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Leveraging Sociodemographic, Digital Exposure, and Knowledge-Based Empowerment Factors to Improve Maternal Health Behaviour Among Married Women in Nigeria: A Cross-Sectional Analysis of the 2018 NDHS

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Research Article

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Abstract

Background

Maternal health behaviour is a key determinant of maternal and child health outcomes in Nigeria, yet disparities in the utilisation of essential services persist. While socioeconomic factors remain important predictors, the role of digital exposure and knowledge-based empowerment in shaping women's health-seeking behaviour is increasingly recognised. This study examines the influence of sociodemographic characteristics, digital exposure, and knowledge-based empowerment on maternal health behaviour among married women in Nigeria, with implications for achieving Sustainable Development Goals (SDGs) 3 and 5.

Methods

This study analysed cross-sectional data from the 2018 Nigeria Demographic and Health Survey (NDHS). The sample comprised 28,888 women aged 15–49 years who were married or cohabiting and had a recent birth at the time of data collection. Outcome variables were the number of antenatal care (ANC) visits and the place of delivery for the most recent birth. Explanatory variables included sociodemographic characteristics, digital exposure indicators, and knowledge-based empowerment measures. Multivariable logistic regression models were used to estimate adjusted associations.

Results

ANC utilisation was significantly associated with age, education, wealth, residence, region, religion, household size, employment, occupation, and partner's characteristics. Digital exposure variables (mobile phone ownership, internet use, frequency of use, and mobile financial transactions) were positively associated with ANC visits. Knowledge-based empowerment factors, including exposure to family planning information via SMS and social media, and key health knowledge indicators, were also significant predictors. Similar patterns were observed for place of delivery, with most sociodemographic, digital exposure, and knowledge-based empowerment variables significantly influencing the likelihood of facility-based delivery.

Conclusions

Digital exposure and knowledge-based empowerment complement traditional socioeconomic determinants of maternal health behaviour. Policies that expand digital access and strengthen women's health knowledge, alongside efforts to reduce structural inequalities, are essential for improving maternal health service utilisation and accelerating progress toward SDGs 3 and 5 in Nigeria.

Background

Health behaviour plays a critical role in determining health outcomes, particularly in maternal and reproductive health contexts. In many low- and middle-income countries (LMICs), health behaviours such as antenatal care (ANC) utilisation, facility-based delivery, immunisation uptake, and family planning adoption are essential determinants of maternal and child survival [1, 2]. Nigeria continues to face significant maternal and child health challenges despite improvements in healthcare infrastructure and policy interventions. Maternal mortality remains among the highest globally, with preventable complications during pregnancy and childbirth contributing significantly to poor health outcomes [3]. Addressing these challenges requires effective behaviour change interventions that encourage women to adopt positive health-seeking practices.

In recent years, digital technologies have emerged as powerful tools for influencing health behaviour and improving access to healthcare information. Information and Communication Technologies (ICTs), including mobile phones, internet platforms, and social media networks, have significantly expanded opportunities for disseminating health information and promoting behavioural change [4, 5]. These technologies have become particularly important in Nigeria, where geographic barriers, limited healthcare personnel, and infrastructural constraints often restrict access to traditional health education channels.

Mobile health (mHealth) interventions have demonstrated significant potential for improving maternal and child health outcomes. Through mechanisms such as SMS reminders, mobile health applications, and digital health education platforms, mHealth initiatives enable the dissemination of timely and relevant health information to women of reproductive age [6, 7]. Empirical studies indicate that women who receive digital health messages are more likely to attend antenatal care appointments, adopt safer childbirth practices, and comply with immunisation schedules [8]. Consequently, digital technologies have become important instruments for behaviour change communication in maternal health programs.

Digital exposure, defined as access to and engagement with digital technologies such as mobile phones, the internet, and online communication platforms, plays a critical role in shaping health behaviour. Through digital exposure, women can access information related to pregnancy care, family planning, nutrition, and child health, enabling them to make informed decisions about their well-being [9, 10]. Exposure to digital health information also strengthens women's awareness of health risks and available healthcare services, which can motivate preventive health actions.

Despite the rapid expansion of digital technologies in Nigeria, significant inequalities remain in access and utilisation. Nigeria has one of the largest telecommunications markets in Africa, with mobile phone penetration exceeding 103 percent of the population by 2023 [11]. However, gender disparities in digital access remain pronounced. The GSMA Mobile Gender Gap Report indicates that only about two-thirds of Nigerian women own mobile phones compared to more than four-fifths of men [12]. Furthermore, women are significantly less likely to access mobile internet services due to affordability constraints, limited digital literacy, and socio-cultural restrictions. These disparities highlight the importance of

considering sociodemographic characteristics when designing behaviour change interventions. Factors such as age, education, wealth status, residence, marital dynamics, and household characteristics influence women's ability to access digital technologies and utilise them effectively for health purposes [13, 14]. Married women in rural or economically disadvantaged communities often face additional barriers including limited financial autonomy, restricted decision-making power, and lower levels of formal education [15].

