Trends, Spatial Pattern and Determinants of Skilled Birth Attendant Utilization in Ethiopia: Data from Ethiopian Demographic and Health Surveys (2005, 2011 and 2016).

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1 **Trends, Spatial Pattern and determinants of Skilled Birth Attendant Utilization in**
2 **Ethiopia: Data from Ethiopian Demographic and Health Surveys (2005, 2011 and**
3 **2016).**

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19 **Plain English summary**

20 Skilled birth attendant is defined as a delivery assisted by qualified Medical Doctors (general
21 practitioners, gynecologist or related specialists), Public Health officers, Nurses,
22 Midwiferies, or health extension workers. This study aimed to assess the trends over the
23 time, spatial distribution and determinants of skilled birth utilization in Ethiopia.

24 Data from the three consecutive national health and demographic survey (2005, 2011, and
25 2016). A total of 32157 pregnant mothers employed for analysis. The trend of skilled birth
26 attendant utilization has been increased from five percent in 2005 to 10% in 2011 and 27.5%
27 in 2016. Skilled birth was clustered with spatial variation across the country. The primary
28 and secondary significant clusters of skilled birth attendants were located in Addis Ababa
29 and Dire Dawa.

30 Skilled birth attendant's utilization was determined by residence, women's educational level,
31 partner's educational level, age at first birth, maternal age at interview, and antenatal care
32 were significantly associated with SBA utilization.

33 In Conclusion; the Skilled birth assistance utilization has shown a substantial increased and
34 showed spatial variation in Ethiopia. We recommend strengthening maternal health programs
35 with special emphasis for uneducated and women from rural parts of a country.

36

Abstract

Introduction: Since 2000, Ethiopia has achieved considerable success in reduction of maternal and child mortality, but progress and distribution across the country in SBA remains unclear. This study aimed to assess the trend, spatial distribution, and determinants of skilled birth attendant utilization in Ethiopia.

Methods: Data from time series community-based cross-sectional study design of Ethiopian Demography and Health Surveys (2005-2016 EDHS) were employed. Data was downloaded and extracted from DHS website (www.dhsprogram.com). Stata version 16.0 for statistical and Arc-GIS version 10.1 and Sat-Scan software's were used for spatial analysis. Multilevel generalized linear model with binomial distribution was fitted to identify community and individual level factors associated with skilled birth attendant utilization. Adjusted odds ratio with 95% confidence interval used to report the association.

Result: The trend of skilled birth attendant utilization has been increased from 5% in 2005 to 27% in 2016. Skilled birth was clustered with spatial variation across the country. The primary and secondary significant clusters of skilled birth attendants were located in Addis Ababa and Dire Dawa. Skilled birth attendant's utilization was determined by residence, women's educational level, partner's educational level, age at first birth, maternal age at interview, and antenatal care were significantly associated with SBA utilization.

Conclusion: The SBA utilization has shown a substantial increased and showed spatial variation in Ethiopia. We recommend strengthening maternal health programs with special emphasis for uneducated and women from rural parts of a country.

Key words: Skill of birth Attendant, Spatial Pattern, Ethiopia

Introduction

The world pledged to improve maternal health within Sustainable Development Goal (SDG) to reduce the maternal mortality ratio (MMR) by 75% and ensure universal access to reproductive health by 2030. Although the global MMR is falling, up to 358, 000 women lose their lives during pregnancy and childbirth each year [1, 2]. Maternal mortality remains a public health priority, with MMRs high (above 300) in 45 countries [2].

According to a joint statement by World Health Organization (WHO), the International Confederation of Midwives (ICM), and the International Federation of Obstetricians and Gynecologists (FIGO), a ‘Skilled Birth Attendant’ [3] is defined as “an accredited health professional such as a midwife, doctor or nurse who has been educated and trained to proficiency in the skills needed to manage normal (uncomplicated) pregnancies, childbirth and the immediate postnatal period, and in identification, management and referral of complications in women and newborns [4]. The "percentage of births attended by a skilled birth attendant" is an indicator that has been adopted by several global monitoring frameworks, including the SDG agenda for regular monitoring as part of target 3.1 for reducing maternal mortality by 2030 [5, 6].

Most obstetric complications could be prevented or managed if women had access to a skilled birth attendant during childbirth. Globally, almost 80 per cent of live births occurred with the assistance of skilled health personnel in the latest period 2012-2017 – up from 62 per cent in the 2000-2005 period, with largest progress occurring in the last 10 years [7, 8]. However, the estimated coverage of births attended by skilled health personnel between

2012-2017 shows inequality between WHO regions as only 59 per cent of the births in the sub-Saharan Africa Region were attended by skilled health personnel whereas more than 68% to 99% of all births are attended by skilled health personnel in non-Sub Saharan Regions [9-11]. The utilization of skilled birth attendant (SBA) in Ethiopia is very across the administrative region [12-15]. Among the nine regions and two administrative cities, the Afar region had the lowest utilization (10%) and Addis Ababa had the highest utilization (86.5%). Majority of the mothers (84%) gave birth to their child at home, mainly assisted by relatives and traditional birth attendants (TBA) [16].

