MODELLING THE EFFECT OF MATERNAL AND CHILD HEALTHCARE SERVICE QUALITY ON NEONATAL MORTALITY IN NIGERIA

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Abstract

The Sustainable Development Goal (SDG) number 3.2 of the United Nations aims for every country in Sub-Saharan Africa, Nigeria inclusive to reach a neonatal mortality rate of less than 12 deaths per 1,000 live births by 2030. But, neonatal deaths in Nigeria currently stood at 69 deaths per 1 000 live births. This might have been caused by low quality of healthcare service provision for pregnant women during ANC visit. Thus, this research investigated the effect of maternal and child healthcare service quality on neonatal mortality in Nigeria. The research employed quantitative research method to pooled disaggregated datasets collected through telephone interviews across ten states (Kaduna, Kano, Sokoto, Nasarawa, Yobe, Bauchi, Borno, Gombe, Niger and Lagos) in Nigeria via proportionate stratified sampling technique. Post-stratification weighting was applied to the descriptive part of the analysis in order to make the study sample size even more representative of the study population. We measured maternal and child healthcare service quality using WHO's ANC service quality assessment instrument known as ANC service components quality assessment metrics questionnaire (ANCCQAM) to elicit information from 5, 000 women of child-bearing age (aged 18-49 years) about their experiences on ANC service provisions at the health facilities across the study locations. The research used Probit regression analysis to estimate the marginal effects of ANC components service provisions on neonatal mortality in Nigeria. The result from the study findings show a negative relationship between ANC service quality assessment metrics (utilization of iron-folic acid supplementations by pregnant women, Intermittent preventive treatment of malaria for pregnant women [IPTp-SP],

delivery cases handled by skilled birth attendants, postnatal care for new born & women's knowledge on postpartum danger signs for neonates) and neonatal mortality in Nigeria. Based on the study findings, the research concluded that maternal and child healthcare service quality does not have significant effect on neonatal deaths in Nigeria. Following the results of the study findings, this research recommends that the federal, state and local governments should restructure the National Health Insurance Authority Act (NHIA) to incorporate health policies for new borns in order to check the idiosyncrasy of neonatal deaths in Nigeria. The study also calls on government, stakeholders in the private sector and non-governmental organizations in re-visioning strategic ways to provide the optimal methods for delivering quality and patients-based ANC services across all PHCs in Nigeria so as to avert the deaths of neonates.

Keywords: *Neonatal Mortality, ANC Service Components, Quality Assessment Metrics, Maternal and Child Healthcare, Probit-Model, PCC-Model, Telephone Polling Methodology, NOIPolls.*

I. INTRODUCTION

The quality of healthcare service for mothers and neonates is critical to the achievement of the Sustainable Development Goal (SDG) number 3.2 of the United Nations and to achieving the Global Strategy for Women's, Children's and Adolescents' Health (WHO, 2023). Therefore, making ANC visit an effective preventive measure of pregnancy-related problems requires monitoring the content and the quality of ANC services provided by healthcare practitioners in developing countries, Nigeria inclusive (USAID, 2023).

However, improvements in the quality of healthcare service of lifesaving interventions for maternal and new borns health in Sub-Saharan African countries including Nigeria have not consistently translated into reductions in neonatal deaths from preventable conditions (USAID, 2023). In addition, evidence shows that neonatal death rate has declined across the globe from 75 deaths per 1,000 live births in 2021 to 38 deaths per 1 000 live births in 2023 (WHO, 2023), but neonatal mortality rate (6.9%) in Nigeria remains unacceptably high in comparison to the target reduction of 12 (1.2%) deaths per 1 000 live births for Sub-Saharan countries (United Nations [UN], 2023).

Consequently, high neonatal mortality rate in Sub-Saharan African countries have been blamed on low quality of ANC service provision on ANC service components- utilization of iron-folic acid supplementations by pregnant women, supply of intermittent preventive treatment of malaria vaccines to pregnant women (IPTp-SP), counseling on the use of chlorhexidine for new borns' cords cleaning, deliveries handled by skilled attendants and women's knowledge about postpartum danger signs for neonates. For example, World Health Organization (WHO, 2023) recommends 3 or more doses (96%) of IPTp-SP for all pregnant women living in areas of moderate-to-high malaria transmission in Sub-Saharan Africa countries including Nigeria; the preventive treatment should start as early as possible in the 2nd trimester and can be administered at monthly intervals up to the time of delivery. But in Nigeria, the estimated prevalence of at least one IPTp-SP dose stood at 26% in 2018 and three or more IPTp-SP doses were 15% in 2023 and 14% in 2023 among pregnant women (WHO, 2023 & UNICEF, 2023). Also, late recognition of the postpartum danger signs of serious illness by parents or caregivers was observed in Nigeria. For instance, UNICEF (2023) reported that the maternal knowledge of postpartum neonatal danger signs in Nigeria ranges from 18%-17% in 2018 and 17% to 16% in 2023 as against 75% WHO's reconmmation. As a result, low IPTp-SP

doses for pregnant women and poor maternal knowledge of newborn postpartum danger signs may increase the chances of neonatal mortality.

