while County Governments should also implement integrated child nutrition and vaccination programs.

County governments should implement strategies to improve vaccination status, particularly among underserved populations and in regions with inadequate healthcare infrastructure. This may include expanding access to vaccination services through mobile clinics, community outreach programs, and integrating vaccination with other healthcare services.

Promote health education and awareness campaigns, especially targeting parents and caregivers in rural areas and those with limited formal education. Emphasize the importance of timely and complete vaccination, as well as proper nutrition and feeding practices, to improve child health outcomes.

Strengthen integration between vaccination programs and other healthcare services, including nutritional support, maternal and child health services, and primary care. This can help address the interconnected nature of vaccination status and nutritional outcomes and ensure comprehensive care for children.

Develop targeted interventions to improve vaccination status and nutritional outcomes among under-vaccinated populations, taking into account socioeconomic factors and cultural beliefs. This may involve community-based approaches, incentives for vaccination, and tailored communication strategies.

Advocate for policies and programs that prioritize child health and nutrition, including increased investment in healthcare infrastructure, social safety nets, and poverty alleviation measures. Strengthen collaboration between government agencies, non-governmental organizations, and community stakeholders to implement effective interventions.

Build capacity among healthcare providers and community health workers to deliver comprehensive healthcare services, including vaccination, nutritional counseling, and growth monitoring. Provide training and resources to enable frontline workers to address the complex interplay between vaccination status and nutritional outcomes effectively.

6.3.5 Implications of the Study Findings

These study findings have the following implications;

1. There is a need to revise vaccination strategies and strengthen integrated mobile clinics and outreach programs to reduce regional disparities and improve access to vaccination services.

2. Tailored programs are essential to address cultural and religious barriers, particularly in regions like Nyanza and Western. Implementing gender-sensitive vaccination campaigns is crucial to promote equal access for both male and female children.
3. The study highlights the importance of subsidies and targeted education programs to support low-income families and increase maternal awareness of the importance of childhood vaccinations.
4. There is a need for improvements in supply chains, logistics, staffing, and vaccine inventory management to prevent disruptions and ensure consistent delivery of immunization services.
5. Facilitating linkages between vaccination programs, child nutrition, and healthcare services is essential to address malnutrition and enhance child growth outcomes.
6. Training healthcare workers to address cultural misconceptions, promote positive attitudes toward vaccination, and provide nutritional counseling is necessary for effective service.
7. Strengthening partnerships between government agencies, NGOs, and communities, alongside improving data collection and monitoring, will help track vaccination status and reduce missed opportunities effectively.

6.6 Recommendations for Future Studies

To fully grasp the ramifications of non-under-vaccination and missed opportunities for vaccination (MOV) on child growth, it is imperative to broaden the age range beyond children aged 0-23 months to encompass all children under 5 years old. Exploring the long-term effects across this wider age spectrum will facilitate the development of tailored interventions suitable for different developmental stages.

While the qualitative segment of this study concentrated on immunization services managers, further research is warranted to capture the perspectives of service providers and caregivers. Investigating their viewpoints regarding health system factors influencing non/under-vaccinations and MOV among children will offer a comprehensive understanding of the contextual nuances shaping vaccination decisions and access to vaccines. Additionally, delving into the operational dynamics of service delivery points will unearth invaluable insights into community-specific challenges, guiding the customization of intervention strategies.

Moreover, it is imperative to explore the immunological implications of vaccination gaps, including non/under-vaccinations and MOV, on growth outcomes. Conducting additional clinical inquiries to unravel the interplay between nutritional status and vaccine-induced immunity will enrich our understanding of the intricate relationship between vaccination and child growth, thereby augmenting the existing knowledge base.

Lastly, further investigations are warranted to elucidate the underlying mechanisms driving the observed associations between vaccination status and nutritional outcomes. By dissecting these mechanisms, we can glean deeper insights into the complex interplay between vaccination, nutrition, and child health, thereby informing more targeted and effective interventions.

