ORIGINAL ARTICLE

Maternal Health Care Services Access Index and Infant Survival in Nigeria

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ABSTRACT

BACKGROUND: Infant mortality rate in Nigeria is among the highest world-wide. Utilization of modern health care facilities during pregnancy and at delivery reduces infant mortality rate. We examined the relationship between Infant Mortality (IM) and Maternal Health Care Services Access Index (MHCI) in Nigeria.

METHODS: This cross-sectional study utilized 2013 NDHS data and included women aged 15-49 years (n=12511). MHCI was obtained from information on antenatal visit, antenatal attendance, tetanus toxoid injection during pregnancy, place of delivery and birth attendance. Cox-proportional hazard and Brass models were used for the analysis (α=0.05).

RESULTS: Mean MHCI was higher among women with lower prevalence of IM. About 5.1% and 3.4% of the women with none and complete MHCI had experienced infant deaths respectively. The hazard of experienced infant deaths was 1.497(1.068-2.098) and 1.466(1.170-1.836) significantly higher among women with no and low MHCI respectively than those with complete MHCI. This pattern was observed when other factors were used as control. The refined IM probability (range=0.0482-0.1102) and IM rates (range=50-119) increased with reduction in the level of MHCI. The IM rate reduces from 119 per 1,000 live births among women whose MHCI score was zero to 50 per 1,000 live births among those with complete MHCI score.

CONCLUSION: Infant death was least experienced among women who had complete MHCI. If women optimize utilization of health facility during pregnancy and delivery, infant deaths will reduce in Nigeria.

KEYWORDS: Infant mortality, Maternal health care, Pregnancy care, Delivery care, Nigeria

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INTRODUCTION

Mortality rate at infancy is the number of deaths per 1,000 yearly live births. Infant mortality rate is central to the measurement of child health and well-being in any population. Worldwide, there has been important progress in infant mortality reduction (1). In 1990 and 2012, 12.6 and 6.6 million under-five children died respectively (1). Consistent reduction in infant mortality rate has been observed in Nigeria in the past few decades. Infant mortality reduced from 87.2 in 1990 to 69 per 1,000 live births in 2013, while under-five mortality reduced from 192.4 to 128 per 1,000 live births over the same period (2,3). Thus, mortality at infancy is approximately half of all deaths among under-five children (2,3). In spite of this achievement, Nigeria was unable to achieve the Millennium Development Goal (MDG) target of a two-thirds reduction in 1990 childhood mortality levels in year 2015. Nigeria, the most populous black nation where physical barriers constitute challenge to accessing care within the health

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system is still among nations having the highest infant mortality worldwide (4,5,6).

Prior to Alma Ata international conference, governments in some developing countries observed that investments in health and the availability of health technologies and health care services were not causing significant impacts on population health (7). The National Health Policy was formulated in 1986 and adopted in 1988. The national health system management was based on the framework designed to establish a comprehensive health care system and address imbalance in health service distribution plus inequality in resource allocation. The policy was revised in 2004 (8), but the implementation of the revision faced some challenges. The Nigerian Government has made frantic efforts to revitalize health care system. Yet, the services are poor in terms of accessibility, affordability and acceptability. The health services indicators are still considered to be worse particularly those related to maternal and child health.

Studies have revealed less utilization of health facilities among pregnant women as an important determinant of infant mortality (4,9). For instance, some pregnant women in Nigeria do not go for antenatal care, and as a result may not access other cares like tetanus toxoid injection and birth attendance from qualified health professionals (2). Antenatal care of at least four visits ensures best maternal and child health outcomes. The advantages of antenatal care particularly when provided by a skilled health worker includes early detection of complications and timely treatment, disease prevention through immunisation and micronutrient supplementation, birth preparedness and counselling for pregnant women (10,11). Also, neonatal tetanus has been found to be among the leading causes of neonatal deaths in developing countries (12). Tetanus toxoid injections are given to pregnant women to avert infant mortality associated with neonatal tetanus which often results when sterile procedures are violated after delivery (13). It is recommended that a woman takes two doses of tetanus toxoid injection during pregnancy for full protection. Nevertheless, if she was vaccinated before becoming pregnant, she may require one or no tetanus toxoid injections during her pregnancy depending on the number of injections she had received in the past and the timing of the last injection (14, 15). Furthermore, births delivered in health facilities are an important factor in reducing mortality arising from pregnancy complications (16). The belief is that if a complication arises during delivery, a skilled health worker can manage it or refers the mother to the appropriate health facility. In addition, the skills and performance of the attendant during delivery is an indication of whether complications are managed correctly under good hygienic practices. While the proportion of births attended by a skilled health worker has increased globally, fewer than 50% of births are attended to by skilled health worker in the African Region (17).