Further, daily iron and folic acid supplementation is currently recommended by WHO (2022) as part of antenatal care service components to reduce the risk of low birth weight, maternal anemia and iron deficiency. It is suggested that the supplement contains 30-60 mg of iron, with the higher dose preferred in settings where anemia in pregnant women is a severe public health problem (≥40%), along with 400 µg of folic acid. However, the United Nations International Children's Emergency Fund (UNICEF, 2023) reported that only 20% of pregnant women in Nigeria had dose of iron folic-acid supplementation during pregnancy with 4% of women in rural areas and 16% in urban areas. Anemia as a result of low uptake of iron-folic supplementation during pregnancy may lead to higher risk of neonatal deaths.

Generally, WHO (2022) recommends a daily chlorhexidine (4%) application to the umbilical cord stump during the first week of life for newborns who are born at home and health facility in settings with a high neonatal mortality (NNM) (NNM rate >30 per 1000). The use of chlorhexidine in this situation may be considered only to replace application of a harmful traditional substance such as cow dung among others to the cord stump (WHO, 2023). But recent report from UNICEF (2023) in Nigeria noted high daily harmful traditional substances (cow dung and toothpaste) (65%) application to the cleaning of umbilical cords of new borns. These harmful traditional practices have the tendency of increasing the cases of neonatal deaths.

The Nigeria Demographic and Health Survey (NDHS, 2018) report showed that only 43% of births in rural areas were assisted by a skilled healthcare provider, leaving just under three in every five women, giving birth with the assistance of unskilled traditional birth attendants (TBAs), community-based birth attendants (CBAs) and other alternative healthcare providers. This development has the chances of increasing the deaths of mothers and new borns.

Nevertheless, compliance to the minimum standard of recommended quality contents for ANC service provision appeared to be lacking in a developing country like Nigeria. According to WHO (2023) and UNICEF (2023) reports, the chances of survival from birth varies widely depending on where a child is born. Sub-Saharan Africa had the highest neonatal mortality rate in 2023 at 27 (25–32) deaths per 1000 live births, followed by central and southern Asia with 23 (21–25) deaths per 1000 live births. A child

born in Sub-Saharan Africa is 10 times more likely to die in the first month of birth than a child born in a high-income country. Country-level neonatal mortality rates in 2023 ranged from 1 death per 1, 000 live births to 44 and the risk of dying before the 28th day of life for a child born in the highest-mortality country was approximately 56 times higher than the lowest-mortality country. Most neonatal deaths (75%) occur during the first week of life, and in 2023, about 1 million newborns died within the first 24 hours in Sub-Saharan African countries (UNICEF, 2023). This may also be attributed to low post-natal care attendance rate for new born and lack of women's knowledge about postpartum danger signs for neonates.

The first 28 days of life – the neonatal period – is the most vulnerable time for a child's survival. Children face the highest risk of dying in their first month of life at an average global rate of 18 deaths per 1,000 live births in 2023, down by 51 per cent from 37 deaths per 1,000 live births in 1990. In comparison, the probability of dying after the first month and before reaching age 1 was estimated at 11 deaths per 1,000 and the probability of dying after reaching age 1 and before reaching age 5 was estimated at 10 deaths per 1,000 in 2023. Globally, 2.3 million children died in the first month of life in 2023 – approximately 6,400 neonatal deaths every day (UNICEF, 2023).

The Nigeria Demographic and Health Survey (2018) and Multiple Indicator Cluster Survey (2021) noted that approximately 262,000 babies die at birth in Nigeria each year, the world's second highest national total. Neo-natal deaths in Nigeria currently stands at 69 per 1,000 live births as against targeted reduction of 12 deaths per 1 000 live births by 2030. Investment in Nigeria's health sector has been high in recent years, although the proportion of women that are able to access quality maternal healthcare services during ANC visit remain low (WHO, 2023). World Health Organization (2023) has ranked Nigeria as the second country with the highest number of neonatal deaths globally contributing about 12% of global neonatal deaths. Hence, this research provides an insight on the need for policy makers to provide evidence-based policy strategies to promote a further reduction in neonatal death in Nigeria.

Globally, empirical studies have shown that maternal and child healthcare service quality have a direct effect on neonatal deaths (Seidu, Ahinkorah, Aboagye, Okyere, Budu, & Yaya, 2022; Agajie et al., 2021 & Liu et al., 2021). However, this study differs from previous researches in several aspects. First, the study analyzed the effects of maternal and child healthcare service quality on neonatal deaths in Nigeria. A generalized linear Probit econometric methodology was employed to calibrate the marginal effects of maternal and child healthcare service quality on neonatal deaths in Nigeria while previous researches that modelled this relationship actually ignored this effect. Second, rather than adopting descriptive statistical analysis as used by Liu et al. (2021) and Lawn et al. (2023). This research conducted both descriptive and inferential statistical analyses to establish the direction of the relationship between maternal and child healthcare service quality and neonatal deaths in Nigeria. This has been adjudged to be a superior measure of empirical gauge (Dimistrios & Hall, 2021).