Factors such as wealth quintile, media exposure, and rural/urban residence were commonly adjudged as significant education of the adolescent mother and her partner were the commonest significant factors that influenced maternal health service utilization. Use of antenatal care also predicted use of skilled birth attendance and use of both predicted use of postnatal care. However, there may be some context-specific factors that need to be considered [17, 18]. This study aimed to assess the trends, spatial distribution, and associated factors of SBA in Ethiopia.

101 **Methods**

102 **Study Design, Setting & period**

103 A time series community based cross-sectional study design was employed using the
104 Ethiopian Demography and Health Surveys (2005-2016 EDHS) to assess the trends, spatial
105 patterns, and associated factors of SBA care service utilization in Ethiopia. The projections
106 of the 2007 population and housing census showed that the estimated total population of
107 Ethiopia was more than 99 million with a total fertility rate of 4.59 by 2015. More than 80%
108 of the Ethiopian population are rural habitants. The mean individual per a household was 4.6.
109 There has been a marked decline in the total fertility rate from 1990 to 2015 (from 6.4 births
110 to 4.59 births per woman) in Ethiopia [[19](#)].

111 The EDHS is considered as the main data source in the country as it was designed to provide
112 population and health indicators at the national and regional levels. The data collection
113 period was from Nov. 2004 to Jan. 2005 for 2005 EDHS, Sept. 2010 through Jan. 2011 for
114 2011 EDHS, and Jan. to June, 2016 for 2016 EDHS. This data analysis was conducted from
115 May 1 to Aug. 10, 2020.

116 **Data Sources**

117 The EDHS was first piloted in Ethiopia in 2000 and a total of four full-scale national surveys
118 (2000, 2005, 2011, and 2016) have been conducted to date. The data were collected by the
119 Central Statistical Agency (CSA) under the supervision of the Ministry of Health (MOH) and
120 technical support provided by the Inner-City Fund (ICF). These surveys deliver pertinent

health and social information (including maternal and child health, trends in key health indicators in population) to monitor policy decisions. This study utilized data from the EDHS of 2005, 2011, and 2016 years. Data also comprised the location data (latitude and longitude coordinates). The data was extracted from Measure Demography and Health Surveys (DHS) website (www.dhsprogram.com) after permission from the host is granted by letter no. 144625.

Sampling design and sampling process

The 1994 and 2007 Population and Housing Census, conducted by the Central Statistical Agency (CSA) provided the sampling frame (1994 for 2005 and 2007 for 2011 and 2016 EDHS) from which samples were drawn. The census contained a complete list of 84,915 enumeration areas (EAs). An EA is a geographical area covering on average 181 households [19, 20]. An EA is a geographic area consisting of a convenient number of dwelling units which served as counting unit for the census. The frame file contains information about the location, the type of residence, and the number of residential households for each of the 81,654 EAs. The cluster and household allocation by region and residence are a function of the average number of women 15-49 per household and of the household and individual response rates (obtained from the previous EDHS). A stratified two-stage cluster sampling procedure was used to select the nationally representative sample in all four surveys, with a high overall response rate that ranged from 95% to 99%. Additional information about data collection, sampling, and questionnaires used in the surveys are described in detail in the respective EDHS reports [21-24]. Because the sample is not self-weighting at the national

level, all data in this report are weighted (using sampling weight for women) unless otherwise specified.

In 2005 EDHS, a representative sample of approximately 14,500 households from 540 (145 urban and 395 rural) clusters was selected. A total of 14,645 households were selected, of which 13,721 (98.5% response rate) interviewed. A total of 14,070 (95.5% RR) eligible women (15-49yrs.) were interviewed, of which 11,163 were giving birth with the preceding five years of the survey period.

For the 2011 EDHS, the sample included 624 EAs, 187 in urban areas and 437 in rural areas. In the second stage, a fixed number of 30 households were selected for each EA. A representative sample of 17,817 households was selected, of which 16,702 (98%) households and 16,515 (95%) women interviewed. The data of 53 (8.5%) clusters were excluded from the spatial analysis as the geographical coordination data was missed.

In EDHS 2016, a total of 15,683 (95%) women in reproductive age were interviewed, but this study used 11,023 women who gave birth in the 5 years preceding the survey in the 642 clusters.

Outcome Variable

Skilled birth attendant was the outcome variable for this analysis. In the EDHS data, the ever-married women of reproductive age group were asked questions regarding their last birth(s) that occurred in the five years preceding the survey as to who assisted them with the delivery. From this specific question, dichotomous variables were created for this analysis. It

was coded as 1 if the woman received assistance at delivery from skilled birth attendants (SBAs) including qualified Medical Doctors (general practitioners, gynecologist or related specialists), Public Health officers, Nurses, Midwiferies, or health extension workers and 0 otherwise

$$Y_{ij} = \begin{cases} 1 & \text{if mothers received assistance at delivery from SBA} \\ 0 & \text{if mothers received assistance at delivery from non SBA} \end{cases}$$

Where SBA is skilled birth attendant, Y_{ij} : outcome variable [3] among individual i in j cluster.

Independent Variables

Factors assumed to influence the use of SBA service utilization [3] including;

Sociodemographic factors: residence (urban, rural), mother's age, household wealth index, mother's and father's education, mother's marital status, and mother's employment status
Obstetric histories: antenatal care, history of dangerous signs (history of chronic disease, eclampsia and preeclampsia, bleeding, or history of abortion)

Statistical analysis

After extracting the EDHS data; Stata version 16.0 was used for editing, recoding, and descriptive and multilevel generalized linear mixed effect model (GLMM) analysis. Geographical Information System (Arc-GIS version 10.1) and Sat Scan software's were used for spatial analysis. Descriptive statistics were used to summarize the overall characteristics of the study participants. Because of the hierarchical nature of DHS data, multilevel GLMM

was fitted with exchangeable correlation structure to identify factors associated with SBA care services.

