MEKELLE UNIVERSITY

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DEPAR TMENT OF STATISTICS

A Multilevel Structural Equation Modeling Approach to Estimate Incompletion of Childhood Vaccination among 12-39 months old in Ethiopia

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APPROVAL SHEET

Department of Statistics, College of Natural & Computational Sciences Mekelle University

As thesis advisors, we hereby certify that we have read the thesis prepared by **Brtawit Aregay** under our guidance, which is entitled "**A Multilevel Structural Equation Modeling Approach to Estimate Incompletion of Childhood Vaccination among 12-39 months old in Ethiopia"**, in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including tables and figures are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

Yemane Hailu (PhD, in Biostatistics)

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As the members of the board of examiners of MSc. thesis open defense examination, we certify that we have read and evaluated the thesis and examined the candidate. Hence, we recommend that the thesis be accepted as it fulfills the requirements for the degree of Master of Sciences in Statistics, Biostatistics Stream.

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DECLARATION

I declare that this thesis entitled "**A Multilevel Structural Equation Modeling Approach to Estimate Incompletion of Childhood Vaccination among 12-39 months old in Ethiopia**" is a result of my genuine work and all sources of materials used, for writing it, have been duly acknowledged. I have submitted this thesis to Mekelle University in the partial fulfillment for the Degree of Master of Sciences in Statistics, Biostatistics Stream. The thesis can be deposited in the university library to be made available to borrowers for reference. I solemnly declare that I have not so far submitted this thesis to any other institution anywhere for that award of any academic degree, diploma or certificate.

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ACRONYMS

Abbreviations	Extended
DPT	Diphtheria, Pertussis, Tetanus
EA	Enumerative Area
EDHS	Ethiopia Demographic ANC Ante Natal Care
BCG	Bacillus Chalmette-Guerin
CI	Confidence Interval
DHS	Demographic Health Survey
EMDHS	Ethiopia Mini Demographic Health Survey
EMOH	Ethiopia Ministry of Health
EPI	Expanded program on Immunization
GAVI	Global Alliance for Vaccine and Immunization
HEP	Health Extension Program
HEW	Health Extension Worker
HIB	Homophiles Influenza Type B
OPV	Oral Polio vaccines
OR	Odds Ratio
RI	Routine Immunization
TT	Tetanus Toxoid
UN	United Nations
UNICEF	United Nations Children Fund
USAID	United States Agency for International Development
USD	United States Dollar
VPD	Vaccine Preventable Disease
WHO	World Health Organization

ABSTRACT

Background: *Childhood immunization is a worldwide ultimate public health intervention significantly plummeting morbidity and mortality linked with preventable diseases. Despite significant efforts to improve vaccination coverage, a considerable proportion of children aged 12-39 months in Ethiopia remaining incompletely vaccinated.*

Objective: *This study intended to employ a Multilevel Structural Equation Modeling (MSEM) approach and framework to broadly analyze the elements contributing to incompleteness of childhood vaccination in Ethiopia.*

Methods: *The study utilized secondary data from the Ethiopian Mini Demographic and health Survey (EMDHS) and adopted both qualitative and quantitative research approaches under descriptive research design. A multilevel logistic regression approach was employed to capture the interplay between individual and community-level factors impacting childhood vaccination status. At individual level, age, sex, education, marital status, and vaccination card were considered, while at the community level, factors such as antenatal care, place of delivery, poverty, media exposure, and living area were explored. The study established a conceptual model integrating these factors and applied a multilevel structural equation modeling approach to estimate their direct and indirect relations with incomplete childhood vaccination. On top of this, the pathways and interdependencies between variables were examined to elucidate the complex associations influencing vaccination outcomes.*

Results: *Preliminary analyses revealed significant direct effects of urban residence (AOR=2.1 & 95%CI of AOR [1.1,3.6] and age (AOR=11.5 & 95% CI of AOR [1.1,2.1]) On childhood vaccination. Additionally, community-level factors such as primary school maternal education (AOR=1.8 & 95% CI of AOR [1.3, 2.5]) and antenatal care follow-up (ANC: AOR=1.5 & 95%CI of AOR [1.0,2.2]) demonstrated varying degrees of influence on vaccination status.*

Conclusions: *The findings from this study grasp noteworthy implications and roles for national and global public health interventions. By identifying the multilayered elements impacting incomplete child vaccination, this research aims to provide evidence-based recommendations to reinforce vaccination programs and reduce the burden of vaccine-preventable diseases among Ethiopian children aged 12-39 months. Furthermore, the contributions of this study lie in its application of a wide-ranging multilevel structural equation modeling (MSEM) approach and framework, offering a nuanced understanding of the intricate web of determinants contributing to incomplete childhood vaccination in Ethiopia. The results are expected to inform targeted interventions and policy changes aimed at enhancing vaccination rates and safeguarding the health of children in national and regional level of Ethiopia as particular and worldwide in general.*

Keywords: *Incompleteness of Child Vaccination; Multilevel Model, Structural Equation Modeling; Multilevel Structural Equation Modeling Approach*

CHAPTER ONE

1. INTRODUCTION

1.1 Background of The Study

Childhood immunization stands as a keystone of global public health efforts, playing a fundamental role in reducing morbidity rates attributed to worldwide preventable disease (WHO, 2021). In Ethiopia, notwithstanding intensive endeavors to augment vaccination coverage, a prominent part of children aged 12-39 months remains inadequately vaccinated (Central Statistical Agency (CSA) of Ethiopia and ICF, 2019). Unraveling the multifaceted web of determinant factors contributing to this incomplete vaccination status is essential in framing targeted interventions and policy modifications to expand vaccination rates in the national and regional level.

Plentiful studies have underlined that the elements of incomplete vaccination are multilayered, encircling not only individual level factors but also broader contextual impacts at various societal levels (Okwaraji et al., 2017; Akwataghibe et al., 2020). At the individual level, variables such as parental education, age, sex, marital status, and vaccination card are recognized as key influencers determining a child's vaccination status (Chen et al., 2020; Alemayehu et al., 2018). Nevertheless, the impact of the community-level facets, including living area, place of delivery, antenatal care, poverty, and media exposures, significantly affects vaccination rates, highlighting the need for a multilevel approach to broadly hold these complexities (Lauridsen et al., 2018; Fadnes et al., 2019).

This study aims to adopt a multilevel structural equation modeling (MSEM) approach and framework to probe the numerous elements contributing to incomplete vaccination among Ethiopian children aged 12-39 months. The justification behind applying a multilevel modeling approach rests upon acknowledging the multifaceted nature of factors impacting incomplete vaccination (Diez Roux, 2018; Enders & Tofighi, 2007). The use of MSEM allows the exploration of both direct associations between impacting factors and incomplete vaccination and the nuanced pathways and mediating factors that underpin vaccination outcomes (Preacher et al, 2011).

MSEM is the combination of two statistical techniques which are known as SEM (structural equation model) and MLM (multilevel linear model /hierarchal model) these techniques were developed independently in the early-to-mid twentieth century. the SEM approach is fast to implement but lakes to answer research questions regarding measurement and relationships that may vary across levels. MSEM involves taking in a suite of (SEM statistical techniques developed for a single level and extending them to consider issues of consistency across time and across groups) we use latent variable approach to solve variation between and within clusters rather than applying cluster –based centering approach. It is causal model and useful where data are nested data which means cases are dependent It is applicable to any type of research design (e.g. experiments, surveys, case studies) or to instruments like questionnaires, interviews, observations, tests. The unique application of MSEM is it can answer research questions relating to variation in measurement and Classification across groups. Where there are unobserved constructs to be measured or latent groups to be identified. (James & Lars-Erik, 2020)

This study attempts to bridge a vital gap in the understanding of childhood vaccination in Ethiopia by integrating advanced multilevel structural equation modeling approach. By employing this analytical framework, the study pursues not only to expose direct relationships between various factors and incompleteness of childhood vaccinations but also to discern the complicated interplay and mediating mechanisms at different levels of influence (Marsh et al., 2004; Byrne, 2016).

Awaited findings are expected to provide dynamic insights that can guide targeted global public health interventions and policies to enrich childhood vaccination rates in Ethiopia. Detecting specific factors across different levels contributing to incomplete vaccinations will form the basis for evidence- based recommendations to strengthen vaccination programs and alleviate the burden of vaccine-preventable diseases among Ethiopian children aged 12-39 months.

In summary, this research aims to contribute to the prevailing body of knowledge regarding child vaccination by employing a multilevel structural equation modeling approach. This pursuit is aimed at providing a all-inclusive sympathetic of the intricate array of factors impacting childhood vaccination incompleteness in Ethiopia, crucial for formulating the most effective global public health interventions and policies to enhance vaccination coverage and safeguarding the health of children in regional, national and global context.

1.2 Statement of the problem

Immunization of children against preventable diseases is an ultimate public health intervention, yet in Ethiopia, a considerable number of children aged 12-39 months persist incompletely vaccinated, notwithstanding all-embracing efforts to boost vaccination coverage (Central Statistical Agency [CSA] Ethiopia and ICF, 2019). This inadequate vaccination coverage among children increases noteworthy concerns regarding the sustained susceptibility of this population to vaccine-preventable diseases.

Even though an improvement of child immunization is the issue of the world health organization (WHO) and all other world health based governmental and non- governmental organizations, obviously, in many countries like Ethiopia, there is poor implementation and evaluation of child health immunizations. As several studies describe, a number of socio-economic factors have been identified to influence the immunization coverage of children in order to enable certain numbers of children to achieve immunization coverage. Among these factors, some are attitudes of the society, educational levels and awareness of the parents, geographical locations and distance of residences from the health centers or any other service providing centers, as well as an affordability of the health facilitating materials, and so on are some of many obstacles.