Beyond access to digital technologies, women's ability to translate health information into meaningful behavioural change depends on their level of empowerment. Knowledge-based empowerment refers to the acquisition of knowledge, confidence, and decision-making capacity that enables individuals to act on health information and adopt healthy practices [16, 17] Digital exposure can enhance such empowerment by providing women with accessible health information and strengthening their ability to participate in healthcare decisions. Understanding the relationships among sociodemographic characteristics, digital exposure, knowledge-based empowerment, and health behaviour is therefore critical for designing effective behaviour change interventions.

Furthermore, harnessing these relationships has important implications for achieving global development objectives. Digital health interventions contribute to Sustainable Development Goal (SDG) 3, which aims to ensure healthy lives and promote well-being for all, particularly by reducing maternal and child mortality [18]. At the same time, expanding women's digital access and empowerment supports SDG 5, which seeks to achieve gender equality and empower all women and girls [19]. Despite increasing attention to digital health in Nigeria, limited studies have examined how sociodemographic factors, digital exposure, and knowledge-based empowerment interact to influence health behaviour among married women. Thus, this study investigates how these three domains interact to predict health behaviour among married women in Nigeria and how these relationships can inform health behaviour change interventions necessary to attain SDGs 3 and 5 in Nigeria by 2030 [20].

Theoretical Framework

The Technology Acceptance Model (TAM) provides a framework for understanding individuals' adoption of digital technologies [21]. According to TAM, technology adoption is influenced primarily by two perceptions: perceived usefulness and perceived ease of use. In the context of digital health interventions, perceived usefulness refers to women's belief that digital platforms can improve their access to health information and healthcare services. Perceived ease of use refers to the extent to which women perceive digital technologies as simple and accessible [22]. When women perceive digital tools as useful and easy to use, they are more likely to adopt them for health-related purposes.

The Health Belief Model (HBM) explains how individuals' perceptions influence their health behaviour [23]. The model suggests that behaviour is influenced by perceived susceptibility to illness, perceived severity of health risks, perceived benefits of preventive actions, and perceived barriers to health

behaviour. Digital platforms can influence these perceptions by providing timely health information that highlights maternal health risks and promotes preventive care practices [24].

The Social Determinants of Health (SDOH) framework emphasises that health outcomes are shaped by social and economic conditions such as income, education, employment, and living environment [25]. These factors influence individuals' ability to access healthcare services and adopt healthy behaviours. In Nigeria, these determinants intersect with digital access. Women with higher education and income levels are more likely to access digital health information and utilise digital health services [26].

Intersectionality theory highlights how overlapping social identities such as gender, socioeconomic status, and geographic location interact to create multiple layers of disadvantage [27]. In Nigeria, married women often face intersecting barriers including gender norms, limited financial autonomy, and restricted digital access [15]. Applying an intersectional perspective helps explain disparities in digital health adoption and highlights the need for inclusive behaviour change interventions that address these structural inequalities.

Review of Empirical Literature

Sociodemographic characteristics significantly influence digital access and utilisation. Education, income, age, and geographic location are among the most important predictors of mobile phone ownership and internet use [13, 14]. Women with higher educational attainment and stable income sources are more likely to own smartphones and engage with digital platforms. Urban residents also tend to have greater digital access due to better telecommunications infrastructure [28]. Gender disparities in digital access remain a major challenge across many African countries. Research indicates that women are consistently less likely than men to own mobile phones and access digital services [12, 29]. These inequalities reduce women's exposure to digital health information and limit the potential impact of digital health interventions.

Digital technologies have become important tools for health promotion and behaviour change communication. Mobile phones, internet platforms, and social media networks enable health authorities to disseminate health messages rapidly and at relatively low cost [2, 5]. In Nigeria, studies show that SMS reminders and mobile applications significantly improve antenatal care attendance and adherence to maternal health guidelines [6, 7]. Studies show that mobile messaging interventions significantly increased facility-based deliveries among women in Cross River State [8]. However, the effectiveness of digital behaviour change interventions depends largely on users' level of digital exposure and their ability to access and interpret digital health information.

Digital technologies can enhance women's empowerment by providing access to health information that strengthens their knowledge and decision-making capacity. Knowledge-based empowerment occurs when individuals gain sufficient information and confidence to make informed choices regarding their health and well-being [16]. Studies show that exposure to digital health information increases women's awareness of maternal health risks and improves their understanding of preventive healthcare practices

[30]. Mobile health programs that provide health education messages have been shown to improve maternal health literacy and encourage proactive health behaviours. However, digital empowerment depends not only on access to devices but also on digital literacy and social support. Women who lack digital skills may not fully benefit from digital health interventions even if they own mobile phones [31].

Knowledge-based empowerment plays a crucial role in shaping health behaviour. Women who possess adequate health knowledge are more likely to seek preventive healthcare services and adopt recommended health practices [17]. Empirical studies show that maternal health education programs significantly improve antenatal care attendance, skilled birth attendance, and child health practices [32]. By strengthening women's knowledge and decision-making capacity, empowerment initiatives can promote sustained behavioural change, although empowerment outcomes are also influenced by broader social and cultural factors such as gender norms, household decision-making dynamics, and access to financial resources [15].

