Infant mortality and risk factors in Nigeria in 2013–2017: A population-level study

Damilola M. Shobiye,[a]* Ayomide Omotola,[b] Yueming Zhao,[c] Jianrong Zhang,[d] Fitriana M. Ekawati,[e] and Hezekiah O. Shobiye[f]

[a]Department of Obstetrics & Gynecology, Massachusetts General Hospital, Boston, USA
[b]Department of Global Pediatric Medicine, St. Jude Children's Research Hospital, Memphis, TN, USA
[c]Department of Medical Ethics and Health Policy, Perelman School of Medicine, University of Pennsylvania, PA, USA
[d]Melbourne Medical School, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, Melbourne, Victoria, Australia
[e]Department of Family and Community Medicine Universitas Gadjah Mada, Indonesia
[f]John F. Kennedy School of Government, Harvard University, Boston, MA, USA

Summary

Background Globally, over the past two decades, many countries have significantly reduced the rate of infant mortality. Yet, in Africa, Nigeria remains one of the countries with the highest infant mortality rate (IMR).

Methods We conducted a population-level study using the 2018 Nigeria Demographic Health Survey (NDHS). A total of 41,668 household data were analyzed retrospectively. The association between each exposure and infant mortality was analyzed in logistic regression models (independently adjusted by demographic and socioeconomic status variables) and confirmed by the multiple comparisons analysis.

Findings The overall IMR of 2013–2017 was 61.5 (95% CI 58.0, 65.3) per 1000 live births. In general, the North-West and North-East regions had the highest IMR, whereas the South-West, South-East and South-South regions had the lowest IMR. The regression analysis found women who delivered their babies at the age <=18 years old (odds ratio (OR): 1.37 [1.17, 1.62]), had religion of Islam (OR: 1.35 [1.10, 1.65]), no ANC visit (OR: 1.69 [1.21, 2.35]), >4 ANC visits (OR: 1.70 [1.23, 2.34]), ANC not at home or skilled provider (0.40 [0.35, 0.46]) and the babies as the first child (OR: 1.23 [1.07, 1.42]) to be associated with higher IMR.

Interpretation Our findings imply that Nigeria is not on track to achieving the SDG target of reducing child mortality by 2030. Sustainable interventions are urgently needed to address the challenges for women of reproductive age, particularly those that are living in the rural areas and Northern regions, having limited/no access to health care/skilled providers, and delivered their first child.

Funding None.

Keywords: Infant mortality (IM); Infant mortality rate (IMR); Nigeria Demographic Health Survey (NDHS); Demographic Health Survey (DHS); World Health Organization (WHO); United Nation Children's Fund (UNICEF); Antenatal Care (ANC)

eClinicalMedicine 2022;51: 101622
Published online 25 August 2022
https://doi.org/10.1016/j.eclinm.2022.101622

Introduction

Infant mortality (IM) is the death of an infant before his or her first birthday.[1] Infant mortality rate (IMR) is a key indicator of the overall health of a society and is essential for social and economic development.[1,2] In the National Demographic Health Survey (NDHS), IMR of each year was calculated as the number of infant deaths among the total number of alive-born children in the year.

In the past two decades, many countries have achieved significant improvements in reducing IM. According to the UN 2018 mortality report, IMR declined by 51% between 2000 and 2017.[2] Despite this progress, wide disparities exist between low-income and high-income countries—76 deaths per 1000 live births and 7 deaths per 1000 live births respectively.[3] Nigeria reported 72 deaths per 1000 live births among infants in 2020 with disparities across its regions and geopolitical zones.[4] Nigeria has worse IMR compared

*Corresponding author.
E-mail address: mshobiye@mgh.harvard.edu (D.M. Shobiye).

Research in context

Evidence before this study

Nigeria is one of countries with the highest infant mortality rate in Africa; however, little is known about the social determinants of the women that contribute to the high mortality rate. The 2018 Nigeria Demographic Health Survey (NDHS) surveyed a total of 41,668 households, which provides an opportunity to conduct a range of statistical analyses to understand the risk factors associated with infant mortality in the country.

Added value of this study

North-West and North-East regions of Nigeria had the highest number of infant deaths compared to the Southern regions. Demographic and socioeconomic factors associated with a higher infant mortality rate were women who delivered their babies at a younger age (i.e., <18 years old) live(d) in rural areas, have limited access to health care, or skilled healthcare providers, and delivered their first child.

Implications of all the available evidence

High infant mortality rate in Nigeria indicates that effective and sustainable interventions are still needed to reduce the challenges and burden from infant mortality for women of reproductive age. This may require the provision of targeted, customized, and localized interventions, particularly for younger women living in the Northern regions, with limited or no access to health care/skilled providers. Further research should investigate the impact of such interventions and how they can be scaled across the country to reduce the rate of infant mortality.

with neighboring West African countries such as Benin, Cameroon, Togo and Ghana, with 57, 48, 44 and 33 deaths per 1000 live births, respectively.[4,5] The rate makes Nigeria one of the countries with the highest IMR rate in Africa.

Studies show that there are several determinants of IM in Nigeria. In 2010, low birth weight was highlighted as the most common cause of IM accounting for 25% of IM.[6] The study also identified lack of delivery attendants, home delivery and traditional birth attendants as predictors of IM in Nigeria. This is supported by Samantha Slinkard et al., 2018 who reported lack of access to Antenatal care (ANC) or delayed ANC initiation as an important risk factor for increased IM.[7] According to the 2013 NDHS report, 34% of women did not receive ANC and only 18% of those who received ANC did so in the first trimester. Some factors are associated with this high IMR in Nigeria, such as age of mother, socioeconomic status and region which contribute to the impact of ANC initiation. Other factors highlighted include place of residence, child's sex, skill of birth attendant, delivery by caesarean operation, birth order, birth interval, maternal education, maternal age, and wealth index.[7–10]

Meanwhile, Nigeria has implemented several interventions and policies to improve IMR. An example is the Nigeria Midwives Service Scheme (MSS), a public sector collaborative initiative established in December 2009 by the National Primary Health Care Development Agency (NPHCDA).[11,12] However, despite these interventions and policies, IMR in Nigeria remains high—the 4th highest in Sub-Saharan Africa as of 2020.[4,13,14]

As Nigeria continues to grapple with the burden of infant mortality, child survival remains an urgent concern. Often, the mortality is related to the antenatal condition of the women—such as pregnancy hypertension, preeclampsia, and anemia—that may complicate preterm births and affect the survival of the baby. These antenatal conditions mentioned above emphasizes the need to address social determinants of IM in the country. Addressing these factors would therefore require a strong design and implementation of targeted, innovative, and sustainable health interventions. For this study, the data from the 2018 Nigeria Demographic and Health Survey will be used to demonstrate the up-to-date epidemiological statistics including the trend in IMR in Nigeria. It will also be used to determine factors associated with IM, in the most recent five years—to understand the changes that might have occurred over the years, which would have impacted the rate of IM. Findings from the study would be useful to public health researchers and policy makers in updating, reviewing, and designing intervention strategies aimed at reducing infant mortality in Nigeria.

Methods

Nigeria demographic and health survey (NDHS)

Nigeria Demographic and Health Survey (NDHS) 2018 is the most up-to-date demographic and health information on the Nigerian population. It is supported by the National Population Commission (NPC) and the National Malaria Elimination Program (NMEP) of the Federal Ministry of Health, Nigeria. In the 2018 NDHS, a total of 41,668 households were surveyed retrospectively in the year of 2018 (from 14 August to 29 December) with a response rate of 99%.[15] The sample was selected using a stratified, two-stage cluster design: the first stage was to select enumeration areas (EAs) as the sampling units; based on each of the 1400 EAs selected, the second stage was a complete listing of households that targeted men and women aged 15–59 and 15–49, respectively, and that were selected randomly for survey.

