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Factors consistently associated with utilisation of essential maternal and child health services in Nigeria: analysis of the five Nigerian national household surveys (2003–2018)

Yoshito Kawakatsu ,[1,2] Christopher Adolph,[3,4] Jonathan F Mosser ,[5] Peter Baffoe,[6] Fatima Cheshi,[6] Hirotsugu Aiga,[7] David Watkins ,[1,8] Kenneth H Sherr[1,9,10]

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For numbered affiliations see end of article.

Correspondence to
Yoshito Kawakatsu;
y.kawakatsu.0829@gmail.com

ABSTRACT

Objective This study aims to identify the individual and contextual factors consistently associated with utilisation of essential maternal and child health services in Nigeria across time and household geolocation.

Design, setting and participants Secondary data from five nationally representative household surveys conducted in Nigeria from 2003 to 2018 were used in this study. The study participants are women and children depending on essential maternal and child health (MCH) services.

Outcome measures The outcome measures were indicators of whether participants used each of the following essential MCH services: antenatal care, facility-based delivery, modern contraceptive use, childhood immunisations (BCG, diphtheria, tetanus, pertussis/Pentavalent and measles) and treatments of childhood illnesses (fever, cough and diarrhoea).

Methods We estimated generalised additive models with logit links and smoothing terms for households' geolocation and survey years.

Results Higher maternal education and households' wealth were significantly associated with utilisation of all types of essential MCH services ($p<0.05$). On the other hand, households with more children under 5 years of age and in poor communities were significantly less likely to use essential MCH services ($p<0.05$). Except for childhood immunisations, greater access to transport was positively associated with utilisation ($p<0.05$). Households with longer travel times to the most accessible health facility were less likely to use all types of essential MCH services ($p<0.05$), except modern contraceptive use and treatment of childhood fever and/or cough.

Conclusion This study adds to the evidence that maternal education and household wealth status are consistently associated with utilisation of essential MCH services across time and space. To increase utilisation of essential MCH services across different geolocations, interventions targeting poor communities and households with more children under 5 years of age should be appropriately designed. Moreover, additional interventions should prioritise to reduce inequities of essential MCH service utilisation between the wealth quantiles and between education status.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study used representative data from five national household surveys conducted in Nigeria from 2003 to 2018, including over 150 000 households.
⇒ Utilisation of nine types of essential maternal and child health (MCH) services were assessed under the same conceptual framework.
⇒ We estimated generalised additive models smoothing over households' geolocation and survey years for each essential MCH service.
⇒ This is the first study to identify maternal, household and geolocational factors consistently associated with essential MCH services across years and households' geolocations in Nigeria.
⇒ Reported associations with service utilisation do not necessarily reflect causal relationships, although we considered both temporal and geographic variations in our analysis.

INTRODUCTION

Universal health coverage (UHC) ensures that all people, regardless of where they live and how much they earn and spend, have access to quality health services with protection from financial hardship and risks. UHC serves as one of 13 targets for Sustainable Development Goal 3. WHO, Organisation for Economic Co-operation and Development and World Bank jointly reported, in their UHC Global Monitoring Report 2021, that the UHC service coverage index (SCI) increased from 45% in 2000 to 68% in 2019 globally.[1] This is attributed largely to the rapid increase in coverage of treatments for infectious diseases and maternal and child healthcare. This progress in UHC has been

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particularly notable in low-income and lower middle-income countries. However, using composite indexes such as SCI to measure progress in attaining UHC obscures large discrepancies in service availability across both countries and types of services. For instance, service coverage for essential maternal and child health services in Nigeria ranged from just 6% for antenatal care (ANC), peripartum care and postnatal care for mothers to 61% for measles vaccination.[2] At the same time, in low-income and middle-income countries unequal coverage of essential maternal and child health services is often reported between rich and poor, the most and least educated and urban and rural areas.[3]

Development of an effective service delivery strategy must begin by identifying the characteristics of the underserved populations who are less likely to have access to essential maternal and child health services. A majority of earlier studies conducted in Nigeria identified and assessed the factors associated with utilisation of only one or two types of essential maternal and child health services such as ANC,[4–6] facility-based delivery,[6–8] family planning,[9 10] childhood immunisation[11–13] and treatment of childhood illnesses.[14 15] The factors identified in these studies include individual characteristics (eg, age, education status, ethnic group, religion, occupation, pregnancy history, wealth status, access to media) and contextual characteristics (eg, distance to a health facility, rurality, neighbourhood socioeconomic status and ethnic diversity). While recognising the importance of earlier studies in increasing utilisation of specific services, in order to develop a comprehensive strategy across essential maternal and child health services—and thereby advance UHC—it is critical to identify factors consistently associated with utilisation across a range of essential maternal and child health services.

Accordingly, this study aims to identify both individual and contextual factors that are consistently associated with utilisation of all nine essential maternal and child health services (ie, ANC, facility-based delivery, modern contraceptive use, immunisations and childhood illnesses), across survey years and household geolocations, using five national representative cross-sectional surveys in Nigeria.