Methods

Data Source and Study Population

This study utilises data from the 2018 Nigeria Demographic and Health Survey (NDHS), conducted by the National Population Commission (NPC) in collaboration with ICF International under the Demographic and Health Surveys Program. The NDHS 2018 provides nationally representative data on population, maternal and child health, fertility, and related demographic and socioeconomic indicators. The survey covered all 36 states of Nigeria and the Federal Capital Territory (FCT), encompassing 774 Local Government Areas (LGAs) and 74 strata defined by urban–rural residence and geopolitical zones.

A stratified two-stage cluster sampling design was employed using enumeration areas (EAs) from the 2006 census as the sampling frame. In the first stage, 1,400 EAs were selected with probability proportional to size (PPS). In the second stage, 30 households were systematically selected from each EA, resulting in a total of 42,000 households initially targeted. Data collection was completed in 1,389 clusters, yielding 40,427 successfully interviewed households, with a household response rate of 99%. Within these households, 41,821 women aged 15–49 years were successfully interviewed, achieving a response rate of approximately 99%. Of the 41,821 women interviewed, 28,888 (69 per cent) reported being married or living with a partner and are the focus of this study.

Study Variables

The analysis focuses on women of reproductive age (15–49 years) who had a live birth within the five years preceding the survey. The primary outcome variables are maternal health behaviours operationalized as: (i) use of antenatal care (ANC) services, measured as the number of visits during pregnancy (coded as six or more visits versus five or fewer or none, consistent with global monitoring

indicators); and (ii) place of delivery, captured as a dichotomous variable indicating health facility delivery versus home or non-facility delivery [33, 34].

Explanatory variables are grouped into three domains. Sociodemographic characteristics include age, education, household wealth index, place of residence, region, marital status, religion, household size, employment status, and partner's education [35–37]. Digital exposure indicators include mobile phone ownership, internet use, frequency of internet use, use of mobile phone for financial transactions, and exposure to family planning information via SMS or social media [38]. Health knowledge variables include awareness of maternal and child health services and knowledge of key health practices (knowledge of the ovulatory cycle, belief that preventive medicine keeps the mother and baby healthy, and belief that malaria can be fully cured by medicine), which are important drivers of health service uptake in LMIC contexts [39, 40].

Statistical Analysis

All analyses applied the NDHS sampling weights to account for the complex survey design and ensure nationally representative estimates. Descriptive statistics summarise respondents' characteristics and the distribution of key variables. Bivariate analyses using chi-square tests assess associations between explanatory variables and maternal health outcomes. Binary logistic regression models were subsequently fitted to examine the independent associations of sociodemographic factors, digital exposure, and health knowledge with ANC utilization and facility delivery, controlling for potential confounders. Clustering at the EA level and stratification by region and urban–rural residence are explicitly accounted for in the regression models.

Data management and statistical analysis were conducted using IBM SPSS Statistics (Version 27). The thresholds for statistical significance were set at $p < 0.001$, $p < 0.01$, and $p < 0.05$.

Model Specification

This study specifies two empirical models with health behaviour as the dependent variable and sociodemographic, digital exposure, and health knowledge factors as independent variables:

Model 1 (Use of ANC): $UseANC = \beta_0 + \beta_1 Age + \beta_2 Edu + \beta_3 WIndex + \beta_4 Resid + \beta_5 Reg + \beta_6 MSt + \beta_7 Relig + \beta_8 NHHMem + \beta_9 EmpStat + \beta_{10} OccupCat + \beta_{11} HPAge + \beta_{12} HPEduc + \beta_{13} MPOwn + \beta_{14} UseInter + \beta_{15} FreInterUse + \beta_{16} UseMPFin + \beta_{17} HFPSMS + \beta_{18} HFPSocMed + \beta_{19} HORSol + \beta_{20} KnoOvuC + \beta_{21} PreMedKMH + \beta_{22} PreMedKBH + \beta_{23} MalFulCMed + \varepsilon$

Model 2 (Place of Delivery): $PlacDel = \alpha_0 + \alpha_1 Age + \alpha_2 Edu + \alpha_3 WIndex + \alpha_4 Resid + \alpha_5 Reg + \alpha_6 MSt + \alpha_7 Relig + \alpha_8 NHHMem + \alpha_9 EmpStat + \alpha_{10} OccupCat + \alpha_{11} HPAge + \alpha_2 HPEduc + \alpha_{13} MPOwn + \alpha_{14} UseInter + \alpha_{15} FreInterUse + \alpha_{16} UseMPFin + \alpha_{17} HFPSMS + \alpha_{18} HFPSocMed + \alpha_{19} HORSol + \alpha_{20} KnoOvuC + \alpha_{21} PreMedKMH + \alpha_{22} PreMedKBH + \alpha_{23} MalFulCMed + \mu$

Where UseANC = use of antenatal care services (6 + visits); PlacDel = place of delivery (health facility); SocDemo = sociodemographic factors (Age, Edu, WIndex, Resid, Reg, MSt, Relig, NHHMem, EmpStat, OccupCat, HPAge, HPEduc); DigExp = digital exposure (MPOwn, UseInter, FreInterUse, UseMPFin); HeaInfo = health information access (HFPSMS, HFPSocMed, HORSol); HeaKno = health knowledge (KnoOvuC, PreMedKMH, PreMedKBH, MalFulCMed); ε, μ = error terms.