The survey was conducted using computer-assisted personal interviewing (CAPI).[15]

Participants, study size

In NDHS, IMR is defined as the number of deaths among the number of alive-born children at ages 0 to 11 months; the deaths include those reported at age 0 but does not include stillbirth. Given the definition of IM, we only included children born at least a year prior to the interview date; therefore, 31,775 children born between 2013 and 2017 were included. Sample weights in descriptive statistics and data analyses were applied to adjust for the over- and under-sampling. According to the DHS, the individual weight for both women and children (variable: v005) is the household weight (variable: hv005) multiplied by the inverse of the individual response rate for women in the stratum. In this manner, the weighted total number of live births are 32,003 in 2013–2017 (2013: 6489; 2014: 6825; 2015: 6752; 2016: 6434; 2017: 5503). Detailed theory and process of sampling and weighting in DHS can be found on these websites: https://dhsprogram.com/publications/publication-dhsg1-dhs-questionnaires-and-manuals.cfm; https://dhsprogram.com/Data/Guide-to-DHS-Statistics/Early_Childhood_Mortality.htm.

Variables

The overall participants' characteristics in 2013–2017 were analyzed prior to further analysis of the survey data. Participants' characteristics include the region (North-Central, North-East, North-West, South-East, South-South and South-West), sex of child (male or female), mother's age (≤18, 19–35 or ≥36), rurality (rural or urban), mother's religion (Christian, Islam or Traditionalism), ethnicity (Igbo, Hausa, Yoruba or other), wealth index (poorest, poorer, middle, richer or richest), mother's education level (no education, primary, secondary or higher educations), insurance coverage (yes or no), place of delivery (skilled provider, home or other), number of antenatal care (ANC) visit (no visit, 1 to 3, 4, ≥5), place of ANC (skilled provider/home or other), caesarean section (c-section; yes or no), first child (yes or no) and low birth weight (yes or no; defined as <2500 g). Also, the geospatial distribution of the overall IMR of all years (2013–2017) was mapped across each state of the country. In addition, a line chart was used to show the trend of IMR in Nigeria and by Nigeria's region. To develop the map and line chart, we used software QGIS (Desktop 3.12.2 version) and RStudio 1.1.423 (RStudio, PBC, Boston, MA). Specific to the IMR in Nigeria, we used time series analysis to present the trend, addressing potential instability due to low sample size over the year. In the line chart, we also present the trend of IMRs globally and in Africa, as the comparison of IMR in Nigeria. The global and African aggregated data of the mortality rate under one year old were directly obtained from the Global Health Data Exchange of the Global Burden of Disease (GBD) Study (open-access resource to the public: http://ghdx.healthdata.org).[16]

Ethics statement

The study is a secondary analysis based on an approved and established program—the Demographic and Health Survey (DHS). We obtained approval to use the data from the DHS repository, including for this publication. All data were obtained from the 2018 Nigeria Demographic and Health Survey. With no identifiable information of respondents, additional ethical approval was not required for the data access. More information about the ethics approval process for DHS can be found here: https://dhsprogram.com/Methodology/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm.

Statistical analysis

We investigated the risk factors of IM for all the combined years and for each single year separately. The exposure is each of the 15 characteristics described above; the outcome is infant mortality (yes or no for each observation). The association between each exposure and IM was analyzed in each of the logistic regression models, independently adjusted by demographic variables including year (only used for all years but not for each year), sex of child, region, rurality, religion, ethnicity (model 1), and socioeconomic variables including wealth index and mother's education (model 2), and both the demographic and socioeconomic variables (model 3). Among the exposures, low birth weight was only analysed based on all years rather than each year due to the limited sample size with a large amount of missing data. The corresponding variable for adjustment was removed if the same variable was used as exposure. In addition, we also applied model 1 only to analyze the associations of wealth index, mother's education, insurance status and rurality with infant mortality, because these four factors are strongly correlated and could have an intersected impact on the IM outcome. Considering that many (a total of 15) exposures were investigated, and the results might be significant by chance, we applied multiple comparisons analysis to further confirm the significant results from the logistic regression models. The confirmation was considered when the p value from the logistic regression was less than the value of 0.05 divided by the number of the exposures, which is 0.003 (0.003 = 0.05/15). Data management and statistical analyses were conducted using Stata SE 15.

Role of the funding source

The authors received no financial support for the research, authorship, or publication of this article. Therefore, there is no role of funding source.

Results

Infant mortality

The details of IMR by population characteristics are presented in Table 1. The overall IMR from 2013 to 2017 was 61.5 (95% CI 58.0, 65.3) per 1000 live births. In each year (from 2013 to 2016), the rate was 50.1 (44.0, 56.9), 60.1 (53.8, 67.1), 68.5 (61.5, 76.3) and 68·6 (61.2, 76.9) per 1000 live births, respectively, as a whole indicating an increasing trend; while in 2017, the rate decreased to 59.9 (52.1, 68.9) per 1000 live births (Figure 1). Nigeria's IMR was far higher than the average of IMR worldwide and was also higher compared to IMR of Africa in 2014–2017 (Supplemental Figure 1). The details of the number of infant births and deaths by population characteristics are documented in Supplemental Table 1.

By population's characteristics at the regional level, the North-West and North-East regions had the highest IMRs of 75.0 (68.1, 82.6) and 67.2 (59.8, 75.3) per 1000 live births respectively between 2013 and 2017; the South-West, South-East and South-South regions had lower IMRs of 42.6 (34.4, 52.6), 44.2 (37.5, 52.2) and 45.0 (36.3, 55·6) per 1000 live births, respectively between 2013 and 2017 (Table 1). In the five-year period, the disparity in IMR by region was more evident in 2015, 2016 and 2017 (Table 1, Supplemental Figure 1). Disparities also existed as seen from the results of the mothers' age, rurality, religion, ethnicity, education level, wealth index, place of delivery, number of ANC visits, and ANC at home or skilled provider. Specifically, we point out that the high IMR was among mothers aged ≤ 18 years old, with 86.5 (75.0, 99.6) per 1000 live births between 2013 and 2017 (Table 1).

Figure 2 further shows the regional disparity of IM by state in Nigeria between 2013 and 2017. A higher IMR was more apparent in the Northern part of Nigeria compared to the Southern part. Specifically, Kebbi in the North-West region, Gombe and Sokoto in the North-East region had the highest IMR, of 104.9 (89.0, 123.3), 100.3 (67.8, 145.9) and 102.9 (80.6, 130.5) per 1000 live births, respectively; Bayelsa in the South-South region and Ogun in the South-West region had the lowest IMR, of 19.0 (10.8, 33.3) and 21.7 (12.0, 39.1) per 1000 live births, respectively. The IMR of each region from 2013 to 2017 discrete years are presented in Supplemental Table 2.