Numerous studies have emphasized the multilayered nature of the problem, focusing that the factors of incomplete childhood vaccination in Ethiopia are intricate and multilayered (Alemayehu et al., 2018; Okwaraji et al., 2017). Individual-level factors, including mother education, child sex, marital status, and vaccination card, play fundamental roles in examining a child's vaccination status (Chen et al., 2020). Nevertheless, comprehensive community-level influences such as residence/living area, place of delivery, antenatal care, poverty, and media exposure pointedly impact vaccination rates, posing encounters for intervention plans and strategies (Fadnes et al., 2019; Lauridsen et al., 2018).

Despite these insights, a wide-ranging understanding of the interrelated and multilevel factors contributing to incomplete childhood vaccination in Ethiopia remains inadequate. Conventional analyses focusing solely on individual-level factors flop to capture the wide-ranging contextual influences that pointedly impact vaccination outcomes (Klein & Hessel, 2016; Dou, 2020). Addressing this gap is critical for framing effective and targeted interventions to improve

vaccination coverage and decrease the burden of vaccine-preventable diseases among Ethiopian children.

Hence, there is a demanding need for a more all-inclusive approach that contemplates the interactions between individual and community-level factors influencing incomplete child vaccination among 12-39 months old children in Ethiopia. Therefore, applying a Multilevel Structural Equation Modeling (MSEM) approach or framework in this setting will enable for a more wide-ranging investigation, clarifying the complicated web of factors that contribute to incomplete child vaccination and uncovering both direct and indirect pathways influencing vaccination outcomes.

This study aims to fill this fundamental gap in knowledge by adopting a multilevel approach to broadly understand the factors of incomplete childhood vaccination in Ethiopia, ultimately contributing to the formulation of evidence-based policies and interventions aimed at increasing vaccination rates among children aged 12-39 months.

Recently, to estimate the coverage of vaccinations many authors used multilevel models (e.g., Kinfe et al., 2019 and Mekonnen et al., 2020). Furthermore, Yismaw et al. (2020) used binary logistic regression with multiple predictors. However, these researchers did not consider the indirect effect of predictors or latent variables. The main gap is the consideration of effect of both direct and indirect predictors on vaccine coverage of children. Therefore, this research proposes that a multilevel structural equation models to incorporate the indirect effect of mediators on the coverage of child vaccination in Ethiopia. The mentioned studies did not consider the effect of latent variables. However, our study proposes to fulfill the gap of previous researches by incorporating the latent variables in consideration. Keeping all the mentioned problems in mind, the authors listed some research questions to be addressed at the completion of this study. Hence, the aim of this study is to fill gaps seen in study topic that are not addressed by other similar researchers.

1.2.1. **Research Questions**

1. What individual-level factors influencing the incompleteness of 12-39 months old childhood vaccination in Ethiopia?
2. What are the community-level factors affecting the incompleteness of 12-39 months old childhood vaccination in Ethiopia?
3. How do we estimate both direct and indirect effect of predictors?

1.3 Objectives of the study

1.3.1 General objective

The main objective of this study is a multilevel structural equation modeling approach to estimate incompletion of childhood vaccination among 12-39 months old in Ethiopia.

1.3.2 Specific Objectives

1. To examine the individual-level factors that influence incompleteness of 12-39 months old childhood vaccination in Ethiopia
2. To determine the community-level factors that impact 12-39 months old childhood vaccination rate in Ethiopia
3. To estimate the direct and indirect effects of entire factors on vaccination incompletion of children aged 12 to39 months.

1.4 Significance of the Study

The significance of conducting a study on " A Multilevel Structural Equation Modeling Approach to Estimate Incompletion of Childhood Vaccination among 12-39 months old in Ethiopia" is multilayered and holds implications for global public health, policy formulation, and targeted interventions. Below are the key points highlighting the significance of this study:

The significance of this study for governments, NGOs, global public health authorities, and physicians: This study aims to broadly understand the elements impacting the incompleteness of childhood vaccination in Ethiopia at both individual and community levels. The investigation of these multilevel determinants is fundamental as it goes beyond traditional individual-focused

approaches, providing an all-inclusive and holistic view of the multifaceted dynamics impacting childhood vaccination outcomes.

Significance of this study for policy formulators and planers: The Findings from this study can provide incredible insights to policymakers and public health authorities in Ethiopia. Realizing and understanding the interrelated elements and pathways contributing to incompleteness of childhood vaccination can enlighten evidence-based policy invention for improving vaccination coverage among 12-39 months old children.

The significance of this study for physicians and medical experts: The research outcomes can guide the development of targeted interventions aimed at improving childhood vaccination rates. By identifying specific factors at different levels that contribute to incompleteness of childhood vaccinations, this study can help in scheming tailored interventions addressing these factors successfully.

The significance of this study for public health monitoring organizations: The findings of this study is expected to provide improved vaccination coverage that directly associates to a reduction in the burden of vaccine-preventable diseases among children. The study may provide substantial improve of childhood vaccination rates through targeted interventions that can lead to a decline in morbidity and mortality rates associated with preventable diseases, contributing to overall public health betterment.

Significance of this study for public health program promoters: The study's findings can provide crucial insights for refining and optimizing existing public health programs related to childhood immunization in Ethiopia. It can aid in the identification of areas that need attention and improvement within these programs.

The significance of this study for academicians and researchers: The study expected to add the knowledge and academic discourse by employing a multilevel structural equation modeling approach. This not only contributes to the existing body of knowledge on childhood vaccination but also provides a methodological and procedural framework that could be applied in similar studies across varied contexts.

The significance of this study for global health initiatives: The study insights garnered from this study may have broader implications beyond Ethiopia, potentially enlightening strategies and policies in other low- and middle-income countries facing similar challenges in childhood immunization programs.

The significance of this study for decision makers: Findings of this study is expected to guide decision makers in providing evidence-based recommendations derived from vigorous data and a sophisticated analytical approach that empowers decision-makers, health practitioners, and stakeholders to make informed decisions and investments to enhance childhood vaccination programs in Ethiopia.

In conclusion, the significance of this study will be important for the society by clarifying the critical social determinants of health and addressing the barriers to better taking full vaccination program. To inform for the plan drafters to know and identify the factors which are the most obstacles and causes or mediators not to cover full vaccination among children aged 12-39 months in Ethiopia.to improve vaccination coverage in individual level in both and reduce factors which causes difference in the community level and also to assign the university to participate in enhancing access to quality services that are accessible, affordable, and acceptable to all communities. To increase access of vaccination and community awareness, researchers need to examine the gap in full vaccination coverage so my study will help to fill the uncovered issues and which is not studied here for further study.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Theoretical literature

In the most developing and low-income countries, the prevalence of fatality is increasing at an alarming rate in infancy and childhood. However, the level of mortality in infancy and childhood is a growing public health concern and an important indicator of the health of the population worldwide. Even though many countries have been striving to decline under five child mortalities by implementing disease preventable immunization access to every child, the prevalence of child mortality in developing world is yet an alarming rate. It is because of lack of exposure and awareness to disease preventable vaccine of many societies.

Despite its long clinical success lack of an adequate vaccination has existed as a vital health problem for many years. A disease preventable vaccine is a common condition which has considerable impact on child mortality and morbidity. As it was cited in Mokennen et al. (2020), a substantial contribution of vaccine preventable diseases to under -five fatality and morbidity is irrefutable (WHO, UNICEF and World bank, 2009).

Henceforth, immunisation can play an important role in addressing public health issues globally, as it has become one of major contributors in preventing communicable disease, particularly in infancy and childhood (Mekonnen et al., 2020). previous evidence shows that about 29% of deaths among under five children are vaccine preventable (Shen, Fields, and, McQustion, 2014) and being fully vaccinated is associated with 22% lower mortality in children (GAVI, 2015).

Previous studies have reported a regular and successful immunization averts an estimated 2 to 3 million deaths every year from diphtheria, tetanus, pertussis (whooping cough), and measles worldwide (Bhatti et al.,2018). However, despite the tremendous efforts made so far, vaccine preventable diseases remain the most serious challenges of public health issues among infancies and children in developing countries including Ethiopia (FMOH, 2015a, 2015b; FMOH, 2016; WHO, 2017).

Further research has established that, around 9 million children in the African region still miss out on life-saving vaccines each year. The study shows one in five children remain unprotected from vaccine preventable disease, which claim the lives of over and one in five children remain unprotected from vaccine preventable diseases, which claim the lives of over 500,000 under five children in Africa every year (WHO, 2021).

To maintain the population's well-being by reducing childhood mortality, the world health organization (WHO) lunched the expanded program on immunization (EPI) in 1974 with the goals of increasing immunization worldwide (Keja et al., 1988)

To prevent outbreaks and to keep the world safe from diseases vaccines are very useful. Since children need more protection from diseases, they need to take vaccines which can assure in to declining and reducing infant and child mortality. There are 6 common vaccines which are given worldwide called as tuberculosis, diphtheria, whooping cough (pertussis), tetanus, polio, and measles. Based on the EPI program the six vaccines are given on routine and outreach bases (EPI 2015) in 2000 the Gavi was created and UNICEF was helping to introduce the new vaccines for developing country like hepatitis B, haemophilus influenzae type b, pneumococcal and rotavirus (UNICEF, 2018).