Results

Sample Description

Table 1
Sample frequency distribution of study participants by sociodemographic, digital exposure, health information, and health knowledge variables (2018 NDHS; n = 28,888)

Variable	Freq	Valid %	Variable	Freq	Valid %
Sociodemographic Characteristics			**Internet Use Frequency**		
Age of the Woman			Not at all	26,365	91.3
29 or younger	12,112	41.9	At least once or more a week	2,523	8.7
30 to 39	10,092	34.9	Use of Mobile Phone for Financial Transactions		
40 or older	6,684	23.2	No or missing	25,306	87.6
Highest Level of Education			**Yes**		
No education/Primary	17,535	60.7	Yes	3,582	12.4
Wealth Index – Quintile			**Health Information Access Measures**		
Poorest	6,395	22.1	Heard of Family Planning via SMS: No	28,023	97.0
Poorer	6,267	21.7	Heard of Family Planning via SMS: Yes	865	3.0
Middle	5,853	20.3	Heard of Family Planning via Social Media: No	27,901	96.6
Richer	5,531	19.1	Heard of Family Planning via Social Media: Yes	987	3.4
Richest	4,842	16.8	Heard of ORS: Never heard of ORS	4,161	14.4
Residence			**Heard of or used ORS**		
Rural	18,485	64.0	Heard of or used ORS	24,727	85.6
Geopolitical Region			**Health Knowledge**		
North Central	5,268	18.2	Knowledge of Ovulatory Cycle: Don’t know	887	3.1
North East	5,668	19.6	Wrong answers	12,135	42.0
North West	8,115	28.1	Correct answer	15,866	54.9
South East	3,207	11.1	Preventive Medicine Keeps Mother Healthy: Agree	27,454	95.0

Variable	Freq	Valid %	Variable	Freq	Valid %
Sociodemographic Characteristics			**Internet Use Frequency**		
South South	2,962	10.3	Preventive Medicine Keeps Baby Healthy: Agree	27,453	95.0
South West	3,668	12.7	Malaria Can Be Fully Cured by Medicine: Agree	25,766	89.2
Religion			**Use of Antenatal Care Services**		
Traditionalist and Other	230	0.8	Don’t know/Other	13,548	46.9
Islam	16,396	56.8	5 or less visits	8,315	28.8
Catholic	2,633	9.1	6 or more visits	7,025	24.3
Other Christian	9,629	33.3	Place of Delivery		
Number of Household Members					
7 or more	11,391	39.4	Home/Other/Missing	20,573	71.2
5 to 6	7,870	27.2	Private facility	2,502	8.7
4 or less	9,627	33.3	Public facility	5,813	20.1
Employment and Partner Characteristics			**Digital Exposure Indicators**		
Employed	20,264	70.1	Mobile Phone Ownership: No	13,674	47.3
Professional/Technical/Managerial	1,677	5.8	Mobile Phone Ownership: Yes	15,214	52.7
Partner aged 40 or older	16,633	57.6	Internet Use: Never used	25,932	89.8
Partner: No educ./Primary	14,632	50.7	Internet Use: Used (last 12 months+)	2,956	10.2

Table 1 presents the percentage distribution of the study participants by sociodemographic characteristics, digital exposure, and health information access. The majority of the women were aged 29 or younger (41.9%), had no education or only primary-level education (60.7%), and belonged to the middle/poorer/poorest wealth quintiles (64.1%). The majority resided in rural areas (64.0%), were from the northern region (65.9%), and were Muslim (56.8%). Of the 52.7% of women who owned a mobile phone, only 10.2% had used the internet in the last 12 months, while just 12.4% used a mobile phone for financial transactions. Only 3.0% heard of family planning via SMS and 3.4% via social media. Over half (54%) reported correct knowledge of the ovulatory cycle, and overwhelming majorities agreed that preventive medicine keeps the mother healthy (95%) and the baby healthy (95%). Most respondents

(89.2%) agreed that malaria can be fully cured by medicine. A small proportion (24.3%) used ANC services at least six times in their last pregnancy, and 28.8% reported using a health facility for their last childbirth.

Bivariate Results

Table 2
Chi-square association between health behaviour outcomes and sociodemographic, digital exposure, and health knowledge factors

Variable / Subcategory	ANC < 6 visits or none (%)	ANC 6 + visits (%)	Non-facility delivery (%)	Health facility delivery (%)	p-value
Age of Woman (p = 0.000)					
29 or younger	41.2	44.3	40.4	45.7	
30 to 39	32.0	44.1	31.6	43.3	
40 or older	26.8	11.7	28.1	11.0	0.000
Education (p = 0.000)					
No education/Primary	69.1	34.5	72.0	32.7	
Secondary	24.6	48.2	22.6	49.4	
Higher	6.3	17.4	5.4	17.9	0.000
Wealth Index (p = 0.000)					
Poorest	26.6	8.4	28.3	6.9	
Poorer	24.2	13.9	25.0	13.5	
Middle	20.0	21.1	19.5	22.2	
Richer	16.7	26.7	15.7	27.6	
Richest	12.5	30.0	11.5	29.7	0.000
Residence (p = 0.000)					
Rural	69.3	47.5	70.8	47.1	
Urban	30.7	52.5	29.2	52.9	0.000
Region (p = 0.000)					
North Central	18.3	18.0	16.5	22.5	
North East	22.9	9.3	22.3	12.9	
North West	33.0	12.8	34.8	11.4	
South East	8.5	19.1	7.3	20.5	
South South	9.0	14.3	10.1	10.7	
South West	8.3	26.5	8.9	22.0	0.000
Religion (p = 0.000)					