METHODS

Dataset

This study uses secondary data from national representative cross-sectional surveys of geolocated households conducted in Nigeria from 2003 to 2018. We combined publicly available data from four Nigeria Demographic Health Surveys (DHS) in 2003, 2008, 2013 and 2018 and Multiple Indicator Cluster Surveys (MICS) in 2016–2017. DHS data were extracted from IPUMS DHS.[16] Detailed methodologies of the four DHS surveys are published elsewhere.[17–21] All surveys employed stratified two-stage or three-stage cluster sampling techniques. The primary sampling unit (PSU) for DHS 2003 was defined as one or more enumeration areas (EAs) used for Population and Housing Census 1991, while the PSU for DHS 2008, DHS 2013, DHS 2018 and MICS 2016/17 was defined as one or more EAs used for the Population and Housing Census 2006.

Table 1 Total number of households interviewed in DHS 2003, 2008, 2013 and 2018 and MICS 2016/17

Surveys	Rural	Urban	Total
DHS 2003	2931	4294	7225
DHS 2008	23346	10724	34070
DHS 2013	22663	15859	38522
DHS 2018	23647	16780	40427
MICS 2016/17	22797	11104	33901

DHS, Demographic Health Survey; MICS, Multiple Indicator Cluster Survey.

The counts of households interviewed in DHS 2003, DHS 2008, DHS 2013, DHS 2018 and MICS 2016/17 are shown in table 1. In DHS 2018, 11 of 27 local government areas in Borno State were excluded from the sampling frame due to insecurity in those districts. Likewise, in MICS 2016/17, a total of 101 EAs in Borno, Yobe and Adamawa states were not surveyed due to insecurity.

To protect the confidentiality of PSU geolocations, the Global Positioning System coordinates of urban PSU locations were randomly displaced within a 2 km buffer, and rural PSUs were displaced within a 5 km buffer (and in 1% of cases, a 10 km buffer). The direction and distance of the displacement for each PSU was randomly selected using a uniform distribution.[22 23] Prior research found that the effect of random displacement across a 10 km^2 grid to be negligible for estimating measles vaccination coverage.[24] Geolocation data for 16 of 3533 PSUs (0.5%) were missing across the four DHS. Similarly, geolocation data for 1 of 2239 PSUs (0.0004%) was missing in MICS 2016/17. After initial random displacement, 14 PSUs (1 in DHS 2008 and 13 in MICS 2016/17) were 'located' either in the sea or out of country's boundaries. We resampled the random displacement of those PSUs until their displaced positions lay inside the relevant boundaries (using a 5 km buffer if possible, and a 10 km buffer if necessary). Of these 14 PSUs, 8 were successfully resampled and 6 cases that could not be appropriately displaced across 10000 attempts were discarded.

Essential maternal and child health services

The essential maternal and child health services considered in this study consist of ANC, facility-based delivery, modern contraceptive use, childhood immunisations (BCG, first and third diphtheria, tetanus, pertussis/pentavalent, measles) and treatments for childhood illnesses. The target group for ANC and facility-based delivery was women aged 15–49 years having given a live birth in the last 23 months, while that for modern contraceptive use was women aged 15–49 years not having wanted to have more children. Children aged 12–23

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Table 2 Definitions and target populations of essential health services

Health service	Definition	Study population
Four or more antenatal care visits	Four of more antenatal care visits with trained health personnel (ie, doctor, nurse, midwife, auxiliary midwife) during pregnancy as of the time of survey	Women aged 15–49 years with a last birth in the last 23 months
Facility-based delivery	Delivery at a public or private health facility in the last 23 months as of the time of survey	Women aged 15–49 years with live births in the last 23 months
Modern contraceptive use	Utilisation of modern contraceptives (ie, the pill, intrauterine device, injection, diaphragm, male condom, female condom, female sterilisation, male sterilisation, implants, foam/jelly, lactational amenorrhoea and emergency contraception) at the time of survey	Non-pregnant women aged 15–49 years who did not want to have more children, including those using sterilisation methods
Childhood immunisation	Children who had received one dose of BCG vaccine	Children aged 12–23 months
	Children who had received first dose of DPT vaccine or pentavalent vaccine	
	Children who had received third dose of DPT vaccine or pentavalent vaccine	
	Children who had received first dose of measles vaccine	
Treatment for common childhood illness	Children under 5 with fever/cough and diarrhoea in the last 2 weeks for whom care was sought at a health facility	Children aged 0–59 months

DPT, diphtheria, tetanus, pertussis.

months and aged 0–59 months were the target groups for immunisation and treatments of childhood illnesses, respectively. Table 2 provides further details on the definitions of and study populations for these essential services.

Conceptual framework and independent variables

Independent variables across essential maternal and child health services were selected based on three earlier studies.[25–27] We considered five types of explanatory variables that might influence health seeking behaviours: (i) individual characteristics; (ii) the built environment; (iii) neighbourhood demographics; (iv) the social environment and (v) the healthcare environment.