When we see in Ethiopia the pneumococcal conjugate vaccine (PCV13) and monovalent human rotavirus vaccine (RV1) were added into the national infant immunization program in November 2011 and October 2012, respectively PCV13 is important to decline a disease which is called sever pneumonia, meningitis, and other, illnesses rotavirus vaccine is also important to decline dehydration and death because it is a virus that causes gastroenteritis; an inflammation of the stomach and intestines(2016 EDHS). As reports showed that in non-developed countries such as Ethiopia coverage of Immunization is not fully covered as required (Yasine and Beyene, 2015).

Knowing the vaccination coverage is important to save children and infant from various infectious diseases of children targeted by loose of vaccines we have to make sure that children souled take completely all vaccinations. A country like Ethiopia which has a heterogeneous population can be faced by the difficulties in addressing vaccination for all regions in the same level. But we need to have a plan and program in order to address difficulty's which are caused by the factors like economic, culture, socio demographic, religion and educational status of the

community differences. In 2019 EDHS was collected information on the coverage of vaccination for all vaccines for children who was born in3 years preceding the survey The survey on differences in vaccination coverage among subgroups of children was useful for program, planning and targeting resources towards areas most in need.

The research gap in the previous study's is the model they used was binary multilevel logistic and MLM which it did not consider testing multilevel mediations, potential bias in the between group variance but latent variable (not directly measured) decomposition of within and between in MSEM provides better estimates than the centering method in MLM.

Ethiopia has a large and diverse population with a range of socio-demographics, religious beliefs, and educational levels, which causes regional variances in vaccination rates. Infectious disease outbreaks in the nation may have under-vaccinated populations as a cause in some areas.

Latest studies in Ethiopia have estimated individual-related factors and community related factors affecting vaccination status Those studies, assumed direct relationships between socio-demographic, socioeconomic factors and childhood vaccination in logistic regression models and multilevel. But in my study in addition to this I was used the predictors of childhood vaccination in different approach such as a direct effect, and some will have an indirect effect and mediating or moderating role between the predictors and childhood vaccination.

Vaccination is one of the most cost effective, essential service and public health preventive measures in country of all low- and high-income levels for vaccine preventable diseases.

Practicing routine immunization programs protect most of the world's children from a number of infectious diseases that previously claimed millions of lives each year (WHO, 2015). Sustainable Development Goals 3(SDGs) targets that to ensure equitable access to vaccination services for all children. Worldwide to reduce and minimize the risk of child mortality, maternal mortality, and burden of infectious diseases child vaccination service and Antenatal care service are adopted. Mothers who were visit ANC can receive counseling and education about the postnatal visit and importance.

To reduce the risk of under-five mortality universally there are six crucial vaccines which are disease preventable and can help the immunity system in children since infant and child

mortality rates are basic indicators of a country ‘s socioeconomic situation and quality of life (UNDP 2007) countries did not have the same coverage of vaccination.

Studies show that globally the highest under-five mortality rate is in sub-Saharan African region and accounts for 52% of this age group’s total deaths. In2018, average deaths was 78 deaths per 1,000 live births, which means 1 in 13 children dying before their fifth birthday. This rate is 16 times higher than the average ratio of 1 in 199 children in high-income countries. But majority of the deaths were preventable or could be treated using vaccination, clean water and sanitation, adequate nutrition, and appropriate care by a trained health care provider as needed and the difference between high and low-income countries can be reduced by giving equal access to the benefits of vaccines regardless of their geographic area , socioeconomic ,or demographic status but this is not the only case vaccine preventable diseases also remain a cause of morbidity and mortality in many low- and middle-income countries (Firew et ta., 2021; Woldie et al., 2021). Not developed countries such as Ethiopia Vaccination coverage achieved much through the expanded national program immunization with the help of GAVI even though it did not accomplish the needed coverage.

As the study’s showed that variable such as four or more antenatal care contacts, childbirth at health facility, improved maternal education, higher household wealth, and frequently listening to the radio and media increased vaccine uptake. Additionally Population size of countries, the rural location of communities and political instability and conflict may have a potential effect in health service activities which may cause to low vaccination coverage to give effective and fast vaccination services involving campaigns and Mass media is use full for creating awareness and promoting positive perceptions towards vaccination and health services. Treatment for mothers by health workers in friendly, respectful, manner may courage to uptake of vaccination services. Health workers may be discouraged to give service in a good manner to mothers who forgot the child’s vaccination card, missed a scheduled appointment, or had a dirty or poorly dressed child. This may also result in feelings of humiliation and discourage mothers from vaccinating their children (Firew et ta., 2021; Woldie et al., 2021).

In Ethiopia females who have completed tenth grade were trained in health extension program modules for one year, to provide family planning and immunization services; which is important to promote preparedness for birth and readiness for compilations of vaccinations and active

management of the third stage of labor among others called health extension workers (Ayal et al., 2020).

2.2 Empirical Literatures

According to Alemu (2014), the cause for imperfect vaccination and non-uptake of immunization services are poorly known. Even though the standard measure of perfect immunization or vaccination coverage may be different from country to country, there may be the standard of WHO based on the vaccination coverage percentage of children who have received the requisite number of vaccine doses irrespective of the vaccine. However, Glauber (2013) suggested that, to maximize protection against vaccine –preventable diseases, a child should take all immunization with in suggested interval.

But due to the reason of lack of awareness or lack of enough education and training many parents in developing countries are reluctant to implement.

As quoted by Mesfin and Shikur (2015), about 29% of under-five child fatalities can be prevented by an adequate vaccine (UNICEF and WHO,2012). As the study of Mesfine and Shikur (2015), showed 1.5million children had been died in 2011 due to the vaccine preventable disease WHO(2014).The study further showed that 16% of under-under five mortality in Ethiopia was recognized due to the lack of an adequate vaccinations (Luelseged et al., 2006).

Furthermore, as cited in Mesfin and Shikur (2015), the report of WHO (2011) showed that, about 83% infants received at least 3 doses of DTP vaccine; however, about 22.4 million failed to take 3 doses. This led to susceptibility of many children to vaccine –preventable diseases and fatalities in the world. Rainey et al. (2011) further showed about 8.4 million children received at least 1 DTP dose, however, they failed completing the required 3-dose series.

According to report of UNICEF and WHO (2012), out of five infants dose not receive 3-dose to save their life from the preventable disease's diphtheria, tetanus and pertussis vaccine.

Moreover, recent work by Yismaw et al. (2019) has reported that, the immunization is one of the most effective and gainful world public health intervention procedures to avert and eliminate life threatening infectious diseases and is expected to avert between 2 and 3 million deaths each year.

Typically, vaccine preventable diseases cover for the death of over 2 million children in year and huge number of them happened in Sup-Saharan Africa (Bishai, 2008; Banteyerga, 2011).

Existing research recognizes, sup-Sahara Africa accounts more than 15 times to die under five years due to preventable and treatable diseases using simple, affordable intervention relative to the developed world in addition to this, about 5.6 million of under –five children mortality have been reported in 2016 due to vaccine preventable disease (Etana and Deressa, 2012; Chan, 2014). The study argued that, parent's education and the frequency of the mother's health care utilization have vital role in rising the rate of full immunization (FDREMH, 2014).

In 2019, 19.7 million children remained unvaccinated for DPT3 vaccine worldwide, of which 48% were in Africa (Helen, 2018). Child vaccination coverage in sub-Saharan Africa was analyzed they were used multilevel regression model to identify predictors of inequality in receiving of full Vaccination. The results shows that the Overall, 56.5% (95% CI: 55.7% to 57.3%) of children received full vaccination, 35.1% (34.4% to35.7%) had incomplete vaccination, while 8.4% (95% CI: 8.0% to 8.8%) of children remained unvaccinated. Full vaccination coverage in Ethiopia in 2019 was 39.09% the study's shows that individual level and community level factors affected the vaccination status (Sako et al., 2023).

A study conducted that Full immunization coverage in Ethiopia was significantly lower than the global target. They used Bivariate and multivariable logistic regression analyses to identify the determinants of full immunization coverage in Ethiopia. They found that overall full immunization coverage was 38.3% (95% CI: 36.7, 41.2). Rural residence (AOR = 0.60, 95% CI:0.43, 0.84), employed (AOR = 1.62, 95% CI: 1.31, 2.0), female household head (AOR = 0.58, 95% CI: 0.44, 0.76), wealth index [middle (AOR = 1.44, 95% CI: 1.07, 1.94) and richness (AOR = 1.65, 95% CI: 1.25,2.19)], primary school maternal education (AOR = 1.38,95% CI: 1.07, 1.78), secondary school maternal education (AOR = 2.19, 95% CI: 1.43, 3.36), diploma graduated mothers (AOR = 1.99, 95% CI: 1.09, 3.61), ANC follow ups (AOR = 2.79, 95% CI:2.17 3.59), and delivery at health facilities (AOR = 1.76, 95% CI: 1.36, 2.24) were significantly and positively associated factors with full immunization.