The data of this analysis included mothers who give birth with the five years preceding survey nested within 540, 626, and 642 EAs for 2005, 2011, and 2016 EDHSs, respectively. Hence, considering the hierarchical nature of the data, multilevel logistic regression models were fitted to identify community and individual level factors associated with SBA by using “**xtnmelogit**” code of STATA.

To test the significance of the variance of random intercept, the likelihood ratio test was applied. Measures of variation for random effect were determined by computing Intraclass correlation coefficient (ICC), and median odds ratio (MOR). The ICC is a measure of within-cluster variation (i.e., the variation between individuals within the same cluster) [25-27], and MOR is the median odds ratio between the individual of higher propensity and the individual of lower propensity when comparing two individuals from two different randomly chosen clusters and it measures the unexplained cluster heterogeneity, the variation between clusters by comparing two persons from two randomly chosen different clusters [27, 28]. The MOR measure is always greater than or equal to 1 and if it is 1, there is no variation between clusters [29]. The within-cluster correlation was measured using ICC, which is expected to be $\geq 10\%$ to use the model.

The formulas for these measurements are as follows;

- i. $ICC = \text{cluster level variance} / \text{total variance}$: i.e. $ICC = \frac{v_i}{v_i + \frac{\pi^2}{3}}$: where v_i = estimated variance in each model, which has been described elsewhere [30].

202 ii. $MOR = \exp(\sqrt{2 * CLUSTER LEVEL VARIANCE}) * invnormal(0.75)$

203 i.e. $MOR = \exp(0.95\sqrt{v_z})$ if v_z = is the cluster level variance.

204 Adjusted odds ratio (AOR) with 95% confidence interval (CI) was reported to show the
 205 strength of the association and its significance for the fixed effect. Variables having p-value
 206 < 0.05 were considered as having significant association with the SBA. The model goodness
 207 of fit was checked and optimal model will be selected using Akaike information criterion
 208 (AIC). The model with the lowest value was considered the best fit model.

209 **Spatial analysis**

210 The spatial analysis was carried out using ArcGIS 10. 1 and Sat Scan 9.6. To produce the
 211 flattened map of Ethiopia, the Ethiopian Polyconic Projected Coordinate System was used
 212 [31]. The units of spatial analysis were DHS clusters (geographic coordinates of EDHS were
 213 collected at cluster level). The aggregated SBA count data was joined to the geographic
 214 coordinates based on each EA unique identification code. To evaluate whether the pattern
 215 expressed is clustered, dispersed, or random across the study areas, global spatial
 216 autocorrelation was assessed with ArcGIS using the Global Moran's-I statistic (Moran's I)
 217 [32]. When p-value indicates statistical significance, a positive Moran's I index value
 218 indicates tendency toward clustering, while a negative Moran's I index value indicates
 219 tendency toward dispersion [33].

220 In the presence of positive global spatial autocorrelation, local spatial cluster of areas with
 221 high or low SBA was detected using Kulldorff's method of purely spatial scan statistic
 222 assuming the discrete Poisson probability model in SaTScan [34]. To avoid the detection of

large clusters, we used a maximum of 10% of the population at risk for the spatial cluster size and the analysis was done using standard Monte Carlo hypothesis testing with 999 Monte Carlo replicates [35, 36]. A cluster is statistically significant when its log-likelihood ratio is larger than the Standard Monte Carlo critical value (C.V) for 0.05 significance level or p-value < 0.05.

Result

Sample characteristics and trends of skilled birth attendant

In three surveys (2005, 2011, and 2016), a total of 32157 pregnant mothers employed for analysis. However, the data of 12 (2.2%) clusters from 2005, 53 (8.5%) clusters from 2011, and 19 (3.0%) from 2016 EDHSs were excluded from the spatial analysis as the geographical information was missed.

The median age of mothers was 28 in 2005 and 2016, and 29 in 2016. The median age at first marriage was increased from 16 to 18 years. Median age at first birth was 18 (range 9-40) years. Of the total, 8,503 (86.23%), 9,668 (82.96%), and 8,667 (81.45%) were rural residents in 2005, 2011 and 2016 respectively. Regarding the educational status, 7,609 (77.16%), 8,142 (69.86%), and 6,838 (64.26%) had no formal education in 2005, 2011 and 2016 respectively.

Women who received ANC follow-up were increased from 28.5% in 2005 to 62.9% in 2016. Similarly, the median time of first ANC was decreased from 5 to 4 months (Tab. 1). Women characteristic are summarized in Tab. 1.

Tab. 1: Sample characteristics of women delivered their baby five years preceding the 2000, 2005, 2011 & 2016 Survey.

Legends: N, total; educ., educational; Sec.⁺, secondary and above; 4+, four and above

Institutional delivery was almost doubled (10.5%) in 2011 and tripled (27.45%) in 2016 compared to 5.92% in 2005. The proportion of women received skilled birth delivery was increased from 5.45% (996/9862) in 2005 to 10.25% (1,603/11631) in 2011 and 27.5% (3,525/10641) in 2016. The magnitude was increased with the increased number of ANC follow-up, educational level and wealth quintile. The trends of skilled birth delivery for rural mothers also increased from 268 (3.15%), to 448 (4.64%) and 1,952 (22.52%) in 2011 and 2016 respectively (Figure 1A, 1B).