Risk factors for infant mortality

In Table 2, we summarize selected results of model 3 (adjusted for demographic and socio-economic variables) indicating risk factors for IM in NDHS data; all detailed results of three models can be found in Supplemental Table 3. According to the logistic regression, results of 2013–2017 data indicated that risk factors of the IMR were: male children (odds ratio (OR) in female: 0.84 [95% CI 0.74, 0.95]), mother aged ≤18 years old (OR: 1.37 [1.17, 1.62]), mother aged ≥36 years old (OR: 1.18 [1.01, 1.37]), religion of Islam (OR: 1.35 [1.10, 1.65]), no ANC visit (OR: 1.69 [1.21, 2.35]), 1-3 ANC visits (OR: 1.53 [1.04, 2.26]), >4 ANC visits (OR: 1.70 [1.23, 2.34]), ANC not at home or skilled provider (OR of ANC at home or skilled provider: 0.40 [0.35, 0.46]), C-section (OR: 1.83 [1.18, 2.84]), and first child (OR: 1.23 [1.07, 1.42]). The multiple comparisons analysis further confirmed the associations of IM with mother aged ≤18 years old, religion of Islam, no ANC visit, >4 ANC visits, ANC not at home or skilled provider, and first child.

In each of 2013–2017, results were still statistically significant for ANC at home or skilled provider, regardless of the model. The significant association results indicated by the logistic regression and confirmed by the multiple comparisons analysis were found in: rurality in 2013 (OR: 1.66 [1.25, 2.21]), Islam in 2015 (OR: 2.07 [1.32, 3.27]) and 2016 (OR: 1.83 [1.21, 2.78]), no ANC visit in 2017 (OR: 2.42 [1.37, 4.29]), ANC at home or skilled provider in 2015 (OR: 0.53 ([0.40, 0.70]), 2016 (OR: 0.26 [0.20, 0.34]) and 2017 (OR: 0.36 [0.26, 0.49]), and the first child in 2014 (OR: 1.63 [1.24, 2.14]) (Table 2).

Discussion

This study used the 2018 NDHS dataset to understand the epidemiological statistics of IMR and its risk factors in Nigeria, for the years of 2013–2017. The results show that IMR in Nigeria increased from 50.1 per 1000 live births in 2013 to 59.9 per 1000 live births in 2017 with aggregate figure of 61.5 per 1000 live births over the five-year period.[15] This rate reinforces Nigeria's rank as one of the leading countries with infant mortality.[17]

At the regional level, our findings show that between 2013 and 2017, the IMR increased for all regions except for the North-East and South-South. Nevertheless, the Northern regions continue to bear the highest burden of infant mortality, particularly the North-West with the highest mortality rate of 77.0 per 1000 live births in 2017. The Northern part of the country is rife with poverty, poor access to antenatal care and insecurity that may prevent access to quality maternal healthcare services. With regards to the determinants of infant mortality, we observed that at the individual level, the gender of the child, birth order, and the mother's age are risk factors for infant mortality. As our findings show, male infants are more likely to experience death relative to female infants. This result is consistent with findings from other studies using the NDHS dataset from prior years.[8,18,19] In addition, children born to women having their first birth are more likely to experience mortality relative to children born to women who have had more than one birth. Lastly, children born to women aged less than 18 and greater than 35 years are at a higher

Characteristics	2013 Infant mortality rate (*N*=6489)	2014 Infant mortality rate (*N*=6825)	Change (%)	2015 Infant mortality rate (*N*=6752)	Change (%)	2016 Infant mortality rate (*N*=6434)	Change (%)	2017 Infant mortality rate (*N*=5503)	Change (%)	2013-2017 Infant mortality rate (*N*=32,003)
Total	50.1 (44.0, 56.9)	60.1 (53.8, 67.1)	20% (1%, 39%)	68.5 (61.5, 76.3)	14% (−3%, 31%)	68.6 (61.2, 76.9)	0% (−15%, 16%)	59.9 (52.1, 68.9)	−12.7% (−27%, 2%)	61.5 (58.0, 65.3)
Region										
North central	42.2 (30.7, 57.7)	56.6 (43.8, 72.9)	34% (−21%, 89%)	73.2 (56.1, 94.9)	29% (−22%, 80%)	58.6 (45.3, 75.6)	−20% (−49%, 9%)	60.3 (43.7, 82.6)	3% (−42%, 48%)	58.3 (51.4, 66.0)
North-East	59.8 (46.5, 76.5)	58.6 (47.0, 72.9)	−2% (−36%, 32%)	81.6 (67.4, 98.4)	39% (−3%, 81%)	78.3 (61.9, 98.5)	−4% (−30%, 22%)	56.6 (43.8, 72.8)	−28% (−52%, −4%)	67.2 (59.8, 75.3)
North-WestNorth-West	61.9 (50.4, 75.7)	68.1 (56.4, 81.9)	10% (−16%, 36%)	78.7 (65.8, 93.8)	16% (−9%, 40%)	90.3 (76.0, 107.0)	15% (−14%, 44%)	77 (61.0, 96.8)	−15% (−37%, 7%)	75 (68.1, 82.6)
South-East	39.7 (28.7, 54.5)	65.9 (49.7, 87.1)	66% (−3%, 136%)	40.1 (28.1, 57.0)	−39% (−66%, −12%)	31 (19.5, 48.9)	−23% (−67%, 22%)	46.6 (32.5, 66.2)	50% (−32%, 133%)	44.2 (37.5, 52.2)
South-South	36.3 (22.0, 59.2)	68.3 (44.6, 103.3)	88% (−33%, 209%)	44.6 (28.5, 69.2)	−35% (−75%, 5%)	40.6 (27.0, 60.5)	−9% (−59%, 41%)	33.8 (19.6, 57.8)	−17% (−63%, 29%)	45 (36.3, 55.6)
South-WestSouth-West	29.7 (16.2, 53.6)	33.7 (22.1, 51.2)	14% (−73%, 100%)	53.5 (34.9, 81.3)	59% (−43%, 160%)	52.5 (35.8, 76.5)	−2% (−58%, 55%)	44.7 (29.6, 67.0)	−15% (−64%, 34%)	42.6 (34.4, 52.6)
Sex of child										
Male	52.2 (44.1, 61.7)	66.7 (57.6, 77.0)	28% (−1%, 56%)	76.4 (66.0, 88.3)	15% (−9%, 38%)	72.2 (62.6, 83.1)	−5% (−24%, 13%)	62.8 (52.6, 74.8)	−13% (−33%, 7%)	66.3 (61.5, 71.4)
Female	47.9 (40.0, 57.3)	53.3 (45.3, 62.7)	11% (−13%, 36%)	60.4 (51.9, 70.3)	13% (−10%, 37%)	64.8 (54.0, 77.7)	7% (−18%, 33%)	56.7 (45.1, 71.1)	−13% (−33%, 7%)	56.6 (51.6, 62.0)
Mother's age										
<=18	78.4 (57.4, 106.3)	88.7 (66.0, 118.1)	13% NA	94.2 (71.2, 123.6)	6% NA	76.7 (58.3, 100.4)	−19% NA	97.4 (65.2, 142.9)	27% NA	86.5 (75.0, 99.6)
19-35	45.3 (38.8, 52.9)	56.2 (49.5, 63.8)	24% (0%, 48%)	64.9 (57.2, 73.6)	16% (−4%, 35%)	66.5 (57.8, 76.4)	2% (−17%, 22%)	52.2 (44.5, 61.2)	−21% (−37%, −6%)	57.2 (53.4, 61.2)
>=36	57.2 (41.4, 78.6)	60.4 (44.0, 82.3)	6% (−42%, 54%)	68.7 (50.9, 92.1)	14% (−36%, 64%)	74.8 (57.7, 96.5)	9% (−34%, 52%)	80.4 (60.6, 105.9)	7% (−33%, 48%)	68.4 (60.2, 77.6)
Rurality										
Urban	34.1 (26.5, 43.7)	55.7 (45.7, 67.6)	63% (12%, 115%)	55.9 (45.2, 69.1)	0% (−28%, 29%)	56.5 (46.8, 67.9)	1% (−27%, 29%)	54.6 (43.0, 69.0)	−3% (−32%, 25%)	51.2 (46.1, 56.8)
Rural	60.7 (52.3, 70.4)	62.9 (55.0, 71.8)	4% (−15%, 22%)	76.2 (67.3, 86.2)	21% (1%, 41%)	76.4 (66.3, 87.9)	0% (−18%, 19%)	63.2 (53.2, 75.0)	−17% (−34%, −1%)	68.1 (63.3, 73.1)
Religion										
Christian	35.8 (28.2, 45.2)	59.4 (49.1, 71.6)	66% NA	44.2 (35.8, 54.5)	−26% NA	39.8 (32.0, 49.4)	−10% NA	47.3 (38.3, 58.4)	19% NA	45.1 (40.9, 49.7)
Islam	59 (50.6, 68.8)	60.5 (52.7, 69.4)	2% NA	81.7 (71.9, 92.7)	35% NA	85.6 (75.2, 97.3)	5% NA	67 (56.2, 79.7)	−22% NA	70.8 (65.9, 76.1)
Traditionalism	31.8 (9.2, 103.6)	112.5 (42.0, 268.3)	254% NA	91.3 (37.4, 206.4)	−19% NA	80.2 (17.4, 299.8)	−12% NA	71.2 (16.6, 258.5)	−11% NA	70.6 (40.0, 121.7)
Ethnicity										
Igbo	40.3 (30.3, 53.6)	60.3 (45.3, 79.8)	49% NA	51.5 (39.0, 67.7)	−15% NA	43.8 (31.8, 60.2)	−15% NA	39.9 (28.8, 55.0)	−9% NA	47.2 (41.2, 53.9)