Maternal and households' characteristics include the explanatory variables of maternal age, household head, education level, marital status, possession of television and radio, possession of means of transport and household's wealth index. Possession of television and radio was categorised into three groups: (i) households possessing both a television and a radio; (ii) households possessing either of them and (iii) households possessing neither of them. Possession of means of transport means was generated using possession of car, motorcycle and bike and categorised into three groups: (i) no means of transport; (ii) one means of transport and (iii) two to three means of transport. The household wealth index was the first principal component estimated by a principal component analysis on the household assets, sources of drinking water, sanitation facilities, type of fuel for cooking and materials of floors for housing units.

Gridded estimates of population density provided by WorldPop were used as a proxy for the built environment.[28] The proportion of households in a PSU living under the poverty line was used as a proxy for neighbourhood demographics and the social environment. As proxy for the healthcare environment, we measured each PSU's travel time to the most accessible health facility using the friction surface developed by the Malaria Atlas Project.[29] Geolocations of health facilities managed by government, community-based organisations and faith-based organisations in Nigeria were provided by the Nature Scientific database, which records locations of health facilities as of 2018.[30] We assume these facilities were present in all years surveyed by DHS; however, because Nature Scientific does not provide the date on which each facility was established, some health facilities may not have existed at the time of some of the five surveys, a possible limitation of our analysis. Finally, the number of health facilities within a 20 km buffer around each PSU was employed as the proxy for the healthcare environment, indicating the availability of accessible health facility options.

In analyses of the utilisation of childhood immunisations and treatments of childhood illnesses, we added additional explanatory variables related to child characteristics (ie, age, sex and birth month). Children's ages were rounded to whole months.

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Data analysis

In addition to descriptive analyses, we estimated generalised additive models (GAMs) with logit links to identify factors associated with the utilisation of essential service v by the ith individual in the dth PSU in the jth state at the t year. The systematic component of the model of v_{idjt} is:

$$\text{logit}\left(v_{idjt}\right) = \beta_0 + \beta_1 DHS_{djt} + \beta_2 Head_{idjt} + \beta_3 \log\left(U5_{idjt}\right) + \beta_4 Poverty_{djt} + \beta_5 Access_{dj} + \beta_6 \log\left(Choice_{dj}\right) + \beta_7 \log\left(PopDensity_{djt}\right) + Age_{idjt}\gamma + Education_{idjt}\delta + Marital_{idjt}\theta + Transport_{idjt}\phi + Wealth_{idjt}\eta + s\left(long_{idj}, lat_{idj}\right) + s\left(month_t\right)$$

$s(long_{idj}, lat_{idj})$: smooth function of longitude and latitude using isotropic smooths on the sphere to account for spatial autocorrelation.

$s(month_t)$: smooth function of time trends.

DHS_{djt}: binary indicator recording 1 if the data source for year t is DHS and 0 if not.

$Head_{idjt}$: binary indicator recording 1 if the household head in year t was a mother and 0 if not.

Age_{idjt}: maternal age of the mother in a household in year t.

$U5_{idjt}$: the number of children under 5 years of age in a household in year t.

$Education_{idjt}$: the education level of the mother in year t.

$Wealth_{idjt}$: the wealth quantile of the household in year t.

$Marital_{idjt}$: the marital status of the mother in year t.

$Media_{idjt}$: possession of TV and/or radio by the household in year t.

$Transport_{idjt}$: possession of means of transport by the household in year t.

$Poverty_{djt}$: proportion of the households living below the poverty line in the dth PSU of the jth state in year t.

$Access_{dj}$: travel time in minutes from the household's PSU to the most accessible health facility.

$Choice_{dj}$: the number of health facilities within 20 km from the household's PSU.

$PopDensity_{djt}$: population density in the dth PSU of the jth state in year t.

We included childhood covariates $ChildAge_{ijt}$ and $ChildSex_{ijt}$ (child's age and sex, respectively) in the models of childhood immunisation and care seeking for common childhood illnesses. We log-transformed population density, the number of health facilities and the number of children under 5 to improve model fit and to account for diminishing marginal effects of these variables. Two of these variables—the count of health facilities within 20 km and the count of children under 5 years of age—could in some cases have a value of precisely zero, posing a problem for taking logs. Rather than adding an arbitrary positive quantity to these count variables, we directly estimate the effect of having zero children (or zero health facilities) by including dummy variables in the model to indicate cases where each is precisely zero. In turn, and without loss of generality, before logging the count of health facilities (or children), we replaced zeros with ones, so that cases in which there are zero health facilities within 20 km (or no children under 5 years of age) affect the outcome only through the dummy variable for that case.[31 32]

We listwise deleted missing data, which accounted for <2% of total cases. Because the guidelines for DHS 2018 recommend against using weights for estimating relationships, we do not use sampling weights in estimating the GAMs.[33] However, sampling weights were used for estimating health service coverage reported in table 3.

