RESEARCH ARTICLE

Compliance towards WHO recommendations on antenatal care for a positive pregnancy experience: Timeliness and adequacy of antenatal care visit in Sub-Saharan African countries: Evidence from the most recent standard Demographic Health Survey data

Aklilu Habte[1]*, Aiggan Tamene[1], Tamirat Melis[2]

1 School of Public Health, College of Medicine and Health Sciences, Wachemo University, Hosanna, Ethiopia, 2 Department of Public Health, College of Medicine and Health Sciences, Wolkite University, Wolkite, Ethiopia

* akliluhabte57@gmail.com

Abstract

Background

Timely and adequate antenatal care (ANC) visits are known to reduce maternal mortality by 20%. Despite the World Health Organization updating its recommendations from four to eight antenatal care contacts, data reporting in the SSA region focused primarily on four visits, and evidence on the timing and adequacy of ANC based on the current recommendation was limited. Hence, this study aimed at assessing the level of timely and adequate ANC visits and their determinants in the 18 Sub-Saharan African countries with the most recent DHS report (2016–2021).

Methods

The data for this study were pooled from the most recent standardized Demographic and Health Survey data of sub-Saharan African countries from 2016–2021. A total of 171,183 (with a weighted frequency of 171,488) women were included and analyzed by using STATA version 16. To account for data clustering, a multivariable multilevel mixed-effect logistic regression analysis was run to determine the effects of each predictor on the receipt of timely and adequate ANC. Adjusted odds ratio with its corresponding 95% confidence interval was used to declare the statistical significance of the independent variables.

Results

The receipt of timely and adequate antenatal care visits was 41.2% (95% CI: 40.9, 41.4) and 10.4% (95% CI: 9.9, 10.2), respectively. Wontedness of pregnancy [AOR = 1.18; 95% CI: 1.13, 1.24], being 1st birth order [AOR = 1.48; 95% CI: 1.41, 2.54], having a mobile phone [AOR = 1.49; 95% CI: 1.26, 2.32], and enrolled in Health insurance schemes [AOR =

Abbreviations: AIC, Akaike's information criterion; ANC, Antenatal Care; AOR, Adjusted odds ratio; CSA, Central Statistical Agency; DHS, Demographic and health survey; EA, Enumeration area; EDHS, Ethiopian Demographic and Health Survey; ICC, Intra Class Correlation Coefficient; PCV, Proportional Change in Variance; PNC, Postnatal Care; PPP, Postpartum Period; SSA, Sub Saharan Africa.

2.03; 95% CI: 1.95, 2.42] were significantly associated with early initiation of ANC. Living in a lower community poverty level[AOR = 2.23; 95% CI: 1.90,2.66], being in the richest wealth quintile [AOR = 1.49; 95% CI: 1.36, 1.62], higher educational level [AOR = 3.63; 95% CI: 3.33, 3.96], the timing of ANC visit [AOR = 4.26; 95% CI: 4.08, 4.44], being autonomous in decision making [AOR = 2.29; 95% CI: 1.83, 2.54] and having a mobile phone [AOR = 1.89; 95% CI: 1.76, 2.52] were identified as significant predictors of adequate ANC uptake.

Conclusion

The findings revealed a low coverage of timely and adequate ANC visits in SSA countries. Governments and healthcare managers in sub-Saharan African countries should leverage their efforts to prioritize and implement activities and interventions that increase women's autonomy, and economic capability, to improve their health-seeking behavior during pregnancy. More commitment is needed from governments to increase mobile phone distribution across countries, and then work on integrating mHealth into their health system. Finally, efforts should be made to increase the coverage of health insurance schemes enrolment for the citizens.

Introduction

Maternal health refers to the health of women before pregnancy, all through pregnancy, intrapartum, and postpartum [1]. Sustainable Development Goal 3 (SDGs) emphasize maternal mortality reduction and improvements in women's health care, to reduce the global maternal mortality ratio (MMR) to 70 per 100,000 live births by 2030 [2, 3]. Despite progress and efforts, maternal and neonatal mortality and morbidity remain major public health concerns in low-income countries [4]. Low and middle-income countries(LMICs) accounted for 94% of all maternal deaths, of Sub-Saharan Africa (SSA) accounted for roughly two-thirds of all maternal deaths [4]. Despite having a very high MMR in 2017, this region has achieved a nearly 40% reduction in MMR since 2000 [5]. Complications during pregnancy, delivery, and the postpartum period are the leading causes of those death and disabilities among women of childbearing age in this region [6, 7].

Modifiable risk factors(undiagnosed infections, high blood pressure, diabetes), and other pre-existing health conditions frequently complicate pregnancy and endanger both mothers' and newborns' lives [8]. However, the majority of those adverse maternal and perinatal outcomes can be prevented by providing cost-effective interventions [6] like high-quality Antenatal care (ANC), which is defined by early initiation, and an adequate number of visits [9, 10]. ANC is one of the four pillars of WHO's safe motherhood initiative [11, 12]. Timely and regular ANC from a skilled provider reduces maternal mortality by 20% [13, 14]. It improves pregnancy outcomes by preventing, detecting, and treating danger signs early on through a series of scheduled visits [15]. It also serves as a gateway to maternal and child health services and provides an opportunity to organize the services required to ensure a healthy pregnancy, safe delivery, and a healthy mother-baby pair [16].

Early or timely initiation, accompanied by regular and adequate visits, has a significant impact on both maternal and fetal health [17]. The recent (2016) WHO recommendations on ANC for a positive pregnancy experience suggest a shift from a focused ANC model with a recommended minimum of four ANC visits (ANC4+) to a more expansive model emphasizing

contact number, timing, and content of care [18, 19]. This model recommends at least eight ANC contacts, with the first and eighth contacts occurring within the 12th and at 40th weeks of gestation, respectively [17, 18]. The increase from four to eight ANC contacts emphasizes the critical need of women who initiate ANC late, as they are less likely to meet the new recommended threshold for a positive pregnancy experience [20]. The first ANC occurring within the first trimester of pregnancy is described as the timely initiation of ANC [18, 21].

Although achieving the previously recommended ANC4+ has been a priority indicator for monitoring maternal health and has been widely reported [3, 22], timely first ANC is not widely reported or emphasized [20, 23]. The global coverage of at least one skilled ANC contact remains high at 86% [24], but the timely initiation of ANC is found to be low [20]. A recent study conducted in LMICs showed that 44.3% of all women had timely ANC initiation; 11.3% achieved ANC8+ [20]. Coverage of timely ANC initiation in low-income countries in 2013 was 24.0%, compared to 81.9% in high-income countries [21]. As per a DHS analysis of Uganda(2010) [25], and Ethiopia(2016) [26], 38.9% and 20.0% of women had a timely first ANC visit, respectively. Regarding the adequacy of ANC visits, analysis of Demographic and Health Survey (DHS) data from eight SSA countries found that only 7.7% of women complied with the new recommendation of at least eight visits [27]. Analysis of DHS data of Bangladesh [28] and Nigeria [29] showed only 6.0 and 17.4% of women made at least eight contacts, respectively. Financial constraints, distance to health facilities, cultural and religious beliefs around disclosure of pregnancy status, gender norms, lack of awareness of pregnancy signs and antenatal care schedules, pregnancy wantedness, perceptions on the need to start ANC early, and quality of care received were factors known to influence the timing and adequacy of ANC [20, 27, 28, 30–33].

Despite the World Health Organization (WHO) updating its recommendations from four to eight antenatal care contacts, data reporting in the SSA region focused primarily on four visits, and evidence on the timing and adequacy of ANC based on the current recommendation was limited [24]. As a result, more research is needed to characterize the number of women who commence ANC on time, the level of receiving recommended visits, the regions that are falling behind, and what it will take to improve the service uptake to meet the revised WHO guidelines. Hence, this study aimed at assessing the level of timely and adequate ANC visits and their determinants in the 18 SSA countries with the most recent DHS report(2016–2021). The findings of this study will be useful to service providers, policymakers, and programmers in their efforts to reduce maternal and child mortality by developing effective interventions to improve the quality of ANC.

Methods

Data source, population, and study period

This study was based on the most recent standardized DHS data from eighteen SSA countries. The DHS is a national survey that is carried out in 90 countries to collect data on basic health indicators. Data for each country were stored in men (MR), women (IR), children (KR), births (BR), and households (HR) files, and data for this study were obtained from the women (IR) file. The selected IR file contains information gathered about pregnancy, delivery, postnatal care, immunization, health, and nutrition. During the data inclusion process, the following criteria were considered: countries with recent standardized DHS reports conducted from 2016 to 2020, and countries with complete cases on the variables of interest (Table 1). Data of the study participants were accessed on November 23, 2022 from DHS office with a reasonable request. A total of 171,488 weighted women who had complete information on the uptake of at least one ANC visit were considered for the current study, and the entire analyses were

Table 1. Description of the SSA countries included in the analysis with their respective sample size, 2016–2021.

Regions	DHS Year	Weighted sample size [n(%)]	Timely ANC [n(%)]	Adequate ANC [n(%)]
Central Region	**2016–2018**	**18,229(10.6)**	**8,723(47.8)**	**1,654(9.1)**
Angola	2016	6,859(4.00)	3,360(49.0)	646(9.4)
Cameroon	2018	11,370(6.6)	5,364(47.2)	1,008(5.9)
Eastern Region	**2016–2021**	**70,851(41.4)**	**29,443(41.6)**	**1,498(2.1)**
Burundi	2017	8,827(5.1)	4,205(47.6)	42(0.5)
Ethiopia	2016	4,757(2.8)	1,540(32.4)	156(3.3)
Madagascar	2021	8,194(4.8)	2,843(34.7)	199(2.4)
Malawi	2017	13,172(7.7)	4,575(44.2)	191(1.4)
Rwanda	2020	6,158(3.6)	3,695(60.0)	16(0.3)
Uganda	2016	9,902(5.8)	2,926(29.5)	187(1.9)
Zambia	2018	7,182(4.2)	2,654(37.0)	91(1.3)
Mauritania	2020	12,659(7.4)	8,377(66.2)	191(1.4)
Western Region	**2018–2020**	**79,645(46.4)**	**31,059(39.0)**	**14,191(17.8)**
Benin	2018	7,814(4.5)	4,398(56.3)	809(10.4)
Gambia	2020	10,611(6.2)	4,552(42.9)	444(4.2)
Guinea	2018	4,548(2.6)	1,470(32.3)	172(3.8)
Liberia	2021	7,768(4.5)	5,605(72.1)	2,101(27.0)
Mali	2018	10,348(6.1)	4,574(44.2)	442(4.3)
Nigeria	2018	32,228(18.8)	7,662(23.8)	8,612(26.7)
Sierra Leone	2020	6,327(3.7)	2,796(44.2)	1,611(25.4)
Southern region	**2016**	**2,763(1.6)**	**1,387(50.2)**	519(18.8)
South Africa	2016	2,763(1.6)	1,387(50.2)	519(18.8)
Total	**2016–2021**	**171,488**	**70,613(41.2)**	**17,863(10.4)**

https://doi.org/10.1371/journal.pone.0294981.t001

conducted on them. Due to a lack of information on service uptake, a total of 10,971 respondents were excluded from the analysis (Missing values).