Table 1 *(Continued)*

Characteristics	2013 Infant mortality rate (*N*=6489)	2014 Infant mortality rate (*N*=6825)	Change (%)	2015 Infant mortality rate (*N*=6752)	Change (%)	2016 Infant mortality rate (*N*=6434)	Change (%)	2017 Infant mortality rate (*N*=5503)	Change (%)	2013-2017 Infant mortality rate (*N*=32,003)
Hausa	60.6	65.5	8%	79.4	21%	83.1	5%	74.7	−10%	72.6
	(51.1, 71.8)	(56.3, 76.0)	NA	(68.6, 91.7)	NA	(71.6, 96.2)	NA	(61.7, 90.0)	NA	(67.0, 78.7)
Yoruba	30.2	37.5	24%	44.9	20%	53.1	18%	39.7	−25%	40.9
	(16.2, 55.6)	(25.1, 55.7)	NA	(26.1, 76.2)	NA	(35.3, 79.1)	NA	(25.3, 61.8)	NA	(32.1, 52.0)
Other	43.9	58.5	33%	65.9	13%	60.6	-8%	51.9	−14%	56.5
	(34.5, 55.7)	(46.5, 73.3)	NA	(54.2, 80.0)	NA	(49.1, 74.7)	NA	(39.8, 67.5)	NA	(50.8, 62.7)
Mother's education										
No education	62.8	64.6	3%	82.2	27%	91.7	12%	70.5	−23%	74.3
	(53.4, 73.7)	(55.1, 75.6)	NA	(71.9, 93.9)	NA	(78.8, 106.6)	NA	(57.6, 86.1)	NA	(68.3, 80.7)
Primary education	44.1	64.3	46%	66	3%	49	−26%	66.2	35%	57.7
	(32.5, 59.4)	(50.4, 81.6)	(−9%, 100%)	(49.6, 87.4)	(−36%, 42%)	(37.1, 64.4)	(−55%, 4%)	(48.7, 89.3)	(−21%, 91%)	(50.7, 65.5)
Secondary education	40.9	54.7	34%	47.8	−13%	52.3	9%	41.7	−20%	47.6
	(31.1, 53.7)	(44.2, 67.5)	(−14%, 81%)	(38.2, 59.7)	(−40%, 14%)	(41.9, 65.1)	(−24%, 43%)	(31.6, 54.9)	(−46%, 6%)	(42.8, 52.9)
Higher education	17.7	42	137%	67.6	61%	38.7	−43%	59.4	53%	44.9
	(9.6, 32.2)	(25.9, 67.3)	NA	(42.8, 105.1)	NA	(24.0, 61.7)	NA	(37.4, 93.1)	NA	(35.1, 57.4)
Wealth index										
Poorest	68.5	68.3	0%	82.5	21%	103.4	25%	56.3	−46%	76.3
	(54.4, 86.0)	(56.1, 82.8)	NA	(67.5, 100.5)	NA	(86.9, 122.6)	NA	(42.9, 73.6)	NA	(68.3, 85.0)
Poorer	59.8	71.2	19%	79.6	12%	69.7	−12%	75.1	8%	71
	(46.9, 75.9)	(56.5, 89.3)	NA	(66.6, 94.8)	NA	(54.2, 89.1)	NA	(59.7, 94.1)	NA	(63.0, 79.9)
Middle	50.8	59.6	17%	72.1	21%	55.1	−24%	59.1	7%	59.6
	(39.3, 65.5)	(46.9, 75.4)	NA	(57.1, 90.6)	NA	(42.5, 71.1)	NA	(44.1, 78.7)	NA	(53.0, 66.9)
Richer	41.2	48.6	18%	51.4	6%	55.8	9%	60	7%	51.1
	(28.5, 59.2)	(37.1, 63.3)	NA	(37.9, 69.3)	NA	(41.0, 75.6)	NA	(43.0, 83.1)	NA	(43.7, 59.6)
Richest	20.6	45.9	123%	46	0%	50.9	11%	44.7	−12%	41.5
	(13.3, 31.8)	(31.7, 66.0)	NA	(31.2, 67.3)	NA	(35.8, 71.9)	NA	(30.0, 66.0)	NA	(34.6, 49.7)
Covered by insurance										
No	49.7	61	23%	69	13%	69.4	1%	60.3	−13%	62
	(43.7, 56.5)	(54.5, 68.1)	(3%, 43%)	(61.9, 76.9)	(−3%, 30%)	(62.0, 77.6)	(−15%, 16%)	(52.3, 69.3)	(−27%, 1%)	(58.4, 65.7)
Yes	64.7	21.9	−66%	45.5	108%	37.2	−18%	42.4	14%	42.3
	(33.1, 122.5)	(7.5, 62.1)	NA	(19.7, 101.5)	NA	(12.0, 109.4)	NA	(14.6, 117.1)	NA	(27.4, 64.7)
Place of delivery										
Home	42.6	65.5	54%	76.9	17%	78.1	2%	62.1	−20%	70.2
	NA	(56.9, 75.3)	(−13%, 121%)	(67·6, 87.3)	(−2%, 37%)	(67.6, 90.1)	(−18%, 21%)	(52.7, 73.2)	(−37%, −4%)	(64.9, 75.9)
Skilled provider	26.6	53	100%	56.1	6%	56.1	0%	55.8	−1%	54
	NA	(44.2, 63.5)	(−18%, 217%)	(45.6, 68.8)	(−24%, 36%)	(46.8, 67.1)	−27%, 27%)	(44.6, 69.5)	(−28%, 27%)	(48.7, 59.9)
Other	27.6	15.9	−42%	43.9	177%	28	−36%	76.7	174%	41.1
	NA	(4.9, 49.7)	NA	(16.3, 112.8)	NA	(8.2, 90.9)	NA	(33.8, 164.8)	NA	(23.4, 71.1)
# of ANC visit										
No visit	47.5	35.3	−26%	45	28%	47.4	5%	61.2	29%	50.9
	NA	(21.1, 58.5)	NA	(30.2, 66.7)	NA	(35.5, 63.1)	NA	(48.5, 77.1)	NA	(43.7, 59.3)