Studies that critically analysed the determinants of infant mortality have found a number of antenatal visits, antenatal attendance, tetanus injection during pregnancy, place of delivery and birth attendance as significant factors in the midst of other variables (18,19). Most of the studies in this area, however, have not gone beyond this stage. Examining the independent relationship between each of these variables and infant mortality may be limited in terms of policy formulation. For example, if a pregnant woman claimed that she has attended antenatal services for the required number of visits recommended by WHO but did not seek care from skilled health professional during the visits or fails to deliver at modern health facility, her health and that of her unborn child may be at risk. The wide-ranging nature of these factors and their interrelatedness require addressing them in an integrated manner to augment infant survival chances. We therefore opine that if the five indices of maternal health care services are combined by scoring each index to produce an aggregate score for individual woman. A score less than specific value can be used to identify whether she is at higher risk of infant mortality or not.

The socio-demographic factors influencing infant death are well established in the literature (20,21,22,23,24,25). The infant mortality rate is also a result of ample variety of health and environmental factors such as the child and maternal nutritional status, maternal health knowledge, level of immunization against childhood diseases, income and dietary intake during pregnancy, accessibility to portable water and basic sanitation, etc (26,27). The proximate determinants of childhood mortality as identified by Mosley and Chen (1984) include maternal factors, environmental contamination, nutrient deficiency, injury and personal illness control (28). However, it is known that infant mortality risks associated with these factors can be reduced if pregnant women utilize modern health facility adequately (28). We therefore aimed to study the association between infant mortality and maternal health care access index in Nigeria.

METHODS

Study area: Nigeria is the African most populous country. The 2013 projected population for Nigeria was 173.6 million (5).

Data collection procedures: We used the 2013 Nigeria Demographic and Health Survey dataset. A three-stage cluster design was used primarily for the data collection. In the original sample, 31,482 women of childbearing age who had live births of 5 years prior to the survey were interviewed. However, the current study focused on women who had complete information on infant survival status, antenatal visit, antenatal attendance, tetanus injection during pregnancy, place of delivery and birth attendance. Among such women, those who gave birth to twins were further excluded from the analysis. Setting these inclusion and exclusion criteria reduced the number of women in the sample for this study to 12,511.

Description of variables: The dependent variable was survival status of infant children (alive=0 or dead=1) and the principal independent variable was Maternal Health Care Services Access Index (MHCI). The MHCI was generated using variables including antenatal visit, antenatal attendance, tetanus injection during pregnancy, place of delivery and birth attendance. Scores were assigned to the responses of individual woman to each of the questions regarding number of antenatal visits (None=0, 1-3=1, ≥4=2), antenatal attendance (None=0, traditional birth attendance=1, unskilled health workers=2, skilled professionals=3), required number of tetanus injection during pregnancy (No=0, Yes=1), place of delivery (Home=0, Others=1, modern health facility=2), and birth attendance (None=0, traditional birth attendance=1, unskilled health workers=2, Skilled professionals=3), thus, producing maximum overall score of 11 and 0 as the minimum. Thereafter, the overall total score x for an eligible respondent was disaggregated into five categories as:

$$MHCI = \begin{cases} \text{None, if} & x = 0 \\ \text{Low, if} & 0 < x < 50\% \text{ of the max. overall score} \\ \text{Medium, if} & 50\% \leq x < 75\% \text{ of the max. overall score} \\ \text{High, if} & 75\% \leq x < 100\% \text{ of the max. overall score} \\ \text{Complete} & 100\% \text{ of the max. overall score} \end{cases}$$

Other independent variables are: *demographic*; (age, marital status, birth order, preceding birth interval, children ever born, marital status and sex of the child), *socioeconomic* (wealth index, education, ethnicity, religion, region, work status, place of work, place of residence and husband's education), *environmental and health related* factors (sources of drinking water, toilet facility, cooking fuel and size of the child at birth).

Method of analysis: Data were analyzed using SPSS version 21. The data were weighted before use to ensure representativeness since cluster design approach was used.

At the first stage of the analysis, Chi-square model was used to establish an association between "infant survival status and independent variables as mentioned above. Thereafter, statistically significant variables (α=5%) were entered into Cox proportional hazard model to determine the strength of the associations between the dependent and independent variables. To conduct this examination, we used five different models as expressed by equations 1-5. Model 1 involved singular use of MHCI; Model 2 included only demographic variables and MHCI; Model 3 incorporated only socioeconomic variables and MHCI, Model 4 included environmental/health related variables and MHCI only, and Model 5 included all variables found to be significantly associated with the dependent variable during bivariate analyses as control to examine their influence on the relationship between infant survival and MHCI. This model was also used to identify the key predictors of infant survival in Nigeria.