Finally, we estimated an additional eight models for each outcome as sensitivity analyses to check the robustness of our findings:

- Model 0a through 0d explore the association between health utilisation outcomes and each of the four consistent factors separately, with only the potential confounders of (smoothed) household geolocation and time controlled.
- Model 1 estimates the association between health utilisation outcomes and the four consistent factors taken together, controlling for (smoothed) household geolocation and time controlled.
- Model 2 builds on model 1 to add controls for other individual characteristics.
- Model 3 builds on model 1 to add controls for population density and proportion of poor households in a community, which proxy for the built environment and neighbouring demographics.

Table 3 Essential health service coverage from 2003 to 2018 in Nigeria

	2003	2008	2013	2016/17	2018
Essential health services	%	%	%	%	%
Four or more antenatal care visits	44.24	44.95	48.90	48.17	51.74
Facility-based delivery	34.19	35.82	37.91	37.12	40.87
Modern contraceptive use	17.72	19.74	23.86	19.18	19.40
BCG vaccination	49.03	50.29	51.62	53.33	66.71
First pentavalent vaccination	42.71	52.45	51.00	49.53	64.96
Third pentavalent vaccination	22.95	36.65	38.93	34.08	50.81
Measles vaccination	37.03	42.61	42.88	41.85	53.96
Treatment for fever/cough	29.07	30.83	58.46	22.02	62.83
Treatment for diarrhoea	19.07	28.28	55.91	24.99	54.44

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- Model 4 builds on model 1 to add controls for time to the accessible health facility and number of health facilities within 20 km, which proxy for the healthcare environment.

Patient and public involvement

Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

Table 3 shows the observed levels of coverage of essential maternal and child health services in 2003, 2008, 2013, 2016/17 and 2018. Overall, essential health service coverage increased from 2003 to 2018. Weighted service coverage of ANC rose from 44.2% to 51.7% over this period, whereas facility-cased delivery and modern contraceptive use rose from 34.2% to 40.9% and 17.7% to 19.4%, respectively. Coverage for all four types of childhood immunisation was below 50% in 2003, and exceeded that threshold for all types in 2018; 62.8% of children having fever and/or cough symptoms visited health facilities for their treatments, while 54.4% of children having diarrhoea symptoms visited health facilities in 2018, more than double the rates of 2003. MICS 2016/17 reported approximately 30%–40% lower coverage of treatment for childhood illnesses than DHS 2018. Tables 4 and 5 show the descriptive statistics of the respondents' characteristics for each outcome.

Table 6 summarises the results of nine GAMs for each essential maternal and child health service. More educated and wealthier mothers were significantly more likely to use all nine types of essential maternal and child health services. Similarly, older mothers were significantly more likely to use ANC, modern contraceptive use, childhood immunisation, treatment of fever and/or cough and of diarrhoea. In addition, having a greater number of means of transport was positively associated with essential service utilisation, with the exception of childhood immunisation. On the other hand, both having more children under 5 years of age and living in poorer communities were negatively associated with utilisation of essential maternal and child health services. Households with longer travel times to the most accessible health facility were significantly less likely to use all types of essential maternal and child health services, with the exception of modern contraceptive use and treatment of fever and/or cough, and diarrhoea. Absence of health facilities within 20 km from a household was negatively associated with utilisation of childhood immunisation and treatment of fever and/or cough, and diarrhoea.

Detailed results of all analyses for each health service are presented in online supplemental files 1–4. Online supplemental file 5 shows the smooth fitting of time, longitude and latitude in the final models for each health service. Also, online supplemental appendix file 6.1–6.9 show the results of sensitivity analyses for each outcome. The results of the full models from table 6 in the main paper are also added in the online supplemental files for convenient comparison. The effects of four variables consistently associated with health service utilisation in our main result did not change significantly in the sensitivity analyses.

DISCUSSION

Using data from the five most recent nationally representative health surveys in Nigeria, this study identified individual-level and community-level factors consistently associated with utilisation of essential maternal and child health services in Nigeria. The sensitivity analyses confirmed the robustness of our findings. The identified factors consistently associated are maternal education, household economic status, having more children under 5 and living in poorer communities. Longer travel time to the most accessible health facility was not significantly associated with all, but a majority of essential maternal and child health services. These factors would be important characteristics across states and time to identify the underserved populations who are less likely to have access to multiple essential maternal and child health services rather than a single health service.

The results of our study reconfirmed that maternal education and household economic status are cross-cutting factors significantly associated with the utilisation of essential maternal and child health services of households in Nigeria. Several earlier studies conducted in Nigeria reported women's education attainment and household economic status as factors significantly associated with utilisation of essential health services such as ANC,[4] facility-based delivery,[7 8 34 35] child immunisations[12] and treatment of childhood illnesses.[14] Meta-analyses have confirmed the importance of maternal education and household economic status for childhood immunisation[36] and child mortality,[37–39] as well. While the Health Equity Assessment Toolkit (HEAT) also provide useful information on inequalities of essential health service coverages within a country using five dimensions of inequity including wealth and education status,[40] this study included more individual and contextual factors than HEAT such as marital status, possession of transportation, population density and time to the most accessible health facility.