In contrast Female household head and rural dwellings were negatively associated with full immunization among 12–23 months old children. They suggested that improving health

education and service expansion to remote areas are necessary to step immunization access. Full immunization coverage among rural residents and urban resident's was 31.7 and 66.6% respectively and they found that Full immunization coverage among Ethiopian administrative regions is heterogeneous, ranging from 8.8% in Afar region to 86.8% in Addis Ababa. Full immunization coverage finding in this study was significantly higher than 2005 and 2011 EDHS reports of 19 and 24%, respectively (Tamirat and Sisay et al 2019). The women with no education had significantly higher odds of their child receiving no polio vaccination (OR 2.34, 95% CI 1.05 to 5.18; $p<0.01$) and incomplete vaccination (OR 1.40, 95% CI 1.04 to 1.87; $p<0.01$). Further, un empowered women also had significantly higher odds of not taking their child for any polio vaccination (OR 1.58, 95% CI 1.17 to 2.12; $p<0.01$) and incomplete vaccination (OR 1.18, 95% CI 1.00 to 1.41; $p=0.04$). Illiteracy, socioeconomic status and empowerment of women remained significant factors linked to poorer uptake of routine polio vaccination (Banteyerga, 2011).

Multivariate analysis was conducted to explore the child and parental factors, including socioeconomic factors that were associated with non-vaccination of children. A concentration index was calculated to measure inequality in childhood vaccination. Results confirm a strong socioeconomic gradient in childhood vaccination in the Republic of Ireland. Concentration indices of vaccination (CI=-0.19) show a substantial pro-rich gradient. Results from the decomposition analysis suggest that a substantial proportion of the inequality is explained by household level variables such as socioeconomic status, household structure, income and entitlement to publicly funded care (29.9%, 24% 30.6% and 12.9% respectively). Rotaviruses remain the major cause of childhood diarrheal disease worldwide and deaths of infants and children in developing countries (Bishai, 2008).

Logistic regression analysis was applied to examine the influence of paternal education on uptake of the first dose of measles vaccination, independent of maternal education, whilst controlling for confounding factors such as respondent's age, urban/rural residence, province/state of residence, religion, wealth and occupation. The results of the analysis show that even if a mother is illiterate, having a father with an education of Secondary (high school) schooling and above is statistically significant and positively correlated with the likelihood of a child being vaccinated for measles, in the six countries analyzed. Paternal education of

secondary or higher level was significantly and independently correlated with measles immunization uptake after controlling for all potential confounders (Firew, 2021).

Study found that more than three-fourth (78%) of children among age group of 12-59 months were missed one or more doses of recommended vaccine. Perceived problem of distance to reach a health facility (AOR=1.24; 95% CI: 1.01, 1.52) and no exposure to media (AOR=1.53; 95% CI: 1.21, 1.93) had higher association with child immunization. With regard to the community-level factors, communities living in Affar region (AOR=8.69, 95% CI: 4.33, 17.42) and communities living in Oromia region (AOR=3.82, 95% CI: 2.27, 6.44) had a positive influence on defaulting of child immunization (Glauber, 2003).

Mother's education, husband employment, mother's religion, mother's antenatal care visit, presence of vaccination document, region and community antenatal care utilization were significantly associated with children full vaccination. The odds of full vaccination were 2.5[AOR = 2.48 95% CI: 1.35, 4.56] and 1.6 [AOR = 1.58 95% CI: 1.1, 2.28] times higher in children of mothers with secondary or higher and primary education respectively than children of mothers with no education (Helen, 2018).

Among 1, 929 children, only 48.6% (95% CI: 46.3 to 50.8%) were fully vaccinated while 37.8% (95% CI: 35.7 to 40.1%) were partially vaccinated. The multilevel ordinal logistic regression model reveled that housewife mother (AOR =1.522, 95%CI: 1.139, 2.034), institutional delivery (AOR =2.345, 95%CI: 1.766, 3.114),four or above antenatal care visits (AOR = 2.657; 95% CI: 1.906, 3.704), children of mothers with secondary or higher education (AOR = 2.008; 95% CI: 1.209, 3.334),Children whose fathers primary education (AOR = 1.596; 95% CI: 1.215, 2.096), from the rich households (AOR = 1.679; 95% CI: 1.233, 2.287) were significantly associated with childhood vaccination (Firew et al., 2021).

Under-five mortality is lower for children vaccinated At least ones compared to those who were unvaccinated (Keja, 1988). Mothers attended antenatal visits exhibited lower risk of Neonates death than those whose mothers did not (Koku, 2019). In addition, giving two tetanus toxoid injections to the mothers before childbirth decreased NM (Glauber, 2003).

2.3. Conceptual Framework for Structural Equation Modelling (SEM)

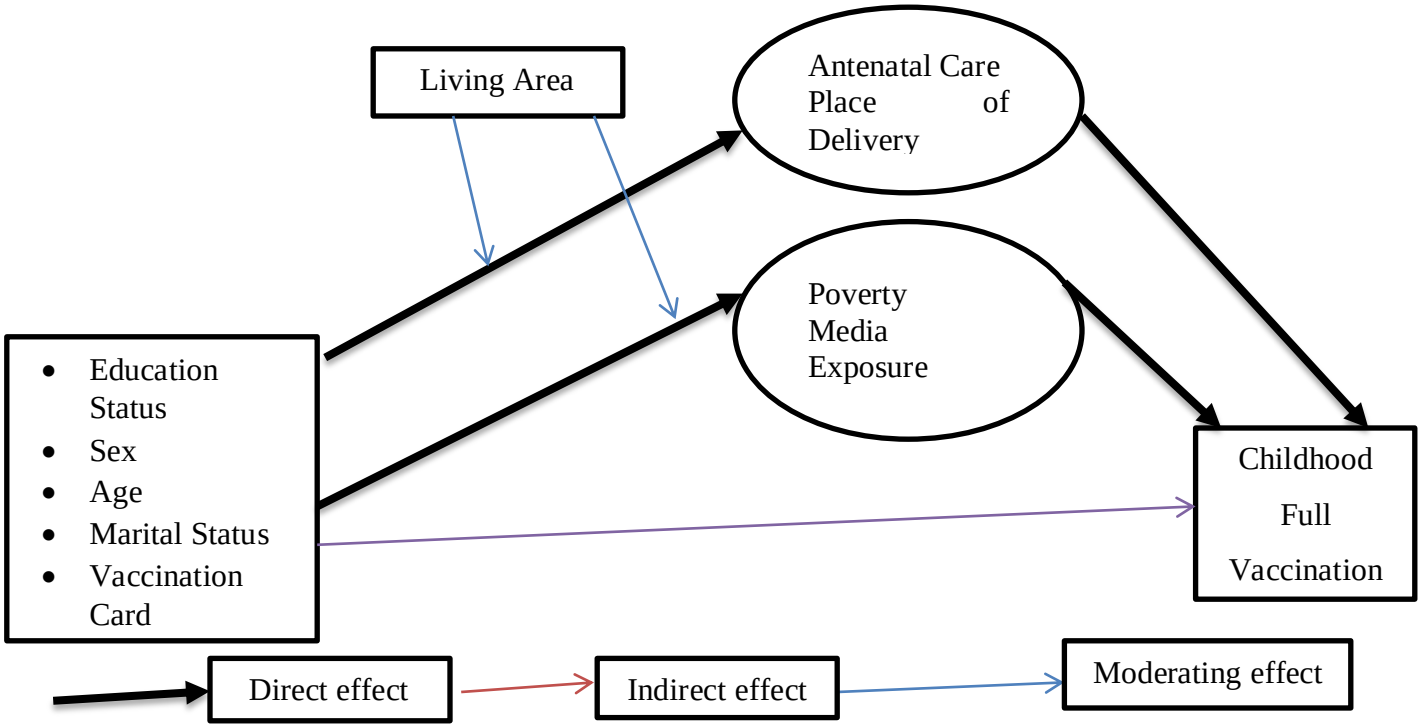

Figure 2.1. Conceptual Framework for SEM

CHAPTER THREE

3. DATA AND METHODOLOGY

3.1. Data Sources and its descriptions

The data for this study was obtained from the second Ethiopian mini Demographic and Health Survey conducted in 2019, which is the fifth DHS implemented by the Central Statistical Agency (CSA) in Ethiopia. The survey was conducted from March 21, 2019, to June 28, 2019, based on a nationally representative sample that provided estimates at the national and regional levels and for urban and rural areas.

3.1.1 Population

The study was conducted in Ethiopia, the population in 2023 is estimated to be 126, 4527,060 million the population in Ethiopia is the second largest populous country in Africa with an annual population growth rate of 2.5%. The country is divided into nine regional and two city administrations. I will use the 2019 EMDHS the census frame is a complete list of the 149,093 EAs created for the 2019 EPHC. An EA is a geographic area covering an average of 131 households. The sampling frame contains information about EA location, type of residence (urban or rural), and estimated number of residential households.)

3.1.2 Target populations

My targeted population is children aged 12-39 month's age in the EMDHS children. Children age of 12–39 months with missing age of child and outcome variable Will be excluded from the study All women aged 15–49 years who were usual members of the selected households will be eligible for female survey.

3.1.3 Study population

All living children aged 12–39 months at the time of the survey were the source population of the study. The survey interviewed 8,855 women of reproductive age (age 15-49) from a nationally representative sample of 8,663 households. The sample was taken using a two stage stratified sampling. Each region was stratified into urban and rural areas.

3.2 Research design and approach

I had used mixed research approach The 2019 EMDHS is a nationwide community-based cross-sectional study. I will undertake an in-depth secondary data analysis using the EMDHS data set. I was extracted the data from EMDHS on line.

3.2.1 Sampling design of 2019 EDHS data

I used the Ethiopia Mini-Demographic and Health Survey (EMDHS) 2019 dataset to analyses childhood vaccination coverage and to estimate.