The equation below expresses the relationship between the dependent and independent variables with an assumption that the time to event and the covariates are related.

$$\log_e\left\{\frac{h_i(t)}{h_0(t)}\right\} = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_p x_{ip}$$

Where;

$h_i(t)$ is the hazard rate for the case i of experienced infant mortality at time t; $h_0(t)$ is the baseline hazard at time t; β_j is the value of the j^{th} regression coefficient; x_{ij} is the value of the i^{th} case of the j^{th} covariate

Model1

$$\log_e\left\{\frac{h_i(t)}{h_0(t)}\right\} = \beta_{j0} + \beta_{j1} \times MHCSAI \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Model 2

$$\log_e\left\{\frac{h_i(t)}{h_0(t)}\right\} = \beta_{j0} + \beta_{j1} \times MHCSAI + \sum_{i=1}^{n}\beta_p x_{ip} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Model 3

$$\log_e\left\{\frac{h_i(t)}{h_0(t)}\right\} = \beta_{j0} + \beta_{j1} \times MHCSAI + \sum_{i=1}^{n}\beta_k x_{ik} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Model 4

$$\log_e\left\{\frac{h_i(t)}{h_0(t)}\right\} = \beta_{j0} + \beta_{j1} \times MHCSAI + \sum_{i=1}^{n}\beta_q x_{iq} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Model 5

$$\log_e\left\{\frac{h_i(t)}{h_0(t)}\right\} = \beta_{j0} + \beta_{j1} \times MHCSAI + \sum_{i=1}^{n}\beta_m x_{im} \ldots\ldots\ldots\ldots\ldots. (5)$$

The data were further analyzed using indirect method to ascertain the influence of MHCI on infant mortality as a result of possible errors in data on reported death. The method was developed by William Brass and further modified by Coale and Trussel (29).

Description of the technique: Brass et al., 1968 showed that the probability of dying between birth and exact age **(a)** can be estimated as $q(x) = k(x) \times D(x)$ where D(x) is the proportion of children dead to women in each age group is an age-specific factor and k(x) referred to as a multiplier and is estimated using the expression:

$$k(x) = a(i) + b(i)(P_1/P_2) + C(i)(P_2/P_3) \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

In this approach, the proportion of children dead to women in age groups 15-20, 20-25, 25-30,..., 45-50 were used to calculate childhood mortality at exact ages (q(x)); 1, 2, 3, 5, 10, 15 and 20. Through mathematical simulations, regression equations were developed which relate the multipliers k(x) to indices of the fertility schedule (United Nations, 1983). Other set of simulations were used to estimate the time reference to which the q(x) values refer.

Due to some limitations in the estimates produced by this method, we further adjusted the childhood mortality using Brass 1-parameter model $(Y = \propto + \beta Y_s)$ where β=1. The procedure involved the use of logit equation:

$$\text{logit}\{q(x)\} = \frac{1}{2}\log\left\{\frac{1-l_x}{l_x}\right\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

This was transformed to Brass relational system of life tables; $\text{logit}\{l(x)\} = \propto + \beta\,\text{logit}\{l_s(x)\}$ often written as $Y = \propto + \beta Y_s$. The logit relational system was used to smooth the estimated values of l(x) (survival probability) against the values from the model life-table. Therefore, if β=1, $\hat{\propto} = Y(x) - Y_s(x)$, thus producing: $Y(1) = \hat{\propto}_1 + Y_s(1)$; $Y(2) = \hat{\propto}_2 + Y_s(2); \ldots; Y(20) = \hat{\propto}_{20} + Y_s(20)$. Estimate of $\hat{\propto}$ was obtained by taking the average values of x=2, x=3 and x=5 which are known to produce reliable values of l(x). Therefore, if $\bar{Y}$ is the average of Y(2), Y(3), and Y(5) and $\bar{Y}_s$ is the average of $Y_s(2)$, $Y_s(3)$ and $Y_s(5)$, then $\hat{\propto} = \bar{Y} - \bar{Y}_s$. This was used to generate the adjusted survival probabilities at childhood. The infant mortality rate was thereafter obtained using the equation; $IMR = \frac{1q_0}{1-0.7\times 1q_0}$

Ethical consideration: Approval was obtained from Nigerian National Ethics Committee (RNEC) before the commencement of the survey. Informed consent was also sought and approved by the study subjects during data collection. The confidentiality of the respondents was also assured.

RESULTS

The data as shown in Table 1 indicate that the percentage of women who experienced infant deaths was 4.3%. Women in the rural areas (4.7%) experienced higher infant deaths than their counterparts in urban areas (3.4%). Women at the two extreme age groups, i.e. 15-24(4.5%) and 35-49(5.5%) had experienced infant deaths higher than those in age groups 25-29 and 35-49 years. Children who were first-born (4.9%) and those who were born as the ≥6th child (5.8%) experienced higher infant deaths than those of birth order 2-3 and 4-5. The preceding birth interval was also found to be significantly associated with infant deaths with children born 7-23 months after the previous experienced the highest infant deaths (4.7%) than any other longer birth intervals. The data further show that of women who experienced infant deaths were the highest among women who had given birth to at least 5 children (5.1%) prior the survey. There was no significant association between of women who experienced infant deaths and sex of the child. The data show that, in most cases, the mean MHCI was higher where the percentage of women who experienced infant death was lower. For instance, the mean MHCI was 6.05±4.2 and higher among urban women 8.72±3.3 than rural 4.75±3.9 (p<0.001).