Data collection tool and procedure

The data was collected through face-to-face interviews by trained data collectors using structured questionnaires developed in the official language of each country. A two-stage cluster sampling approach was used to choose respondents for the DHS survey. The initial phase was selecting sample locations (clusters) comprised of enumeration areas (EAs). The second stage was a systematic sample of houses. A household listing operation was done in each of the designated EAs, and households to be included in the survey were selected at random from the list. Finally, this study considered combined DHS data from 18 SSA countries, with a weighted sample of 171,488 reproductive-age women who had at least one child within five years preceding the survey. The detailed sampling technique used during DHS is discussed in the Demographic and Health Survey Sampling and Household Listing Manual developed by ICF International [34].

Measurement of variables of the study

Outcome variables: the study has two outcome variables:

The first outcome variable: Was the timing of ANC commencement which was assessed by the question "When was your first antenatal check (in a month)?" the responses were converted into binary outcomes, as early and Late initiation. Women who received their first ANC

visit within the first 3 months (or 12 weeks after the onset of pregnancy) were categorized as "Early = 1", otherwise "Late = 0" [18].

The second outcome variable: Was the uptake of adequate ANC visits which was assessed by the question "How many times did you receive ANC visits throughout your last pregnancy?' The responses ranged from 1–20 visits and were then dichotomized into "Adequate = 1" (if a mother got at eight and more visits) and "Inadequate = 0" "if the mother got fewer than eight visits" [18].

Explanatory variables. Based on a review of the recent literature, variables with theoretical and practical significance in ANC uptake were extracted from the dataset and categorized into individual and community-level factors (Table 2).

Table 2. List of the individual- and community-level factors that affect the timing and adequacy of ANC, in SSA countries 2016–2021.

Individual-level factors	
variables	Description
Maternal age	15–24, 25–34, 35 and above
Marital status	In marital relations, live with a partner, in non-marital relation
Women's and husbands' education	No education*, primary, secondary and higher education
Occupation	Employed and unemployed*
Wealth index	Richest, richer, middle, porer, poorest*
Family size	≤5memeber, >5 memeber*
Sex of head of Household	Female, male*
Parity	Nulliparous, primiparous, multiparous, Grand multiparous*
Birth order	1, 2, 3, 4 and ≥5*
Pregnancy status	Wanted then, wanted later, wanted no more*
Termination of pregnancy	Yes, no*
Contraceptive utilization	Yes, no*
Decision-making capacity[a]	Autonomous, non-autonomous*
Frequency of reading a newspaper, listening to the radio, and watching television	Almost every day, at least once a week, less than once a week, not at all*
Distance to a health facility	Not a big problem, big problem*
Getting permission to go to a health facility for medical care	Not a big problem, big problem*
Getting money needed for treatment	Not a big problem, big problem*
Having a mobile phone	Yes, no*
Being member of health insurance schemes	Yes, no*
Community-level factors	
Residence	Urban, rural*
Region	Southern, Central, Western, Eastern*
Community level poverty	Low, moderate, high*
	*Reference for the categories

[a] **Autonomy in decision-making:** Was measured using three constructs: (i) health care (healthcare autonomy), (ii.) major household purchases (economic autonomy), and (iii.) visits to friends or family (movement autonomy). A score of one (= 1) was assigned if women could decide alone or in collaboration with their husbands, whereas a score of zero (= 0) was assigned if a husband's decision was made alone or in collaboration with others. After all, a composite index was created and had a minimum and maximum value of 0 and 3, respectively. Women who scored at least one were considered autonomous; otherwise, they were considered non-autonomous [35, 36].

https://doi.org/10.1371/journal.pone.0294981.t002

Data management and statistical analyses

Compiled DHS reports of 18 SSA countries were checked for consistency and missing values. Cleaning, recoding, variable generation, labeling, and analysis were done by using STATA/SE version 16.0. The data were weighted to restore the statistical representativeness of the survey and to account for sample design. As a result, sample weights were used to estimate proportions and frequencies to account for disproportionate sampling and non-response. The weighting procedure was thoroughly discussed in the Demographic and Health Survey Sampling and Household Listing Manual developed by ICF International [34]. To describe the background characteristics of the study participants, descriptive statistics such as frequencies, percentages, and means were computed. The percentage and number of women in each category who received timely and adequate ANC were presented. To determine the distribution of timing and ANC adequacy across covariates, a cross-tabulation test was performed. The variance inflation factors (VIF) showed no collinearity between explanatory variables (VIF = 1.42).

The hierarchical nature of the DHS data contradicts the assumptions of the classic logistic regression model: independence of observations and homogeneity of variance. This violation occurred because women were nested within a cluster on the notion that women in the same cluster are more similar. Besides, unobserved cluster characteristics such as the availability and accessibility of health services, cultural norms, and dominant health beliefs may influence the receipt of timely and adequate ANC [34]. Thus, advanced models are required to overcome the shortcomings caused by inter-cluster heterogeneity, and a multilevel mixed-effects logistic regression model was preferred to identify significant predictors.

First, a multilevel bivariable logistic regression was performed to investigate the independent relationship between the covariates and the outcomes of interest (timing and adequacy of ANC visits). Those significant variables at p-values <0.25 were included in the multilevel mixed-effect multivariable logistic regression. Four models were used in this process: Models I, II, III, and IV. A model-I is a null model devoid of explanatory variables that shows the variance in timing and adequacy of ANC visits that could be ascribed to the cluster. Model II and III were models with the individual- and community-level factors, respectively. The full model (Model IV) examines the effect of individual and community-level predictors on both outcome variables concurrently. To demonstrate the strength and significance of the association, the adjusted odds ratio with the corresponding 95% confidence interval was calculated and reported. Variables with a p-value< 0.05 were considered to have a significant association with the outcome variables (timing and adequacy of ANC).

Fixed and random effect estimates and model selection. Fixed and random effects were used to denote the measure of variation in the outcome of interest. In the random effect analysis, differences between clusters were examined using the intraclass correlation coefficient (ICC), a proportional change in variance (PCV), and median odds ratio (MOR). ICC is the proportion of variance explained by the population's group structure, whereas PCV is the total variation attributed to individual-level and community-level factors when compared to the null model [29, 37]. MOR is defined as the median value of the odds ratio between the clusters at high and low risk of early and adequate ANC visit when two clusters are randomly selected [37]. Of all the four models, the fourth one had the lowest AIC value in both cases (1st and 2nd outcome variables) and was selected as the best model fit for the data. Furthermore, as fitted models progressed from the empty model (Model-I) to Model-II, Model-III, and Model-IV, the value of the deviance (-2*log-likelihood) results consistently decreased, indicating that the fitted models were a better fit to the data.

Ethical consideration and consent to participate. Following registration with possible justification, ICF International granted permission to access the dataset used for this study.

The retrieved data were only used for the registered research, and data were not shared with anyone other than the coresearchers. The information was kept private, and no attempt was made to identify any household or individual respondent. The DHS also declared that informed consent was obtained from all subjects and/or their legal guardian during the primary data collection.

Results

Sociodemographic characteristics of study participants

This study included 171,488 weighted women from 18 SSA countries who had at least one child within five years before the survey. The majority of study participants were from the western (79,645, 46.4%) and Eastern (70,851, 41.4%) %) regions of SSA. Nigeria, with 32,228 (18.8%), and South Africa, with 2,762(1.6%), were represented by the largest and smallest study participants, respectively. The mean (±SD) age of women in this study was 29.2(±7.24) years which, 43,856(25.6%) of them belong to the age group 25–34 years. one-third (33.3%) and 30.7% of women and their husbands, respectively, did not attend any formal education. The majority of the participants, 105,768(61.7) were from rural areas (Table 3).

Obstetric characteristics of respondents

More than half of the respondents (51.0%) were multiparous (had 2–4 living children). Almost three-quarters (73.7%) of pregnancies were wanted, and 14.6% of women reported having faced pregnancy termination in their lifetime. Two-thirds (65.9%) of women received four or more antenatal care visits, and 5.8% gave birth by Caesarean section (Table 4).

Health service-related characteristics of the respondents

Women had no exposure to reading newspapers, listening to the radio, and watching television in 85.9%, 43.4%, and 56.6% of cases, respectively. Nearly two-thirds, 109,430 (63.8%) of respondents were autonomous in decision-making. Long distances to a health facility, not having permission to go to a health facility, and not having enough money for treatment were major problems for 35.4%, 16.6%, and 50.1% of women, respectively. Only 7% of women were enrolled in health insurance schemes (Table 5).

The overall uptake of timely ANC visits and its distribution across covariates

In eighteen SSA countries, the overall prevalence of timely initiation of ANC visits was 41.2% (95% CI: 40.9, 41.4). The central region had the highest proportion of timely ANC uptake (47.8%). When it comes to specific countries, Liberia and Nigeria had the highest (72.2%) and lowest (23.8%) prevalence, respectively (Fig 1).

Half (50.5%) of women in the richest wealth quintile started ANC within the first trimester as compared to 37.7% of women in the poorest wealth quintile group (X^2 = 1013.31, p<0.001). There was also a significant difference in early ANC uptake across women's educational level, with 52.0% of women who attend higher education starting their ANC visit on time, compared to 37.9% of those with no formal education(X^2 = 644.30, p<0.001)(Table 3). The uptake of timely ANC initiation also varied across various obstetric characteristics of respondents. It was higher (51.0%) among women who received four or more ANC visits compared to women who received only one visit throughout their pregnancy (4.7%) (X^2 = 1013.31, p<0.001). It also varies across birth order, mode of delivery, and parity (Table 4). The majority of women who read newspapers, listen to the radio and watch television almost every day started their

Table 3. Distribution of Sociodemographic characteristics of study participants across timeliness and adequacy of ANC visits in SSA, 2016–2021.