The 2019 Ethiopian Population and Housing Census (EPHC) was conducted in 2019, and all census enumeration areas (EAs) were used to form the sampling frame for the EMDHS. The 149,093 EAs produced for the 2019 EPHC are provided in full in the census frame. An EA is a region that typically has 131 households. Information regarding the EA location, home type (urban or rural), and the expected number of residential households are all included in the sampling frame. Nine geographical regions and two administrative cities make up Ethiopia's administrative divisions. In order to produce estimates of key indicators for the country as a whole, for urban and rural areas separately, as well as for each of the nine regions and the two administrative cities, the sample for the 2019 EMDHS was created.

Two phases of stratification and selection were used for the 2019 EMDHS sample. 21 sampling strata were produced after stratifying each region into urban and rural areas. In two steps, independent selections of EA samples were made in each stratum. By classifying the sampling frame within each sampling stratum before sample selection, according to administrative units in various levels, and by using a probability proportional to size selection at the first stage of sampling, implicit stratification and proportional allocation were achieved at each of the lower administrative levels. Using an equal distribution, 25 EAs were chosen from eight regions in order to guarantee that survey precision was equivalent across regions. From each of the three bigger regions, 35 EAs were chosen: the Southern Nations, Nationalities, and Peoples' Region (SNNPR), Amhara, and Oromia. A total of 305 EAs (93 in urban areas and 212 in rural areas) were chosen in the first stage, with independent selection in each sample stratum and a probability proportional to EA size (based on the 2019 EPHC frame). In all chosen EAs, a household listing operation was conducted from January through April 2019. The lists of

households that were produced served as a sampling frame for choosing the households in the subsequent step. Some of the major EAs that were chosen for the 2019 EMDHS have more than 300 households. To minimize the task of household listing, each large EA selected for the 2019 EMDHS was segmented. Only one segment was selected for the survey, with probability proportional to segment size. Household listing was conducted only in the selected segment; that is, a 2019 EMDHS cluster is either an EA or a segment of an EA.

Hybrid model combining factors from the individual and community levels referred to as a mixed model, which also known as a combined model so I have used mixed model and the multilevel structural equation model to analyses the direct and indirect effect. The Analysis was done using Stata software.

3.2 Variables included in the study

As illustrated in the literature review and from 2019 EMDHS the following variables will be considered in this study.

3.2.2 The Response variable

The outcome variable Y will be child's vaccination status. It is a binary outcome variable that will be coded as "1" to mean completely vaccinated if he/she receives one BCG, three doses of DPT, at least three doses of OPV and a measles vaccine or "0" to mean incompletely vaccinated if the child missed one or more doses of the above listed vaccines [19]

3.2.3 Explanatory variables

Individual and community level factors for child not fully vaccinated were extracted from EDHS 2019.

3.2.3.1. Individual-Level Factors

a) Socio-economic factors

Mother's education: the category in the EDHS was coded as no education, primary education, secondary education and higher education. But, in my study secondary and higher education

were combined since their percentage was small and mothers who attended secondary school and higher education may not differ significantly for full vaccination status of child.

Wealth index: is derived from the different properties of the households in order to assess the household's cumulative living standard. The five categories in the EDHS were implemented with no change as categorize to poorest, poorer, middle, richer, and richest.

Exposure to mass media: Frequency of listening to radio and watching television were considered as exposure to mass media in my study. There were three categories for this variable: not exposure to radio and television, exposed to either radio or television, exposure to both radio and television.

Child's vaccination card: Vaccination and other health cards were used to identify children who have vaccination cards and those children who have not cards at the time of survey.

b) Socio-Demographic Factors

Age of mother: Measured in year which the age was categorized into three groups: 15-24years; age 25-34years; and age 35-49 years.

Religion: The dominant religion in the country was: Orthodox, Muslim, and Protestant with minorities was merged into one category and labeled as 'other'.

Marital status: There were two categories for this variable as the EMDHS living with partner; not living with partner. The former included women formally married and women living with a partner as married, while the latter contained never married women as well as those widowed, divorced or separated.

c) Health Care services

Place of delivery: The responses for place of delivery collected in the EDHS data are many categories I had categorized it as home delivery, and health facilities.

3.2.3.2 Describing community aggregates

In EDHS data there is no data that can directly define the characteristics of the clusters except place of residence and region. Then I had created other community level by aggregating the

individual looks with my concern in a cluster to vaccination status since all the aggregated variables were not normal so were computed using the proportion of a given variables' subcategory with which i were concerned in a given cluster.

3.2.3.2. Community -Level Factors

Community wealth status: It is distinct as the part of poor or poorest mothers within the cluster. Within the cluster part of poor or poorest were aggregated and can show us over all poverty status within the cluster. I have two categories for this variable with reference to the national mean value; higher amount of poor poorest mothers and lower amount of poor or poorest mothers within the cluster.

Community women education: Was defined as the proportion of mother's who attended primary/secondary/higher education within the cluster. The aggregate of individual mother's primary/secondary/higher educational attainment can show the general educational status of Women within the cluster. There were two categories for this variable with reference to the national median value: higher proportion of mother's who attended primary/secondary/higher education and lower proportion of mother's who attended primary/secondary/higher education within the cluster.

Community institutional delivery: It is defined as the proportion of mother's who delivered their child in the health institution within the cluster. The aggregate of individual mothers who delivered their child in the health institution within the cluster can show the overall institutional delivery of the cluster. There were two categories with reference to the national median value; lower proportion of mother's who delivered their child in the health institution, and higher proportion of mother's who delivered their child in the health institution within the cluster.

Community media exposure: Was defined as the proportion of mother's who were exposed to media and not exposed within the cluster in the in a week. The aggregate of individual mothers who were exposed to media and not exposed can show the overall media exposure status of mother's within the cluster. There were two categories for this variable: with reference to the national median value; lower proportion of mother's who were not exposed to media and higher proportion of mother's who were exposed to media within the cluster.

Community ANC utilization: Was defined as the proportions of mother's who visit antenatal care at least one visit within the cluster. The aggregate of individual mother who visit antenatal care at least one visit can show the overall antenatal care utilization of mother's within the cluster. There were two categories for this variable: with reference to the national median value; lower proportion of mother's who visit antenatal care at least one visit and higher proportion of mother's who visit antenatal care at least four visits within the cluster.

3.3 Methods for data analysis

3.3.1 Multilevel modelling

Traditionally, data are aggregated prior to analysis by composing one sum score per individual and averaging this sum score over all observed individuals. First drawback is that these averages have different standard errors because the variance of the underlying individuals differs between communities and because the number of individuals per community differs. Second drawback is the implicit assumption that all items have equal weight in relation to the latent variable being measured. I used a multilevel structural equation model, to treat the individuals (level 1) as nested observations within communities (level 2), as alternative analysis method to overcome the drawbacks.

The model I used in the research includes a factor model measuring a latent variable at the level of the individual and at the level of the community. Then, in the same model, the latent variables will be regressed on covariates to assess the vaccination completion. Inferences was used to obtained about the Incompletion of the vaccination using the proposed model.

the data follow a hierarchical structure with individuals nested within communities where the number of observed individuals is highly unbalanced across communities.

In this paper, as i explain in the above aggregating such data have several drawbacks and I had used a model that overcomes the drawbacks. Without the requirement to aggregate the data beforehand, the MLSEM model can be used to compare two or more characteristics on a latent variable using measurements from several (unbalanced) events

Hierarchical linear modeling (multilevel regression) can be extended to latent variable models as well. When data are hierarchically structured, assumptions about the independence of

observations are violated in regression and SEM. ML-SEM model will be used for estimating incompletion of children vaccination aged12-39 months.

3.3.3 Data preparations

For the multilevel model: The data analyzed in this paper are the vaccination statues data coming from cross sectional data. In the multilevel data I had used 4 models, the null model only the fixed model which is the dependent variable only, modell2 the individual predictors only analysis, the 3rd model was the analysis only with community predictors the last model 4 was the mixed model of individual and community level predictors analysis.

3.3.4 Notation and ML-SEM model

Considering the vaccination status data, In this study our data is hierarchical in nature with two (individual and community) levels. Given there are many approaches to combing MLM and SEM, in this study an approach by Muthen and Asparouhov's (2008) two-level model has been adopted. The model involves three fundamental equations.

Measurement model: $Y_{ij} = v_j + \Lambda_j \eta_{ij} + K_j X_{ij} + \varepsilon_{ij}$ (1)

Within structural model: $\eta_{ij} = \alpha_j + B_j \eta_{ij} + \Gamma_j X_{ij} + \zeta_{ij}$ (2)

Between structural model: $\eta_j = \mu + \beta_j \eta_j + \gamma X_j + \zeta_j$ (3)

Where i and j index, respectively are cases (level 1 units) and clusters (level 2 units). Vectors and matrices with j subscripts contain elements that may vary across clusters. $Y_{ij}(p \times 1)$ is a vector of measured variables; $v_j(p \times 1)$ contains intercepts; $\varepsilon_{ij}(p \times 1)$ is a vector of level 1 errors; $\Lambda_j(p \times m)$ is a matrix of loadings linking observed variables to m latent variables; $\eta_{ij}(m \times 1)$ is a vector of latent variables or random coefficients; $X_{ij}(q \times 1)$ and $X_j(s \times 1)$ contain, respectively, exogenous level 1 and level 2 regressors; $\alpha_j(m \times 1)$ contains latent intercepts; $K_j(p \times q)$, $\Gamma_j(m \times q)$, and $B_j(m \times m)$ contain structural coefficints; $\eta_j(r \times 1)$ contains all of the j-subscripted random coefficients from v_j, Λ_j, K_j, α_j, B_j, and Γ_j; $\mu(r \times 1)$ contains means of

those coefficients; $\beta(r \times r)$ and $\gamma(r \times s)$ contain structural coefficients linking random effects to each other and to exogenous regressors, respectively; and $\zeta_{ij}(m \times 1)$ and $\zeta_j(r \times 1)$ contain, respectively, residuals for level 1 and level 2 latent variable and random effect regressions. Finally, $\zeta_{ij} \sim MVN(0, \Psi)$ and $\zeta_j \sim MVN(0, \psi)$.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1. Results

4.1.1. Descriptive Data Analysis

The factors that affect the vaccination status of children 12 to 39 months of old are presented at table 4.1 the total number of population /children /are 2101. Among the total 59.21%of the specified age group vaccinated fully and 40.79% of them not vaccinated.