Table 1 (Continued)

Characteristics	2013 Infant mortality rate (*N*=6489)	2014 Infant mortality rate (*N*=6825)	Change (%)	2015 Infant mortality rate (*N*=6752)	Change (%)	2016 Infant mortality rate (*N*=6434)	Change (%)	2017 Infant mortality rate (*N*=5503)	Change (%)	2013-2017 Infant mortality rate (*N*=32,003)
1-3 visits	0	44.7	−96%	46.7	4%	34.4	−26%	51.6	50%	43.4
	NA	(19.8, 97.9)	NA	(26.6, 80.7)	NA	(23.9, 49.1)	NA	(36.5, 72.5)	NA	(34.4, 54.7)
4 visits	0	36.1	−96%	34.9	−3%	22.3	−36%	26.5	19%	27.4
	NA	(18.9, 67.9)	NA	(19.3, 62.4)	NA	(12.6, 39.0)	NA	(16.7, 41.6)	NA	(21.0, 35.8)
>4 visits	12.9	31.3	143%	38.4	23%	32.2	−16%	44.2	37%	36.9
	NA	(21.0, 46.5)	(−206%, 491%)	(27.9, 52.8)	(−40%, 85%)	(24.8, 41.6)	(−51%, 18%)	(35.0, 55.6)	(−12%, 86%)	(32.1, 42.4)
ANC at home or skilled provider										
No	51.3	66.1	29%	81.4	23%	115.3	42%	103.7	−10%	74.8
	(45.1, 58.3)	(58.7, 74.4)	(8%, 50%)	(72.6, 91.1)	(4%, 42%)	(101.0, 131.4)	(17%, 66%)	(87.2, 123.0)	(−29%, 8%)	(70.0, 79.9)
Yes	9.2	37.6	308%	39.2	4%	30.8	−21%	42.3	37%	36.9
	(2.3, 36.1)	(27.6, 51.0)	(−272%, 888%)	(30.5, 50.1)	(−37%, 46%)	(25.4, 37.3)	(−46%, 4%)	(35.3, 50.7)	(0%, 75%)	(33.2, 41.0)
C-section										
No	33.5	60.5	80%	68.9	14%	68.6	0%	57.6	−16%	63.1
	NA	(54.0, 67.6)	(17%, 144%)	(61.7, 76.9)	(−3%, 31%)	(61.1, 77.1)	(−16%, 15%)	(50.3, 66.0)	(−30%, −2%)	(59.2, 67.3)
Yes	71.2	51	−28%	56.1	10%	75.2	34%	147.8	97%	80.5
	NA	(25.4, 99.7)	NA	(26.6, 114.3)	NA	(41.2, 133.4)	NA	(76.6, 266.3)	NA	(55.7, 115.0)
First child										
No	50.0	55.0	10%	64.8	18%	72.2	11%	58.6	−19%	60.2
	(43.3, 57.7)	(48.8, 62.1)	(−10%, 30%)	(57.4, 73.2)	(−1%, 37%)	(64.4, 80.9)	(−6%, 29%)	(50.8, 67.5)	(−34%, −4%)	(56.5, 64.1)
Yes	50.3	79.1	57%	83.0	5%	53.2	−36%	65.4	23%	66.7
	(38.3, 65.6)	(63.4, 98.2)	(6%, 109%)	(66.6, 103.0)	(−27%, 37%)	(38.8, 72.5)	(−61%, −11%)	(48.1, 88.4)	(−21%, 67%)	(59.1, 75.2)
Low birth weight										
No	NA	NA	NA	NA	NA	NA	NA	NA	NA	25.5 (21.3, 30.6)
Yes	NA	NA	NA	NA	NA	NA	NA	NA	NA	37.3 (21.9, 31.1)

***Table 1*: Infant mortality by population characteristics in 2013−2017 (per 1000 births).**

ANC: Antenatal care; C-section: Caesarean section; NA: Not applicable.

Note: Due to the small sample size or large variation, confidence intervals cannot be calculated in which "not applicable (NA)" is marked.

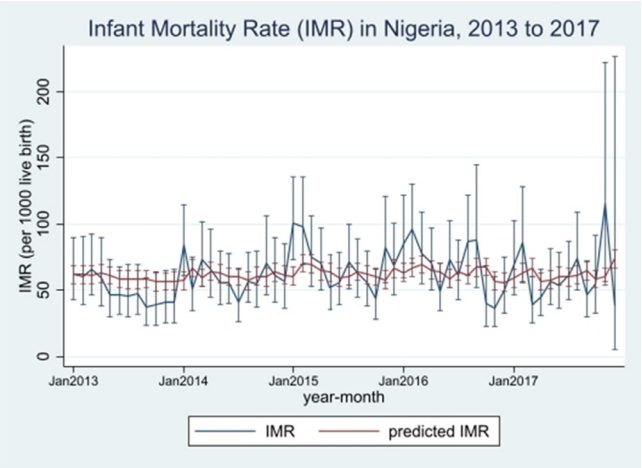

Figure 1. Trend of infant mortality rate from 2013 to 2017. Blue and red lines represent the calculated and predicted infant mortality rates, respectively, in years from 2013 to 2017. Each data point on lines is the point estimate and its 95% confidence interval for infant mortality rate in each month.

risk of experiencing death relative to children born to women aged 19 to 35.

At the demographic level, we observed that rurality and religion are risk factors for infant mortality. Children born to women living in the rural areas relative to urban areas are more likely to experience death as infants. Living in rural areas could be associated with higher levels of poverty and dearth of quality health services to prevent infant mortality. This pattern has been documented severally in the literature.[18,19] In addition, our findings show that children born to women who reported Islam as a religion were more likely to experience death as infants. This association may have nothing to do with Islamic practice but could be because of the prevalence of high mortality rate in the North, where Islamic religion is more predominant.

At the level of healthcare delivery, the number of ANC visits, type of delivery, and location of ANC visits are risk factors for infant mortality. With regards to the number of ANC visits, our findings show that children born to women who had less than the recommended ANC visits of 4 were more likely to experience death relative to women who went for the recommended visits. ANC visit is a strong predictor of health facility delivery by a skilled health professional and postnatal care utilization.[20] Thus, ensuring that pregnant women have access to timely ANC services is crucial to reducing infant mortality. However, we also observed that children born to women who went for more than the recommended ANC visits of 4 were more likely to experience death. The mechanism for this result is unclear since high ANC visits should correlate with better health outcomes. Our hypothesis is that there might be some health-related conditions among the women or their babies so that they have to visit ANC more than the recommended time. However, the type and quality of services received during the visit is not known and may influence the outcome of care for the infants.