Variable categories	Total	Early initiation of ANC visits		Adequacy of ANC visits ($\geq$ 8 visits)	
		Yes [Frequency (%)]	Significance (X^2)	Yes [Frequency (%)]	Significance (X^2)
Regions					
Eastern	70,851(41.4)	29,443(41.6)	270.97**	1,498(2.1)	1313.2**
Western	79,646(46.4)	31,059(39.0)		14,191(17.8)	
Central	18,229(10.6)	8,724(47.8)		1,655(9.1)	
Southern	2,790(1.6)	1,387(50.2)		519(18.8)	
Current Age		1			
15–24	50,021(29.1)	19,906(39.8)	59.38*	3,959(7.9)	387.68**
25–34	79,166(46.2)	33,386(42.2)		9,047(11.4)	
35–49	42,301(24.7)	17,322 (41.0)		4,857(11.5)	
Marital status					
In marital relation	124,066(72.4)	49,372(39.8)	207.19**	12,906(10.4)	3.88
Live with partner	22,486(13.1)	10,449(46.5)		2,438(10.8)	
Non-marital relation	24,936(14.5)	10,792(43.3)		2,518(10.1)	
Educational status					
No education	57,054(33.3)	21,641(37.9)	644.30**	3,476(6.1)	612.31**
Primary	56,282(32.8)	22,770(40.5)		3,349(5.9)	
Secondary	49,423 (28.8)	21,663(43.8)		8,113(16.4)	
Higher	8,729 (5.1)	4,540(52.0)		2,924(33.5)	
Husband's education					
No education	44,971(30.7)	17,646 (39.2)	517.42**	2,618(5.8)	746.53**
Primary	38,920(26.6)	14,717(37.8)		2,060(5.3)	
Secondary	42,287(28.9)	17,603(41.6)		6,648(15.7)	
Higher	13,652(9.3)	6,406(46.9)		3,503(25.7)	
Don't know	6,694(4.6)	3,437(51.3)		508(7.6)	
Residence					
Urban	65,720(38.3)	29,841(45.4)	561.60**	11,403(17.3)	1623.14**
Rural	105,768(61.7)	40,772(38.6)		6,459(6.1)	
Family size					
$\leq$5memeber	75,046(43.8)	31,973 (42.6)	52.40*	9,407(12.5)	467.36**
>5 memeber	96,442(56.2)	38,641(40.1)		8,455(8.8)	
Wealth index combined					
Poorest	32,410(18.90)	12,227(37.7)	1013.31**	1,599(4.9)	1916.41**
Poorer	35,001(20.41)	13,213(37.8)		2,144(6.1)	
Middle	35,552(20.73)	13,622 (38.3)		3,091(8.7)	
Richer	35,364(20.62)	14,798(41.8)		4,411(12.5)	
Richest	33,161(19.34)	16,754(50.5)		6,619(20.0)	
Sex of household head					
Male	134,920(78.7)	53,876(39.9)	305.02**	14,000(10.4)	16.84
Female	36,568(21.3)	16,737 (45.8)	0.00	3,862(10.6)	
Community level poverty					
Low	60,363(34.9)	24,614(40.8)	20.54	8,645(50.1)	1321.78
Moderate	58,057(34.1)	24,067 (41.4)		4,429(25.7)	
High	53,068(31.0)	21,932 (41.2)		4,188(24.3)	

** p-values<0.001

* p-values<0.05

Table 4. Distribution of obstetric characteristics of study participants across timeliness and adequacy of ANC visits in SSA, 2016–2021.

Variable categories	Total	Early initiation of ANC visits		Adequacy of ANC visits (> = 8 visits)	
		Yes [Frequency (%)]	Significance (X²)	Yes [Frequency (%)]	Significance(X²)
Parity					
Nulliparous	1,682(1.0)	691 (41.0)	446.04**	167(9.9)	397.59**
Primiparous	39,382(23.0)			4,554(11.6)	
Multiparous	87,580(51.0)	36,819 (42.0)		10,085(11.5)	
Grand multiparous	42,844 (25.0)	15,680(36.6)		3,056(7.1)	
Caesarean delivery					
Yes	161,634(94.2)	65,173(55.2)	767.85**	16,087(9.9)	494.41**
No	9,854(5.8)	5,4410 (40.3)		1,775(18.0)	
Pregnancy status when she became pregnant					
Wanted	126,425(73.7)	53,165(42.0)	184.72**	13,949(11.0)	121.56*
Mistimed	34,437(20.0)	13,529(39.3)		2,995(8.7)	
Unwanted	10,626(6.2)	3,919(36.9)		918(8.6)	
Ever faced termination of pregnancy					
No	146,455(85.4)	59,650(40.7)	76.83*	14,941(10.2)	27.50
Yes	25,033(14.6)	10,963(43.8)		2,921(11.7)	
Contraceptive utilization					
Modern method	49,072 (28.7)	21,297()	199.11*	4,771(9.7)	807.5**
Traditional method	5,223(3.0)	2,240 ()		1,283(24.6)	
Nonusers	117,193(68.3)	47,076()		11,808(10.1)	
Frequency of ANC					
1 visit	7,966(4.7)	2,232(28.0)	712.13**		
2 visits	14,323(8.4)	2,645(18.5)			
3 visits	36,120(21.0)	8,123 (22.5)			
≥4 visits	113,079(65.9)	57,613(51.0)			
Timing of ANC initiation				11,153(64.6)	1937.34**
Within 12 weeks				6,109(35.4)	
>12 weeks					
Birth order					
First	36,948(21.6)	16,492(45.3)	571.51**	4,246(11.5)	54.20*
Second	33,069(19.3)	14,460(44.6)		4,141(12.5)	
Third	27,634(16.1)	11,720 (43.5)		3,254(11.8)	
Ourth	21,870(12.8)	8,770 (41.1)		2,230(10.2)	
Fifth and above	51,966(30.3)	19,171(38.3)		3,991(7.7)	

** p-values<0.001

* p-values<0.05

ANC visits for their recent pregnancy on time as compared to their counterparts (p<0.001) (Table 5).

Adequacy of ANC visit and its distribution across covariates

The overall uptake of adequate ANC (at least eight visits) was 10.4% (95% CI: 9.9, 10.2). The western region had the highest proportion of women receiving adequate ANC (17.8%). In terms of specific countries, Nigeria and Rwanda had the highest (26.7%) and lowest (0.3%) prevalence, respectively (Fig 2).

Table 5. Distribution of Health service-related characteristics of study participants across Timely initiation of ANC and the uptake of recommended items of care in SSA, 2016–2021.

Variable categories	Total	Early initiation of ANC visits		Adequacy of ANC visits($> = 8$ visits)	
		Yes [Frequency (%)]	Significance (X^2)	Yes [Frequency (%)]	Significance (X^2)
Reading newspaper					
Not at all	147,321(85.9)	58,885(40.0)	458.22**	13,860(9.4)	924.05**
Less than once a week	14,948(8.7)	6,979 (46.7)		2,459(16.4)	
At least once a week	8,808(5.14)	4,503 (51.1)		1,470(16.7)	
Almost everyday	411(0.2)	247(60.1)		74(18.1)	
Listening to a radio					
Not at all	74,454(43.4)	29,161(39.2)	253.839*	6,086(8.2)	140.61*
Less than once a week	38,626(22.5)	16,303(42.2)		4,749(12.3)	
At least once a week	55,392(32.3)	23,645(42.7)		6,823(12.3)	
Almost everyday	3,017(1.8)	1,505(49.9)		204(6.8)	
Watching television					
Not at all	97,094(56.6)	36,735(37.8)	985.04*	6,252(6.4)	1233.3*
Less than once a week	25,804(15.5)	11,059(42.9)		3,354(13.0)	
At least once a week	43,576(25.1)	20,346(46.7)		7,849(18.0)	
Almost everyday	5,013(2.9)	2,473(49.3)		407(8.12)	
Had a mobile phone					
No	80,091(46.7)	28,890(36.0)	1400.01*	4,832(6.0)	1721.23*
Yes	91,398(53.3)	41,724(46.7)		13,030(14.3)	
Autonomy in decision making					
Non-autonomous	62,058(36.2)	24,409(39.3)	157.56*	5,622(9.0)	135.65*
Autonomous	109,430(63.8)	46,204 (42.2)		12,240(11.2)	
Distance to a health facility					
Big problem	60,690(35.4)	24,122(39.8)	12.759	4,831(8.0)	478.99*
Not a big problem	110,798(64.6)	46,492(42.0)		13,031(11.8)	
Getting permission to go to a health facility					
Big problem	28,452(16.6)	12,152(42.7)	50.07	2,6789(9.4)	38.17
Not a big problem	143,037(83.4)	58,462 (40.9)		15,184(10.6)	
Getting money needed for treatment					
Big problem	85,816(50.1)	34,221(39.9)	160.65*	7,698(9.0)	321.85*
Not a big problem	85,672(49.9)	36,392(42.5)		10,164(11.9)	
Covered by health insurance					
No	159,301(92.9)	63,467(39.8)	1230.31*	16,872(10.4)	97.33
Yes	12,187(7.1)	7,146 (58.6)		991(8.1)	