In Table 1, infant death was mostly experienced by women in the poorest wealth quintile (5.1%) and least experienced by those in the richest wealth quintile (2.8%). A reverse pattern was observed for the mean MHCI across the wealth quintiles where the highest mean MHCI score was observed among women in the richest (9.99±2.1) and least by their counterparts in the poorest (2.60±2.9) wealth quintile.

Table 1: Distribution of Infant Survival Status According to Socio-demographic Characteristics.

Background Characteristics	**% Infant Deaths**	**Total Women**	**χ^2-value** (p-value)	**Mean MHCI±σ**	**F-value** (p-value)
Total	4.3	12511		6.05±4.2	
Residence			**11.128**		**313.1**
Urban	3.4	4120	0.001	8.72±3.3	<0.001
Rural	4.7	8391		4.75±3.9	
Age group			**22.659**		**39.512**
15-24	4.5	2911	<0.001	5.37±4.0	<0.001
25-29	3.4	3345		6.19±4.1	
30-34	3.5	2636		6.53±4.1	
35-49	5.5	3619		6.13±4.2	
*Mean±σ***	*30.8±8.4*	*29.9±7.3*			
Marital status			**3.411**		
Currently in Union	4.2	12100	0.051	6.03±4.1	
Formerly in Union	6.6	411		6.77±3.9	
Birth order			**33.908**		**214.146**
1st Birth	4.9	2017	<0.001	6.96±4.1	<0.001
2-3	3.2	3939		6.50±4.1	
4-5	3.6	3116		6.09±4.1	
6+	5.8	3439		4.98±4.0	

Table 1 Continued…

Preceding birth interval			**6.578**		**53.795**
7-23	4.7	2118	0.160	5.64±4.2	<0.001
24-35	4.4	4025		5.66±4.1	
36-59	3.6	3183		5.91±4.2	
60+	3.9	1168		6.97±4.1	
1st Birth	4.9	2017		6.96±4.1	
Children ever born			**20.160**		**182.41**
1-2	4.4	4072	<0.001	6.82±4.1	<0.001
3-4	3.1	3604		6.33±4.1	
5+	5.1	4835		5.20±4.1	
*Mean±σ**	*4.7±3.2*	*4.17±2.7*			
Sex of the child			**3.822**		**8.180**
Male	4.6	6369	0.051	6.16±4.1	0.004
Female	3.9	6142		5.95±4.1	
Wealth Index			**20.328**		**208.3**
Poorest	5.1	2840	<0.001	2.60±2.9	<0.001
Poorer	5.0	2934		4.34±3.6	
Middle	3.8	2454		6.72±3.8	
Richer	4.1	2271		8.37±3.3	
Richest	2.8	2012		9.99±2.1	
Highest educational level			**11.449**		**251.6**
No education	4.9	5980	0.010	3.55±3.5	<0.001
Primary	4.1	2562		6.92±3.7	
Secondary	3.5	3155		8.95±2.9	
Higher	3.3	814		10.49±1.4	
Ethnicity			**19.413**		**200.6**
Hausa/Fulani	4.8	5019	<0.001	3.59±3.5	<0.001
Igbo	5.3	1232		9.67±2.4	
Yoruba	2.5	1519		9.99±1.9	
Others	4.0	4741		6.45±3.9	
Religion			**0.247**		**131.1**
Christianity	4.2	4862	(0.884)	8.23±3.5	<0.001
Islam	4.4	7504		4.68±3.9	
Others	4.1	145		4.33±3.9	
Media Exposure			**9.668**		**152.8**
None	4.9	4337	0.022	3.83±3.6	<0.001
Low	4.3	4062		5.52±4.0	
Medium	3.4	3080		8.55±3.2	
High	4.2	1032		10.06±2.0	
Region			**23.937**		**117.3**
North Central	3.5	1944	<0.001	7.55±3.7	<0.001
North East	4.2	2496		5.04±3.6	
North West	5.0	4082		3.38±3.5	
South East	5.5	996		9.60±2.5	
South South	4.4	1340		7.02±3.9	
South West	2.6	1653		9.50±2.7	
Respondent currently working			**0.046**		**38.112**
No	4.3	3706	0.830	4.95±4.1	<0.001
Yes	4.3	8805		6.52±4.1	
Husband/Partner's educational level			**21.564**		**147.6**
No education	5.2	4788	<0.001	3.21±3.3	<0.001
Primary	4.0	2406		6.58±3.8	
Secondary	3.9	3583		8.03±3.5	
Higher	2.7	1682		9.19±2.8	
Don't know	3.8	52		6.15±3.7	

Percentage of women who experienced infant deaths falls consistently with increasing level of education. Conversely, the MHCI increases with increasing level of education (p<0.001). According to ethnic group, infant mortality was mostly experienced by Igbo women (5.3%) and least by Yoruba (2.5%). The data further revealed that women in the Southwest region had the least infant deaths (2.6%) among the six regions in Nigeria and the highest in Northwest (5.5%) (p<0.001).