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APPENDICES

Appendix 1: Data abstraction tools

Socio-demographic and economic characteristics tool DHS 2003, 2008/2014

Sociodemographic and economic characteristics		
Variable	**Definition**	**Categories/ data type**
Sex of the child	Child's sex	1. Male 2. Female
Childbirth order	Child's birth order in the family	Numeric
Number of children in the household	Number of children living in the household	Numeric
Parity	Number of living children	Numeric
Mothers' age category	The age of the mother	15-19; 20-24; 25-29; 30-34; 35-39; 40-44; 45-49
Marital status	Marital status of the mother	Categorical
Religion	Maternal religion	Categorical
Occupation	Maternal occupation of the mother	Categorical
Wealth quintile	Socio-economic status of the household	Lowest poor, second, Middle, 4th less poor, least poor
Number of antenatal care	Number of antenatal care visits during pregnancy	Numeric
Place of delivery	Skilled birth delivery in a health facility	Categorical
Residence	Location of mother	1. Rural 2. Urban
County /Regions	Eight regions in Kenya	

Epi Schedule and scenarios for MOV definitions based on contact with health services

Scenario	Timing of contact with health facility	Reason for contact with health facility	Eligible vaccination at the time of contact with health facility
1	Birth or < = 5 weeks	□ Facility delivery	□ BCG
		□ Baby postnatal check within two months	□ Oral Polio Vaccine (OPV)
		□ Given vitamin A1	
		□ Given vitamin A2	
2	6 - 9 weeks	□ Fever/ cough treatment	□ BCG
		□ Diarrhoea treatment	□ OPV1
		• Baby postnatal check within two months	□ Pentavalent 1
		□ Given vitamin A1	• Pneumococcal 1
		□ Given vitamin A2	□ Rotavirus 1
3	10 - 13 weeks	□ Fever/cough treatment	□ BCG
		□ Diarrhoea treatment	□ OPV 0,1 and 2
		□ Given vitamin A1	□ Pentavalent 1,2
		□ Given vitamin A2	□ Pneumococcal 1,2
			□ Rotavirus 1,2
4	14 weeks - 8 months	□ Fever/cough treatment	□ BCG
		□ Diarrhoea treatment	□ OPV 0,1,2 and 3
		□ Given vitamin A1	□ Pentavalent 1,2,3
		□ Given vitamin A2	□ Pneumococcal 1,2,3
			□ Rotavirus 1,2
5	> = 9 months	□ Fever/cough treatment	□ BCG
		□ Diarrhoea treatment	□ OPV 0,1,2 and 3
		□ Given vitamin A1	□ Pentavalent 1,2,3
		□ Given vitamin A2	□ Pneumococcal 1,2,3
		□ Given iron pills/syrup	□ Rotavirus 1,2
		□ Given drugs for intestinal parasites	□ Measles

Anthropometric indices using WHO classifications

Socio-demographic and economic characteristics		
Variable	**Definition**	**Categories/ data type**
Date of measurement	Date of interview	Numeric
Sex of the child	Gender of the child	1. Male 2. Female
Weight in kgs	Weight of the child	Numeric
Height in cms	Height of the child	Numeric
Age of the child in months	Childs age in months	Numeric
Body mass index	Weight/(height in m)* height in m)	Numeric
Mid-upper arm circumference	Measurement of arm circumference	Numeric
Stunting	Height-for-Age (HAZ)	HAZ <-2
Wasting	Weight-for-height (WHZ)	WHZ <-2
Underweight	Weight-for-Age (WAZ2)	WAZ <-2

Appendix 2: Key informant interview guide for Health Managers

1. What are some health problems that affect children in this community?
2. How are children protected from being affected by these health problems/diseases?
    a. ***Probe: If vaccination is not mentioned, ask:*** **What about vaccination?**

Key questions: General vaccination

3. How does the community feel about childhood vaccination?
4. What can you tell us about the childhood vaccination services in this community?
    a. ***Probe for levels of satisfaction with the vaccination services they receive from public and/or private clinics/hospitals, ask:*** **What is good and what is not so good about the vaccination services?**
    b. ***Probe for reasons for their satisfaction or dissatisfaction, ask:*****Why?**
5. In your opinion, what are some of the ways these vaccination services can be improved?

Key questions: Vaccine compliance

6. In [*Country*], as you may be familiar with, the national programme sets a vaccine schedule. How would you describe compliance with vaccination schedules in this community?
7. Many children do NOT receive all their recommended vaccines on time. What are some of the reasons children do NOT receive all their vaccines at the right time?
8. What will be your suggestion for helping children receive all their recommended vaccines according to the schedule?