Variable / Subcategory	ANC < 6 visits or none (%)	ANC 6 + visits (%)	Non-facility delivery (%)	Health facility delivery (%)	p-value
Islam/Traditionalist/Other	63.9	37.7	65.2	38.7	
All Christians	36.1	62.3	34.8	61.3	0.000
Household Size (p = 0.000)					
7 or more	42.3	30.4	42.6	31.5	
5 to 6	25.4	33.0	25.1	32.5	
4 or less	32.3	36.5	32.2	36.0	0.000
Employment Status (p = 0.000)					
Unemployed	32.6	21.5	32.6	23.2	
Employed	67.4	78.5	67.4	76.8	0.000
Partner Education (p = 0.000)					
No education/Primary	57.9	28.1	60.6	26.1	
Secondary	29.3	47.7	28.1	48.1	
Higher	12.8	24.1	11.4	25.9	0.000

Table 2 presents statistical associations between health behaviour outcomes and sociodemographic characteristics. Use of ANC services (six or more visits) and health facility delivery were significantly associated with all sociodemographic variables examined, including age, education, wealth index, place of residence, geopolitical region, religion, number of household members, employment status, occupation category, partner's age, and partner's education (all p-values = 0.000).

Multivariate Results

Table 3

Adjusted odds ratios (OR) and 95% confidence intervals (CI) for the associations between sociodemographic, digital exposure, and health knowledge factors and maternal health behaviour outcomes (ANC utilisation and place of delivery)

Variable	Model 1: ANC (6 + visits) OR (95% CI)	p	Model 2: Place of Delivery (Health Facility) OR (95% CI)	p
Sociodemographic Characteristics				
Age of the Woman				
29 or younger (ref)	1.00		1.00	
30 to 39	0.92 (0.85, 1.00)	.047	0.91 (0.84, 0.98)	.018
40 or older	0.29 (0.26, 0.32)	.000	0.25 (0.23, 0.28)	.000
Education				
No education/Primary (ref)	1.00		1.00	
Secondary	1.34 (1.23, 1.45)	.000	1.65 (1.53, 1.79)	.000
Higher	1.78 (1.54, 2.05)	.000	2.29 (1.99, 2.64)	.000
Wealth Index				
Poorest (ref)	1.00		1.00	
Poorer	1.31 (1.17, 1.47)	.000	1.65 (1.47, 1.85)	.000
Middle	1.49 (1.32, 1.68)	.000	2.27 (2.02, 2.56)	.000
Richer	1.52 (1.33, 1.73)	.000	2.42 (2.13, 2.75)	.000
Richest	1.66 (1.44, 1.92)	.000	2.67 (2.31, 3.08)	.000
Residence				
Rural (ref)	1.00		1.00	

Note: Significance levels p ≤ .1, p ≤ .05, p ≤ .01, p ≤ .001. ANC model: Chi-square = 5764.423; -2 Log likelihood = 26284.990; Nagelkerke R^2 = 0.270. POD model: Chi-square = 7671.022; -2 Log likelihood = 27006.277; Nagelkerke R^2 = 0.334. ANC = antenatal care; CI = confidence interval; NDHS = Nigeria Demographic and Health Survey; OR = odds ratio; ORS = oral rehydration solution; POD = place of delivery; ref = reference category.

Variable	Model 1: ANC (6 + visits) OR (95% CI)	p	Model 2: Place of Delivery (Health Facility) OR (95% CI)	p
Urban	1.15 (1.07, 1.24)	.000	1.18 (1.10, 1.27)	.000
Geopolitical Region				
North Central (ref)	1.00		1.00	
North East	0.53 (0.47, 0.59)	.000	0.64 (0.57, 0.70)	.000
North West	0.52 (0.47, 0.58)	.000	0.35 (0.32, 0.39)	.000
South East	1.91 (1.70, 2.14)	.000	1.63 (1.45, 1.82)	.000
South South	1.46 (1.30, 1.63)	.000	0.54 (0.49, 0.61)	.000
South West	2.75 (2.48, 3.05)	.000	1.31 (1.18, 1.45)	.000
Religion				
Islam/Traditionalist/Other (ref)	1.00		1.00	
All Christians	1.10 (1.01, 1.20)	.038	1.14 (1.05, 1.24)	.020
Number of Household Members				
7 or more (ref)	1.00		1.00	
5 to 6	0.94 (0.87, 1.02)	.115	0.91 (0.84, 0.98)	.013
4 or less	0.67 (0.61, 0.72)	.000	0.62 (0.57, 0.67)	.000
Employment Status				
Unemployed (ref)	1.00		1.00	
Employed	1.13 (1.04, 1.23)	.006	1.12 (1.03, 1.21)	.009
Occupation Category				

Note: Significance levels p ≤ .1, p ≤ .05, p ≤ .01, p ≤ .001. ANC model: Chi-square = 5764.423; -2 Log likelihood = 26284.990; Nagelkerke R^2 = 0.270. POD model: Chi-square = 7671.022; -2 Log likelihood = 27006.277; Nagelkerke R^2 = 0.334. ANC = antenatal care; CI = confidence interval; NDHS = Nigeria Demographic and Health Survey; OR = odds ratio; ORS = oral rehydration solution; POD = place of delivery; ref = reference category.