Moreover, this study found that having more children under 5 and living in poorer communities were negatively associated with utilisation of the full range of essential maternal and child health services. Earlier systematic reviews reported that women with higher parity less frequently used ANC and facility-based delivery in low-income and middle-income countries.[41–43] A previous study conducted in Nigeria also reported childbirth order was significantly associated with the uptake of vaccinations.[12] On the other hand, it was reported that primigravidae could be more likely to seek advice and assistance for their deliveries.[44] Mothers in the households with a

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Table 4 Descriptive statistics of maternal and contraceptive service utilisation and independent variables in Nigeria

	Fourth ANC	Facility-based delivery	Modern contraceptive use
Independent variables	N=47 433	N=50 398	N=26 931
Data source			
DHS	37 425 (78.8%)	40 448 (80.2%)	19 937 (74.0%)
MICS	10 063 (21.2%)	10 005 (19.8%)	6994 (26.0%)
Maternal and households' characteristics			
Household head			
Self	45 173 (95.1%)	47 922 (95.0%)	22 353 (83.0%)
Others	2315 (4.9%)	2531 (5.0%)	4578 (17.0%)
Maternal age (mean (SD))	28.3 (6.89)	28.3 (6.86)	39.5 (7.19)
Maternal education level			
No education	22 205 (46.8%)	23 147 (45.9%)	8981 (33.3%)
Primary	8638 (18.2%)	9331 (18.5%)	7298 (27.1%)
Secondary	13 528 (28.5%)	14 610 (29.0%)	7934 (29.5%)
Higher	3117 (6.6%)	3365 (6.7%)	2718 (10.1%)
Marital status			
Never married	1183 (2.5%)	1227 (2.4%)	988 (3.7%)
Married or live together with a partner	45 311 (95.4%)	48 170 (95.5%)	22 764 (84.5%)
Others	994 (2.1%)	1056 (2.1%)	3179 (11.8%)
Possession of TV and radio			
None	13 743 (28.9%)	14 388 (28.5%)	6058 (22.5%)
At least one	18 297 (38.5%)	19 379 (38.4%)	9018 (33.5%)
Both of them	15 448 (32.5%)	16 686 (33.1%)	11 855 (44.0%)
Possession of transport means			
No transport means	21 606 (45.5%)	22 960 (45.5%)	12 795 (47.5%)
One transport means	19 843 (41.8%)	21 088 (41.8%)	10 279 (38.2%)
Two to three transport means	6039 (12.7%)	6405 (12.7%)	3857 (14.3%)
Wealth quantile			
Poorest	8882 (18.7%)	9352 (18.5%)	5389 (20.0%)
Poor	9620 (20.3%)	10 077 (20.0%)	5375 (20.0%)
Middle	9628 (20.3%)	10 214 (20.2%)	5399 (20.0%)
Rich	9607 (20.2%)	10 250 (20.3%)	5330 (19.8%)
Richest	9751 (20.5%)	10 560 (20.9%)	5438 (20.2%)
Number of children under 5 (mean (SD))	2.18 (1.14)	2.21 (1.16)	0.962 (1.11)
Geolocational characteristics			
Proportion of poorest households in a PSU	0.187 (0.285)	0.185 (0.284)	0.200 (0.317)
Population density (mean (SD))	1690 (4480)	1720 (4520)	2350 (5240)
Time to the most accessible health facility (mean (SD))	15.1 (22.8)	14.9 (22.7)	11.5 (19.6)
Number of health facilities within 20 km (mean (SD))	51.3 (39.8)	51.9 (40.2)	61.5 (42.7)

ANC, antenatal care; DHS, Demographic Health Surveys; MICS, Multiple Indicator Cluster Surveys; PSU, primary sampling unit.

greater number of children under 5 years of age could need to spend more time and other resources taking care of the children. It could be difficult for them to find someone who takes care of children during their absence while receiving health services. They may also face additional logistical challenges in accessing health facilities. Some may have negative stereotypes about the quality of essential health services due to their previous dissatisfying experiences that could discourage them from using health services.[45] This study also found that mothers living in poorer communities were less likely to use all essential maternal and child health services, even after adjusting for distance to and availability of health facilities and household economic status. Another study in Nigeria reported

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Table 5 Descriptive statistics of utilisation of child health services and independent variables in Nigeria