Figure 1: Trends of skilled birth attendant education, order of birth, wealth index and maternal health service and regional states of Ethiopia.

Spatial analysis of SBA utilization

Spatial distribution and Autocorrelation of SBA.

The high proportion of skilled delivery was observed in Dire Dawa, Harari, Southern Oromia, Somali, and Benishangul Gumuz regions which ranges from 61.9% to 100%. The low proportion of skilled delivery was observed in Amhara and some parts of Oromia and Tigray regions of Ethiopia.

The clustered patterns of all surveys showed differences in skilled birth attendant utilization occurred over the study area. Global Moran Index indicated that there is less than 1% likelihood that clustered pattern could be the result of random chance. The bright red colors to the end tails indicate increased significance level. All surveys indicated (Moran I (2005) = 0.263: $p < 0.001$, (2011) = 0.175: $p = 0.001$, (2016) = 0.085: $p < 0.001$) there was spatial variability in skilled birth delivery for women in Ethiopia (Figure 2A, 2B, 2C).

Figure 2: Spatial autocorrelation of skilled birth attendant across the regions of Ethiopia, EDHS 2005, EDHS 2011, and EDHS 2016.

Legends: (Moran's I figure showed represents as follows A=2005, B=2011 and C=2016).

Spatial scan analysis

Totally, most likely 32 (10 for 2005, 10 for 2011, and 12 for 2016 EDHSs) significantly high clusters were identified (Figure 3, figure 4, figure 5, Tab. 2). In 2005 and 2011, primary and secondary clusters with high SBA were found around Addis Ababa and Dire Dawa respectively. In 2016, the possible clusters with high SBA were recorded in Addis Ababa (primary) and Dire Dawa and Harari (secondary) (Tab. 2).

Tab. 2: Identified primary and secondary clusters with high SBA Utilization, Ethiopia

Legends: E, east; N, North; km, kilometers; S, survey; LLR, log-likelihood ratio; RR, relative ratio; 1⁰, primary clusters; 2⁰ secondary clusters

Figure 3: Spatial scan statistics of skilled birth attendant across the regions of Ethiopia in EDHS 2005.

Legend: LLR, loglikelihood ratio

Figure 4: Spatial scan statistics of skilled birth attendant across the regions of Ethiopia in EDHS 2011

Legend: LLR, loglikelihood ratio

Figure 5: Spatial scan statistics of skilled birth attendant across the regions of Ethiopia, in EDHS 2016

Legend: LLR, loglikelihood ratio

Determinants of SBA utilization

In the mixed-effect multivariable logistic regression model; residence, women's educational level, partner's educational level, age at first birth, and antenatal care were significantly associated with SBA for all EDHS (2005, 2011 and 2016). However, age of women was significantly associated with SBA in 2005 and 2016, whereas distance from health facilities had significant association with SBA in 2011 and 2016 (**Tab. 3**).

For variables showing association in all surveys (**Tab. 3**), taking the most recent survey (EDHS 2016), the odds of SBA were decreased by 78% (AOR:0.22; 95%CI:0.15, 0.32) among rural residents compared to urban. The likelihood of SBA among women aged 35 years and above, and 20-34 years was decreased by 60% and 50% respectively, compared to mothers whose age was less than 20 years. Contrary, as the age at first delivery was increased by 1 year, the odds of SBA were increased by 15% (AOR:1.06; 95%CI:1.03, 1.08).

Compared to uneducated mothers, the odds of receiving SBA were higher by 54% (AOR:1.54, 95%CI: 1.29, 1.85) for mothers completed at primary level, and three times (AOR: 2.86, 95%CI: 2.06, 3.97) for mothers completed secondary or higher educational

level. Women whose partner completes secondary or higher educational level received SBA twice (AOR:1.89; 95%CI:1.46, 2.43) whose partner had no education. The odds of SBA for rich women were increased by 61% (1.99 (1.53, 2.58), whereas 2.64 (AOR:2.64; 95%CI:1.90, 3.67) times higher among richest compared to poorest women.

Receiving SBA among respondents who reported that distance to a health institution is a big problem was lower by 31% (AOR:0.71; 95%CI: 0.60, 0.84) compared to those who reported finding a health institution is not a big problem. Compared to women who never attend ANC service, the likelihood of receiving SBA was increased by 2.6 (AOR:2.61; 95%CI: 2.02, 3.37) for mothers who attend at most ANC visits and increased by more than four times (AOR:4.32; 95%CI: 3.34, 5.60) by attending optimal ANC (at least four times) respectively.

Tab. 3:Associated factors of skilled birth delivery determined by multilevel mixed effects generalized linear regression (Binomial family) for 2005, 2011, and 2016 EDHS.