Variable	Model 1: ANC (6 + visits) OR (95% CI)	p	Model 2: Place of Delivery (Health Facility) OR (95% CI)	p
Manual/Agricultural/Other (ref)	1.00		1.00	
Clerical/Sales/Services	1.02 (0.95, 1.10)	.553	0.95 (0.88, 1.02)	.180
Professional/Technical/Managerial	0.98 (0.86, 1.12)	.800	0.83 (0.72, 0.95)	.006
Partner's Age				
29 or younger (ref)	1.00		1.00	
30 to 39	1.07 (0.96, 1.19)	.242	1.11 (1.00, 1.24)	.059
40 or older	0.84 (0.74, 0.96)	.008	0.83 (0.73, 0.94)	.003
Partner's Education				
No education/Primary (ref)	1.00		1.00	
Secondary	1.34 (1.24, 1.46)	.000	1.54 (1.42, 1.67)	.000
Higher	1.50 (1.34, 1.67)	.000	1.84 (1.65, 2.04)	.000
Digital Exposure Factors				
Mobile Phone Ownership				
No (ref)	1.00		1.00	
Yes	1.30 (1.20, 1.40)	.000	1.34 (1.24, 1.45)	.000
Internet Use				
Never used (ref)	1.00		1.00	
Used (last 12 months or earlier)	1.33 (1.08, 1.64)	.009	1.06 (0.85, 1.31)	.605
Internet Use Frequency				
Not at all (ref)	1.00		1.00	

Note: Significance levels p ≤ .1, p ≤ .05, p ≤ .01, p ≤ .001. ANC model: Chi-square = 5764.423; -2 Log likelihood = 26284.990; Nagelkerke R^2 = 0.270. POD model: Chi-square = 7671.022; -2 Log likelihood = 27006.277; Nagelkerke R^2 = 0.334. ANC = antenatal care; CI = confidence interval; NDHS = Nigeria Demographic and Health Survey; OR = odds ratio; ORS = oral rehydration solution; POD = place of delivery; ref = reference category.

Variable	Model 1: ANC (6 + visits) OR (95% CI)	p	Model 2: Place of Delivery (Health Facility) OR (95% CI)	p
At least once or more a week	0.68 (0.55, 0.85)	.001	0.99 (0.79, 1.24)	.940
Use of Mobile Phone for Financial Transactions				
No or missing (ref)	1.00		1.00	
Yes	0.90 (0.81, 1.00)	.043	0.82 (0.74, 0.91)	.000
Health Information Access				
Heard of Family Planning via SMS				
No (ref)	1.00		1.00	
Yes	0.84 (0.70, 1.00)	.048	0.84 (0.70, 1.00)	.052
Heard of Family Planning via Social Media				
No (ref)	1.00		1.00	
Yes	1.26 (1.07, 1.50)	.007	1.24 (1.04, 1.47)	.017
Heard of Oral Rehydration Solution				
Never heard of ORS (ref)	1.00		1.00	
Heard of or used ORS	1.62 (1.47, 1.79)	.000	1.46 (1.33, 1.60)	.000
Health Knowledge				
Knowledge of the Ovulatory Cycle				
Else (ref)	1.00		1.00	
Correct answer	1.11 (1.05, 1.19)	.001	1.16 (1.09, 1.23)	.000
Preventive Medicine Keeps Mother Healthy				
Disagree or other (ref)	1.00		1.00	

Note: Significance levels p ≤ .1, p ≤ .05, p ≤ .01, p ≤ .001. ANC model: Chi-square = 5764.423; -2 Log likelihood = 26284.990; Nagelkerke R^2 = 0.270. POD model: Chi-square = 7671.022; -2 Log likelihood = 27006.277; Nagelkerke R^2 = 0.334. ANC = antenatal care; CI = confidence interval; NDHS = Nigeria Demographic and Health Survey; OR = odds ratio; ORS = oral rehydration solution; POD = place of delivery; ref = reference category.