Thirdly, in terms of data collection method, a telephone polling methodology was used as a means of data collection for this research with large sample size unlike Pati et al. (2021) and Pell et al. (2021) who used datasets collected from clinical records in some few selected hospitals with small sample size to address neonatal deaths issue in their study locations. Also, Ampeh et al.

(2018) and Amaral et al. (2022) noted that telephone interviews cover large range of sample size within a short period of time compared to other survey data collection methods. However, in order to properly formulate policies for maternity and child healthcare service quality that will halt neonatal fatalities and from Nigeria experience through time, this study seeks to provide answer to the research question below:

What is the effect of maternal and child healthcare service quality on neonatal mortality in Nigeria?

An understanding of these issues can help policy makers in formulating health policies that will halt neo-natal mortality rate in Nigeria. Therefore, the purpose of this study is to investigate the effect of maternal and child healthcare service quality on neo-natal mortality in Nigeria. The research is structured as follows: The literature review and research methodology are presented in the subsequent section. The empirical findings and discussion of the findings are presented in part four, and the conclusion and suggestions for developing policy are presented in section five.

II. LITERATURE REVIEW

The theoretical foundation that underpins this research is the person centered care (PCC) theory developed by McCormack and McCance (2006). Theory modelled the link between maternal and child healthcare service quality and neonatal mortality. The Framework has a number of assumptions. First, there are three levels of interacting contexts at play in achieving maternal and child healthcare service quality. The three levels include: i) Societal and; ii) women's health-seeking behaviours; and iii) facility-level factors, including the provision of technical care and the person-centered dimensions of care. Second, there is a bidirectional influence between health-seeking behaviours and quality of maternal healthcare service women experience at the facility (McCormack & McCance, 2006). PCC assume that not only does the decision to seek care influence women's experiences in the facility, but that the quality of care in the facility will also influence communities' and individuals' perceptions of care, needs for care, expectations of care, and ultimately seeking care which will in turn reduce maternal morbidity and neonatal mortality rates (Tarekegne et al., 2022). In addition, following the WHO's (2022) ANC service components quality of care framework, the framework assumes a bidirectional relationship between provision of quality ANC service and PCC. In the work of Gothenburg (2016), Person-centered quality maternal health care service is responsive care to individual women's preferences, needs, and values and ensuring that their values guide all clinical decisions during ANC visit and all through the Continuum of care. However, Tarekegne, Giru and Mekonnen (2022) also noted that person-centered quality maternal healthcare service is a key dimension of the quality of maternity care that increases client satisfaction and institutional delivery by lowering neonatal fatalities.

Conceptually speaking, WHO (2022) noted that, the standard quality of service provided during ANC visit is comprised of three components: the first one is assessment (that is, history taking, physical examination, and laboratory tests), the second one is health promotion (that includes nutrition advice, planning the birth, information regarding pregnancy, subsequent contraception, and immunization), and the last one is care provision (that is comprised of tetanus toxoid immunization, psychosocial support, and recordkeeping). Although there is a variation of strategies about the

content of ANC in different countries, WHO recommends a core set of ANC service quality which include blood pressure measurement, tetanus toxoid vaccination, urine testing, iron-folic acid tablet supplementations, body weight measurement, and counseling about danger signs for neonates for a developing country like Nigeria. Meanwhile, neonatal mortality is the probability of a child dying during the first 28 days postpartum, expressed per 1,000 live births.

Be that as it may, attention has been shifted from the utilization of maternal healthcare programmes by women of child-bearing age to measuring the quality of maternal healthcare service provided by healthcare practitioners from the time a woman is pregnant to the point of delivery and beyond. However, many authors have analyzed the relationship between maternal and child healthcare service quality and neonatal deaths globally using econometric methods but thus far, the exact nature of the relationship is not settled and the degree of the association between these two variables have been the subject of an ongoing discourse in the literature. Hence, Seidu, Ahinkorah, Aboagye, Okyere, Budu, and Yaya (2022) employed logistic regression analysis using the DHS datasets of 17 Sub-Saharan to analyzed the Continuum of care for maternal, newborn, and child health in 17 Sub-Saharan African countries. The study found that women whose partners had secondary or higher level of education, those with health insurance, those who decide alone on their healthcare, those with joint healthcare decision, those exposed to radio, those who started antenatal care early and those in southern Africa had higher odds of completing the continuum of care. The study concluded that the factors that are associated with the maternal, newborn, and child health continuum of care include women's autonomy in decision-making, partners' level of education, health insurance coverage, early initiation of antenatal care, exposure to radio, and residing in Southern Africa.

Similarly, Sahoo, Negi, Patel, Mishra, Palo, and Pati (2021) also employed content analysis and systematic review to analyzed the challenges in maternal and child health services delivery and access during pandemics or public health disasters in low-and middle-income countries. The findings indicate that low utilization and access to healthcare services have been described as common challenges to MCH. The study concluded that unavailability of personal safety equipment and fear of infection were primary factors that affected service delivery.