Independent variables	BCG N=22 982	First pentavalent N=22 909	Third pentavalent N=22 860	Measles N=22 903	Fever/Cough treatment N=28 589	Diarrhoea treatment N=13 876
Data source						
DHS	17 596 (76.6%)	17 564 (76.7%)	17 558 (76.8%)	17 544 (76.6%)	19 697 (68.9%)	10 409 (75.0%)
MICS	5386 (23.4%)	5345 (23.3%)	5302 (23.2%)	5359 (23.4%)	8892 (31.1%)	3467 (25.0%)
Maternal and households' characteristics						
Household head						
Self	1250 (5.4%)	1252 (5.5%)	1251 (5.5%)	1251 (5.5%)	1438 (5.0%)	525 (3.8%)
Others	21 732 (94.6%)	21 657 (94.5%)	21 609 (94.5%)	21 652 (94.5%)	27 151 (95.0%)	13 351 (96.2%)
Maternal age (mean (SD))	28.8 (6.85)	28.8 (6.85)	28.8 (6.85)	28.7 (6.84)	29.4 (7.00)	28.8 (7.11)
Maternal education level						
No education	10 462 (45.5%)	10 429 (45.5%)	10 417 (45.6%)	10 416 (45.5%)	13 727 (48.0%)	8164 (58.8%)
Primary	4153 (18.1%)	4140 (18.1%)	4125 (18.0%)	4143 (18.1%)	5373 (18.8%)	2397 (17.3%)
Secondary	6696 (29.1%)	6676 (29.1%)	6660 (29.1%)	6680 (29.2%)	7866 (27.5%)	2805 (20.2%)
Higher	1671 (7.3%)	1664 (7.3%)	1658 (7.3%)	1664 (7.3%)	1623 (5.7%)	510 (3.7%)
Marital status						
Never married	535 (2.3%)	531 (2.3%)	531 (2.3%)	534 (2.3%)	538 (1.9%)	230 (1.7%)
Married or live together with a partner	21 865 (95.1%)	21 796 (95.1%)	21 749 (95.1%)	21 789 (95.1%)	27 178 (95.1%)	13 295 (95.8%)
Others	582 (2.5%)	582 (2.5%)	580 (2.5%)	580 (2.5%)	873 (3.1%)	351 (2.5%)
Possession of TV and radio						
None	6526 (28.4%)	6501 (28.4%)	6486 (28.4%)	6503 (28.4%)	9041 (31.6%)	4808 (34.6%)
At least one	8623 (37.5%)	8607 (37.6%)	8592 (37.6%)	8598 (37.5%)	11 087 (38.8%)	5726 (41.3%)
Both of them	7833 (34.1%)	7801 (34.1%)	7782 (34.0%)	7802 (34.1%)	8461 (29.6%)	3342 (24.1%)
Possession of transport means						
No transport means	10 406 (45.3%)	10 384 (45.3%)	10 368 (45.4%)	10 377 (45.3%)	12 719 (44.5%)	6086 (43.9%)
One transport means	9658 (42.0%)	9617 (42.0%)	9596 (42.0%)	9618 (42.0%)	11 884 (41.6%)	5961 (43.0%)
Two to three transport means	2918 (12.7%)	2908 (12.7%)	2896 (12.7%)	2908 (12.7%)	3986 (13.9%)	1829 (13.2%)
Wealth quantile						
Poorest	4459 (19.4%)	4451 (19.4%)	4447 (19.5%)	4440 (19.4%)	5830 (20.4%)	3421 (24.7%)
Poor	4443 (19.3%)	4432 (19.3%)	4426 (19.4%)	4432 (19.4%)	5989 (20.9%)	3335 (24.0%)
Middle	4628 (20.1%)	4614 (20.1%)	4597 (20.1%)	4614 (20.1%)	5987 (20.9%)	2959 (21.3%)
Rich	4526 (19.7%)	4506 (19.7%)	4499 (19.7%)	4509 (19.7%)	5760 (20.1%)	2450 (17.7%)
Richest	4926 (21.4%)	4906 (21.4%)	4891 (21.4%)	4908 (21.4%)	5023 (17.6%)	1711 (12.3%)
Number of children under 5 (mean (SD))	2.10 (1.11)	2.10 (1.10)	2.10 (1.10)	2.10 (1.10)	2.21 (1.18)	2.29 (1.21)
Child characteristics						
Sex						
Male	11 713 (51.0%)	11 673 (51.0%)	11 653 (51.0%)	11 671 (51.0%)	14 604 (51.1%)	7178 (51.7%)
Female	11 269 (49.0%)	11 236 (49.0%)	11 207 (49.0%)	11 232 (49.0%)	13 985 (48.9%)	6698 (48.3%)
Month age (mean (SD))	17.0 (3.44)	17.0 (3.44)	17.0 (3.44)	17.0 (3.45)	27.5 (16.3)	24.1 (15.3)
Geolocational characteristics						
Proportion of poorest households in a PSU	0.194 (0.287)	0.194 (0.288)	0.194 (0.288)	0.194 (0.287)	0.204 (0.296)	0.249 (0.321)
Population density (mean (SD))	1800 (4690)	1800 (4690)	1800 (4690)	1800 (4690)	1560 (4160)	1360 (3750)

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Table 5 Continued

Independent variables	BCG N=22 982	First pentavalent N=22 909	Third pentavalent N=22 860	Measles N=22 903	Fever/Cough treatment N=28 589	Diarrhoea treatment N=13 876
Time to the most accessible health facility (minutes: mean (SD))	14.7 (22.4)	14.8 (22.5)	14.8 (22.5)	14.7 (22.5)	15.5 (23.1)	17.0 (24.3)
Number of health facilities within 20 km (count: mean (SD))	52.4 (40.5)	52.4 (40.5)	52.4 (40.5)	52.4 (40.5)	50.0 (39.0)	45.1 (37.1)