Legends: SBA, skilled birth attendant; AOR, adjusted odds ratio; hh, Household; #, optimal ANC if 4 or more visits during pregnancy; @, cluster level factor; CrI, credential interval; MOR, median odds ratio; CI, confidence interval; Secondary education is if one complete grade 12 or more; *: <0.05, **: <0.01, ***: <0.001

The interclass correlation of 2016 EDHS model (ICC: 0.17, 95%CI: 0.14, 0.22) showed observations from the same cluster are usually more similar to each other than observations from different clusters (**Tab. 3**). Thus, the cluster level random effects comprise approximately 16-17% of the total residual variance in the model. In addition, the MOR showed the residual heterogeneity between areas (MOR=2.72) was of greater relevance than was the impact of the person's level of factors for understanding variations in the odds of receiving a skilled birth attendant (**Tab. 3**).

327

328 **Discussion**

329 This study aimed to assess the trend, identifies the spatial distribution and determinants of
330 SBA in Ethiopia over the ten years. The delivery attended by skilled birth attendants
331 increased from 10% to 26% over the 10 years. The improvement might be due to the focus of
332 training health cadres since the inclusion of SBA as a key outcome indicator in the MDGs
333 after the 1999 International Conference on Population and Development (ICPD) [37, 38]
334 based on the 2004 WHO/FIGO/ICM joint statement on the definition of the skilled attendant
335 [39]. Additionally, increment in coverage of antenatal utilization and sociodemographic
336 improvement in the country might also contribute for the advancement of SBA.

337 There was a persisting spatial variation of SBA across the country as there was a significant
338 clustering in all surveys. The high magnitude of SBA was reported in urban setups whereas
339 comparatively low proportion was reported in rural parts of regions. This could be due to the
340 area with high SBA are relatively urban in which health facilities are more accessible,
341 occupied by high proportion of skilled birth attendants and women are more educated.

342 Age at interview was negatively associated with SBA. Most of the young mothers in this age
343 group had lower parity that might decrease mother's confidence and experience to deliver at
344 home. In Ethiopia, it is reported adolescent girls are more likely to visit ANC service which
345 could boost the chance of being attended by skilled birth attendant [40, 41]. The finding is in
346 line with reports of studies conducted in Ethiopia [42, 43]. However, showed discrepancies
347 with the previous study conducted in Ghana as the older women had more likelihood of

348 receiving SBA [\[44\]](#). The difference comes from the higher induction and caesarean delivery
349 in former study

350 Age at first birth is positively associated with the SBA. The association might be indirectly
351 affected by education status of women during marriage, which is the most important
352 predictor of age at first birth. Education is also increasing the chance of readiness that related
353 to birth preparedness and complications [\[45\]](#). Hence, being pregnant for the first time
354 increase the chance of birth preparedness including choice of birth attendant.

355 The SBA was higher by two to three times among higher quintiles of wealth index compared
356 to the poorest ones. The result is similar with the association reported in Bangladesh [\[46\]](#),
357 South Sudan [\[47\]](#), and India [\[48\]](#). the study conducted in 2013-2014 in Malawi also reported
358 usage for health services was lowest among women belonging to the lowest wealth quintile
359 [\[49\]](#). Similarly, the local study in Ethiopia [\[50\]](#) also reported the high income level is
360 positively associated with the SBA. Even though the institutional delivery is free of charge in
361 Ethiopia, wealth might be determining the other fees charged for required drugs and supplies
362 that poorest mothers did not afford.

363 The likelihood of SBA for rural residents was decreased by 70% to 83% compared to the
364 urban. This might be due to the socioeconomic inequalities, access to health information, and
365 differences in health services access (antenatal care or institutional delivery) between urban
366 and rural settings in the country. The result was comparable with studies conducted in
367 Malawi [\[49\]](#), Bangladesh [\[46\]](#), and Malawi [\[49\]](#).

Both mothers and their partner's educational level were positively associated with SBA persistently in all surveys. Receiving SBA was higher by more than fifty percent for mothers completed primary and three times for mothers with secondary or higher educational level. Educated mothers had the control over resources within the household, more open and better communication with the husband, more decision-making power, increased self-worth, better coping abilities, and negotiating skills as well as reduced power differential towards health care providers and thus better communication and ability to demand adequate services [51]. The previous studies conducted in Namibia [52], Bangladesh [46], Malawi [49], and South Sudan [47] also support similar view.

The SBA was 10% to 89% higher among women whose partner was completed at primary and secondary or post-secondary educational level compared to women whose partner was no formal education. A study conducted in Kenya [53, 54] and analysis from Kenya's KDHS 2008-09 [55]. It is believed that educated husbands are better understand the benefits of SBA, had better attitudes and cultural beliefs. It is also hypothesized that educated person is more likely to seek skilled care and higher interest to new health-related information.

Positive association was observed between SBA and number of ANC follow-up. The trend of skilled birth attendant over the last ten years was increased with the increment of optimal (four or more times) antenatal care utilization. Antenatal care is empowering mothers by exposing them to the health information benefit of institutional delivery of postnatal care. Moreover, women receive the identification of preexisting health conditions, early detection of complications arising during pregnancy, and birth preparedness and complication planning

which expose them to skilled birth attendants [56]. The finding is in agreement with studies conducted in Bangladesh [46] and South Sudan [47].