In another development, Agajie, Abera, Yimer, Yaregal, Muhidin, Kelbessa, Ayana and Shaweno (2021) adopted content analysis to study the barriers to maternal and child health care service uptake in Assosa Zone, Benishangul Gumuz Region of Ethiopia using a qualitative study. Poor health facility readiness, poor economy of families, lack of ambulance, cultural and traditional beliefs, providers being male, and unprofessional behaviours were found to be major barriers hindering the uptake of maternal healthcare service. The research concluded that poor health facility readiness, indirect costs, inaccessibility to health facilities, cultural and traditional practices were among the major barriers to quality maternal and child healthcare service uptake in the study location.

In another scenario, Liu, Kang, He, Miao, Qiu, Xia, Zhu, Liang, Li, Wang, Liu, (2021) adopted descriptive statistics to study neonatal mortality and leading causes of deaths in China. The study used data from National Maternal and Child Health Surveillance System. The datasets comprised neonates of surveillance districts (gestational week: ≥28weeks) who died after delivery. The study found that neonatal mortality rate of China has steadily decreased from 5.9 deaths per 1000 live births in 2014 to 3.9 deaths per 1000 live births in 2018. The study also reported that the leading causes of neonatal deaths were preterm birth, intrapartum complications and pneumonia, the research also reported that mortality rates of these three causes fell significantly between 2014 and 2018 but contributed to a higher proportion of deaths in rural areas than urban areas. The study concluded that the leading preventable causes of neonatal deaths in the urban and rural areas were same across the study locations.

Tadesse, Negussie and Aychiluhm (2021) also employed bivariate and multivariate logistic regression analysis to examined neonatal mortality and its associated factors among neonates admitted at public hospitals in pastoral region, Ethiopia. A health facility-based cross-sectional study was conducted on 403 neonates admitted to the neonatal intensive care units (NICUs) from January 2015 to December 2019. A multivariable logistic regression analysis used in the study showed that lack of antenatal care (ANC) follow up, giving birth through cesarean section, having admission temperature less than 36.5°C, birth asphyxia and having a length of stay greater than five days in the hospital were significantly associated with neonatal mortality in the pastoral region of Ethiopia. The study concluded that the rate of neonatal mortality in pastoral region is still high compared to the national data.

Lawn, Bhutta, Ezeaka and Saugstad (2023) equally adopted descriptive statistics to analyzed the ending preventable neonatal deaths using a multi-country evidence to inform accelerated progress to the Sustainable Development Goal by 2030. The research applied a five-phase NMR transition model based on national analysis for 195 UN member states. The study found that neonatal mortality could be reduced to the SDG target of ≤12/ 1,000 with further scale-up of small and sick newborn care. The study concluded that in reducing neonatal mortality further, more investment is required in infrastructure, device bundles (e.g., phototherapy, ventilation), and careful attention to infection prevention. Also, Ewere and Eke (2020) adopted logistic regression analysis and quasi-secondary datasets from 2018 Nigeria Demographic and Health Survey to analyzed neonatal mortality in Nigeria. The study found that antenatal care, post-natal care and place of delivery had significant impact on neonatal mortality in Nigeria. The study concluded that facility deliveries had significant impact on neonatal mortality at the 95% confidence level.

Al-Sheyab, Khader, Shattnawi, Alyahya, and Batieha (2020) adopted multivariate logit model to analyzed the risk factors, and causes of neonatal deaths in Jordan using datasets from Jordan stillbirths and neonatal surveillance system. The study found that the odds of deaths in the ministry of health hospitals were almost 21 times higher than that in private hospitals. The study also found that the main causes of neonatal deaths that occurred pre-discharge were respiratory and cardiovascular disorders and low birthweight and pre-term. The research equally reported that the main maternal conditions that attributed to these deaths were complications of the placenta and cord, complications of pregnancy, medical and surgical conditions. The study concluded that the rate of neonatal mortality has not decreased since 2012 and the majority of neonatal deaths occurred could have been prevented.

In another study conducted by Dare, Oduro, Owusu-Agyei, Mackay, Gruer, Manyeh, Nettey, Phillips, Asante, Welaga, and Pell (2021) in Ghana, the research employed Pearson chi-square,

univariate and multivariate logit models to examined neonatal mortality rates, characteristics, and risk factors for neonatal deaths in Ghana. The study extracted datasets on livebirths from the health and demographic surveillance systems in Navrongo (2004–2012) and Kintampo (2005–2010) Ghana. The study found that the main causes of neonatal deaths in Navrongo and Kintampo were treatable infections from malaria. The study concluded that the risk of death was higher among hospital births than home births while the majority of the deaths occurred at home.

Moreover, Sahoo, Negi, Patel, Mishra, Palo, and Pati (2021) also employed content analysis and systematic review to analyzed the challenges in maternal and child health services delivery and access during pandemics or public health disasters in low-and middle-income countries. The study found significant relationship between poverty, health facility and accessibility of quality maternal and child healthcare service in the study locations. The research concluded that proximity of health facility is a strong determinant of quality maternal and child healthcare accessibility.