Variable	Model 1: ANC (6 + visits) OR (95% CI)	p	Model 2: Place of Delivery (Health Facility) OR (95% CI)	p
Agree	1.35 (1.08, 1.67)	.007	1.65 (1.34, 2.03)	.000
Preventive Medicine Keeps Baby Healthy				
Disagree or other (ref)	1.00		1.00	
Agree	1.16 (0.94, 1.44)	.175	1.10 (0.90, 1.35)	.353
Malaria Can Be Fully Cured by Medicine				
Disagree/Don't know (ref)	1.00		1.00	
Agree	1.20 (1.08, 1.33)	.001	1.01 (0.91, 1.11)	.876

Note: Significance levels p ≤ .1, p ≤ .05, p ≤ .01, p ≤ .001. ANC model: Chi-square = 5764.423; -2 Log likelihood = 26284.990; Nagelkerke R² = 0.270. POD model: Chi-square = 7671.022; -2 Log likelihood = 27006.277; Nagelkerke R² = 0.334. ANC = antenatal care; CI = confidence interval; NDHS = Nigeria Demographic and Health Survey; OR = odds ratio; ORS = oral rehydration solution; POD = place of delivery; ref = reference category.

Table 3 presents two models showing adjusted odds ratios (OR) and 95% confidence intervals (CI) for associations between maternal health behaviour and their predictors. Model 1 examines ANC utilisation (six or more visits) and explains 27.0% of the variation (Nagelkerke $R^2 = 0.270$). Model 2 examines health facility delivery and explains 33.4% of the variation (Nagelkerke $R^2 = 0.334$).

With respect to ANC utilisation, odds were lower for older women (age 30–39: OR = 0.92, CI = 0.85–1.00; age 40+: OR = 0.29, CI = 0.26–0.32) and higher for women with secondary (OR = 1.34, CI = 1.23–1.45) or higher education (OR = 1.78, CI = 1.54–2.05). Wealthier women were more likely to use ANC services, with odds increasing progressively from poorer (OR = 1.31) to richest quintile (OR = 1.66). Urban residence (OR = 1.15), Christian religion (OR = 1.10), and employment (OR = 1.13) were positively associated with ANC utilisation. Regional variations were pronounced, with higher odds in the South West (OR = 2.75) and South East (OR = 1.91), and lower odds in North East (OR = 0.53) and North West (OR = 0.52) relative to North Central. Mobile phone ownership (OR = 1.30) and internet use (OR = 1.33) were positively associated with ANC visits. Women who had heard of family planning via social media (OR = 1.26) and had heard of or used oral rehydration solution (OR = 1.62) also had higher odds of adequate ANC. Knowledge of the ovulatory cycle (OR = 1.11), belief that preventive medicine keeps the mother healthy (OR = 1.35), and belief that malaria can be cured (OR = 1.20) were independently associated with higher ANC utilisation.

Similar patterns were observed for health facility delivery. Education, wealth, urban residence, and partner's education were all positively associated with facility delivery. Mobile phone ownership (OR =

1.34), exposure to family planning via social media (OR = 1.24), awareness of ORS (OR = 1.46), knowledge of the ovulatory cycle (OR = 1.16), and belief that preventive medicine keeps the mother healthy (OR = 1.65) were significantly associated with higher odds of facility delivery.

Discussion

The findings of this study demonstrate that digital exposure and knowledge-based empowerment are critical determinants of maternal health behaviour among married women in Nigeria. Specifically, access to health information and health knowledge significantly influence the utilisation of maternal health services such as antenatal care and health facility delivery. These findings reinforce the growing body of literature that emphasises the transformative role of digital technologies in promoting positive health behaviours in low- and middle-income countries [6, 2, 5].

The results further indicate that sociodemographic characteristics significantly shape maternal health behaviour in Nigeria. Variables such as age, education, wealth status, residence, geopolitical region, religion, household size, employment status, and partner's educational level were found to significantly influence women's use of antenatal care services. These findings align strongly with the Social Determinants of Health framework, which posits that health outcomes are influenced by structural conditions such as education, income, occupation, and geographic location [25, 26]. Women with higher socioeconomic status, greater educational attainment, and urban residence generally possess greater access to health services and health information, thereby increasing their likelihood of engaging in preventive health behaviours. The strong influence of wealth, education, and geographic region observed in this study further highlights persistent inequalities in access to digital health resources across Nigeria.

In contrast, women living in rural areas and economically disadvantaged communities, particularly in northern Nigeria, remain relatively marginalised. This pattern reflects the digital divide, which describes the unequal distribution of access to digital technologies across social groups [12, 29]. The digital divide has important implications for maternal health outcomes because women without access to digital technologies are less likely to receive health information that motivates preventive health behaviours. This finding emphasises the need for targeted digital inclusion initiatives that specifically address the needs of rural, low-income, and less-educated women in Nigeria.

The study findings demonstrate that digital exposure, including mobile phone ownership and internet use, is positively associated with both ANC utilisation and health facility delivery. Women who owned mobile phones had 1.30 times higher odds of adequate ANC utilisation and 1.34 times higher odds of facility delivery compared to those without phones. These findings are consistent with evidence from Nigeria and Sub-Saharan Africa showing that mobile phone ownership enhances women's access to maternal health information and facilitates timely utilisation of healthcare services [13, 4]. The positive association between mobile phone ownership and health facility delivery further suggests that mobile health (mHealth) interventions can be effective tools for promoting safe delivery practices.