In table 2, the data depict that 4.0% and 4.7% of women who obtain drinking water from improved and unimproved sources had experienced infant deaths respectively. A similar pattern was observed among the women in terms of use of toilet facility and type of cooking fuel. For example, women who use clean fuel (3.3%) experienced lower infant deaths than those who use biomas (5.5%) (p<0.001). The percentage of women who reported infant deaths was highest among women whose children were of small size at birth (6.3%). Also, the proportion of women who experienced infant deaths reduces consistently with increasing level of MHCI. The percentage ranges from 3.4% among women with complete score of MHCI to 5.1% among women with zero MHCI (p<0.001).

Table 2: Distribution of Infant Survival Status According to Environmental and Health related Characteristics

Background Characteristics	**% Infant Deaths**	**Total Women**	**χ^2-value** (p-value)	**Mean MHCI±σ**	**F-value** (p-value)
Total	4.3	12511			
Sources of drinking water			**3.600**		**802.927**
Improved	4.0	6987	0.058	6.97±4.0	<0.001
Unimproved	4.7	5524		4.90±4.1	
Toilet facility			**0.124**		**682.484**
Improved	4.2	6162	0.724	7.02±4.0	<0.001
Unimproved	4.3	6349		5.12±4.1	
Cooking Fuel			**6.777**		**226.10**
Clean fuel	3.3	2205	0.009	9.58±2.7	<0.001
Biomas	4.5	10306		5.30±4.0	
Size at birth			**21.365**		**138.977**
Small	6.3	1768	<0.001	4.68±4.1	<0.001
Average	4.1	5061		5.98±4.2	
Larger than average	3.9	5682		6.55±4.1	
Maternal Health Care Services Access Index			**13.713**		
None	5.1	927	0.008		
Low	5.0	4179			
Medium	4.3	2785			
High	3.7	1126			
Complete	3.4	3494			

**Significant at 0.1%; **Significant at 1.0%; ***Significant at 5.0%; NA: Not Applicable*

In Figure 1, the data show that women who experienced infant deaths had lower percentage of MHCI for scores 7, 9, 10 and 11 than those whose infant children were alive at the time of the survey. This is an indication that women who lost their children at infancy accessed maternal health services less than those who did not lose their children. There was a significant difference between the Mean MHCI (6.08±4.2) of women whose infant children were alive and those who lost their infant children (5.41±4.1) (p<0.001).