Globally, several studies have examined the effect of maternal and child healthcare service quality on neonatal mortality. For example, Agajie et al. (2021) assessed the barriers to maternal and child health care service quality while Tadesse et al. (2021) also examined neonatal mortality and its associated factors among neonates admitted at public hospitals in Ethiopia while Ewere and Eke (2020) analyzed the impact of antenatal care, postnatal care attendance and delivery at heath facility on neonatal deaths in Nigeria. Also, Liu et al. (2021) equally examined neonatal mortality and leading causes of deaths in China. However, there is a few empirical evidence on the effect of maternal and child healthcare service quality on neonatal mortality in Nigeria context. To the best of our knowledge, only Dare et al. (2021) and Ewere and Eke (2020) have analyzed the effect of maternal and child healthcare service quality on neonatal deaths in Burkina Faso and Nigeria while Sahoo et al. (2021) also examined the challenges in maternal and child health service delivery and access during pandemics or public health disasters in Mali, Liberia and Niger. However, Sahoo et al. (2021) findings did not necessarily extrapolate and generalized to the entire middle and low income countries including Nigeria while the analysis of Ewere and Eke (2020) did not capture the quality of healthcare service women received during ANC visit. The study of Ewere and Eke (2020) did not investigate the quality of the components of antenatal care services provided to pregnant women during ANC visit as it is being carried out in this study. In addition, the previous studies have used quasi-secondary aggregated data collected through case studies clinical records and relied on datasets from 2010 to 2018 and 2004–2012. But, our study fills this knowledge gap by using much recent disaggregated datasets of 2022 generated through telephone polling methodology. Empirically, none of the studies reviewed in this research especially in Nigeria have used telephone polling methodology in addressing the issue of neonatal deaths and poor maternal and child healthcare service quality in Nigeria. To bridge this literature gap, we examine the effect of maternal and child healthcare service quality on neonatal deaths in Nigeria using a telephone polling methodology. The findings are critical and could provide a basis for policy formulation and implementation in improving MNCH through continuum of care.

III. METHODOLOGY
III.1. Description of Variables and Sources of Data

This study examined the effect of maternal and child healthcare service quality on neonatal mortality in Nigeria. The research used a recent datasets collected through telephone interviews. The datasets used for this study were sourced from NOIPolls. Table 1 contains additional information on the survey datasets used for this research.

Table 1: Description of Variables and Sources of Data

Variables of ANC Components	Variable Measurements	Source
Neonatal mortality (NNM)	Neonatal mortality : Deaths among live births during the first 28 completed days of life.	NOIPolls
Utilization of iron-folic acid supplementations by pregnant women (FEU)	Iron-folic acid supplementation during pregnancy is among the very effective interventions to prevent iron deficiency anemia, low birth weight, and prematurity	NOIPolls
Intermittent preventive treatment of malaria for pregnant women (*IPTp-SP*)	IPTp-SP entails administration of a curative dose of an effective antimalarial drug (currently sulfadoxine-pyrimethamine) to all pregnant women without testing whether or not they are infected with the malaria parasite. WHO recommends 3 or more doses of *IPTp*-SP for all *pregnant women* living in areas of moderate-to-high *malaria* transmission in Africa.	NOIPolls
Delivery cases handled by skilled birth attendants (SBA)	Skilled birth attendant (SBA) refers to an accredited health professional (doctor, nurse or midwife) who has been educated and trained to proficiency in the skills needed to manage uncomplicated pregnancies, childbirth and the immediate postnatal period.	NOIPolls
Postnatal care for child [using of Chlorhexidine for cleaning the cords of new borns] (PNCC)	Postnatal care for child is the care given a newborn baby immediately after the birth and for the first six weeks of life	NOIPolls
Women's knowledge about postpartum danger signs for neonates (*PDS)*	The key postpartum danger signs for neonates include: Unable to feed/poor feeding, convulsion, respiratory rate of 60/more (fast breathing), severe chest	NOIPolls

	in-drawing (difficulty in breathing), temperature of = 37.5 °C (fever), temperature = 35.5 °C (hypothermia), only moves when stimulated/not even when stimulated (weakness/lethargy).	

Note: This study measured maternal and child healthcare service quality using World Health Organization's ANC service components quality assessment metrics (ANCCQAM) to elicit information from women about their experiences on ANC service provisions across health facilities in Nigeria.

Source: NOIPolls (2022)

III.2. Data Collection Method

The datasets used for the empirical section of this study were collected through telephone interviews. The innovative mobile telephone data collection methodology yields a large sample size in a relatively short period compared to other survey data collection methods (Ampeh et *al.,* 2018 & Amaral, et *al.,* 2022). Therefore, high mobile telephone penetration rates in developing countries Nigeria inclusive provide new opportunities for alternative sampling and data collection method.

However, for the purpose of this research, a fairly representative random sample of 5 000 participants were primary selected via random-digit dialling national telephone methodology and supplemented with in-person interviewing in areas with less than 80% mobile phone ownership such as the rural areas of the sampled states. For the sake of the telephone survey, 106, 684 telephone numbers of women of child-bearing age (aged 18-49 years) were randomly selected and dialed (through randomization processes) from over 70 million phone numbers in NOIPolls' database classified into different categories. The stratification of the survey sample size and post stratification weights applied to this survey helps reduced non-response biasedness and improve statistical precisions. This study considered non-response biasedness by estimating call outcomes and response rate according to the American Association of Public Opinion Research guidelines for telephone interviews (2022).