Key questions: Missed opportunities

9. In some cases, children who visit health facilities, for different reasons, still do not get all the needed vaccines. In your opinion, what are some reasons **some health workers** may not be willing or able to give children all their recommended vaccines on time when they visit the clinic/hospital?
10. Some children receive some, but not all the vaccines they need. In your opinion, what are some of the reasons **mothers/caregivers** may not be willing or able to ensure that their children receive all their recommended vaccines on time when they visit the clinic/hospital?

11. What are the **ways you can recommend** for ensuring that children receive all their recommended vaccines on time whenever they have the opportunity of visiting a clinic/hospital for any reasons? (They may be visiting for immunization, nutrition, treatment of other ailments, or accompanying an adult to the clinic/hospital)?

Appendix 3: Maseno University School of Graduate Studies (SGS) proposal approval

MASENO UNIVERSITY

SCHOOL OF GRADUATE STUDIES

Office of the Dean

Our Ref: PHD/PH/00075/2019

Private Bag, MASENO, KENYA
Tel:(057)351 22/351008/351011
FAX: 254-057-351153/351221
Email: sgs@maseno.ac.ke

Date: 11th February, 2021

TO WHOM IT MAY CONCERN

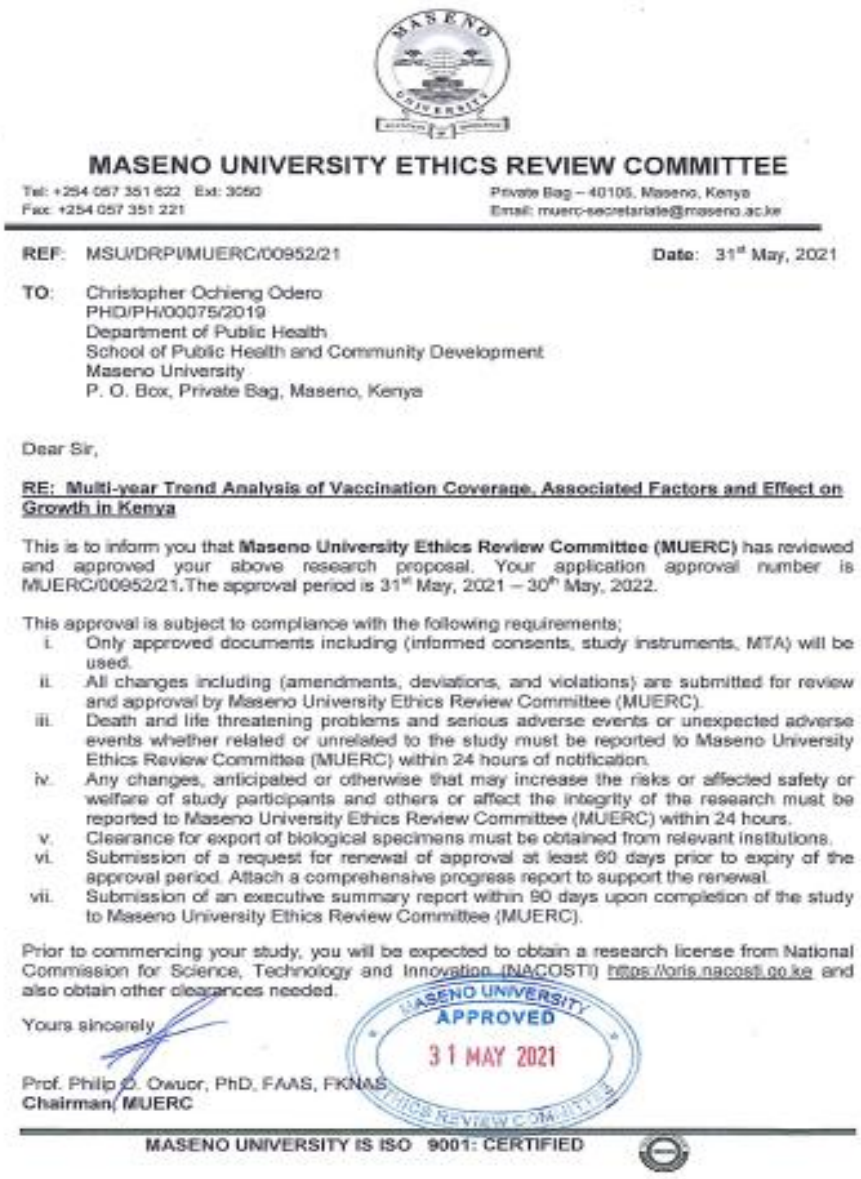
RE: PROPOSAL APPROVAL FOR CHRISTOPHER OCHIENG' ODERO PHD/PH/00075/2019

The above named is registered in the Doctor of Philosophy Programme in the School of Public Health and Community Development, Maseno University. This is to confirm that his research proposal titled "A Multi-Year Analysis of Trends in Vaccination Coverage, Associated Factors and Effect on Child Growth in Kenya." has been approved for conduct of research subject to obtaining all other permissions/clearances that may be required beforehand.