** p-values<0.001

* p-values<0.05

In the richest wealth quintile, 20.5% of women received adequate ANC, compared to 4.9% of women in the poorest wealth quintile (X^2 = 1916.41, p<0.001). There was also a significant difference in adequate ANC uptake across women's educational levels, with 33.5% of women in higher education getting adequate ANC visits, compared to 6.19% of those with no formal education (X^2 = 612.31, p<0.001) (Table 3). The uptake of adequate ANC visits varied across the obstetric characteristics of respondents. It was higher (64.6%) among women who started their visit within 12 weeks of gestation compared to women who started later (X^2 = 1937.34, p<0.001). It also varies by birth order, mode of delivery, and parity (Table 4). The magnitude
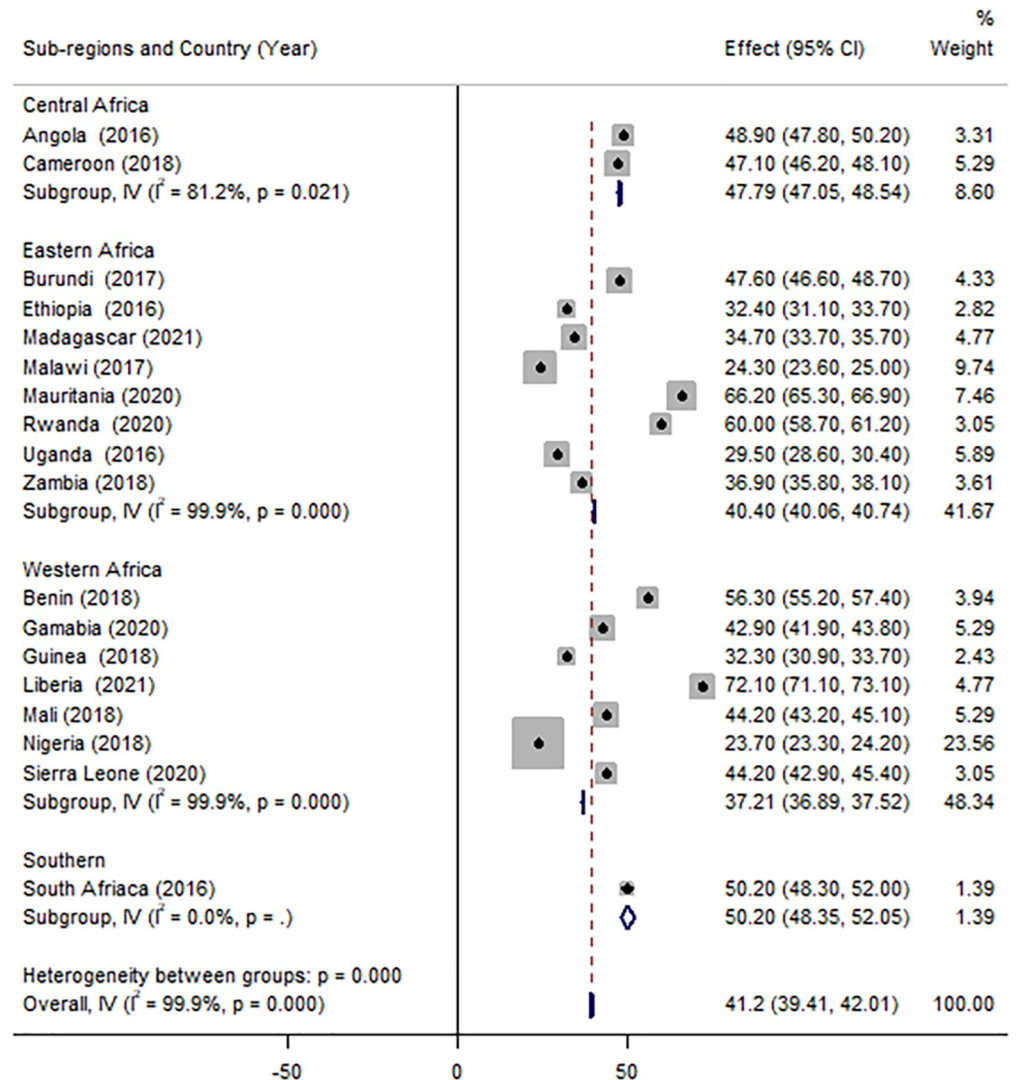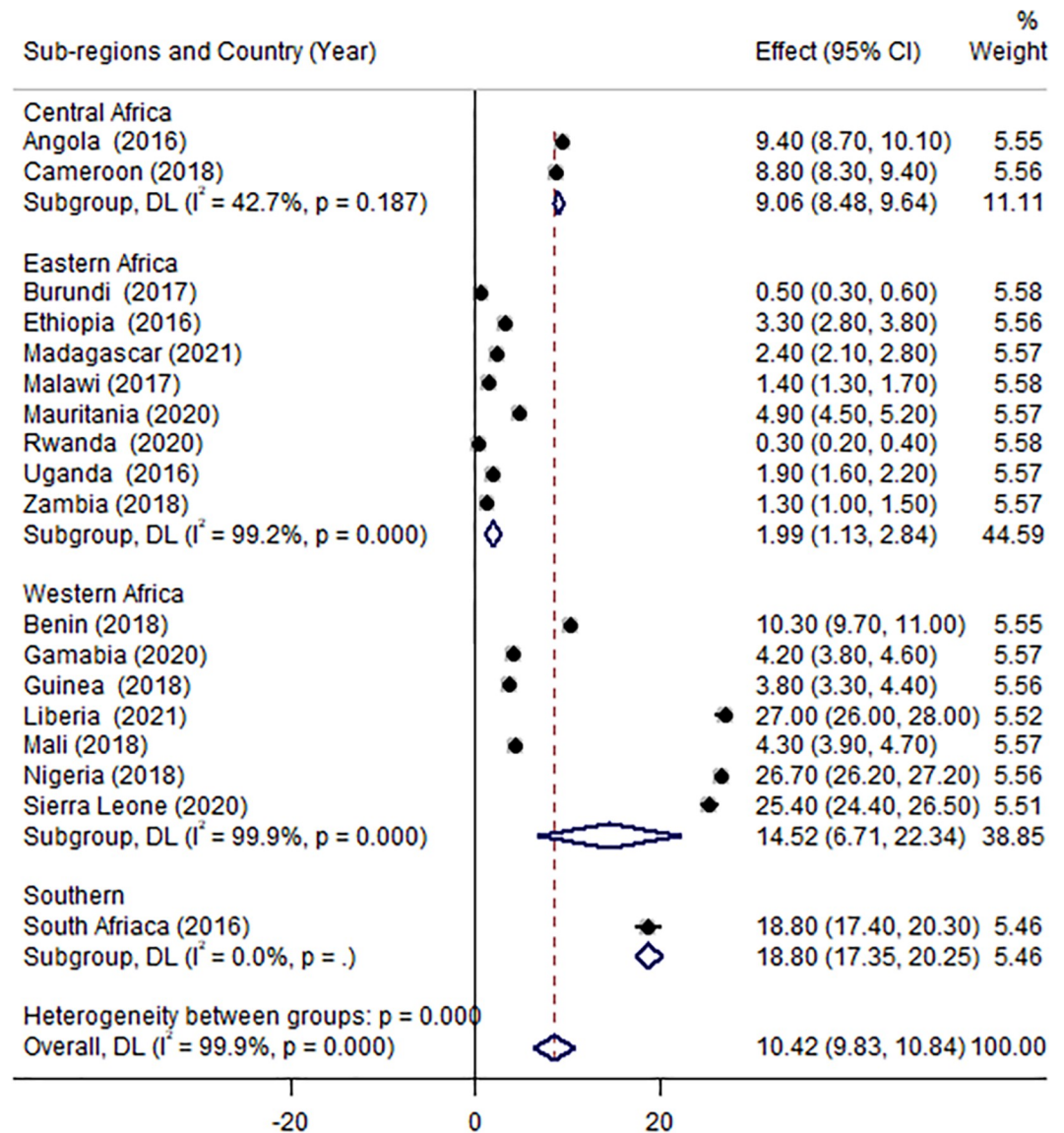
Fig 1. Forest plot depicting the pooled prevalence of early ANC initiation by country and sub-regions, 2016–2021.

https://doi.org/10.1371/journal.pone.0294981.g001

of receiving adequate ANC varies among women who read newspapers, listen to the radio, and watch television (p<0.001) (Table 5).

The receipt of WHO-recommended items of care during visits

Data on the provision of the essential components of ANC services during pregnancy were considered: weight and blood pressure measurement, urine and blood sample testing, TT injection at least twice, iron supplementation, deworming for intestinal parasites, HIV/AIDS prevention counseling, and provision of HIV test as part of ANC service. When the individual components were considered, blood pressure measurement was the most common item received by 152,705 (89.0%) of women, closely followed by iron supplementation (88%) and a blood sample taken (87.6%). Ultrasound examination was a component received by only 9.1% of the women (Fig 3).

Fig 2. Forest plot depicting the pooled prevalence of adequate ANC visits by country and sub-regions, 2016–2021.
NOTE: Weights and between-subgroup heterogeneity test are from random-effects model.

Determinants of early initiation of ANC service

In bivariable multilevel logistic regression, variables namely region, age of women, respondents' educational status, marital status, residence, family size, wealth index, the sex of head of household, wontedness of pregnancy, experiencing termination of pregnancy, contraceptive uptake, birth order, reading a newspaper, listening radio, watching television, having a mobile phone, autonomy in decision-making, having money for medical care, and enrollment in health insurance were associated with early initiation of ANC at p-value <0.25. The preceding multilevel bivariable logistic regression analysis presents the unadjusted effects of the explanatory variables on the timely initiation of ANC. Thus, a multilevel mixed-effect multivariable logistic regression analysis was performed to identify variables significantly associated with the
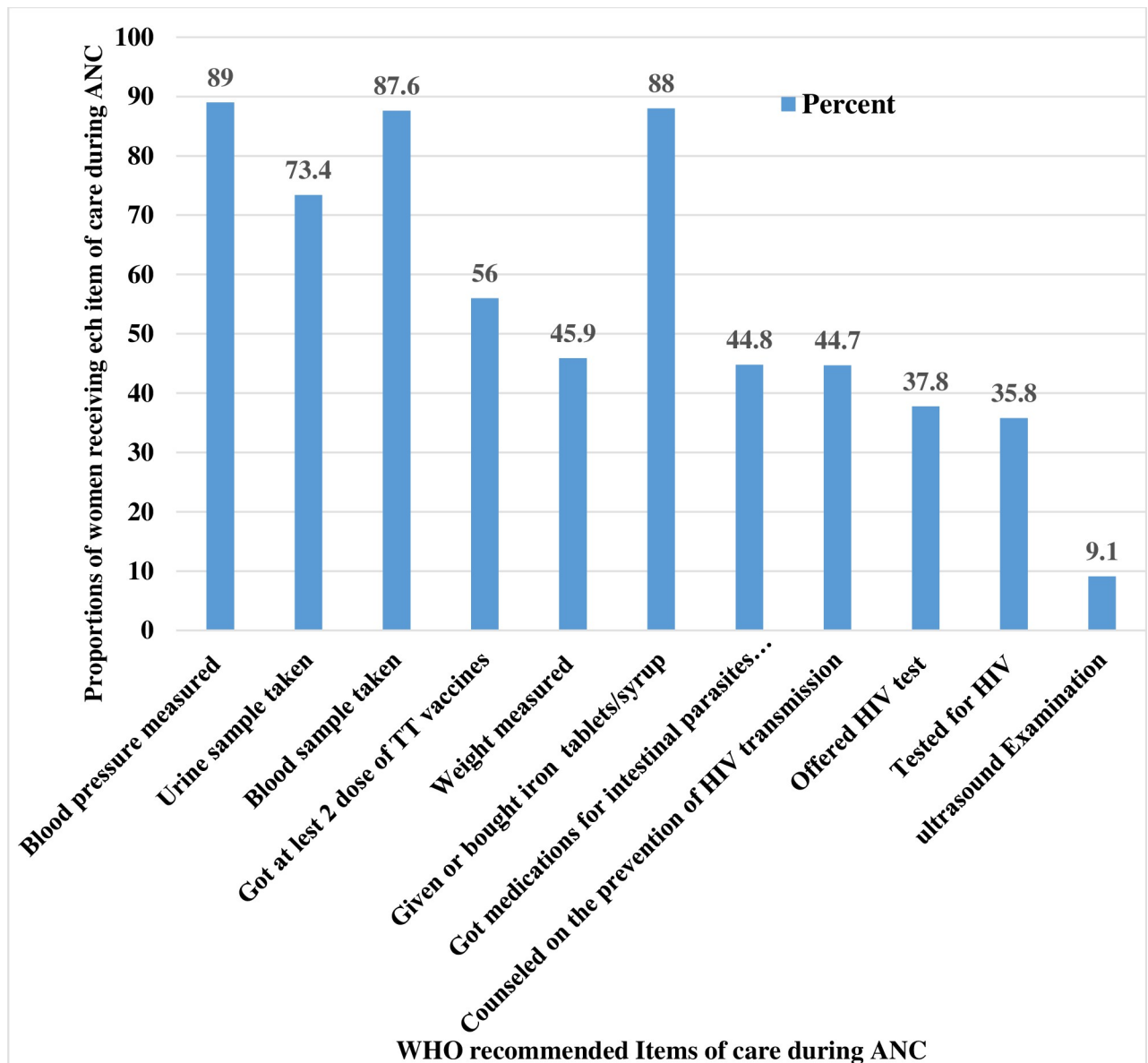
Fig 3. Distribution of contents care provided to women during ANC visits in SSA countries, 2016–2021.