Furthermore, children born to women who received C-section during delivery were more likely to experience death as infants relative to children born to women who did not deliver through C-section. The higher likelihood of death for infants born through C-section could be due to the complexity of the procedure, category of the c-section (primary or repeat) and the lack of a quality skilled health provider to oversee the process and address any complications that may arise during child delivery. In fact, many studies have documented the association between C-section and infant mortality.[7,18]

Finally, the location of ANC visits is extremely crucial. Children born to women who received ANC at home or from a skilled provider were more likely not to experience death relative to children born to women who did not receive ANC at home or from a skilled provider. The place where ANC is received is important, particularly when it is delivered by an untrained person, who may not be able to recognize signs of complications and provide necessary guidance on how to receive timely and quality care. In Nigeria, particularly in the rural areas, there is a prevalence of cultural practices that promotes the use of traditional birth attendants during pregnancy and delivery. Studies have shown that care received at this level and through such personnel is more likely to be suboptimal and lack the clinical components necessary for a good-quality care.[21,22]

With regards to reducing the high IMR, Nigeria has implemented several interventions and policies to improve infant mortality. An example is the Nigeria Midwives Service Scheme (MSS), a public sector collaborative initiative established in December 2009 by the National Primary Health Care Development Agency (NPHCDA). The goal of MSS was to facilitate an

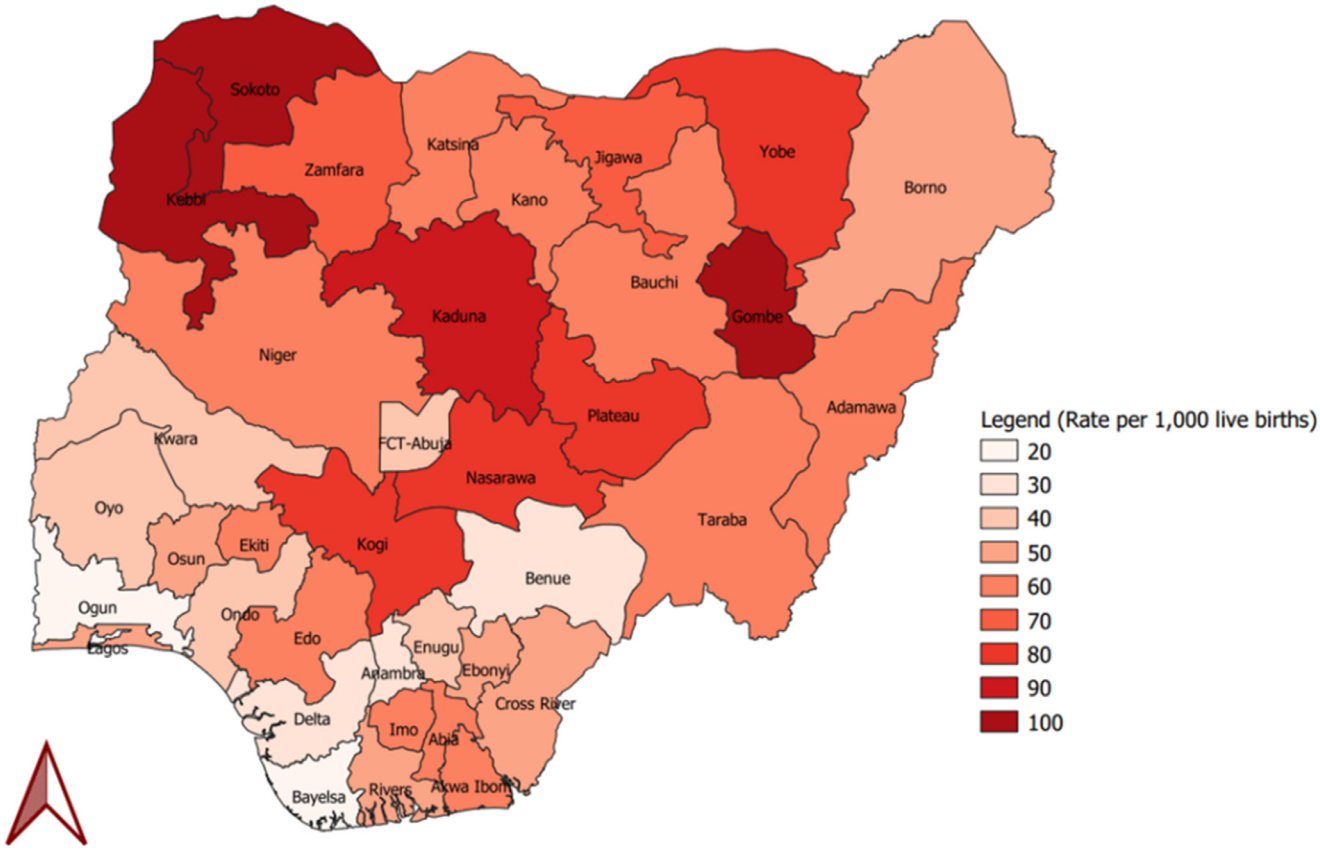

Figure 2. Infant mortality rate of 2013 to 2017 by the state of Nigeria. Categorized symbolism was used to represent the rate of infant mortality in each state: whereby the lighter the color ramp, the lower the rate of infant mortality (20 per 1,000 live births) and the darker the color ramp, the higher the rate of infant mortality (100 per 1000 live births).

increase in the coverage of skilled Birth Attendance (SBA) to reduce maternal, newborn and child mortality in rural, underserved areas in Nigeria by December 2015. MSS was implemented by deploying midwives, including newly qualified, unemployed, and retired midwives to selected primary health care (PHC) facilities in rural communities equipping clinics to provide basic emergency obstetric care. The first phase of the initiative took place in 652 PHC facilities across the 36 states in Nigeria with over 10 million people served. Based on our results, however, the persistent high IMR means that Nigeria is not on track to achieving the SDG target of reducing child mortality by 2030 despite interventions and policies like the MSS. The Nigerian government would need to fully evaluate the design and impact of all old and current policies, learn from them, and use the findings to re-create context-specific interventions that would help mitigate the high prevalence of infant mortality in the country.

A recent comparison study linked the socioeconomic inequalities in the North with the high prevalence of IMR in the region.[23] The government must continue to work intentionally and collaboratively with the private sector, international donors, healthcare providers and community actors to prioritize maternal and childcare interventions in the North if it hopes to reverse the increasing infant mortality trend in the country. Evidence abounds in the literature linking children of younger mothers to having poorer health outcomes including mortality.[24–26] Studies have also shown the association between older maternal age and adverse birth and child outcomes.[27,28] Having children born to both younger and elderly women at higher risk of infant mortality means that interventions to reduce child mortality must be targeted to address the entire spectrum of a woman's reproductive period.

According to our results and the previous evidence, specifically, some interventions for improving the mothers' condition need to be considered. Such as improving antenatal to postnatal care across regions to ensure a healthy pregnancy, labor, and delivery for both the mother and the infant; evaluating the delivery method procedures in cases such as c-section, to avoid preventable complications during child delivery that could lead