According to Gallup (2022) and Word Development Indicators (2023) reports, a good response rates for telephone interviews hovers around 5% to 30% and above. Therefore, the response rate for this research was estimated at 35.3% for the ten states under review with 95% confidence level and +-5% margin of error. This is in line with the response rates generated in the studies conducted in Guinea Conakry, Ghana and Sudan by Ampeh et al. (2018) and Romero et al. (2022) using telephone interviews. Response rates in telephone interviews are comparatively the same with other data collection methodologies (Amaral, Dinarte-Diaz, Dominguez, Perez-Vincent & Romero, 2022 & Ampeh et *al.,* 2018; L'Engle, Sefa, Adimazoya, Yartey, Lenzi, Tarpo, Heward-Mills, Lew & Ampeh, 2018).

This research employed quantitative research methodology to pooled disaggregated datasets across ten states in Nigeria in order to the test the validity of the hypotheses established in the study. This study used survey datasets conducted by NOIPolls in 2022 on maternal and child healthcare service quality across ten states in Nigeria under a project funded by Bill and Melinda Gates Foundation. These ten states include Kaduna, Kano, Sokoto, Nasarawa, Yobe, Bauchi, Borno, Gombe, Niger and Lagos. According to Nigeria Demographic and Health Survey (NDHS, 2018) and Multiple Indicators Cluster Survey (MICS, 2021), these study locations represent a fair share of women of reproductive age in Nigeria. The justification for the choice of the study locations is that the issue of neonatal deaths is much more prevalent in the northern region of Nigeria comparatively while Lagos state serves as a comparative indicator (WHO, 2023 & UNICEF, 2022).

In addition, a proportionate stratified sampling technique was used to sampled 5,000 targeted women of child-bearing age, aged 18-49 across ten states in Nigeria. The sample size was stratified into gender, states, senatorial districts and local government areas to make it a representative of the study population, the study sampled 500 participants each across the ten states making a total of 5 000 sample size. The reliability of the instrument used for this survey was tested using the Cronbach's Alpha, and the reliability index achieved was 0.78, indicating that the questionnaire used for this study is reliable and consistent. The research employed a set of analytical tools which include descriptive statistics (frequency counts and percentages) and generalized linear Probit model to analyzed the survey datasets. In the descriptive statistical section of this study, the datasets were weighted in order to make the sample size even more representative of the study population.

III.3. MODEL SPECIFICATION

This study measured maternal and child healthcare service quality using World Health Organization's (2022) ANC components quality assessment instrument known as ANC service components quality assessment metrics (ANCCQAM) to elicit information from women about their experiences on ANC service provisions across health facilities in the study locations. Therefore, ANC service quality as operationalized in this research evaluate the satisfaction pregnant women received during their antenatal care visit at the health facility-this is denoted by maternal and child healthcare service quality. Based on the WHO's ANC service components quality assessment metrics for a developing country like Nigeria, we hypothesized that the utilization of iron-folic acid supplementations by a pregnant woman, delivery cases handled by skilled birth attendants, postnatal care child (using Chlorhexidine syrup for cleaning the cords of new born), women's knowledge about postpartum danger signs for neonates and intermittent preventive treatment of malaria for pregnant women will predict neonatal mortality in Nigeria.

The econometric method used in this study is the generalized linear Probit model. Generalized linear Probit model is a procedure that takes account of heteroscedasticity of the disturbances as well as restricting predictions to values between **0** and **1**. In the prototype generalized linear Probit model developed for this present study, the probability of observing responses (A birthing woman delivery at the health facility or otherwise: a proxy variable for neonatal deaths) is defined in terms of a single unobserved index or stimulus, and the standard cumulative normal distribution with mean 0 and variance 1 is used to transform the index to the probability value. An iterative procedure making use of the maximum likelihood estimation technique is employed in estimating the unknown parameters of the independent variables.

According to Dimitrios and Hall (2021), the generalized linear Probit model is most appropriate for this study for a number of reasons. First, neonatal death is dichotomous in nature (a new born may die within or after 28 days of delivery which is denoted by **1**

and **0** otherwise). Hence, a method that restricts the value of the predictor variable to **0** and **1**, as the case with the Probit model should be the method of discrete choice. Second, Probit analysis outperforms most of the other competing approaches (logit and tobit models) in terms of efficiency and effectiveness in minimizing heteroscedasticity (Gujarati, 2007). In our Probit model, dependent variable $Y = 1$ if a neonate dies within or after 28 days of delivery and $Y = 0$ if otherwise. Therefore, the probability (ρ) of a neonate surviving within or after 28 days of delivery over the odds of not surviving is calibrated in equation 2 below:

$$NNM = \beta_o + \beta_1 FEU + \beta_2 SBA + \beta_3 PNCC + \beta_4 PDS + \beta_5 IPTp - SP + \mu t \quad (1)$$

$$\rho = Prob(Y = 1/X) = \int_{-\infty}^{\chi'\beta} (2\pi)^{-1/2} exp\left(-\frac{t^2}{2}\right) dt = \Phi(\chi'\beta)$$