https://doi.org/10.1371/journal.pone.0294981.g003

outcome of interest. Accordingly, the region where the respondents lived, planning status of the pregnancy, birth order, having a phone number, and enrollment in health insurance schemes were found to be significantly associated with the early initiation of ANC visits.

Women from Eastern and Central SSA regions had a 41% (AOR = 1.41, 95% CI: 1.32, 1.48) and 24% (AOR: 1.24; 95% CI: 1.17, 1.32) higher chance of starting ANC at the right time, respectively. The pregnancy planning status was found to be a significant predictor of early initiation of ANC. When compared to their counterparts, the odds of starting ANC on time were 1.18 times higher in women with wanted pregnancies (AOR = 1.18, 95% CI: 1.13, 1.24). When compared to women with more than the fifth birth order, those with the first birth order had a 48% higher chance of initiating ANC visits on time (AOR = 1.48; 95% CI: 1.41, 1.54). Having a mobile phone was also identified as a significant predictor of the timely initiation of ANC.

Those women who had a mobile phone had a 49% higher chance of commencing their prenatal care on time (AOR = 1.49; 95% CI: 1.26, 1.82). The odds of starting ANC follow-up in the first trimester were 2 times higher among those women who enrolled in health insurance schemes (AOR = 2.03; 95% CI: 1.95, 2,42).

The ICC in the empty model implied that the variation across countries accounted for 15.3% of the total variation in the receipt of adequate ANC visits. Furthermore, the MOR was 1.35 (95% CI: 1.26, 1.43), indicating that when women moved from late ANC initiation countries, their odds of getting timely ANC visit increased by 1.35 times. Both individual- and community-level variables explained 14.3% of the national variation seen in the empty model (PCV = 14.3%) (Table 6).

Determinants of adequate ANC visits among women

Again, a bivariable multilevel logistic regression was done between each explanatory variable and outcome variables. Accordingly, region, level of community poverty, age of women, respondents' educational status, residence, wealth index, the sex of the head of household, wontedness of pregnancy, experiencing termination of pregnancy, birth order, reading a newspaper, watching television, having a mobile phone, autonomy in decision-making, having money for medical care, ease of distance to a nearby health facility, autonomy in decision making and enrollment in health insurance were associated with the uptake of adequate ANC at p-value <0.25. Community-level poverty, the household wealth index, women's educational status, early initiation ANC visits, being autonomous in decision-making and having a mobile phone were identified as significant predictors of adequate ANC service uptake in a multilevel mixed-effect multivariable logistic regression analysis.

As compared to women from the eastern region, the odds of receiving adequate ANC visits were 13.1 times (AOR = 13.16, 95% CI: 12.34, 14.04) and 13.42 times (AOR = 13.42, 95% CI: 11.74, 15.33) higher for those women from western and southern regions, respectively. Women living in lower community level poverty were 2.23 times more likely to receive adequate ANC visits than women living in higher community level poverty (AOR = 2.23, 95% CI: 1.90, 2.66). Similarly, the odds of receiving adequate ANC visits were 1.49 times higher among those women in the richest wealth quintile as compared to their counterparts (AOR = 1.49, 95% CI: 1.36, 1.62). As compared to women with no formal education, the likelihood of receiving adequate ANC visits was 3,63 times higher for those who attended higher education (AOR = 3.63, 95% CI: 3.33, 3.96). Women who began their first ANC visit within 12 weeks of gestation had a 4.26-fold higher chance of receiving adequate ANC visits (AOR = 4.26, 95% CI: 4.08, 4.44). Those women who had a mobile phone had an 89% higher chance of receiving adequate ANC (AOR = 1.89; 95% CI: 1.76, 2.32). In terms of decision-making capabilities, autonomous women had a 2.29 times higher chance of receiving adequate ANC than non-autonomous women (AOR = 2.29; 95% CI: 1.83, 2.54).

The ICC in the empty model implied that the variation across countries accounted for 40.9% of the total variation in the receipt of adequate ANC visits. Furthermore, the MOR was 4.22 (95% CI:3.95, 4.49), indicating that when women moved from low to high ANC usage countries, their odds of getting adequate ANC increased by 4.22 times. Both individual- and community-level variables explained 39.5% of the national variation seen in the empty model (PCV = 39.5%) (Table 7).

Discussion

Antenatal care coverage is a key performance indicator that has been reported globally to assess maternal health [20]. Although evidence on the number of ANC contacts is readily

Table 6. Results of a multilevel mixed-effect multivariable logistic regression analysis to identify the factors affecting the early initiation of ANC in SSA, 2016–2021.

Variable categories	Model I(null model)	Model II (individual-level factors)	Model III (community-level factors)	Model-IV (full model)
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR(95% CI)
Current Age				
15–24		1		
25–34		1.15(1.12, 1.19)		1.04(0.98,1.18)
35–49		1.20(1.15, 1.25)		1.19(0.83, 1.24)
Educational status				
No education		1		1
Primary		0.95(0.92, 0.97)		0.83(0.79, 1.15)
Secondary		0.94(1.92,1.07)		0.98(0.76, 1.19)
Higher		1.24(0.90, 1.43)		1.12(0.85,1.21)
Family size				
< = 5 member		1		1
>5 members		0.96(0.93, 0.98)		0.95(0.93, 0.97)
Wealth index combined				
Poorest		1		1
Poorer		0.94(0.91, 0.97)		0.93(0.90, 0.96)
Middle		0.88(0.85, 0.91)		0.96(.84, 1.09)
Richer		0.92(0.89, 1.06)		1.01(0.96, 1.03)
Richest		1.13(1.08, 1.17)		1.15(0.98, 1.23)
Sex of household head				
Male		1		1
Female		1.26(1.23, 1.29)		1.12(0.98, 1.23)
Pregnancy status				
Wanted		1.33(1.08, 1.18)		1.18(1.13,1.24)*
Mistimed		1.04(0.99, 1.09)		1.07(0.98, 1.12)
Unwanted		1		1
termination of pregnancy				
No		1		1
Yes		1.12(1.05,1.14)		1.07(0.97, 1.11)
Contraceptive usage				
Modern method		1.08(1.06, 1.11)		1.04(0.95, 1.07)
Traditional method		0.97(0.91, 1.03)		0.95(0.89, 1.01)
Non-users		1		1
Frequency of ANC				
1 visit		1		1
2 visits		1.33(0.59,0.68)		1.43(0.97, 1.68)
3 visits		1.53(0.88, 1.68)		1.63(0.86, 1.88)
≥4 visits		3.11(2.96, 3.28)		3.28(3.10, 3.45)*
Birth order				
First	1.52(1.46, 1.59)			1.48(1.41, 1.54)*
Second		1.40(1.34,1.46)		1.37(1.32, 1.43)*
Third		1.26(1.21,1.31)		1.24(1.20, 1.29)
Fourth		1.11(1.07,1.15)		1.10(0.96, 1.14)
Fifth and above		1		1
Listening to a radio				
Not at all		1		1

(*Continued*)

Table 6. (Continued)

Variable categories	Model I(null model)	Model II (individual-level factors)	Model III (community-level factors)	Model-IV (full model)
	AOR (95% CI)	**AOR (95% CI)**	**AOR (95% CI)**	**AOR(95% CI)**
< once a week		1.02(0.99, 1.05)		1.03(0.91, 1.07)
At least once a week		0.95(0.92, 0.97)		0.96(0.93, 1.28)
Almost everyday		1.06(0.97, 1.17)		1.12(1.02, 1.23)
Watching TV				
Not at all		1		1
< once a week		1.05(1.02, 1.08)		1.07(0.95, 1.12)
At least once a week		1.07(1.04, 1.10)		1.09(0.92, 1.13)
Almost everyday		1.09(0.92, 1.17)		1.01(0.92, 1.09)
Had a mobile phone				
No		1		1
Yes		1.27(1.24, 1.29)		**1.49(1.26, 2.32)**[*]
Decision making				
Non-autonomous		1		1
Autonomous		1.15(1.12, 1.17)		1.10(0.95, 1.14)
Distance to a health facility				
Big problem		1		1
Not a big problem		1.14().91, 1.16)		1.12(1.09, 0.98)
To Get money for treatment				
Big problem		1		1
Not a big problem		1.01(0.98,1.03)		1.04(0.91,1.13)
Covered by health insurance				
No		1		1
Yes		2.22(2.13, 2.32)		**2.03(1.95, 2.42)**[*]
Regions				
Eastern			0.98(0.77, 1.09)	1.40(1.32, 1.48)
Western			0.88(0.86, 1.00)	0.99(0.94, 1.05)
Central			1.02(0.99, 1.04)	1.24(1.17, 1.32)
Southern			1	1
Residence				
Urban			1.13(1.08, 1.21)	1.04(0.98, 1.07)
Rural			1	1
Random effects				
Variance	1.19	1.03	1.04	1.02
ICC	15.3%	13.4%	10.3%	11.5
AIC	232,766.9	229,766.9	229,778.5	226,106.5
BIC	232,887.0	230,787.3	229,838.8	226,508.5
MOR	1.52(1.48, 1.56)	1.41(1.37, 1.45)	1.42(1.38, 1.46)	1.35 (1.26, 1.43)
PCV	Reference	13.4%	12.6%	14.3%
Model fitness				
Log-likelihood	-115381.4	-114,098.7	-114,883.2	-113, 013.2
Deviance	230,768.8	228,197.4	229,766.4	226, 026.4

Key: 1: Reference category; AOR = Adjusted odds ratio

** Statistically significant at p-value <0.05

Table 7. Results of a multilevel mixed-effect multivariable logistic regression analysis to identify determinants of the receipt of adequate ANC in SSA, 2016–2020.