15 FEB 2021
Prof. J.O. Agure

Maseno University *ISO 9001:2008 Certified*

Appendix 4: Maseno University Ethics Review Committee (MUERC) proposal approval



MASENO UNIVERSITY ETHICS REVIEW COMMITTEE

Tel: +254 057 351 622 Ext: 3050
Fax: +254 057 351 221

Private Bag – 40105, Maseno, Kenya
Email: muerc-secretariate@maseno.ac.ke

REF: MSU/DRPI/MUERC/00952/21 **Date**: 31st May, 2021

TO: Christopher Ochieng Odero
PHD/PH/00075/2019
Department of Public Health
School of Public Health and Community Development
Maseno University
P. O. Box, Private Bag, Maseno, Kenya

Dear Sir,

RE: Multi-year Trend Analysis of Vaccination Coverage, Associated Factors and Effect on Growth in Kenya

This is to inform you that **Maseno University Ethics Review Committee (MUERC)** has reviewed and approved your above research proposal. Your application approval number is MUERC/00952/21.The approval period is 31st May, 2021 – 30th May, 2022.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by Maseno University Ethics Review Committee (MUERC).
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to Maseno University Ethics Review Committee (MUERC) within 24 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to Maseno University Ethics Review Committee (MUERC) within 24 hours.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to Maseno University Ethics Review Committee (MUERC).

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

MASENO UNIVERSITY APPROVED 31 MAY 2021 ETHICS REVIEW COMMITTEE

Yours sincerely

Prof. Philip O. Owuor, PhD, FAAS, FKNAS
Chairman, MUERC

MASENO UNIVERSITY IS ISO 9001: CERTIFIED

Appendix 5: National Commission for Science, Technology and Innovation (NACOSTI) proposal approval

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **825505**

Date of Issue: **09/July/2021**

RESEARCH LICENSE

This is to Certify that Mr.. Christopher Odero of Maseno University, has been licensed to conduct research in Baringo, Bomet, Bungoma, Busia, Elgeyo-Marakwet, Embu, Garissa, Homabay, Isiolo, Kajiado, Kakamega, Kericho, Kiambu, Kilifi, Kirinyaga, Kisii, Kisumu, Kitui, Kwale, Laikipia, Lamu, Machakos, Makueni, Mandera, Marsabit, Meru, Migori, Mombasa, Muranga, Nairobi, Nakuru, Nandi, Narok, Nyamira, Nyandarua, Nyeri, Samburu, Siaya, Taita-Taveta, Tanariver, Tharaka-Nithi, Transnzoia, Turkana, Uasin-Gishu, Vihiga, Wajir, Westpokot on the topic: A MULTI-YEAR ANALYSIS OF TRENDS IN VACCINATION COVERAGE, ASSOCIATED FACTORS AND EFFECT ON CHILD GROWTH IN KENYA. for the period ending : 09/July/2022.

License No: **NACOSTI/P/21/11585**

825505

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

Appendix 6: National Stakeholder Informed Consent Form

This is the consent form that has been approved by Maseno University REC.

Research Team

Maseno University

Principal Investigator:

Mr. Christopher Odero (christodero@gmail.com)

Co-Investigators;

1. Dr. Doreen Othero (daothero@hotmail.com)
2. Prof. Collins Ouma (collinouma@yahoo.com)

1. We are asking you to be in a research study.

We are asking you to participate n this study as an immunization services manager either at the National or County level. The information we gain from you and your insights as an immunization services manager are valuable in understanding vaccination coverage gaps in Kenya and inform the development of corrective strategies.

2. What do we want to learn in this study?

In this study, we want:

- To establish the trends of Non-vaccination, Under-vaccination and Missed Opportunities for Vaccination (2003-2014) amongst children 0-23 months in Kenya.
- To determine the influence of demographic and socio-economic factors on Non-vaccination, Under-vaccination and Missed Opportunities for Vaccination amongst children 0-23 months in Kenya for the period 2003-2014.
- To explore the influence of health system factors on Non-vaccination, Under-vaccination and Missed Opportunities for Vaccination of children aged 0-23 months in Kenya.
- To determine the effects of Non-vaccination, Under-vaccination, and Missed Opportunities for Vaccination on the growth rates of children aged 0-23 months in Kenya for the period 2003-2014.