DHS, Demographic Health Surveys; MICS, Multiple Indicator Cluster Surveys; PSU, primary sampling unit.

that poverty level and the infrastructure level of communities in which mothers live were important determinants of child mortality.[46] Poorer communities tend to lack basic infrastructure, including paved roads and public transport, which enable timely and inexpensive access to essential health services. In addition, some mothers in poor rural communities might be either directly or indirectly influenced by the anti-immunisation resistance movement observed in Northern Nigeria State.[47 48] On the other hand, those living in urban poor communities, particularly slum dwellers, may have language barriers to accessing health services in addition to financial and geographic barriers.[8]

Consistent with several earlier studies, longer travel times to the most accessible health facility were significantly associated with the utilisation of most, though not all, essential maternal and child health services.[43 49 50] In addition, households with at least one health facility within 20 km were significantly more likely to use child immunisation services and treatments of fever and/or cough, and diarrhoea, suggesting the opportunity and/or financial cost of travel matters for utilisation. Similarly, those having means of transport can more easily access health facilities in the search of essential health services, with the possible exception of child immunisation services, which are provided at most private and public health facilities, and through outreach services and house-to-house campaigns. It is thus unsurprising that possession of means of transport did not significantly increase utilisation of child immunisation services.

As shown in online supplemental file 5, temporal trends in the models of essential maternal and child health services varied. Spatial trends varied by health services, too. For example, the northern parts of Nigeria had generally lower coverage areas than other states.

The data source variable (ie, DHS or MICS) would partially account for systematic differences between the surveys, while other covariates such as a smoothing function of longitude and latitude could also reflect the portion of the differences. As shown in table 3, the service coverage in MICS 2016/17 were similar to that in DHS 2018 except for treatment for childhood fever/cough and diarrhoea. The possible reasons for this include differences in sampling methodology, translated questionnaires in local languages or may reflect true differences in outcomes due to different data collection periods or changes in trends over time.

The results of this study suggest several policy implications. In the short-term, service delivery points (eg, health facilities and outreach service points) should be located closer to inhabitants in a community by: (i) ensuring availability and readiness of essential health services at existing service delivery points; (ii) establishing additional primary healthcare centres and (iii) strategically implementing outreach services such as campaigns. These interventions would mitigate physical barriers to access to essential health services, especially among poor households who live far from current service delivery points. In the middle-term and long-term, education attainment of pregnant women and mothers is one of the key determinants potentially modifiable by future interventions. Policy makers and programme managers should place a greater emphasis on increasing enrolment rates in primary and secondary education among females to improve education outcomes themselves, and to enhance health service utilisation. Moreover, poorer households and communities should be prioritised to mitigate discrepancies in utilisation of essential health services between the poor and the rich.

In addition, our study focused on the relationship between social conditions and healthcare utilisation. Healthcare utilisation, however, is only one of the factors that influence health outcomes. Further study is needed to fully illuminate the relationships between the drivers of healthcare utilisation, utilisation itself and health outcomes.

Limitations of the study

There are four types of limitations of the study. First, causality between service utilisations and the independent variables could not be established, although we considered both temporal and geographic variations into our analysis. Second, our analytical framework does not capture the full complexity of interactions between the independent variables. Third, immunisation status is vulnerable to recall bias. Although it is preferable to use more reliable data from home-based records (eg, child vaccination cards and maternal and child health

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Table 6 Results summary of generalised additive models for essential health services using five national-representative data from 2003 to 2018 in Nigeria