Variable categories	Model I(null model)	Model II (individual-level factors)	Model III (community-level factors)	Model-IV (full model)
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR(95% CI)
Current Age				
15–24		1		
25–34		1.19(1.13,1.26)		1.04(0.98,1.18)
35–49		1.62(1.51, 1.73)		1.29(0.83, 1.54)
Educational status				
No education		1		1
Primary		0.84(0.80, 1.29)		1.46(1.38, 1.54)
Secondary		1.90(1.80, 2.00)		2.11(1.99, 2.23)
Higher		3.80(3.50, 4.13)		3.63(3.33, 3.96)*
Wealth index combined				
Poorest		1		1
Poorer		1.18(1.10, 1.27)		0.93(0.90, 0.96)
Middle		1.35(1.26, 1.44)		1.16(0.84, 1.09)
Richer		1.36(1.27, 1.46)		1.28(1.19, 1.388)*
Richest		1.43 (1.33,1.55)		1.49(1.36, 1.62)*
Sex of household head				
Male		1		1
Female		1.04 (1.0, 1.09)		1.12(0.98, 1.23)
Parity				
Grand multiparous		1		1
Multiparous		1.58(1.45, 1.72)		1.28(0.97, 1.51)
Primiparous		1.02(1.75, 2.33)		1.23(0.92, 1.38)
Nulliparous		1.94(1.5, 2.44)		1.27(0.98, 1.40)
Pregnancy status				
Unwanted		1		
Mistimed		0.94(0.86, 1.03)		1.07(0.98, 1.12)
Wanted		0.99(0.92, 1.07)		1.18(1.13,1.24)
Termination of pregnancy				
No		1		1
Yes		1.08(1.03, 1.13)		1.07(0.97, 1.11)
Timing of ANC initiation				
Late(>12 wks)		1		1
Early (<12 wks)		3.6(3.45, 3.73)		4.26(4.08, 4.44)*
Reading newspaper				
Not at all		1		1
< once a week		0.87(0.82, 0.93)		1.03(0.91, 1.07)
At least once a week		0.93(0.86, 1.04)		0.96(0.93, 1.28)
Almost everyday		1.25(0.86, 1.81)		1.12(0.92, 1.14)
Watching television				
Not at all		1		1
< once a week		1.09(0.56, 0.74)		1.07(0.95, 1.12)
At least once a week		1.12(1.06, 1.18)		1.09(0.92, 1.13)
Almost everyday		1.17(1.11,1.24)		1.01(0.92, 1.09)
Had mobile phone				
No		1		1

(Continued)

Table 7. (Continued)

Variable categories	Model I(null model)	Model II (individual-level factors)	Model III (community-level factors)	Model-IV (full model)
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR(95% CI)
Yes		1.61(1.24, 1.70)		1.89(1.76, 2,32)*
Decision making				
Non-autonomous		1		1
Autonomous		2.35(1.81, 2.49)		2.29(1.83, 2.54)*
Distance to a health facility				
Big problem		1		1
Not a big problem		1.07(1.02, 1.12)		1.12(1.09, 0.98)
Accessing money for health service				
Big problem		1		1
Not a big problem		0.96(0.92, 1.01)		1.04(0.91,1.13)
Covered by health insurance				
No		1		1
Yes		1.22(1.08, 1.52)		1.03(0.95, 2.42)
Regions				
Eastern			1	1
Central			5.03(4.65, 5.45)	6.30(5.28, 6.30)
Southern			14.24(12.70, 15.96)	13.42(11.74, 15.34)
Western			8.98(8.48, 9.53)	13.16(12.34, 14.0)
Residence				
Rural			1	1
Urban			1.95(1.87, 2.03)	1.29(0.98, 1.37)
Community level poverty				
Higher			1	1
Moderate			0.87(0.72, 1.05)	0.81(0.67, 0.98)
Low			2.65(2.26, 3.11)	2.23(1.9, 2.66)*
Random effects				
Variance	2.28	1.97	1.35	1.38
ICC	40.9%	37.5%	27.9%	27.8%
AIC	99,532.0	90745.0	91023.8	82749.14
BIC	99,552.1	91096.8	91104.2	83161.21
MOR	4.22(3.95, 4.49)	3.82(3.58, 4.06)	2.93(2.78, 3.08)	2,93(2.78, 3.08)
PCV	Reference	13.6	44.3	39.5
Model fitness				
Log-likelihood	-49764.01	-45,337.5	-44,763.9	-40,733.5
Deviance	99528.02	90,675	89,562.8	81,467.0

Key: 1: Reference category; AOR = Adjusted odds ratio

** Statistically significant at p-value <0.05 in the final model

available, the reports were based on the previously recommended ANC4+, and countries' performance based on the new WHO recommendation [18], particularly in SSAs, was not thoroughly assessed. Thus, effective ANC promotion and a positive pregnancy experience among women in the SSA region necessitate a thorough understanding of the timing and adequacy of ANC contacts. The current study was aimed at assessing the magnitude and predictors of timing and adequacy of ANC among women of SSA countries based on the most recent DHS data (2016–2021).

According to the current study, less than half (41.2%, 95% CI: 40.9, 41.4) of women in SSA countries initiated ANC during the first trimester of pregnancy, as recommended by WHO. This finding is lower than a recent study conducted in LMICs(44.3%) [20] and higher than DHS analyses of Uganda (38.9%) [25], and Ethiopia(20.0%) [26]. On the other hand, 10.4% (95% CI: 9.9, 10.2) of women in SSA got the newly set WHO recommendation of a minimum of 8 contacts which was lower than a study in LMICs(11.3%) [20], and DHS report of Nigeria (17.4%) [29] but higher than DHS analysis of eight SSA from 2010-2016(7.7%) [27], Bangladesh (6.0%) [28]. Overall, the current study reveals that compliance with the updated recommendation is low, most likely because it has not been adopted as a national policy in all countries, and more emphasis should be placed on its implementation.

Planning status of the pregnancy, birth order, having a phone number, and enrollment in health insurance schemes were found to be significantly associated with the early initiation of ANC visits. On the other hand, Community-level poverty, the household wealth index, women's educational status, early initiation ANC visits, being autonomous in decision-making, and having a mobile phone were identified as significant predictors of adequate ANC service uptake.

Birth order was identified as a factor significantly associated with the early initiation of ANC, with women with the first birth order being more likely to begin their third ANC visit earlier than mothers with birth orders of five or more. Further analysis of national studies conducted in the Brussels Metropolitan region [38], Haiti [39], Zambia [40], Nigeria [41], Uganda [42], and Ethiopia [10, 26, 43] supported this finding. The possible justification is that for women with first birth orders, the pregnancy is new to them, and they are concerned about having to deal with pregnancy complications, so they want to contact healthcare providers as soon as possible. Women with high birth orders, on the other hand, may be preoccupied with child-rearing and other home activities, which prevents them from seeking an early ANC visit [43]. As a result, women with high birth orders deserve special attention because they account for the highest proportion of the population (30.3%).

The odds of receiving early ANC is higher among those women with a wanted pregnancy. This finding was supported by studies conducted in Rwanda [25], Kenya [44], and Ethiopia [10, 26]. This could be because those women were well prepared from the start and had a better chance of detecting the pregnancy earlier at health facilities, leading them to begin the visits earlier. Besides, a woman with a wanted pregnancy is more likely to seek appropriate care for her pregnancy and is eager to obtain any information presumed to be important for their fetus from health care professionals and peers or friends, all of which leads them to begin their ANC early. Couples, on the other hand, are typically less vigilant about receiving ANC services in the event of unwanted pregnancy [28]. Thus, healthcare providers should be trained in identifying unwanted pregnancies and linking them to service delivery points by providing culturally appropriate support to those women [45].

The likelihood of early initiation of ANC visits was higher among those women who were enrolled in health insurance schemes. This was supported by studies conducted in Rwanda [25], Ghana [46, 47], Nigeria [48] and Taiwan [49]. A systematic review conducted in low- and middle-income countries also revealed that health insurance can influence the use and quality of maternal and child services and is known to potentially improve maternal and neonatal health outcomes [50]. This could be because health insurance schemes act as a pro-poor equalizing agent in healthcare financing by reducing out-of-pocket payments [51], which could offset the impact of monetary shortages that cause ANC to be delayed. Such health insurance schemes are known to improve the utilization of healthcare through financial protection, resource mobilization, and social exclusion [52]. Thus, the governments of SSA countries should work on the enrollment of their population in those schemes.

Having a mobile phone was also positively associated with the uptake of timely and adequate ANC visits. This finding was supported by studies conducted in Nigeria [53], Ghana [54], and Zanzibar [55]. This could be because women who owned a mobile phone were more likely to receive text message reminders for ANC appointments and other health information which resulted in positive health behavior, which could lead to them receiving timely and adequate ANC visits [56]. Thus, using mobile phones in health systems through mHealth to improve antenatal care service utilization is vital for SSA countries, which have the lowest antenatal care attendance compared to other regions [57].

The odds of receiving adequate ANC visits were higher among those women living in low community poverty levels and households with the richest wealth quintile as compared to their counterparts. Studies conducted in Bangladesh [28], Nepal [58], Nigeria [59], and Pakistan [23], supported this finding. This might be due to women in better socioeconomic status having more ability to pay for both direct and indirect health care costs. Economic factors may influence women's health-seeking behavior in many ways in the SSA region, where 40% of the population lives below the US$1.90-per-day poverty line in 2018, accounting for two-thirds of the global extremely poor population [60, 61]. Thus, governments should be involved in planning and implementing packages that improve the economic status of society, particularly women, in order to improve the adequacy of ANC and other maternal and child health services.