Socio-Demographic Factors description in the study, 73.47% dwellers were in rural area, from mothers age group 15-49 the highest respondent's age group was in 25-34 most of the respondents had 2-3 children in the birth order category which means 31.27 % and has the lowest birth order 1 in 22.12% when we observe marital status of the respondents' categories, 94.51% were living with partner or married and 5.5 were not living with partner

The socioeconomic description of the respondents showed that in the wealth index category 23.6% of the respondents were in poorest category and 20.06% respondents were in the richest category.52.88% of respondents had not gotten proper get education women's who are exposed to media were 33.67% and those who are not exposed were 66.33%. In this study respondents who had not vaccination card and other health document are 66.14% the antenatal visit and place of delivery for these respondents was 41.35% women visits above 4 times in to health care places and 51.79% were delivered at home.

The percentage of vaccination status in the 12-39 months' old differs from state to state the higher percentage of fully vaccinated were found in Addis Ababa in 82.99% and who had lowest vaccination status were showed in afar region by 13.37%. Other and catholic vaccination status had higher level of not fully vaccinated (80.36%). women's who are living with partner had higher getting the full immunization than children than their mothers not living with partner. those women who visit health places above 4 times had higher percentage of vaccinating their children (41.35) and women's who give birth at home had lower percentage of vaccinating their child (24.65%). the respondents who are richest had higher

percentage of taking the full vaccination for their children are (64.27%) and mothers who are the exposed ones to media exposure had higher getting of the full vaccination (51.11%) than who did not exposed (63.33%). children who had vaccination card get the full vaccination (64.65%) than who don't have the card (30.06%). women's who are in the group age who had >6 children in the birth order category had lower full vaccination than the other birth order group. Males were received full vaccination (45.64%) females were vaccinated fully (30.04%) which is lower than male.

Table 4.1 Individual level and community-level cross tabulation of full vaccination status

Covariates	Categories	Vaccination		Chi square	P value
		No	yes		
Maternal age cat	15-24	60.3	39.7	2.1204	0.6996
	25-34	56.82	43.18		
	35-49	59.43	40.57		
Mother education	No education	67.88	32.12	95.5657	0.000
	Primary	51.59	48.41		
	Secondary or higher	38.89	61.11		
Mothers Religion	Orthodox	43.6	56.4	101.6219	0.0000
	Protestant	66.61	33.42		
	Muslim	64.58	35.42		
	Catholic /traditional/	80.36	19.64		
ANC	None	79.99	20.01	206.7516	0.0000
	Incomplete	63.04	36.96		
	4+	39..85	60.15		
Wealth index	Poorest	73.51	26.49	146.42	0.0000
	Poorer	61.88	38.12		
	Middle	62.42	37.58		
	Richer	57.72	42.28		
	Richest	35.73	64.27		
Media exposure	Not exposed	63.33	36.67	41.1973	0.001
	Exposed to media	48.89	51.11		
Ownership of card	No	69.94	30.06	231.4177	0.000
	Yes	35.35	64.65		
Bord	1	50.22	49.78	47.7934	0.0030
	2-3	53.35	46.65		
	4-5	61.37	38.63		

	>=6	69.87	30.13		
Sex of child	Male	54.36	45.64	12.4792	0.017
	Female	61.96	38.04		
Place of delivery	Home	75.35	24.65	259.7210	0.0000
	Health facility	40.67	59.33		
Place of residence	Urban	40.23	59.77	105.0735	0.0004
	Rural	64.98	35.02		
Community media	Low	69.04	30.96	21.35	0.0238
	High	55.94	44.06		
Com education	Low	69.96	30.04	48.0598	0.0039
	High	53.48	46.52		
	Low	49.25	50.75	79.6911	0.0007
Comm pov	High	68.5	31.5		
Comm ANC	Low	74.95	25.05	312.3017	0.0000
	High	36.61	63.39		
Comm PLD	Low	79.46	20.54	141.5965	0.0000
	High	50.51	49.49		
	Tigray	28.09	71.91	268.1606	0.0000
Region	Afar	86.63	13.37		
	Amhara	38.53	61.47		
	Oromia	68.44	31.56		
	Somalia	85.91	14.09		
	Benshangul	39.38	60.62		
	Snnpr	64.62	35.38		
	Gambela	59.89	40.11		
	Harery	64.27	35.73		
	Addis abeba	17.01	82.99		
	Dire dawa	40.39	59.61		

[1]

[1] KEY: Bord Birth order number: ANC anti natal care, PLD place of delivery

4.1.2. Multilevel analysis to identify predictors of complete vaccination status

Table 4.2 Multilevel analysis to identify predictors of complete vaccination status

		COR [95% CI]	AOR [95% CI]		
Variable		Bivariate	Model II	Model III	Model IV
Individual factors					
Age	15-24	1	1		1
	25-34	1.5 [1.1, 1.9]**	1.5 [1.2,2.1]**		1.5[1.1,2.1]**
	35-49	1.2 [0.9, 1.8]	1.7 [1.2,2.6]**		1.8[1.2,2.6]**
Mother education	No formal education	1	1		1
	Primary	2.0 [1.5, 2.7]***	1.8 [1.3,2.4]***		1.8[1.3,2.5]***
	Secondary or higher	2.8 [1.9, 4.0]***	1.4 [0.9,2.1]		1.4[0.9,2.2]
Marital status	Living with partner	1.7 [1.0, 2.9]*	1.7 [0.9,2.8]		1.7[0.9,2.8]
	Not living with partner	1	1		1
Antenatal care	None	1	1		1
	Incomplete	2.4 [1.7, 3.4]***	1.5 [1.1,2.2]*		1.5[1.0,2.2]*
	4+	5.5 [3.8, 8.0]***	2.2 [1.5,3.3]***		2.1[1.4,3.2]***
Wealth index	Poorest	1	1		1
	Poorer	1.7 [1.2, 2.5]**	0.9[0.7,1.5]		0.9[0.7,1.5]
	Middle	1.9 [1.2, 2.5]**	0.9[0.6,1.3]		0.9[0.6,1.4]
	Richer	2.5 [1.6, 3.9]***	0.9[0.5,1.4]		0.9[0.5,1.5]
	Richest	7.2 [4.6,11.3]***	1.0[0.5,2.0]		1.0[0.5,2.0]
Media exposure	Not exposed	1	1		1
	Exposed	1.9 [1.4, 2.5]***	1.0 [0.7,1.4]		1.0[0.7,1.4]
Vaccination document	Yes	5.7 [4.4, 7.5]***	3.8 [2.9,4.9]***		3.7[2.8,4.9]***
	No	1	1		1
Delivery place	Home	1	1		1
	Health facility	3.8 [2.9, 5.1]***	1.7 [1.3, 2.4]***		1.6 [1.1, 2.2]**
Residence	Rural	1	1		1
	Urban	6.4 [3.9, 10.8]***	2.1 [1.2,3.7]**		2.1 [1.2, 3.6]*

Region	Tigray	1	1		1
	Afar	0.02 [0.01, 0.06]***	0.05[0.02, 0.13]***		0.06[0.02,0.15]***
	Amhara	0.6 [0.2,1.3]	0.8[0.4,1.6]		0.8[0.4,1.7]
	Oromia	0.2 [0.1, 0.4]***	0.2[0.1,0.5]***		0.3[0.1,0.6]**
	Somali	0.03 [0.01,0.01]***	0.1[0.0,0.23]***		0.11[0.04,0.28]***
	Benishangul	0.5 [0.2, 1.1]	0.6[0.3,1.3]		0.6[0.3,1.4]
	SNNPR	0.2 [0.1,0.4]***	0.3 [0.1,0.6]**		0.3[0.2,0.7]**
	Gambella	0.2 [0.1, 0.5]**	0.3 [0.1,0.6]**		0.3[0.1,0.7]**
	Harari	0.3[0.1,0.7]**	0.2 [0.1,0.4]***		0.2[0.1,0.5]**
	Addis Ababa	2.7[0.9,7.3]	0.5 [0.2,1.4]		0.6[0.2,1.5]
	Dire Dawa	0.7[0.3,1.7]	0.5 [0.2, 1.2]		0.6[0.2,1.3]
Community factors					
Community education	Low	1		1	1
	High	4.3 [2.6, 7.2]***		1.2 [0.8, 2.0]	0.8[0.5,1.3]
Community poverty	Low	6.0 [3.7, 9.5]		1.5 [0.9, 2.5]	0.8 [0.5,1.3]
	High	1		1	1
Community ANC	Low	1		1	1
	High	6.8 [4.4,10.5]***		2.5 [1.6, 4.0]***	1.2 [0.8,1.9]
Community home delivery	Low	9.4 [6.1,14.5]***		4.1 [2.4, 7.0]***	1.5[0.9, 2.4]
	High	1		1	1

2

Interpretations of Multilevel analysis in complete vaccination status

A multilevel logistic regression model was fitted to identify independent predictors of complete vaccination status. The result based on each model is as follows:

1. Null Model

[2] **Notes; *statistically significant at P-Value < 0.05; ** statistically significant at P-value <0.01; *** statistically significant at P-value <0.001;1=reference.**

The random intercept for the cluster variable was 0.73 saying that if a cluster is randomly selected the odds of complete vaccination is 27% lower compared to odds of incomplete vaccination.