Variables	ANC	Facility-based delivery	Modern contraceptive use	BCG vaccine	First pentavalent vaccine	Third pentavalent vaccine	Measles vaccine	Treatment of fever/ cough	Treatment of diarrhoea
Data source: DHS	1.151	0.948	1.176	1.608	1.204	1.098	1.416	10.540	5.066
Household head	1.056	1.162	0.751	1.123	1.117	1.171	0.944	1.058	1.051
Maternal age (ref. <20 years old)									
20–24 years old	1.181	0.935	4.875	1.358	1.383	1.317	1.495	1.057	1.032
25–29 years old	1.251	0.914	6.786	1.508	1.512	1.505	1.731	1.079	1.138
30–34 years old	1.295	0.957	7.235	1.502	1.515	1.468	1.785	1.086	1.120
35–39 years old	1.237	1.031	7.316	1.685	1.735	1.607	1.924	0.989	1.063
40 years or older	1.191	1.017	4.370	1.631	1.639	1.619	1.907	1.141	1.014
Maternal education level (ref. no education)									
Primary	1.701	1.714	2.187	1.780	1.764	1.587	1.661	1.427	1.306
Secondary	2.402	2.857	2.476	3.237	3.071	2.558	2.523	1.588	1.361
Higher	5.690	8.990	2.779	7.853	6.790	4.616	6.053	1.809	1.562
Marital status (ref. never married)									
Married or live together with a partner	1.411	1.274	2.445	1.015	1.075	1.217	1.001	1.003	1.225
Others	1.313	1.166	1.209	1.040	1.057	0.990	1.009	0.925	0.954
Possession of TV and radio (ref. none)									
At least one	1.000	1.016	0.909	0.995	1.061	0.985	0.984	1.084	1.104
Both	1.110	1.119	0.976	1.105	1.101	1.059	1.006	1.138	1.223
Possession of transport (ref. no means of transport)									
One means of transport	1.091	1.103	1.142	0.992	0.945	0.999	1.008	1.049	1.090
Two to three means of transport	1.198	1.111	1.241	1.019	0.980	1.030	1.000	1.170	1.133
Wealth quantile (ref. poorest)									
Poor	1.126	0.967	0.938	1.069	1.053	1.167	1.095	1.119	1.055
Middle	1.380	1.224	1.097	1.193	1.180	1.264	1.259	1.163	1.207
Rich	1.677	1.583	1.296	1.520	1.471	1.624	1.479	1.218	1.268
Richest	2.614	2.737	1.435	2.432	2.309	2.281	2.261	1.250	1.430
No children under 5*			0.854						
Number of children under 5 in households†	0.795	0.763	0.693	0.762	0.774	0.819	0.839	0.942	0.877
Child characteristics									
Child sex: female				1.015	0.998	1.022	1.010	0.952	0.962
Child age: months				1.004	1.009	0.999	1.038	0.999	1.002
Geolocational characteristics									
Proportion of poorest households in a PSU	0.366	0.431	0.566	0.429	0.495	0.439	0.585	0.487	0.536
Population density†	1.066	1.094	1.010	1.060	1.019	1.013	1.016	0.991	1.014

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Table 6 Continued

Variables	ANC	Facility-based delivery	Modern contraceptive use	BCG vaccine	First pentavalent vaccine	Third pentavalent vaccine	Measles vaccine	Treatment of fever/ cough	Treatment of diarrhoea
Time to the most accessible health facility	0.997	0.998	1.000	0.997	0.997	0.996	0.998	1.000	0.998
No health facilities within 20 km	0.511	0.655	1.964	0.419	0.158	0.142	0.186	0.392	0.313
Number of health facilities within 20 km†	1.006	1.085	1.051	1.073	1.093	1.102	1.104	0.985	0.887

Entries are AORs estimated by generalised additive models with logistic links and smoothing over time and households' geolocations. Blue shading indicates statistically significant AORs >1 at the 0.05 level, pink shading indicates significant AORs <1 and unshaded entries are not significantly different from AORs of 1.
*This variable is only included for models of modern contraceptive use, as the study population for other essential services (mothers aged 15–49 years with a last birth in the last 23 months and children aged 12–23 months) had at least one child under 5 in their households.
†Log-transformed.
ANC, antenatal care; AOR, adjusted OR; DHS, Demographic Health Surveys; PSU, primary sampling unit.

cards), since these records are often not missing, especially in households with vulnerable mothers, reliance on parental recall is often unavoidable. Notably, studies in Tanzania and South Africa reported a high level of agreement in data between parental recall and home-based records.[49 50] Finally, the two variables of healthcare environment 'travel time to the most accessible health facility using friction surface' and 'the number of health facilities within 20 km from local residence' were assumed as the time-invariant variables in this study, due to its poor data availability, although the relationship between these variables and service utilisation might vary over time.

CONCLUSIONS

This study identified factors consistently associated with utilisation of essential maternal and child health services in Nigeria. Higher female education attainment and wealthier households were positively associated with utilisation of all the essential health services. Living in poorer communities and having more children under 5 years of age were negatively associated with utilisation. Appropriate prioritisation and intervention aimed at these factors should be implemented by the government and its development partners. As a short-term intervention, increasing service delivery points for poor communities would mitigate the negative effect of several factors identified here.

Author affiliations
[1]Department of Global Health, University of Washington, Seattle, Washington, USA
[2]Department of Community-based Rehabilitation Sciences, Graduate School of Biomedical Sciences, Nagasaki University, Nagasaki, Japan
[3]Department of Political Science, University of Washington, Seattle, Washington, USA
[4]Center for Statistics and the Social Sciences, University of Washington, Seattle, Washington, USA
[5]Department of Health Metrics Sciences, University of Washington, Seattle, Washington, USA
[6]UNICEF, Abuja, Nigeria
[7]Department of Health System Development, School of Tropical Medicine and Global Health, Nagasaki University, Nagasaki, Japan
[8]Department of Medicine, University of Washington, Seattle, Washington, USA
[9]Department of Epidemiology, University of Washington, Seattle, Washington, USA
[10]Department of Industrial & Systems Engineering, University of Washington, Seattle, Washington, USA

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ORCID iDs
Yoshito Kawakatsu http://orcid.org/0000-0003-1853-533X
Jonathan F Mosser http://orcid.org/0000-0001-9093-3186
David Watkins http://orcid.org/0000-0001-6341-9595

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