Women's educational status was associated with adequate ANC uptake, with women with a higher educational level having a higher likelihood of receiving adequate ANC visits than women with no education. Demographic analysis of Nigeria [29, 62], Zmabia [40], and Ethiopia [10] supported this finding. This could be because educated women are more likely to hear, comprehend, and understand information about the importance of ANC services via various channels (print and social media), and they are more likely to receive an adequate number of ANC. Maternal education can also improve healthcare literacy, making women more aware of danger signs and potentially able to identify pregnancy complications. Education, on the other hand, is known to increase women's autonomy in household decision-making and ability to decide about their own safety, which may result in compliance with the recommended number of ANC visits [35].

Similarly, the likelihood of receiving adequate ANC visits was higher among autonomous women. This finding was supported by studies conducted in Nigeria [63, 64], Bangladesh [65], Afghanistan [66], and Indonesia [67]. This could be because women's health decision-making autonomy prevents men or their male partners from exerting dominance and influence over women's decisions to seek ANC, resulting in a high number of ANC visits [68]. Restricting women's autonomy in making reproductive rights decisions may hinder the opportunity to obtain appropriate maternal health services [67]. There was broad agreement that a gender perspective should be taken into account in all development efforts, including sexual and reproductive health [69]. As a result, government bodies at the regional and national levels must work together to improve women's autonomy through interventions that increase their self-reliance and decision-making capacity.

The timing of ANC visits was a significant predictor of receipt of adequate ANC, with women who had their first ANC visit during the first trimester being 4.26 times more likely to receive adequate ANC. Studies conducted in Nigeria [29], Bangladesh [28, 70], Nepal [71] and Ethiopia [72] were in tandem with this finding. This could be because women who visit a health facility early in their pregnancy have enough time for consecutive visits, and the information they receive during the initial visit may facilitate continuity of care throughout the pregnancy, resulting in an adequate number of ANC visits [23]. Thus, encouraging mothers to

arrive early to begin ANC is critical to ensuring continuity of care, which opens the door to being informed about danger signs and complications during pregnancy.

The current study's findings were based on an analysis of the most recent large data sets covering 18 SSA countries, which were collected using standardized and validated data collection instruments and methodology, making the findings more generalizable. Besides, because of the clustering effect of DHS data, a multilevel-modeling approach was used in the analysis, providing disaggregated evidence on individual and community-level determinants for designing contextual interventions. Furthermore, the analysis considered both the timeliness and adequacy of ANC based on current WHO recommendations, and thus the findings could be used as input for SSA governments.

Even with the aforementioned benefits, the study has limitations. First, because the data were collected through retrospective interviews with a select group of women who had given birth within the previous five years, the findings may be prone to recall bias. Second, because the data is cross-sectional, the findings are subject to social desirability bias and fail to address the cause-effect relationship. It was also difficult to assess the relationship between other residual variables, such as cultural influence across countries.

Conclusion

The findings revealed a low coverage of timely and adequate ANC visits in SSA countries, implying poor compliance with the WHO recommendation on ANC for positive pregnancy experiences. Planning status of the pregnancy, birth order, having a phone number, and enrollment in health insurance schemes were found to be significantly associated with the early initiation of ANC visits. On the other hand, Community-level poverty, the household wealth index, women's educational status, early initiation ANC visits, being autonomous in decision-making, and having a mobile phone were identified as significant predictors of adequate ANC service uptake. Governments and healthcare managers in SSA countries should leverage their efforts to prioritize and implement interventions that increase women's empowerment, particularly their autonomy in decision-making and economic capability, in order to improve their health-seeking behavior during pregnancy. More commitment is needed from governments to increase mobile phone distribution across countries, with a focus on households with childbearing women, and then work on integrating mHealth into their health system. Finally, efforts should be made to increase the coverage of health insurance schemes enrolment for their citizens.

Acknowledgments

Author Contributions

Conceptualization: Aklilu Habte.

Data curation: Aklilu Habte, Tamirat Melis.

Formal analysis: Aklilu Habte, Aiggan Tamene.

Methodology: Aklilu Habte, Aiggan Tamene, Tamirat Melis.

Resources: Aklilu Habte.

Software: Aklilu Habte.

Supervision: Aklilu Habte.

Validation: Aklilu Habte.

Visualization: Aklilu Habte, Aiggan Tamene.

Writing – original draft: Aklilu Habte, Aiggan Tamene, Tamirat Melis.

Writing – review & editing: Aklilu Habte, Aiggan Tamene.

References

1. WHO. Maternal Health, WHO Regional Office for Africa [Internet]. 2022. Available from: https://afro.who.int/health-topics/maternal-health.

2. Callister L.C. and Edwards J.E., Sustainable development goals and the ongoing process of reducing maternal mortality. Journal of Obstetric, Gynecologic & Neonatal Nursing, 2017. 46(3): p. e56–e64. https://doi.org/10.1016/j.jogn.2016.10.009 PMID: 28286075

3. Organization, W.H., Strategies towards ending preventable maternal mortality (EPMM). 2015.

4. Organization, W.H. and UNiCEF, Trends in maternal mortality: 1990 to 2010. Trends in Maternal Mortality: 1990 to 2010, 2012: p. 72–72.

5. Organization, W.H., Trends in maternal mortality 2000 to 2017: estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. 2019.

6. Say L., et al., Global causes of maternal death: a WHO systematic analysis. The Lancet global health, 2014. 2(6): p. e323–e333. https://doi.org/10.1016/S2214-109X(14)70227-X PMID: 25103301

7. Dol J., et al., Timing of maternal mortality and severe morbidity during the postpartum period: a systematic review. JBI Evidence Synthesis, 2022. 20(9): p. 2119–2194. https://doi.org/10.11124/JBIES-20-00578 PMID: 35916004

8. Gupton A., Heaman M., and Cheung L.W.K., Complicated and uncomplicated pregnancies: women's perception of risk. Journal of Obstetric, Gynecologic, & Neonatal Nursing, 2014. 30(2): p. 192–201.

9. Koblinsky M., et al., Quality maternity care for every woman, everywhere: a call to action. The Lancet, 2016. 388(10057): p. 2307–2320. https://doi.org/10.1016/S0140-6736(16)31333-2 PMID: 27642018

10. Teshale A.B. and Tesema G.A., Prevalence and associated factors of delayed first antenatal care booking among reproductive age women in Ethiopia; a multilevel analysis of EDHS 2016 data. PloS one, 2020. 15(7): p. e0235538. https://doi.org/10.1371/journal.pone.0235538 PMID: 32628700

11. Organization, W.H., Advancing safe motherhood through human rights. 2001, World Health Organization.

12. Stanton M.E., et al., Beyond the safe motherhood initiative: accelerated action urgently needed to end preventable maternal mortality. Global Health: Science and Practice, 2018. 6(3): p. 408–412. https://doi.org/10.9745/GHSP-D-18-00100 PMID: 30093525

13. Oyerinde K., Can antenatal care result in significant maternal mortality reduction in developing countries. J Community Med Health Educ, 2013. 3(2): p. 2–3.

14. Akbar R., et al., Impact of antenatal care on maternal morbidity in three military hospitals of punjab, pakistan. Pakistan Armed Forces Medical Journal, 2021. 71(5): p. 1682.

15. Chiang R.K.Q. and Shorey S., Men's experiences of antenatal care services in low-income and middle-income countries: A qualitative systematic review. Birth, 2022. https://doi.org/10.1111/birt.12688 PMID: 36309934

16. Haruna U., Dandeebo G., and Galaa S.Z., Improving access and utilization of maternal healthcare services through focused antenatal care in rural Ghana: a qualitative study. Advances in Public Health, 2019. 2019.

17. Lattof S.R., et al., Developing measures for WHO recommendations on antenatal care for a positive pregnancy experience: a conceptual framework and scoping review. BMJ open, 2020. 9(4): p. e024130.

18. Organization W.H., WHO recommendations on antenatal care for a positive pregnancy experience. 2016: World Health Organization.

19. Organization, W.H., WHO recommendations on antenatal care for a positive pregnancy experience: summary: highlights and key messages from the World Health Organization's 2016 global recommendations for routine antenatal care. 2018, World Health Organization.

20.   Jiwani S.S., et al., Timing and number of antenatal care contacts in low and middle-income countries: analysis in the countdown to 2030 priority countries. Journal of global health, 2020. 10(1). https://doi.org/10.7189/jogh.10.010502 PMID: 32257157

21.   Moller A.-B., et al., Early antenatal care visit: a systematic analysis of regional and global levels and trends of coverage from 1990 to 2013. The Lancet Global Health, 2017. 5(10): p. e977–e983. https://doi.org/10.1016/S2214-109X(17)30325-X PMID: 28911763

22.   United Nations, Children's Fund (UNICEF) and the World Health Organization (WHO). Tracking Progress towards Universal Coverage for Reproductive, Newborn and Child Health: The 2017 Report. 2017 file:///C:/Users/user/Downloads/Countdown-2030.pdf.

23.   Agha S. and Tappis H., The timing of antenatal care initiation and the content of care in Sindh, Pakistan. BMC pregnancy and childbirth, 2016. 16(1): p. 1–9. https://doi.org/10.1186/s12884-016-0979-8 PMID: 27460042

24.   UNICEF for Every child, Antenatal care, https://data.unicef.org/topic/maternal-health/antenatal-care/.

25.   Manzi A., et al., Assessing predictors of delayed antenatal care visits in Rwanda: a secondary analysis of Rwanda demographic and health survey 2010. BMC Pregnancy and Childbirth, 2014. 14(1): p. 290. https://doi.org/10.1186/1471-2393-14-290 PMID: 25163525

26.   Woldeamanuel B.T. and Belachew T.A., Timing of first antenatal care visits and number of items of antenatal care contents received and associated factors in Ethiopia: multilevel mixed effects analysis. Reproductive health, 2021. 18(1): p. 1–16.

27.   Odusina E.K., et al., Noncompliance with the WHO's recommended eight antenatal care visits among pregnant women in sub-Saharan Africa: a multilevel analysis. BioMed Research International, 2021. 2021. https://doi.org/10.1155/2021/6696829 PMID: 34589549

28.   Islam M.M. and Masud M.S., Determinants of frequency and contents of antenatal care visits in Bangladesh: Assessing the extent of compliance with the WHO recommendations. PLOS ONE, 2018. 13(9): p. e0204752. https://doi.org/10.1371/journal.pone.0204752 PMID: 30261046

29.   Ekholuenetale M., Benebo F.O., and Idebolo A.F., Individual-, household-, and community-level factors associated with eight or more antenatal care contacts in Nigeria: Evidence from Demographic and Health Survey. Plos one, 2020. 15(9): p. e0239855. https://doi.org/10.1371/journal.pone.0239855 PMID: 32976494

30.   Ifenne D.I. and Utoo B.T., Gestational age at booking for antenatal care in a tertiary health facility in north-central, Nigeria. Nigerian medical journal: journal of the Nigeria Medical Association, 2012. 53(4): p. 236.