(2)

Where NNM is the dependent variable and the independent variables from equation **1** is defined as FEU = utilization of iron-folic acid supplementations by a pregnant woman, *SBA* = delivery cases handled by skilled birth attendants, PNCC = postnatal care for child (using chlorhexidine for cleaning the cords of new borns), PDS = Women's knowledge about postpartum danger signs for neonates while IPTp= Intermittent preventive treatment of malaria for pregnant women. Where Φ is the cumulative distribution function of a standard normal variable which ensures $0 \le p \le 1$, x is vector of factors that determine or explain the variation in neonatal outcome and β is vector of parameters or coefficients that reflects the effect of changes in x on the probability of a neonate not dying within or after 28 days of delivery.

The marginal effects provide insights into how the explanatory variables change the predicted probability odds of neonatal deaths. Neonatal outcome is determined by the elements of vector x representing the independent variables as denoted in equation 1. The relationship between a specific variable and the outcome of the probability is interpreted by means of the marginal effect, which accounts for the partial change in the probability. The marginal effect associated with explanatory variables in x vector on the probability $Prob(Y = 1/X)$ holding the other variables constant, can be derived as follows:

$$\frac{\partial \rho}{\partial \chi_k} = \varphi(\chi'\beta)\beta_k \quad (3)$$

The marginal effect on dummy variables were estimated differently from continuous variables. The marginal effects estimated using the "delta method" involves the use of calculus to show how much the (conditional) probability of the outcome variable changes when there is a change in the value of an explanatory variable, holding all other explanatory constant at their values. It is worth noting that unlike the linear regression case where the estimated regression coefficients are the marginal effects, there is a need for the additional level of computation to estimate the marginal effects having computed the Probit regression. The marginal effects were derived from equation 3. Hence, the marginal effect for the Probit regression outputs is denoted by equation 4.

$$\Delta = \Phi(\bar{\chi}\beta, d = 1) - \Phi(\bar{\chi}\beta, d = 0) \quad (4)$$

The marginal effects provide insights into how the explanatory variables shift the probability of frequency of neonatal deaths.

IV. FINDINGS AND DISCUSSION OF RESULTS

This section presents the research findings and discussion of results. First, we estimated the coefficients of the parameters. Second, we also estimate the crude odds-ratios for the estimated parameters. Third, we calibrated the marginal effects of the dummy variables differently from the explanatory variables for the purpose of policy recommendations. Therefore, this section begins with the socio-demographic backgrounds of the study participants in the last five years.

Table 2: Weighted Socio-Demographics Characteristics of the Study Participants (Obs=5 000)

Socio-Demographic variables		Frequency (Counts)	Percentage (%)
Age-Group	18 - 20 Years	72	2
	21-25 Years	454	10
	26 - 30 Years	1189	25
	31 - 35 Years	1453	29
	36 - 40 Years	1174	25
	41 - 45 Years	342	7
	46-49 Years	91	2
Marital Status	Married	4662	97
	Divorced	31	1
	Widowed	82	2
Occupation	Government Workers/Civil Servants	560	12
	Professional workers	339	7
	Healthcare workers	127	3
	Petty Traders	1722	32
	Business Owners (Self-employed)	407	9
	Farmers	76	2
	Artisans	187	4
	Full time housewife	738	16
	Students	265	6
	Unemployed Youths / Adults	329	8
	Others	25	1
Income Categories	₦0 - ₦20,000	3198	61
	₦20,001 - ₦50,000	976	20
	₦50,001 - ₦100,000	232	6
	₦100,001 - ₦	43	1

| | | | | | | Higher/University Education | 1543 | 32 |
| | | | | | | Others | 105 | 2 |

Level of Education	150,000		
	Prefer not to say	200	7
	Not applicable	126	5
	No formal education	277	7
	informal education	663	15
	Primary school completed	573	12
	Junior Secondary School completed	562	10
	Senior secondary school completed	1052	23

Source: Authors' Computation (2023)

Table 2 presents the socio-demographic backgrounds of the study participants such as age-group, marital status, occupation, income categories and level of educational attainments in the last five years. The table indicates that (4,662) 97%, (31) 1% and (82) 2% of the respondents were married, divorced and widowed respectively. Table 1 equally shows that the study participants were between the reproductive age of 18-49 years.