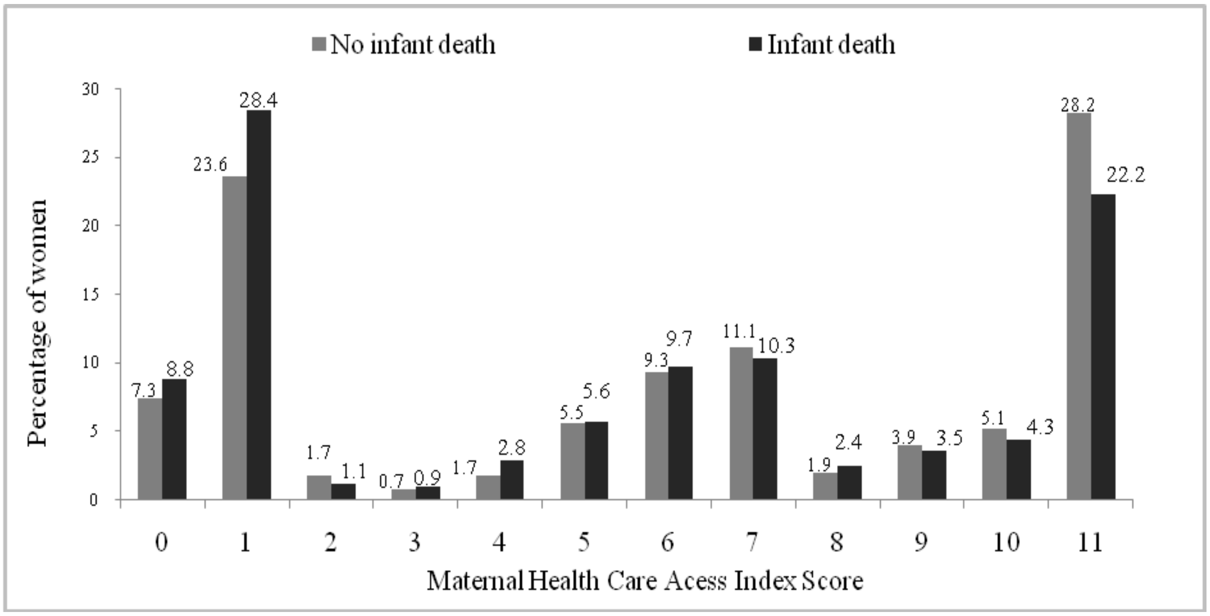

Figure 1: *Percentage distribution of MHCI score*

Multivariate results: In table 3, the data show that the hazard of infant mortality were 1.497 (p<0.05) and 1.466 (p<0.01) higher among women with none and low MHCI respectively than those with complete MHCI (Model 1). A similar pattern but with reduction in hazard ratio of infant mortality was observed among the levels of MHCI when demographic and health related factors were independently used as control (Model 2 and Model 4). However, when socio-demographic, environmental and health related variables were jointly included in the regression equation, the hazard ratio of infant mortality was not significant related to MHCI (Model 5).

The identified predictors of infant mortality are birth order, preceding birth interval, children ever born, husband's/partner's educational level and infant size at birth. The hazard of infant mortality was found to be significantly higher among infants of women who were of sixth birth order than those with first birth. The hazard of infant death was 1.532 (p<0.01) times higher among children who were small in size at birth than those who were larger than average size at birth.

Table 3: Cox regression of the relationship between infant mortality and background Characteristics, Nigeria, 2013.

Background Characteristics	**Model 1** HR	**Model 2** AHR	**Model 3** AHR	**Model 4** AHR	**Model 5** AHR
Maternal Health Care Services Access Index					
None	1.497***	1.268	1.105	1.267	1.009
1-5 score	1.466**	1.305***	1.148	1.312***	1.140
6-8 score	1.270	1.180	1.122	1.178	1.136
9-10	1.099	1.046	1.043	1.046	1.027
Complete *(Ref. Cat.)*	1.000	1.000	1.000	1.000	1.000
Age group					
15-24 *(Ref. Cat.)*		1.000			1.000
25-29		0.901			0.923
30-34		0.881			0.914
35-49		1.221			1.254
Residence					
Urban *(Ref. Cat.)*		1.000			1.000
Rural		1.206			1.189

Table 3. Continued…

Birth order					
1st Birth *(Ref. Cat.)*		1.000			1.000
2-3		0.825			0.832
4-5		1.318			1.337
6+		1.970***			1.940***
Children ever born					
1-2 *(Ref. Cat.)*		1.000			1.000
3-4		0.590**			0.588**
5+		0.492**			0.488**
Region					
North Central			1.154		1.212
North East			1.151		1.171
North West			1.379		1.430
South East			1.484		1.423
South South			1.501		1.412
South West *(Ref. Cat.)*			1.000		1.000
Wealth Index					
Poorest			1.375		1.251
Poorer			1.453		1.364
Middle			1.182		1.150
Richer			1.385		1.385
Richest *(Ref. Cat.)*			1.000		1.000
Highest educational level					
No education *(Ref. Cat.)*			1.000		1.000
Primary			0.928		0.933
Secondary			0.922		0.920
Higher			0.848		0.865
Ethnicity					
Hausa/Fulani *(Ref. Cat.)*			1.000		1.000
Igbo			1.361		1.410
Yoruba			0.956		0.970
Others			1.044		1.035
Media Exposure					
None *(Ref. Cat.)*			1.000		1.000
Low			0.750		0.731
Medium			0.725		0.727
High			0.708		0.706
Husband/Partner's educational level					
No education *(Ref. Cat.)*			1.000		1.000
Primary			0.785		0.826
Secondary			0.860		0.919
Higher			0.623***		0.643***
Don't know			0.762		0.821
Cooking Fuel					
Clean fuel *(Ref. Cat.)*				1.000	1.000
Biomas				1.184	1.186
Size at birth					
Small				1.569*	1.532*
Average				1.036	1.014
>Average *(Ref. Cat.)*				1.000	1.000
-2 Log Likelihood	***10079.6****	***10030.9****	***10042.2*****	***10062.9*****	***9985.3****

**Significant at 0.1%; **Significant at 1.0%; ***Significant at 5.0%; Ref. Cat.: Reference Category; AHR: Adjusted Hazard Ratio*

Table 4: Estimated Smoothed Childhood Mortality Probability According to Maternal Health Care Services Access Index, 2013 Nigeria Demographic and Health Survey.