Characteristics	2013 OR (95%CI)	2014 OR (95%CI)	2015 OR (95%CI)	2016 OR (95%CI)	2017 OR (95%CI)	2013-2017 OR (95%CI)
Region						
North central	1.00	1.00	1.00	1.00	1.00	1.00
South-East	0.96 (0.46, 1.99)	1.36 (0.60, 3.08)	0.47 (0.22, 1.00)[a]	0.41 (0.19, 0.88)[a]	1.22 (0.49, 3.05)	0.77 (0.53, 1.12)
Sex of child: female	0.92 (0.72, 1.17)	0.79 (0.63, 1.00)[a]	0.78 (0.63, 0.98)[a]	0.90 (0.71, 1.15)	0.90 (0.66, 1.22)	0.84 (0.74, 0.95)[a]
Mother's age						
<=18	1.49 (1.02, 2.18)[a]	1.56 (1.11, 2.21)[a]	1.32 (0.94, 1.85)	1.00 (0.72, 1.40)	1.81 (1.16, 2.81)[a]	1.37 (1.17, 1.62)[a,b]
19-35	1.00	1.00	1.00	1.00	1.00	1.00
>=36	1.27 (0.86, 1.86)	1.04 (0.73, 1.50)	1.02 (0.72, 1.45)	1.11 (0.80, 1.53)	1.57 (1.10, 2.23)[a]	1.18 (1.01, 1.37)[a]
Rurality (model 1)	1.66 (1.25, 2.21)[a,b]	1.01 (0.78, 1.32)	1.20 (0.92, 1.58)	1.17 (0.91, 1.49)	0.95 (0.67, 1.34)	1.17 (1.02, 1.34)[a]
Religion						
Christian	1.00	1.00	1.00	1.00	1.00	1.00
Islam	1.45 (0.86, 2.47)	0.84 (0.57, 1.22)	2.07 (1.32, 3.27)[a,b]	1.83 (1.21, 2.78)[a,b]	0.85 (0.53, 1.36)	1.35 (1.10, 1.65)[a,b]
Ethnicity						
Igbo	1.68 (0.79, 3.59)	0.74 (0.36, 1.55)	2.14 (1.07, 4.31)[a]	2.66 (1.38, 5.13)[a]	0.46 (0.19, 1.12)	1.31 (0.92, 1.85)
Hausa	1.00	1.00	1.00	1.00	1.00	1.00
Wealth index (model 1)						
Poorest	1.16 (0.78, 1.74)	1.23 (0.84, 1.78)	1.05 (0.73, 1.49)	1.69 (1.16, 2.45)[a]	0.81 (0.51, 1.29)	1.17 (0.97, 1.41)
Middle	1.00	1.00	1.00	1.00	1.00	1.00
Richest	0.48 (0.28, 0.82)[a]	0.80 (0.50, 1.28)	0.70 (0.43, 1.14)	1.07 (0.68, 1.67)	0.93 (0.57, 1.53)	0.79 (0.63, 1.00)
Mother's education (model 1)						
No education	1.00	1.00	1.00	1.00	1.00	1.00
Primary	0.85 (0.58, 1.23)	1.01 (0.72, 1.42)	0.96 (0.67, 1.36)	0.62 (0.44, 0.89)[a]	1.13 (0.73, 1.75)	0.90 (0.76, 1.06)
Secondary	0.92 (0.63, 1.35)	0.85 (0.60, 1.19)	0.83 (0.59, 1.18)	0·77 (0.57, 1.04)	0.75 (0.46, 1.23)	0.82 (0.69, 0.98)[a]
Higher	0.43 (0.21, 0.89)[a]	0.68 (0.38, 1.22)	1.26 (0.75, 2.11)	0.56 (0.32, 0.97)[a]	1.12 (0.61, 2.04)	0.81 (0.61, 1.08)
Place of delivery						
Home	1.13 (1.13, 1.13)[a]	1.06 (0.76, 1.49)	0.98 (0.71, 1.36)	0.84 (0.62, 1.13)	0.76(0.52, 1.11)	0.91 (0.76, 1.09)
Skilled provider	1.00	1.00	1.00	1.00	1.00	1.00
Other	3.46(3.46, 3.46)	0.30 (0.09, 0.99)[a]	1.05 (0.35, 3.15)	0.53 (0.14, 1.91)	2.11 (0.83, 5.35)	0.89 (0.49, 1.63)
# of ANC visit						
No visit	NA	0.71 (0.28, 1.81)	1.05 (0.48, 2.27)	1.70 (0.86, 3.36)	2.42 (1.37, 4.29)[a,b]	1.69 (1.21, 2.35)[a,b]
1-3 visits	NA	1.09 (0.38, 3.15)	1.27 (0.54, 2.99)	1.39 (0.68, 2.84)	2.01 (1.08, 3.74)[a]	1.53 (1.04, 2.26)[a]
4 visits	NA	1.00	1.00	1.00	1.00	1.00
> 4 visits	NA	1.05 (0.45, 2.48)	1.44 (0.69, 2.99)	1.74 (0.91, 3.33)	1.98 (1.14, 3.42)[a]	1.70 (1.23, 2.34)[a,b]
ANC at home or skilled provider	0.24 (0.06, 0.98)[a]	0.60 (0.42, 0.85)[a]	0.53 (0.40, 0.70)[a,b]	0.26 (0.20, 0.34)[a,b]	0.36 (0.26, 0.49)[a,b]	0.40 (0.35, 0.46)[a,b]
C-section	NA	1.07 (0.50, 2.32)	1.00 (0.44, 2.28)	1.82 (0.90, 3.68)[a]	4.59 (2.00, 10.55)[a]	1.83 (1.18, 2.84)[a]
First child	1.12 (0.80, 1.56)	1.63 (1.24, 2.14)[a,b]	1.42 (1.09, 1.85)[a]	0.81 (0.57, 1.16)	1.24 (0.87, 1.6)	1.23 (1.07, 1.42)[a,b]

***Table 2*: Factors to infant mortality (summary results).**

OR: Odds ratio; NA: Not applicable.

[a] Significant difference in the logistic model.

[b] Significant difference based on the multiple comparison analysis (conducted only for the results of all years): p value from the logistic model <0.003 (0.003=0.05/15 of risk factors).

Note: 1) All the above selected results are based on model 3 (adjusted by demographic variables including year (only used for all years but not for each year), sex of child, region, rurality, religion, ethnicity, and socioeconomic variables including wealth index and education), except for the results of rurality, wealth index and mother's education, for which we applied model 1 only (adjusted by demographic variables), since these three factors are strongly correlated and could have intersected impact on infant mortality so that each of them should not be adjusted by wealth index and mother's education in model 3; 2) during analysis for the demographic exposures (region, sex of child, rurality, religion, ethnicity), the same variable used for adjustment was removed in models.

to death. Additionally, strategies to maintain the availability of health care workers in low resource settings need to be sustained to improve maternal care quality. Lastly, with the recent development of the pandemic on an already strained health system, we recommend further research into the effect of COVID-19 on the SDG target of reducing child mortality by 2030.

This is a large, population-level study analyzing IMR in Nigeria. Along with the descriptive demonstration of cross-sectional and trend analyses on overall IMR and IMR by participants' characteristics, we also investigated how the characteristics could be associated with the risk of IM. For the analysis on the association, we used rigorous methods including the application of

careful adjustment in the statistical models as well as the use of multiple comparisons analysis to confirm the statistical significance from the models. However, this study is not without any limitations. The NDHS was conducted in a retrospective manner at a population-level scale. Accordingly, the survey is not specifically designed to investigate infant mortality and its risk factors. Also, it is likely that some responses to the survey would have been limited due to potential recall bias and a small sample size of participants. Especially for the association between low birth weight and IM, the quality of the variable, low birth weight (small sample size with a large amount of missing data in the NDHS), mainly accounted for the non-positive result on its association with IMR, which should be considered as non-meaningful value for data interpretation. Potentially valuable variables that are missing in the study include gestational age, diseases occurring during the infant period, mothers' and infants' nutrition status, etc. For a potential risk factor, the impact of these variables deserves to be investigated among Nigerian people in future studies. Some of these variables (e.g., low birth weight, gestational age) could be valuable as used for adjustment; again, we failed to fully use the variables due to the availability or quality as mentioned. Furthermore, the results from our study may not indicate a causal effect between risk factors and IM, due to the cross-sectional design. This is the main reason we investigated the associations for each year separately between 2013 and 2017, to know whether a temporary effect could occur in the associations. However, the investigations by year were affected by the limited sample size. Regarding sample size, we did not provide a sample size estimate in the research, since the NDHS is likely the largest population-level survey with available variables to investigate IMR and its risk factors in the country.