3. Will this study help you?

Being in this research study will not help you personally. What we learn may help decision-makers have a better understanding of childhood immunization coverage and equity of Kenya's vaccination services, and how vaccination in general impacts child growth and health outcomes.

4. What will happen during the study?

Here is what will happen in this study: We will ask you questions about your role in vaccination programs/ child health in Kenya. The interview will be tape-recorded so we can later write down what was said. If you do not wish to be recorded, please let us know and we will write down the discussions in a notebook or don't join the study.

The interview should take about 45 minutes of your time to answer these questions. You do not have to answer any questions that make you uncomfortable.

We will share the results of the study with all study participants, health leaders in Kenya, and others. We may write an article or share the study results at meetings or on websites.

5. What are the risks of this study?

All research studies have some risks. Here are risks that could come from being in this study and how we will try to address those risks.

Discomfort

- You may feel uncomfortable with some questions we ask. You do not need to answer any question that makes you feel uncomfortable.

Loss of Confidentiality

- We keep your personal information secure. All information about you is kept in locked files and available only to the research team. We use a number instead of your name on study forms. However, there is always a small chance that someone who is not allowed could see your personal information by mistake. If this happens, we will tell you.

6. How we use and protect your personal information

We will use a number instead of your name on your data collection forms. Because we use a number instead of your name, no one will be able to know what study information belongs to you.

In this study, we will record some personal information about you. We need this information to show that you meet the study requirements as a National vaccine manager. We will also need your name, email, and phone number to reach you during the study. We will keep your personal information confidential.

The study team keeps a link between your name and your study number. After 3 years we will destroy the link and any documents that identify you.

7. Who can see your personal information

Groups who oversee our research can see study records. These are people from Maseno University and Kenya's ethics committees, including in Maseno.

- They may see your name and other personal information.
- They are not allowed to share any personal information about you.

8. What happens to your information when the study ends?

What we learn from research can help develop plans for reducing gaps in vaccination coverage. We will share what we learn in this study with others. We will remove your name and any personal information when we share the study information with others.

We will keep your information stored in password-protected computer files. We will keep the data for 3 years. After that time, we will destroy the data.

We may write an article or share the study results at meetings or on websites.

We may put the study data in a public database. This lets other researchers see and use the results. We will not share information that will identify you. When data from the study are destroyed, we will notify the Maseno University Ethics Review Committee.

9. Will you be paid for being in this study?

You will not be paid for being in this interview.

10. Your rights

- **You do not have to be in this study.** You can say yes or no to joining. You can leave the study at any time. If you do not join or if you leave the study early, you will not have any penalties. You should not feel pressured to join or stay in the study.
- **By signing this consent form, you do not lose any rights you normally have.**

Maseno University is responsible for data use of this study and, however unlikely, for any misuse of the data. If you have any concerns about his, please contact:

The Secretary, Maseno University Ethics Review Committee, Private Bag, Maseno; Telephone numbers: 057-51622, 0722203411, 0721543976, 0733230878

Email address: muerc-secretariate@maseno.ac.ke Or muerc-secretariate@gmail.com

By signing below, I affirm that

- ☐ ***Yes,*** *please tick* I agree to take part in this study
- ☐ **Yes,** *please tick* I agree that the interview is audio recorded.
- ☐ ***Yes,*** *please tick* I agree that information I give will be stored and may be used further in the future.
- ☐ ***Yes,*** *please tick* I agree to the use of anonymous quotes in future reports and publications

Who to contact if you have questions

- If you have questions about this study, please call Chris Odero, Tel: 0710236251.

If you have questions about your rights in this research study, please contact:

The Secretary, Maseno University Ethics Review Committee, Private Bag, Maseno; Telephone numbers: 057-51622, 0722203411, 0721543976, 0733230878

Email address: muerc-secretariate@maseno.ac.ke Or muerc-secretariate@gmail.com

Signing my name below means I have explained this research study to you and answered your questions to the best of my ability. I will give you a copy of this form to keep

Appendix 9: Map of Kenya showing the 47 Counties