Table 4: Generalized Linear Probit Model Outputs on the Effect of Maternal and Child Healthcare Service Quality on Neonatal Deaths in Nigeria (Obs=5 000)

Independent Variables	Coefficients	Std. Error	Z-Values	P-Values	Odds-Ratios	(95% CI)		Marginal Effects
						Lower	Upper	
Women's knowledge about Postpartum danger signs for neonates (PDS)	-18.0530	0.0490	-5.1930	0.860	89.948	0.8610	1.0430	0.1020
Postnatal care child (PNCC) (Chlorhexidine)	-34.0940	0.0847	-4.2340	0.080	64.910	0.7710	1.0750	0.5160
Delivery cases handled by skilled birth attendants (SBA)	-4.5870	0.0251	-7.2800	0.986	16.798	1.7120	1.8890	0.3450
Iron-folic acid supplementations (FEU)	-12.5560	0.3015	-6.6250	0.610	24.211	0.1170	0.3810	0.1270
Intermittent preventive treatment of malaria (IPTp-SP)	-16.1830	0.0246	-5.5830	0.590	34.833	0.7930	0.8740	0.1370
(Intercept)	0.6620	0.3363	-4.8760	0.896	1.939	1.0030	3.7480	0.1470
Log-likelihood	-56.956			Akaike I.C.				0.5650
Restricted Log-L	-180.654			Schwarz I.C.				0.3456
Mac-Fadden Pseudo R^2	0.8950			HQIC				0.7893
χ^2 *(df=5)*	345.456			Ben./Lerman				0.5672
Model significant level	0.000			Cramer				0.3451
Hosmer-Lemeshow χ^2	34.560			Veall/Zim.				0.4367

***Variables are significant at α = 5%

Source: Authors' Computation (2023)

Table 4 illustrates that the ANC service components quality assessment indicators which form our independent variables in this research are all insignificant with their probability values greater than α= 5%. Therefore, table 4 suggests the acceptance of the null

hypothesis that maternal and child healthcare service quality does not have significant effect on neonatal deaths in Nigeria and that the alternative hypothesis is not true. By implication, this means that the maternal and child healthcare service quality assessment indicators in table 4 are less likely to halt the deaths of neonates in Nigeria. The results from Probit regression marginal effect outputs indicates that a -18.0530 decrease in women's knowledge about postpartum danger signs (*PDS*) for neonates may increase the risk rate of neonatal deaths by 10.2%. This result is consistent with the study conducted by Dare et al. (2021), Sahoo et al. (2021) and Pati et al. (2021) whose studies reported insignificant relationship between neonatal deaths and the components of antenatal and postnatal cares services provided before and after postpartum at the health facilities by the health practitioners. The result also tallies with the study conducted by Eghrari et al. (2023) who found low knowledge of new born danger signs among pregnant women in Papua, New Guinea.

Also, computations from the iterative Probit marginal effect explain further that for postnatal care for child (using chlorhexidine for cleaning the cords of new borns) [*PNCC*], that a -34.0940 decrease in the chances of applying the chlorhexidine syrup for cleaning the cords of new borns or taking a new born for post-natal check-up will increase the risk rate of bacterial infections and neonatal deaths by 51.6 percentage points. In addition, -4.5870 shift in the probability of delivery cases not being handled by skilled birth attendants [*SBA]* at the health facility is more likely to increase the chances of neonatal deaths by 34.5 percentage points. A shift in the probability [-12.5560] in the utilization of iron-folic acid supplementations by a pregnant woman [*FEU*] may increase the risk of low birth weights and neonatal deaths by 12.7% percentage points. In another scenario, -16.1830 shifts in the probability of a pregnant woman not getting intermittent preventive treatment of malaria vaccines [IPTp-SP], may increase the risks of malaria transmission and neonatal deaths by 13.7%. This result corroborates the findings of Al-Sheyab et al. (2020) and Lawn et al. (2023) whose study found that the main maternal conditions attributed to neonatal deaths were complications of the placenta, malaria and cord infections. This result equally tallies with the findings from Dare et al. (2021) whose study found the main causes of neonatal deaths in Navrongo and Kintampo Ghana to be treatable infections from malaria infections and low birth weights due to lack of iron-folic acid supplementations.

V. CONCLUSION AND POLICY RECOMMENDATIONS

Following the results of the analysis of the effect of maternal and child healthcare service quality on neonatal deaths in Nigeria, this research concluded that the ANC components quality assessment metrics on ANC service provisions for pregnant women such as utilization of iron-folic acid supplementations by pregnant women, intermittent preventive treatment of malaria vaccines for pregnant women [IPTp-SP], postnatal care child, women's knowledge about postpartum danger signs for neonates and delivery cases handled by skilled birth attendants have not significantly halt neonatal mortality rate in Nigeria. This is due to poor accessibility and availability, poor provider-client interactions, a lack of facility resources, such as a lack of equipment and drugs, a shortage of qualified professionals, and other administrative issues. Also, results from the survey findings show that ANC service quality assessment metrics were negative across the study locations and this have accounted for the high rate of neonatal mortality in

Nigeria. Therefore, based on the results from the findings of this research, this study recommends the need for government to re-prioritized interventions for neonatal health through National Child Health Policy in order to halt the menace of neonatal deaths in Nigeria. The study also calls on government, stakeholders in the private sector and the non-governmental organizations in re-visioning strategic ways to provide the optimal methods for delivering quality and patients-focused maternal and perinatal healthcare services during ANC visit across all PHCs in Nigeria so as to avert the deaths of new borns.

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