2. Model II

In Model II, individual factors only were fitted and the significant variables identified were age category, maternal educational status, antenatal care, vaccination card, delivery place, residence, and region. Accordingly, the odd of complete vaccination was 1.5 and 1.7 times higher in women in the age group 25 to 34 and 35 to 49, respectively, compared to women in the age group 15 to 24 years. A child of a woman who attended primary education had 1.8 times higher chance of complete vaccination compared to a child of a woman with no formal education. Four plus ANC visit significantly increase the odds of complete vaccination by 2 folds compared to no antenatal care visit. A child with vaccination card was about 4 times to be completely vaccinated compared to a child without vaccination card. Institutional delivery increases the odds of complete vaccination by 70%. The odds of complete vaccination were double in children from urban areas. Compared to Tigray, the odds of complete vaccination were lower in afar (AOR=0.05), Oromia (AOR=0.2), Somali (AOR=0.1), SNNPR (AOR=0.3), Gambella (AOR=0.3), Harari (AOR=0.2).

3. Model III

In Model III, community level factors like community educational level, community poverty level, community home delivery status, and community antenatal care status were fitted. Two of the four variables were significantly associated with complete vaccination status. Accordingly, the odds of complete vaccination status were 2.5 times higher in community with high level of ANC visit. The odds of complete vaccination were also 4-folds in community with low home delivery.

4. Model IV

In model four, both individual and community level factors were fitted. The Significant variables identified were age category, maternal educational status, antenatal care, vaccination card, delivery place, residence, and region. Accordingly, the odds of complete vaccination

were 1.5 and 1.8 times higher in women in the age group 25 to 34 and 35 to 49, respectively, compared to women in the age group 15 to 24 years. A child of a woman who attended primary education had 1.8 times higher chance of complete vaccination compared to a child of a woman with no formal education. Four plus ANC visit significantly increase the odds of complete vaccination by 2 folds compared to no antenatal care visit. A child with vaccination card had odds of complete vaccination that is 3.7 times higher compared to a child without vaccination card. Institutional delivery increases the odds of complete vaccination by 60%. The odds of complete vaccination were double in children from urban areas. Compared to Tigray, the odds of complete vaccination were lower in afar (AOR=0.06), Oromia (AOR=0.3), Somali (AOR=0.1), SNNPR (AOR=0.3), Gambella (AOR=0.3), Harari (AOR=0.2).

Table 4.2 shows that Null model approved that there is statistically significant variation in full vaccination status across clusters, according to the finding (ICC=50.1%) indicates cluster factors account for 50.1% of variation in vaccination status.

4.1.2.1. Goodness of Fit Test

The intra class correlations coefficient (ICC) and the proportional change in variance (PCV) were used to show the random effects or the measure of variance. The variation with in the same cluster was measured using (ICC).

Table 4.3 random effects and model comparison

	Null	*Model1*	*Model2*	*Model3*
Random effect results				
ICC (%)	*50.19635*	*22.22121*	*35.6367*	*21.62323*
PCV (%)	*Reference*	*71.8*	*45.3*	*72.7*
Model fit statistics				
AIC	*2411.492*	*2075.936*	*2291.07*	*2078.38*

The final best-fit model (Model 3) was simultaneously improved for both individual- and community-level factors. Individual and community-level factors together accounted for about 72.7% (PCV = 72.7%) of the variation in vaccination status between cluster.

Based on the AIC the Multilevel mixed model 3 was (Model IV) was found to be the best model to fit the data with minimum AIC 2078.38 respectively (Table 4.3).

4.1.3. MLSEM Results and Interpretation

A multilevel generalized structural equation model to estimate mediation effects, education increases the odds of complete vaccination status by 7% via increasing odds of institutional delivery. Frequent ANC visit or being in Urban area increase the odds of complete vaccination by 14% via increasing odds of institutional delivery. As education level increases, the odds of complete vaccination increases by 14% via increasing frequency of ANC visit. Institutional delivery increases odds of complete vaccination by 50% via increasing the chance of having a vaccination card or document.

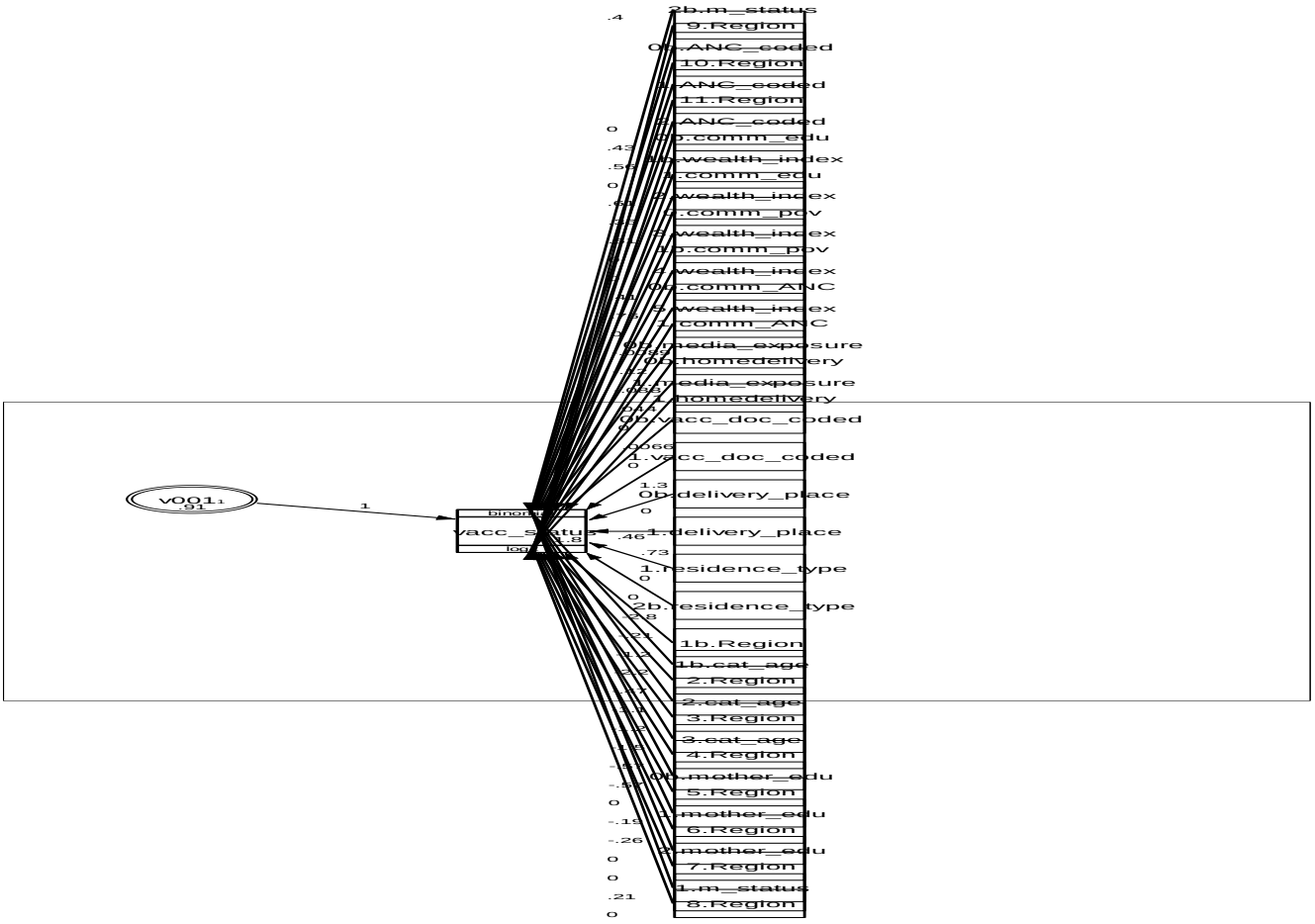

Figure 4.1 AOR of Multilevel Structural Equation Modeling (MLSEM)