31.   Okedo-Alex I.N., et al., Determinants of antenatal care utilisation in sub-Saharan Africa: a systematic review. BMJ open, 2019. 9(10): p. e031890. https://doi.org/10.1136/bmjopen-2019-031890 PMID: 31594900

32.   Onoh R., et al., Pattern and determinants of antenatal booking at abakaliki southeast Nigeria. Annals of medical and health sciences research, 2012. 2(2): p. 169–175. https://doi.org/10.4103/2141-9248.105666 PMID: 23439716

33.   Tessema Z.T., Tesema G.A., and Yazachew L., Individual-level and community-level factors associated with eight or more antenatal care contacts in sub-Saharan Africa: evidence from 36 sub-Saharan African countries. BMJ open, 2022. 12(3): p. e049379. https://doi.org/10.1136/bmjopen-2021-049379 PMID: 35273040

34.   ICF International. 2012. Demographic and Health Survey Sampling and Household Listing Manual. MEASURE DHS, Calverton, Maryland, U.S.A.: ICF International https://www.dhsprogram.com/pubs/pdf/DHSM4/DHS6_Sampling_Manual_Sept2012_DHSM4.pdf.

35.   Gebeyehu N.A., et al., Women decision-making autonomy on maternal health service and associated factors in low-and middle-income countries: Systematic review and meta-analysis. Women's Health, 2022. 18: p. 17455057221122618. https://doi.org/10.1177/17455057221122618 PMID: 36062751

36.   Ghose B., et al., Women's decision-making autonomy and utilisation of maternal healthcare services: results from the Bangladesh Demographic and Health Survey. BMJ open, 2017. 7(9): p. e017142. https://doi.org/10.1136/bmjopen-2017-017142 PMID: 28882921

37.   Siegmunt O., Intraclass Correlation, Median Odds Ratio, and Ecological Reliability, in Neighborhood disorganization and social control. 2016, Springer. p. 43–45.

38.   Beeckman K., Louckx F., and Putman K., Determinants of the number of antenatal visits in a metropolitan region. BMC Public Health, 2010. 10.

39.   Babalola S.O., Factors associated with use of maternal health services in Haiti: a multilevel analysis. Revista Panamericana de Salud Pública, 2014. 36: p. 1–09. PMID: 25211671

40. Chewe M.M., Muleya M.C., and Maimbolwa M., Factors associated with late antenatal care booking among pregnant women in Ndola District, Zambia. African Journal of Midwifery and Women's Health, 2016. 10(4): p. 169–178.

41. Aremu O., Lawoko S., and Dalal K., Neighbor -hood socioeconomic disadvantage, individual wealth status and patterns of delivery care utilization in Nigeria: a multilevel discrete choice analysis. Int J Women's Health, 2011. 3.

42. Bbaale E., Factors influencing timing and frequency of antenatal care in Uganda. The Australasian medical journal, 2011. 4(8): p. 431. https://doi.org/10.4066/AMJ.2011.729 PMID: 23393530

43. Muchie K.F., Quality of antenatal care services and completion of four or more antenatal care visits in Ethiopia: a finding based on a demographic and health survey. BMC pregnancy and childbirth, 2017. 17(1): p. 1–7.

44. Ochako R. and Gichuhi W., Pregnancy wantedness, frequency and timing of antenatal care visit among women of childbearing age in Kenya. Reproductive health, 2016. 13(1): p. 1–8. https://doi.org/10.1186/s12978-016-0168-2 PMID: 27142068

45. World Health Organization (WHO) & United Nations Children Education Fund (UNICEF) (2003) Antenatal Care in Developing Countries: Promises, Achievements and Missed Opportunities: An Analysis of Trends, Levels, and Differentials: 1990–2001. WHO & UNICEF, G.

46. Owoo N.S. and Lambon-Quayefio M.P., National health insurance, social influence and antenatal care use in Ghana. Health economics review, 2013. 3(1): p. 1–12.

47. Dixon J., et al., National health insurance scheme enrolment and antenatal care among women in G hana: is there any relationship? Tropical Medicine & International Health, 2014. 19(1): p. 98–106.

48. Aliyu A.A. and Dahiru T., Predictors of delayed Antenatal Care (ANC) visits in Nigeria: secondary analysis of 2013 Nigeria Demographic and Health Survey (NDHS). The Pan African medical journal, 2017. 26. https://doi.org/10.11604/pamj.2017.26.124.9861 PMID: 28533847

49. Chen C.-S., Liu T.-C., and Chen L.-M., National Health Insurance and the antenatal care use: a case in Taiwan. Health policy, 2003. 64(1): p. 99–112. https://doi.org/10.1016/s0168-8510(02)00141-0 PMID: 12644332

50. Comfort A.B., Peterson L.A., and Hatt L.E., Effect of health insurance on the use and provision of maternal health services and maternal and neonatal health outcomes: a systematic review. Journal of health, population, and nutrition, 2013. 31(4 Suppl 2): p. S81. PMID: 24992805

51. Habte A., et al., Towards universal health coverage: The level and determinants of enrollment in the Community-Based Health Insurance (CBHI) scheme in Ethiopia: A systematic review and meta-analysis. PloS one, 2022. 17(8): p. e0272959. https://doi.org/10.1371/journal.pone.0272959 PMID: 35980888

52. Mebratie A.D., et al., The impact of Ethiopia's pilot community based health insurance scheme on healthcare utilization and cost of care. Social Science & Medicine, 2019. 220: p. 112–119. https://doi.org/10.1016/j.socscimed.2018.11.003 PMID: 30419495

53. McNabb M., et al., Assessment of the quality of antenatal care services provided by health workers using a mobile phone decision support application in northern Nigeria: a pre/post-intervention study. PLOS one, 2015. 10(5): p. e0123940. https://doi.org/10.1371/journal.pone.0123940 PMID: 25942018

54. Amoah B., et al., Boosting antenatal care attendance and number of hospital deliveries among pregnant women in rural communities: a community initiative in Ghana based on mobile phones applications and portable ultrasound scans. BMC pregnancy and childbirth, 2016. 16(1): p. 1–10. https://doi.org/10.1186/s12884-016-0888-x PMID: 27301244

55. Lund S., et al., Mobile phones improve antenatal care attendance in Zanzibar: a cluster randomized controlled trial. BMC pregnancy and childbirth, 2014. 14(1): p. 1–10.

56. Guy R., et al., How effective are short message service reminders at increasing clinic attendance? A meta-analysis and systematic review. Health services research, 2012. 47(2): p. 614–632. https://doi.org/10.1111/j.1475-6773.2011.01342.x PMID: 22091980

57. Manyati T.K. and Mutsau M., A systematic review of the factors that hinder the scale up of mobile health technologies in antenatal care programmes in sub-Saharan Africa. African Journal of Science, Technology, Innovation and Development, 2021. 13(1): p. 125–131.

58. Joshi C., et al., Factors associated with the use and quality of antenatal care in Nepal: a population-based study using the demographic and health survey data. BMC Pregnancy Childbirth, 2014. 14.

59. Fagbamigbe A.F. and Idemudia E.S., Assessment of quality of antenatal care services in Nigeria: evidence from a population-based survey. Reproductive health, 2015. 12(1): p. 1–9. https://doi.org/10.1186/s12978-015-0081-0 PMID: 26382228

60. Sidze E., et al., Inequalities in Access and Utilization of Maternal, Newborn and Child Health Services in sub-Saharan Africa: A Special Focus on Urban Settings. Maternal and child health journal, 2021: p. 1–30.

61. Atake E.H., Socio-economic inequality in maternal health care utilization in Sub-Saharan Africa: Evidence from Togo. The International Journal of Health Planning and Management, 2021. 36(2): p. 288–301.

62. Adekanle D. and Isawumi A., Late antenatal care booking and its predictors among pregnant women in South Western Nigeria. Online Journal of Health and Allied Sciences, 2008. 7(1).

63. Ifelunini I.A., et al., Women autonomy and demand for maternal health services in Nigeria: Evidence from the Nigeria Demographic and Health Survey. African Journal of Reproductive Health, 2022. 26(4): p. 65–74. https://doi.org/10.29063/ajrh2022/v26i4.7 PMID: 37584985

64. Solanke B.L., et al., What predicts delayed first antenatal care contact among primiparous women? Findings from a cross-sectional study in Nigeria. BMC Pregnancy and Childbirth, 2022. 22(1): p. 1–11.

65. Haider M.R., Qureshi Z.P., and Khan M.M., Effects of women's autonomy on maternal healthcare utilization in Bangladesh: Evidence from a national survey. Sexual & reproductive healthcare, 2017. 14: p. 40–47. https://doi.org/10.1016/j.srhc.2017.09.002 PMID: 29195633

66. Rahman M., Saha P., and Uddin J., Associations of antenatal care visit with utilization of institutional delivery care services in Afghanistan: intersections of education, wealth, and household decision-making autonomy. BMC pregnancy and childbirth, 2022. 22(1): p. 1–10.

67. Rizkianti A., et al., Women's decision-making autonomy in the household and the use of maternal health services: an Indonesian case study. Midwifery, 2020. 90: p. 102816. https://doi.org/10.1016/j.midw.2020.102816 PMID: 32823256

68. Seidu A.-A., et al., Continuum of care for maternal, newborn, and child health in 17 sub-Saharan African countries. BMC Health Services Research, 2022. 22(1): p. 1–10.

69. Cohen S.A. and Richards C.L., The Cairo consensus: population, development and women. Family planning perspectives, 1994. 26(6): p. 272–277. PMID: 7867776

70. Sarker B.K., et al., Status of the WHO recommended timing and frequency of antenatal care visits in Northern Bangladesh. PLOS ONE, 2020. 15(11): p. e0241185. https://doi.org/10.1371/journal.pone.0241185 PMID: 33151964

71. Acharya D., et al., Impact of mass media on the utilization of antenatal care services among women of rural community in Nepal. BMC research notes, 2015. 8(1): p. 1–6. https://doi.org/10.1186/s13104-015-1312-8 PMID: 26264412

72. Shiferaw K., et al., Adequacy and timeliness of antenatal care visits among Ethiopian women: a community-based panel study. BMJ open, 2021. 11(12): p. e053357. https://doi.org/10.1136/bmjopen-2021-053357 PMID: 34949623