In 2005 EDHS, the distance from health facilities was not associated with SBA. However, it was negatively associated with SBA in 2011 and 2016 EDHS. Women who reported the distance from health facilities is big problem were 29% (2016 EDHS) to 31% (2011 EDHS) less likely to receive SBA. The discrepancy might be originated from the difference in health service coverage over the past years. Before 2000, most part of the country (Ethiopia) had low coverage where all women share the same problem whereas the improvement in primary health coverage along with frontline health extension workers [57]. This might be giving privilege to the urban and semiurban areas. The finding is also in agreement with studies conducted in North Gondar [58] and South West Shewa [59], Ethiopia, and in Bangladesh [60].

Strength and limitations

Our model results affirm the strong methodological gains of spatial and advanced models for national estimation of SBA utilization and its determinants. The description of ten-year trends of SBA is another strength of this analysis.

Despite our extensive and systematic efforts to diagnose and improve the models, the study is not without limitations. First, removing DHS clusters without geographic coordinate information might under or overestimate the study finding. The second limitation was the location of data values was displaced up to 2 kilometers for urban and up to 5 kilometers for rural areas to ensure respondent confidentiality, thus, this was the challenge to know the

exact cases' location. Another limitation was small samples from Somali region in 2005 and 2011 might be affect the result of the region because DHS does not provide distinct weights for different levels, such as region, cluster or household-level weights.

Conclusion

The SBA utilization has shown a substantial increase over time from 2005 to 2016. Skilled birth attendant utilization showed spatial variation in Ethiopia. We recommend strengthening maternal health programs with special emphasis for uneducated and women from rural parts of a country. There is also need for more national studies highlighting the regional disparities in maternal healthcare service utilization.

Abbreviation

ANC: Antenatal care

CSA: Central Statistical Agency

DHS: Demographic and health survey

EDHS: Ethiopian Demographic and Health Survey

GLMM: Generalized Linear Mixed Effect Model

MOH: Ministry of Health

SBA: Skilled Birth Attendance

428 SGD: Sustainable Development Goal

429 WHO: World Health Organization

430 **Declarations**

431 **Ethics approval and consent to participate**

432 This study use the secondary data from the DHS repository and does not require ethical
433 approval.

434 **Consent for publication**

435 Not applicable

436 **Availability of data and materials**

437 The datasets generated and/or analysed during the current study are available in the
438 <https://dhsprogram.com/data/available-datasets.cfm> repository. Additionally, all data
439 generated or analysed during this analysis will be found from the corresponding author upon
440 request.

441 **Competing interests**

442 The authors declare that they have no competing interests.

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No fund was received for the designing of the study, analysis, and interpretation of data and in writing the manuscript.

Authors' contributions

LDR conceptualize this study and major contributors in designing data acquisition, analysis, and interpretation. The other authors (AT, BST and ABW) were drafting and revising the article for intellectual content. All authors read and approved the final manuscript.

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618 Table 4: Sample characteristics of women delivered their baby five years preceding the 2000,
619 2005, 2011 & 2016 Survey.

Factors	Category	Total (%)			Skilled delivery (%)		
		2005	2011	2016	2005	2011	2016
Antenatal care	N	6,589	7758	7193	810	1287	2812
	0	4,442 (67.4)	4,260 (54.9)	2,481 (34.5)	125 (15.4)	174 (13.5)	212 (7.5)
	1	260 (4.0)	338 (4.4)	342 (4.8)	18 (2.2)	30 (2.3)	103 (3.7)
	2	279 (4.2)	527 (6.8)	563 (7.8)	20 (2.5)	56 (4.3)	196 (7.0)
	3	439 (6.7)	901 (11.6)	1,187 (16.5)	87 (10.7)	206 (16.0)	552 (19.6)
	4+	1,169 (17.7)	1,732 (40.7)	2,620 (36.4)	560 (69.1)	821 (63.8)	1,749 (62.2)
Educational level	N	9,861	11,631	10,641	1025	1603	3,525
	0	7,609 (77.2)	8,124 (69.9)	6,838 (64.3)	314 (30.6)	506 (31.6)	1,338 (38.0)