Age group	P(i)	D(i)	Age x	$l(x)_{Es}$	$l(x)_{Br}$	Y(x)	Y(s)	Adj Y(x)	Adj. q(x)	Ref. Period
MHCSAI = None; Mortality level =14.46; $\overline{Y(x)}$ = -0.8567; $\overline{Y(s)}$ = -0.10218; $\bar{\hat{\alpha}}$ = -0.1650										
15-19	1.3750	.1364	1	.9920	.8906	-1.0483	-1.2093	-1.0443	.1102	2010.3
20-24	2.4264	.1693	2	.8652	.8652	-.9296	-1.0951	-.9301	.1347	2008.8
25-29	4.1205	.2275	3	.7782	.8539	-.8829	-1.0488	-.8838	.1459	2007.5
30-34	5.5956	.2217	5	.7665	.8411	-.8331	-.9982	-.8332	.1589	2006.6
35-39	7.2761	.2521	10	.7230	.8267	-.7812	-.9449	-.7799	.1737	2005.9
40-44	8.5391	.2719	15	.7022	.8161	-.7449	-.9068	-.7418	.1849	2004.7
45-49	7.6235	.2901	20	.6856	.8007	-.6954	-.8558	-.6908	.2008	2002.1
MHCSAI = Low; Mortality level =16.32; $\overline{Y(x)}$ = -1.0054; $\overline{Y(s)}$ = -0.10218; $\bar{\hat{\alpha}}$ = -0.164										
15-19	1.2201	.1379	1	.9910	.9134	-1.1780	-1.2093	-1.1929	.0843	2010.3
20-24	2.1548	.1318	2	.8953	.8953	-1.0730	-1.0951	-1.0787	.1036	2008.8
25-29	3.6158	.1636	3	.8410	.8871	-1.0306	-1.0488	-1.0324	.1126	2007.5
30-34	5.3055	.1882	5	.8024	.8774	-.9842	-.9982	-.9818	.1231	2006.6
35-39	6.8006	.2092	10	.7708	.8662	-.9338	-.9449	-.9285	.1350	2005.8
40-44	7.8983	.2264	15	.7529	.8577	-.8984	-.9068	-.8904	.1442	2004.5
45-49	9.4688	.2607	20	.7184	.8452	-.8489	-.8558	-.8394	.1572	2002.0
MHCSAI = Medium; Mortality level = 16.55; $\overline{Y(x)}$ = -1.0252; $\overline{Y(s)}$ = -0.10218; $\bar{\hat{\alpha}}$ = -0.0034										
15-19	1.2162	.1167	1	.9981	.9161	-1.1952	-1.2093	-1.2127	.0813	2010.2
20-24	2.0685	.1298	2	.8989	.8989	-1.0923	-1.0951	-1.0985	.1000	2008.6
25-29	3.3961	.1501	3	.8547	.8910	-1.0503	-1.0488	-1.0522	.1087	2007.4
30-34	4.9153	.1417	5	.8513	.8817	-1.0041	-.9982	-1.0016	.1189	2006.5
35-39	6.3397	.1792	10	.8035	.8708	-.9540	-.9449	-.9483	.1305	2005.7
40-44	7.5628	.2044	15	.7766	.8626	-.9186	-.9068	-.9102	.1394	2004.5
45-49	8.5934	.2199	20	.7622	.8505	-.8692	-.8558	-.8592	.1521	2002.0
MHCSAI = High; Mortality level = 18.75; $\overline{Y(x)}$ = -1.2412; $\overline{Y(s)}$ = -0.10218; $\bar{\hat{\alpha}}$ = -2.2194										
15-19	1.2200	.1475	1	1.0471	.9407	-1.3821	-1.2093	-1.4287	.0543	2009.6
20-24	1.7150	.0967	2	.9310	.9310	-1.3012	-1.0951	-1.3145	.0673	2008.0
25-29	2.8272	.1022	3	.9001	.9262	-1.2652	-1.0488	-1.2682	.0733	2007.1
30-34	4.1024	.1219	5	.8684	.9203	-1.2231	-.9982	-1.2176	.0805	2006.8
35-39	5.4390	.0996	10	.8870	.9130	-1.1753	-.9449	-1.1643	.0888	2006.8
40-44	6.8022	.1212	15	.8625	.9074	-1.1411	-.9068	-1.1262	.0951	2006.2
45-49	8.5938	.1891	20	.7879	.8986	-1.0910	-.8558	-1.0752	.1043	2003.8
MHCSAI = Complete; Mortality level = 19.22; $\overline{Y(x)}$ = -1.3037; $\overline{Y(s)}$ = -0.10218; $\bar{\hat{\alpha}}$ = -2.820										
15-19	1.2000	.0667	1	1.0208	.9456	-1.4281	-1.2093	-1.4913	.0482	2009.6
20-24	1.6522	.0909	2	.9374	.9374	-1.3529	-1.0951	-1.3771	.0599	2007.9
25-29	2.4691	.0718	3	.9317	.9332	-1.3186	-1.0488	-1.3308	.0653	2006.7
30-34	3.5000	.0835	5	.9118	.9280	-1.2782	-.9982	-1.2802	.0717	2006.2
35-39	4.8166	.1113	10	.8762	.9214	-1.2310	-.9449	-1.2269	.0792	2005.9
40-44	5.7909	.1151	15	.8720	.9164	-1.1971	-.9068	-1.1888	.0849	2005.2
45-49	6.7755	.1340	20	.8527	.9083	-1.1467	-.8558	-1.1378	.0932	2002.8