Women who were exposed to digital health information, such as messages about family planning through SMS or social media and information about ORS, were significantly more likely to utilise ANC services. This aligns with evidence from DHS analyses in Sub-Saharan Africa showing that women exposed to health information through media and communication channels are more likely to attend recommended antenatal care visits [41–43]. Furthermore, access to health information enhances maternal health literacy and strengthens women's perception of the importance and benefits of preventive maternal healthcare services [44–46].

Knowledge-based empowerment indicators, such as knowledge of the ovulatory cycle, belief in the benefits of preventive medicine, and understanding that malaria can be cured, were independently associated with increased utilisation of ANC services [43, 47]. Broader health literacy, including understanding the importance of preventive medicine and recognising treatable conditions such as malaria, has been shown to improve women's perceptions of susceptibility to pregnancy-related complications and the benefits of skilled maternal care [48, 49].

Evidence from maternal health studies in LMICs shows that skilled birth attendants and access to emergency obstetric services are among the most effective interventions for preventing maternal and neonatal deaths [34, 50]. Evidence from Nigeria further highlights the importance of institutional delivery, as findings from NDHS studies show that a substantial proportion of births still occur outside health facilities [51, 52]. Multilevel analyses of the 2018 NDHS reveal that health facility delivery is strongly associated with prior ANC attendance, maternal education, and household wealth [52, 53]. Digital exposure and knowledge-based empowerment significantly increase women's likelihood of delivering in health facilities, suggesting that digital health interventions can play an important role in promoting safe childbirth practices.

From a policy perspective, these findings suggest that behaviour change interventions should focus on expanding digital inclusion among women. Programs that promote mobile phone ownership, increase internet access, and support digital literacy can significantly enhance women's exposure to health information [54–56]. Furthermore, initiatives that encourage women's use of mobile platforms for communication, financial transactions, and information seeking can strengthen their engagement with digital health services [11, 57]. Expanding women's digital access and literacy represents a critical pathway for enhancing health knowledge, promoting preventive health behaviours, and ultimately improving maternal health outcomes in developing countries [54, 55].

Conclusions

This study examined the associations between sociodemographic characteristics, digital exposure, knowledge-based empowerment, and maternal health behaviour among married women in Nigeria using the 2018 NDHS. The findings demonstrate that maternal health behaviour, particularly ANC utilisation and health facility delivery, is influenced by a complex interaction of structural, technological, and cognitive factors. Sociodemographic characteristics such as education, wealth status, residence, and

partner's educational level significantly shape women's access to healthcare services through digital exposure. Digital exposure, measured through mobile phone ownership, internet use, social media engagement, and mobile financial transactions, plays an important role in promoting positive maternal health behaviours. In addition, knowledge-based empowerment emerged as a critical pathway through which digital exposure influences health behaviour. Women who possess accurate reproductive health knowledge and positive beliefs about preventive medicine are more likely to utilise ANC services and deliver in health facilities.

These findings suggest that effective behaviour change interventions should adopt an integrated approach that combines digital health strategies with women's empowerment initiatives. Expanding digital access, promoting digital literacy, and strengthening women's access to reproductive health information can significantly improve maternal health outcomes. By harnessing the relationships between sociodemographic characteristics, digital exposure, and knowledge-based empowerment, policymakers and health practitioners can design more effective behaviour change interventions that improve maternal health and accelerate progress toward SDGs 3 and 5 in Nigeria by 2030 [18, 20].

Abbreviations

ANC
Antenatal care
AOR
Adjusted odds ratio
CI
Confidence interval
DHS
Demographic and Health Survey
EA
Enumeration area
FCT
Federal Capital Territory
HBM
Health Belief Model
ICT
Information and Communication Technology
LMIC
Low- and middle-income country
mHealth
Mobile health
NDHS
Nigeria Demographic and Health Survey
NPC

National Population Commission
OR
Odds ratio
ORS
Oral rehydration solution
POD
Place of delivery
PPS
Probability proportional to size
SDG
Sustainable Development Goal
SDOH
Social Determinants of Health
SMS
Short message service
SPSS
Statistical Package for the Social Sciences
TAM
Technology Acceptance Model.

Declarations

Ethics approval and consent to participate

This study is based on secondary analysis of publicly available, de-identified data from the 2018 Nigeria Demographic and Health Survey (NDHS), conducted by the National Population Commission (NPC) of Nigeria in collaboration with ICF International. Ethical approval for the NDHS was obtained by the survey administrators from the National Health Research Ethics Committee of Nigeria (NHREC) and the ICF Institutional Review Board. All participants provided written informed consent prior to participation in the original survey. As this study involves secondary analysis of anonymised data with no direct contact with human participants, additional ethics approval was not required. Data access was obtained through registration with the DHS Program (www.dhsprogram.com).

Consent for publication

Not applicable. This manuscript does not contain data from any individual person in any identifiable form.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

M.O. conceptualised the study, supervised the research, contributed to the theoretical framework, and reviewed and revised the manuscript. A.E. conducted the literature review, performed the data analysis, drafted the original manuscript, and prepared the final version for submission. All authors read and approved the final manuscript.

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Data Availability

The datasets analysed during the current study are publicly available through the DHS Program repository. Data can be requested and downloaded at no cost following registration at: https://dhsprogram.com/data/available-datasets.cfm

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