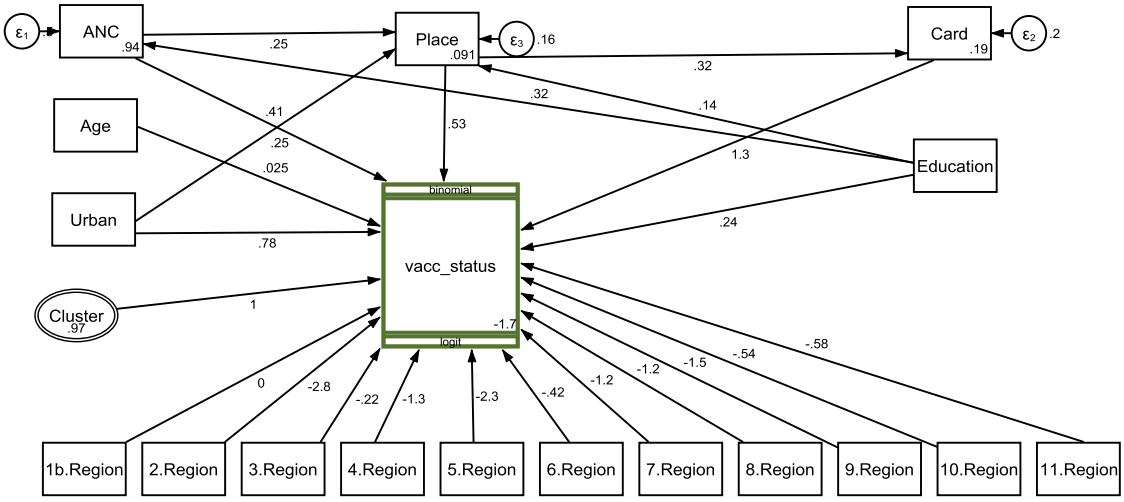

Figure 4.2 Presentation of Multilevel Structural Equation Modeling (MLSEM)

4.2 DISCATIONS

In Ethiopia there is low vaccination status for the children because of so many things like in my study as I try to see the individual and community predictors which can affect to children not to complete the vaccinations and had try to study the country level causes or to see the individual and community variables which can be consequences for child full vaccination completion in the country because one characteristic to see a country development it is necessary to see the population and kids health so in order to accomplish and give services for populations in order to get full health and experiencing a good and healthy life vaccinating children is mandatory and very necessary action but in Ethiopia fully completing vaccination status is very low so my study is concerned with the factors which can be area seen to change the status to fully accomplish the EPI aims.

The objective of the study was to clarify and asses the demographic, socio economic and health services status and to examine in which regions taking full vaccination status based on the EMDHS 2019 data.in this study I have used 2101 children's to see the predictors and factors from this children's 40.79% of them were fully vaccinated since 59.29% them were not complete their vaccination. in my study I had used multilevel and multilevel structural equation model to identify the individual and community level factors for the accomplishment of full vaccination in Ethiopia based on this analysis I have found that age category, maternal educational status, antenatal care, vaccination card, delivery place, residence, and region. Were significant at the multilevel analysis this finding was consistent with (Koku Sisay Tamirat et al, 2019) findings primary school maternal education (AOR = 1.38,95% CI: 1.07, 1.78), secondary school maternal education (AOR = 2.19, 95% CI: 1.43, 3.36), diploma graduated mothers (AOR = 1.99, 95% CI: 1.09, 3.61), ANC follow ups (AOR = 2.79, 95% CI:2.17 3.59), and delivery at health facilities (AOR = 1.76, 95% CI: 1.36, 2.24) were significantly associated factors with full immunization. And it is related to the findings of (Ayal Debie ,1 et al, 2020) , secondary or above educated mothers (AOR = 2:48; 95% CI: 1.41, 4.36), richest wealth status (AOR = 2:24; 95% CI: 1.16, 4.32), ≥four ANC visits (AOR = 2:77 ; 95% CI: 1.90-4.02), employed mothers (AOR = 1:66; 95% CI: 1.26, 2.18), urban residence (AOR = 1:84; 95% CI: 1.00, 3.51), and children in city administration (AOR = 2:66; 9% CI: 1.53, 4.62) were positively associated with vaccination status. And it is in line and very related to the result of (Sewunet Sako , et al, 2023) which shows

as Mothers who attended primary (AOR=2.16; 95% CI: 1.43–3.26), secondary (AOR=2.02; 95% CI: 1.07–3.79) and higher education (AOR=2.67; 95% CI: 1.25–5.71); being in union (AOR=2.21; 95% CI: 1.06–4.58); kept vaccination cards (AOR=26.18; 95% CI: 15.75–43.53); children receiving vitamin A1 (AOR=4.14; 95% CI: 2.9–5.9); living in Afar (AOR=0.14; 95% CI: 0.04–0.45), Somali (AOR=0.19; 95% CI: 0.06–0.60), Gambela (AOR=0.22; 95% CI: 0.06–0.77), Harari (AOR=0.14; 95% CI: 0.04–0.52) and Dire Dawa (AOR=0.23; 95% CI: 0.06–0.79) regions; and rural residents (AOR=0.53; 95% CI: 0.30–0.93) were factors significantly associated with childhood vaccination.

The full vaccination status of Ethiopia was higher than findings in Somalia (11.6%), Mauritania (35.3), Nigeria (33.2%), Chad (11.4%), and the Republic of Central Africa (17.3%) [5,6]and it were lower as compared to the studies conducted in Togo (63.7%), Cameroon (53.6%), Timor-Leste (52.6%), Uganda (52.5%), Coted'Ivoire (50.5%) DR Congo (49.8%), and Haiti (45.8%) as quoted in (Koku, et al, 2019).

In the multilevel structural equation model, I had gotten significant predictors which are place of delivery with vaccination card, education with place of delivery, education with poverty education with antenatal care, place of residence (urban) with place of delivery all these predictors explain their effect on full vaccination of child as a mediator and direct predictors. Education increases the odds of complete vaccination status by 7% via increasing odds of institutional delivery. Frequent ANC visit or being in Urban area increase the odds of complete vaccination by 14% via increasing odds of institutional delivery. As education level increases, the odds of complete vaccination increases by 14% via increasing frequency of ANC visit. Institutional delivery increases odds of complete vaccination by 50% via increasing the chance of having a vaccination card or document. This results are the exponential product of the two related pridictores.this finding is inline related to the study that was conducted in india Parental education was significantly associated indirectly with higher rates of full vaccination ($\beta = 0.11$). Area of residence moderated the role of religion ($\beta = 0.24$) (Abraham, et al, 2020)

CHAPTER FIVE

5. CONCULTION AND RECOMENDITHONS

5.1. Conclusions

There is difference in regional and country level completing the full vaccination program since the children with vaccination card has significant effect in vaccinating gaining equitable and ensuring to offer moderated health care services is essential in Ethiopia.

The adoption of a MSEM in evaluating the incompleteness of 12-39 months old childhood vaccination among in Ethiopia has provided critical insights into the intricate array of elements impacting vaccination coverage. The entire findings of this study discovered the multilayered nature of influences at both individual and community levels, highlighting the noteworthy impact of factors such as maternal education, age, child sex, marital status, and vaccination card at individual level and residence/living area, antenatal care, place of delivery, poverty, and media exposure at community-level childhood vaccination.

The findings of this research underlined the necessity for a all-inclusive and holistic understanding of impacting factors on childhood vaccination, focusing on the intricate interaction between various factors. The MSEM approach enabled for the investigation of both direct and indirect relationships, providing a nuanced grasp of the pathways through which individual and community-level elements interact to influence incompleteness of childhood vaccination in Ethiopia particularly and throughout the globe in general.

In conclusion, the application of Multilevel Structural Equation Modeling provides a robust framework to extricate the multilayered factors impacting incomplete childhood vaccination aged 12-39 months in Ethiopia. The study's wide-ranging approach sheds light on the nuanced web of determinants impacting incompleteness of child vaccination rates and offers a concrete foundation for emerging targeted interventions to improve childhood immunization coverage and regional, national, and global public health in general.

5.2. Recommendations

As my study found that most of the children's are not fully vaccinated this is an obstacle to accomplish the aim of EPI program they didn't complete the vaccination as it scheduled in the EPI so it is necessary and I recommend to create awareness to the women's who are not educated by the health extension workers and expanding media because those who exposed to media had higher proportion of completing the vaccination program and giving awareness and the government to give high attention to health care services in the rural area because in my finding mothers who visit antenatal care and who give birth at health institutions had higher completing the vaccination program so addressing this difficulty's in the rural area can give and increase the full vaccination completion in Ethiopia.

The government, NGOs, physicians, medical experts, and all other concerned bodies need to implement targeted interventions focusing on improving maternal education, improving delivery service, reducing poverty, providing vaccination cards regularly, providing enough media cover about the significance of childhood vaccination and immunization, working on socio-economic conditions, and ensuring better healthcare access including antenatal care. These interventions could significantly contribute to increasing childhood vaccination rates.

The governmental and global public health care promoters and policy makers have to advocate for policy changes that address community-level determinants impacting childhood vaccination, such as refining and improving healthcare infrastructure, strengthening regional and national policies to encourage childhood vaccination campaigns, and engaging with cultural beliefs that might influence vaccine uptake.

Establish the comprehensive education and awareness campaigns at both individual and community levels to highlight the importance of childhood vaccination. Adapt these campaigns to address specific concerns related to global public healthcare, cultural perceptions, and socio-economic disparities.

The academicians and research experts have to conduct further research, considering progressive dynamics and assorted regional and national contexts to comprehend the evolving nature of factors impacting childhood vaccination. This could involve longitudinal studies that capture

changes in policies, socio-economic conditions, community understandings, and cultural beliefs through over time.

The data scientist and collectors have work in enhancing better data collection instruments to ensure improved quality and all-inclusive data that captures the multifaceted influences on childhood vaccination. Precise and reliable data are vital for conducting vigorous and robust analyses and developing effective interventions.

In summary, the findings from this study emphasize the significance of employing a multilevel approach, specifically MSEM, in understanding the complexities of childhood vaccination in Ethiopia. The recommendations aim to guide policy changes and targeted interventions to bolster vaccination programs and reduce the burden of vaccine-preventable diseases among Ethiopian children aged 12-39 months.

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