In conclusion, higher risks for infant mortality rates in Nigeria were found for women who were less than 18 years old, from rural areas, have limited or no access to health care/skilled providers, and women who delivered their first child. The associations are influenced by mothers' community, financial hardship, and inability to access quality of care.

Contributors

Literature search – D.M.S., A.O., and F.M.E.; Study Design – Y.Z., J.Z., and H.O.S.; Data collection, Data Analysis – Y.Z., D.M.S., and J.Z.; Data Interpretation, Result – Y.Z., J.Z., and D.M.S.; Figures – Y.Z., D.M.S., and J.Z.; Discussion – H.O.S., D.M.S., and J.Z.; Conclusion – D.M.S.; Writing, review and editing – D.M.S., H.O.S., J.Z., F.M.E., A.O. Each author substantially contributed to conducting this study, adding intellectual content and approved the final draft. All authors had full access to the data in the study and take responsibility for the integrity and accuracy of the data analysis.

Data sharing statement

The data used to produce the analysis are readily available upon request from: https://dhsprogram.com/data/dataset_admin/login_main.cfm.

Declaration of interests

The authors declare no conflicts of interests.

Acknowledgments

We want to thank the DHS team for making this data accessible. The authors received no financial support for the research, authorship, or publication of this article.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2022.101622.

References

1 Centers for Disease Control and Prevention (CDC). Infant mortality. 2022. https://www.cdc.gov/reproductivehealth/maternalinfanthealth/infantmortality.htm. Accessed 31 July 2022.
2 UN Inter-agency Group for Child Mortality Estimation (UNIGME). Trends in child mortality: report 2018. United Nations International Children's Emergency Fund (UNICEF). https://www.unicef.org/media/47626/file/UN-IGME-Child-Mortality-Report-2018.pdf. Accessed 31 July 2022.
3 Wang H, Abajobir AA, Abate KH, et al. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970–2016: a systematic analysis for the global burden of disease study 2016. *Lancet*. 2017;390:1084–1150.
4 The World Bank. Mortality rate, infant (per 1000 live births) - Sub-Saharan Africa. https://data.worldbank.org/indicator/SP.DYN.IMRT.IN?locations=ZG&name_desc=false. Accessed 31 July 2022.
5 United Nations International Children's Emergency Fund (UNICEF). UNICEF data warehouse. https://data.unicef.org/resources/data_explorer/unicef_f/?ag=UNICEF&df=GLOBAL_DATAFLOW&ver=1.0&dq=CMR±NGA±GHA±BEN±TGO.CME_MRY0.M&startPeriod=1970&endPeriod=2020. Accessed 31 July 2022.
6 Lawoyin TO, Olawuyi JF, Onadeko MO. Factors associated with exclusive breastfeeding in Ibadan, Nigeria. *J Hum Lact*. 2001;17:321–325.
7 Slinkard SA, Pharr JR, Bruno T, et al. Determinants of infant mortality in South-East Nigeria: results from the healthy beginning initiative, 2013–2014. *Int J MCH AIDS*. 2018;7:1–8.
8 Morakinyo OM, Fagbamigbe AF. Neonatal, infant and under-five mortalities in Nigeria: an examination of trends and drivers (2003–2013). *PLoS One*. 2017;12:e0182990.
9 Jacdonmi I, Suhainizam M, Jacdonmi G. Breastfeeding, a child survival strategy against infant mortality in Nigeria. *Curr Sci*. 2016;110:1282–1287.
10 Adedini SA, Odimegwu C, Imasiku EN, Ononokpono DN, Ibisomi L. Regional variations in infant and child mortality in Nigeria: a multilevel analysis. *J Biosoc Sci*. 2015;47:165–187.
11 Abimbola S, Okoli U, Olubajo O, Abdullahi MJ, Pate MA. The midwives service scheme in Nigeria. *PLoS Med*. 2012;9:e1001211.
12 National Primary Health Care Development Agency (NPHCDA). Nigeria midwives service scheme. 2011.
13 Barasa F. Highest infant mortality rates in Africa. WorldAtlas. 2018. https://www.worldatlas.com/articles/african-countries-with-the-highest-infant-mortality-rates.html. Accessed 31 July 2022.
14 Oritogun K, Oyewole O, Daniel O. Comparison of statistical models used for assessing factors associated with infant mortality in Nigeria. *Ann Health Res*. 2016;2:37–43.
15 National Population Commission (NPC), Nigeria. Nigeria Demographic and Health Survey 2018. 2019. https://www.dhsprogram.com/pubs/pdf/FR359/FR359.pdf. Accessed 31 July 2022.
16 Global Burden of Disease (GBD) Study. Global Health Data Exchange (GHDx). http://ghdx.healthdata.org. Accessed 31 July 2022.

17 UN Inter-agency Group for Child Mortality Estimation (UNIGME). Stillbirth and child mortality estimates. www.childmortality.org. Accessed 31 July 2022.
18 Adewuyi EO, Zhao Y, Lamichhane R. Risk factors for infant mortality in rural and urban Nigeria: evidence from the national household survey. *Scand J Public Health*. 2017;45:543–554.
19 Ezeh OK, Agho KE, Dibley MJ, Hall JJ, Page AN. Risk factors for postneonatal, infant, child and under-5 mortality in Nigeria: a pooled cross-sectional analysis. *BMJ Open*. 2015;5:e006779.
20 Dahiru T, Oche OM. Determinants of antenatal care, institutional delivery and postnatal care services utilization in Nigeria. *Pan Afr Med J*. 2015;21:321.
21 Ebuehi OM, Akintujoye I. Perception and utilization of traditional birth attendants by pregnant women attending primary health care clinics in a rural Local Government Area in Ogun State, Nigeria. *Int J Womens Health*. 2012;4:25–34.
22 Ofili A, Okojie O. Assessment of the role of traditional birth attendants in maternal health care in Oredo local government area, Edo State, Nigeria. *J Community Med Prim Health Care*. 2005;17:55–60.
23 Ayoade MA. Regional and socioeconomic inequalities in infant mortality in Nigeria. *GeoJournal*. 2020;85:515–533.
24 Alam N. Teenage motherhood and infant mortality in Bangladesh: maternal age-dependent effect of parity one. *J Biosoc Sci*. 2000;32:229–236.
25 Finlay JE, Ozaltin E, Canning D. The association of maternal age with infant mortality, child anthropometric failure, diarrhoea and anaemia for first births: evidence from 55 low- and middle-income countries. *BMJ Open*. 2011;1:e000226.
26 Sharma V, Katz J, Mullany LC, et al. Young maternal age and the risk of neonatal mortality in rural Nepal. *Arch Pediatr Adolesc Med*. 2008;162:828–835.
27 Fall CH, Sachdev HS, Osmond C, et al. Association between maternal age at childbirth and child and adult outcomes in the offspring: a prospective study in five low-income and middle-income countries (COHORTS collaboration). *Lancet Glob Health*. 2015;3:e366–e377.
28 Kozuki N, Lee AC, Silveira MF, et al. The associations of parity and maternal age with small-for-gestational-age, preterm, and neonatal and infant mortality: a meta-analysis. *BMC Public Health*. 2013;13 (Suppl 3):S2.