	1	1,548 (15.7)	2,925 (25.1)	2,678 (25.2)	236 (23.0)	636 (39.6)	1,256 (35.6)
	2	704 (7.1)	582 (5.0)	1,125 (10.5)	475 (46.4)	461 (28.8)	931 (26.4)
Educational level of partner	N	9,757	11,418	9,933	1003	1553	3201
	No educ.	5,834 (59.8)	5,964 (52.2)	4,928 (49.6)	183 (18.3)	279 (18.0)	913 (28.5)
	Primary	2,538 (26.0)	4,177 (36.6)	3,220 (32.4)	219 (21.8)	618 (39.8)	1,078 (33.7)
	Sec. ⁺	1,385 (14.2)	1,277 (11.2)	1,785 (18.0)	601 (59.9)	656 (42.2)	1,210 (37.8)
Problem-Health access	N	9,861	11,631	10,641	1025	1603	3,525
	Big	6,942 (70.4)	8,594 (73.9)	5,834 (54.8)	372 (36.3)	662 (41.3)	1,235 (35.0)
	Small	2,919 (29.6)	3,037 (26.1)	4,807 (45.2)	653 (63.7)	941 (58.7)	2,290 (65.0)
	Later	1,649 (16.7)	2,099 (18.1)	1,491 (14.0)	189 (18.4)	322 (20.1)	559 (15.9)
	No more	1,571 (15.9)	951 (8.2)	661 (6.2)	195 (19.0)	143 (8.9)	205 (5.82)
Residence wealth Index	N	9,861	11,631	10,641	1025	1,603	3,525
	Urban	1,358 (13.8)	1,985 (17.1)	1,974 (18.6)	733 (71.5)	1,155 (72.1)	1,573 (44.6)
	Rural	8,503 (86.2)	9,646 (82.9)	8,667 (81.5)	292 (28.5)	448 (27.9)	1,952 (55.4)
		9,861	11,631	10,641	1025	1603	3525
	Poorest	2,529 (25.7)	3,620 (31.1)	3,993 (37.5)	49 (4.8)	113 (7.1)	509 (14.4)
	Poorer	1,846 (18.7)	2,107 (18.1)	1,782 (16.8)	27 (2.6)	76 (4.7)	469 (13.3)
	Middle	1,837 (18.6)	1,863 (16.0)	1,466 (13.8)	53 (5.7)	74 (4.6)	432 (12.3)
	Richer	1,672 (17.0)	1,869 (16.1)	1,308 (12.3)	91 (8.89)	164 (10.2)	463 (13.1)
	Richest	1,977 (20.1)	2,172 (18.7)	2,092 (19.7)	805 (78.5)	1,176 (73.4)	1,652 (46.9)
Sex of HH head		9,861	11,631	10,641	1025	1,603	3,525
	Male	8,527 (86.5)	9,448 (81.2)	8,383 (78.8)	762 (74.3)	1,165 (72.7)	2,681 (76.1)
	Female	1,334 (13.5)	2,183 (18.8)	2,258 (21.2)	263 (25.7)	438 (27.3)	844 (23.9)
Age		9861	11631	10641	1025	1603	3525
	Less than 20	533 (5.4)	514 (4.4)	404 (3.8)	63 (6.2)	67 (4.2)	178 (5.1)
	20-34	6,899 (70.0)	8,336 (71.7)	7,692 (72.3)	792 (77.3)	1,293 (80.7)	2,634 (74.7)
	35 and above	2,429 (24.6)	2,781 (23.9)	2,545 (23.9)	170 (16.6)	243 (15.2)	713 (20.2)

Terminat e pregnanc y	N	9,861	11,631	10,641	1025	1,603	3,525
	No	9,148 (92.8)	10,467 (90.0)	9,736 (91.5)	925 (90.2)	1,428 (89.1)	3,211 (91.1)
	Yes	713 (7.2)	1,164 (10.0)	905 (8.5)	100 (9.8)	175 (10.9)	314 (8.9)

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621 Table 2: Identified primary and secondary clusters with high SBA Utilization, Ethiopia.

S	Identified clusters	Coordinates /radius	LLR	RR	P- value
2 0 0 5	1 ⁰ 139, 86, 454, 240, 140, 523, 84, 2, 164, 510, 491, 411, 256, 302, 185, 310, 226, 403, 452, 23, 381, 311, 220, 263, 327, 357, 271, 20, 260, 19, 62, 331, 468, 135, 501, 124, 129, 488, 237, 362, 408, 536, 356, 332, 431, 293, 398, 316, 281	(8.962153 N, 38.767544 E) / 12.76 km	341.84	9.62	0.001
	2 ⁰ 169, 141, 208, 378, 179, 63, 318, 306, 524, 272, 85, 294, 422, 495, 386, 3, 300, 375, 321, 91, 456, 366, 301, 173, 473, 521, 493, 95, 469, 121, 287, 446, 92, 275, 369, 228, 371, 89, 114, 285, 166, 79, 476, 478, 155, 358, 345, 117, 525, 425, 429, 38, 196, 391	(9.534712 N, 42.075720 E) / 29.09 km	149.72	4.06	0.001
2 0 1 1	1 ⁰ 103, 441, 630, 481, 394, 167, 156, 495, 374, 326, 265, 353, 614, 519, 24, 458, 587, 546, 485, 523, 535, 2, 96, 34, 336, 272, 23, 591, 525, 162, 22, 517, 238, 197, 380, 603, 491, 611, 328, 36, 9, 618, 186, 599, 141, 212, 173, 309, 214, 82, 595, 613, 289, 430	(8.986108 N, 38.695201 E) / 18.85 km	368.30	7.89	0.001
	2 ⁰ 138, 286, 345, 270, 436, 200, 590, 352, 602, 78, 400, 455, 203, 376, 205, 483, 456, 308, 596, 170, 529, 448, 549, 446, 645, 194, 616, 440, 59, 182, 285, 572, 576, 429, 501, 51, 169, 373, 159, 544, 3, 4, 573, 275, 74, 431, 632, 44, 355, 415, 305, 179, 516, 331, 575, 150, 451, 465, 343, 606, 494, 128, 370, 564, 137, 323, 312, 114, 428	(9.544242 N, 42.033091 E) / 29.52 km	313.99	5.57	0.001
2 0 1 6	1 ⁰ 159, 302, 293, 195, 635, 59, 110, 414, 305, 264, 225, 19, 61, 582, 108, 15, 639, 314, 100, 31, 626, 451, 107, 645, 539, 369, 170, 487, 247, 153, 91, 339, 155, 11, 532, 608, 144, 428, 330, 464, 463, 509, 112, 145, 560, 211, 475, 261,	(9.002245 N, 38.749238 E) / 68.22 km	195.00	3.05	0.001