P(i): Parity; D(i): Proportion of Children Dead; q(x): Probability of dying; l(x): Probability of surviving; MHCSAI =Maternal Health Care Service Access Index; ES: Estimated; Br: Brass; Ref.: Reference; $\overline{Y(x)}$*: logitl(x); ;*$\overline{Y(s)}$*: logitl(s);* $\bar{\bar{\alpha}}$*: Mean of estimated parameter* α

In table 4, the data show that at different levels of MHCI (None, Low, Medium, High, and Complete), the refined childhood mortality probability estimate increases as the age of the child increases. For instance, among the group of women who had no MHCI, the refined childhood mortality probability increases from 0.1102 among infants to 0.2008 among young adults.

The data further show that infant mortality probability increases considerably as the level of MHCI increases. For instance, the probability of dying at exact age 1 year was highest among women whose MHCI was zero (0.1102) and least among women whose MHCI was complete (0.0482).

The estimated infant mortality rates which were obtained from the smoothed childhood mortality probabilities 4 are displayed in table in figure 2. The data show that infant mortality rate reduces from 119 per 1,000 live births among women whose MHCI score was zero to 50 per 1,000 live births among those with complete MHCI score.

DISCUSSION

Access to good health care during pregnancy is essential for mothers' health and development of her unborn child (10,31). In some instances, healthy behaviours after delivery and parenting skills are acquired during pregnancy (31). Accessing formal health system during pregnancy increases the chance of using skilled attendant at birth and this may contribute to good health of a child in the first year of life (10). While studies have shed some light on how infant mortality has been affected by access to maternal health care services (32,33), most are poorly documented and none has combined as an entity antenatal visit, antenatal attendance, tetanus injection during pregnancy, place of delivery and birth attendance as provided in the current study.

The proportion of women who experienced infant deaths was 4.3% and was lowest among children of mothers with maximum MHCI score. Also, across different categories of women, infant death was found to be lower where mean MHCI was higher. The direction of prevalence of infant death found in this study is consistent with the literature on the association between maternal health care services access and infant survival (34). Our findings emphasize the need for women to score at least 9 points out of 11 maximum score for access to health care services during pregnancy and child birth.

The results of the multivariate analysis presented in this article show that when all the five indicators of MHCI (antenatal visit, antenatal attendance, tetanus injection during pregnancy, place of delivery and birth attendance) were piece-wise introduced into the Cox regression equation. None was significantly related to infant survival status. However, the composite index of these indices was found to be significantly related to infant survival status. The likelihood of infant death was higher among women with none and low MHCI than those with high and complete MHCI. This pattern was sustained when potential confounding socio-economic factors were used as control. However, including environmental and health related variables into the model reduced the strength of the relationship between MHCI and infant death. This finding is an indication that the degree of risk of infant death associated with MHCI may be strengthened if environmental and health related factors are compromised. The indirect approach utilized in this study corroborated the inverse relationship between MHCI and infant death. The infant mortality probability reduces noticeably as the level of MHCI increases. This pattern was also found for the estimated infant mortality rates where the rate was 119 per 1000 live births among women with none MHCI score compared to 50 per 1000 live births for those who had complete MHCI score.

In this study, the variables found to be predictors of infant mortality are birth order, preceding birth interval, children ever born, husband's/partner's educational level and size at birth. The patterns of relationship with infant mortality exhibited by these variables are similar to the observed patterns in previous studies conducted in sub-Saharan Africa and other settings (22,35,36). For instance, our study shows that infant mortality rates and odds were found as having a U-shaped relationship with birth order with first and higher-order births experiencing higher risk of death than middle-order births. This pattern is consistent with the findings of Choe and colleagues' (37) and Bitte's (38) study. Furthermore, higher infant mortality occurred among children whose fathers had lower education than those babies born to fathers with higher level of education, this substantiates the result from earlier studies (39,40).

The data used in this study is secondary. Therefore, we cannot completely rule out the limitation of such data while interpreting this study's findings. In this study, information were sought from women on the survival status of their children; some dead children might not have been reported.

In Nigeria, there was a reduction in the level of infant death and probability of dying as the level of MHCI increases. If women optimize the use of health facility during pregnancy and child delivery, IM rate will reduce in Nigeria. The necessary intervention should involve the provision of packages of essential primary health care services for children across a variety of care that spans pregnancy, childbirth and after delivery, leading to care for children in the first one year of life. Health programs that monitor women during pregnancy and delivery would enhance the survival of children at infancy in Nigeria.

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