274, 287, 252, 402, 90, 236, 83, 353, 147, 303, 40, 290,
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2⁰ 281, 523, 242, 311, 642, 166, 202, 352, 613, 514, 473, 493, (9.561432 N, 102.02 2.01 0.001
27, 444, 185, 519, 471, 224, 385, 5, 535, 390, 606, 273, 5
631, 151, 74, 111, 467, 380, 363, 282, 190, 644, 610, 30, 42.037215 E)
101, 140, 43, 546, 381, 495, 288, 329, 383, 238, 419, 357, / 32.89 km
443, 173, 396, 60, 393, 594, 614, 28, 228, 157, 397, 56,
387, 257, 534, 44, 179, 607, 321, 58, 29, 194, 418, 240, 25,
500, 587, 115, 133, 483, 580, 557

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623 Table 3: Determinants of skilled birth attendant determined by multilevel mixed effects
624 generalized linear regression (Binomial family) for 2005, 2011 and 2016 EDHS.

SBA	2005	2011	2016
	AOR (95CI)	AOR (95CI)	AOR (95CI)
Age category (years)			
15-19	1	1	1
20-34	0.57 (0.36, 0.89) *	0.99 (0.64, 1.53)	0.50 (0.36, 0.70) ***
35 and above	0.40 (0.24, 0.68) **	0.74 (0.45, 1.20)	0.43 (0.30, 0.62) ***
Region @			
Addis Ababa	1	1	1
Tigray	0.25 (0.12, 0.51) ***	0.15 (0.08, 0.29) ***	0.92 (0.39, 2.19)
Afar	0.30 (0.12, 0.75) *	0.15 (0.07, 0.31) ***	0.12 (0.05, 0.31) ***
Amhara	0.23 (0.12, 0.45) ***	0.30, (0.16, 0.57) ***	0.18 (0.08, 0.43) ***
Oromia	0.37 (0.20, 0.68) **	0.26 (0.14, 0.47) ***	0.23 (0.10, 0.54) **
Somali	0.34 (0.13, 0.91) *	0.32 (0.15, 0.65) **	0.21 (0.09, 0.51) ***
Ben-Gumuz	0.46 (0.22, 0.98) *	0.42 (0.22, 0.83) *	0.283 (0.12, 0.68) **
SNNP	0.19 (0.10, 0.36) ***	0.21 (0.11, 0.42) ***	0.32 (0.13, 0.76) *
Gambela	0.96 (0.48, 1.93)	0.66 (0.34, 1.30)	0.25 (0.10, 0.61) **
Harari	1.11 (0.56, 2.18)	0.86 (0.45, 1.63)	0.46 (0.19, 1.13)

Dire Dawa	0.67 (0.34, 1.31)	1.43 (0.76, 2.72)	0.45 (0.180, 1.11)
Residence[@]			
Urban	1	1	1
Rural	0.29 (0.19, 0.46) ***	0.17 (0.12, 0.26) ***	0.22 (0.15, 0.32) ***
Educational Level			
No education	1	1	1
Primary	1.50 (1.10, 2.03) **	1.77 (1.41, 2.22) ***	1.54 (1.29, 1.85) ***
≥Secondary	2.50 (1.72, 3.63) ***	4.14 (2.78, 6.15) ***	2.86 (2.06, 3.97) ***
Partner's Educational level			
No education	1	1	1
Primary	1.39 (1.00, 1.92)	1.41 (1.11, 1.80) **	1.10 (0.92, 1.31)
≥Secondary	2.09 (1.47, 2.99) ***	2.19 (1.59, 3.0) ***	1.89 (1.46, 2.43) ***
Head of hh			
Male	1	1	1
Female	1.19 (0.88, 1.59)	1.22 (0.97, 1.54)	1.15 (0.94, 1.42)
Age at first birth	1.11 (1.07, 1.14) ***	1.06 (1.04, 1.09) ***	1.06 (1.03, 1.08) ***
History of Abortion			
No	1	1	1
Yes	1.29 (0.83, 2.01)	1.26 (0.92, 1.73)	1.00 (0.78, 1.29)
ANC follow up			
No	1	1	1
Sub optimal	3.20 (2.30, 4.45) ***	2.61 (2.02, 3.37) *	2.61 (2.02, 3.37) ***
Optimal [#]	5.67 (4.18, 7.70) ***	4.32 (3.34, 5.60) ***	4.32 (3.34, 5.60) ***
Wealth index			
Poorest	1	1	1
Poor	0.82 (0.44, 1.54)	1.14 (0.76, 1.71)	1.88 (1.49, 2.38) ***
Middle	1.20 (0.66, 2.18)	1.02 (0.67, 1.54)	1.72 (1.34, 2.20) ***
Rich	2.10 (1.23, 3.59) **	1.61 (1.11, 2.35) *	1.99 (1.53, 2.58) ***

Richest	3.52 (2.02, 6.14) ***	2.35 (1.54, 3.60) ***	2.64 (1.90, 3.67) ***
Distance from health facility @			
Small problem	1	1	1
Big problem	0.83 (0.66, 1.11)	0.69 (0.56, 0.86) ***	0.71 (0.60, 0.84) ***
Model summary			
ICC	0.16(0.12, 0.24)	0.17 (0.13, 0.24)	0.17 (0.14, 0.22)
MOR (95% CrI)	2.70 (1.80, 3.64)	2.72 (2.47, 2.98)	2.72 (1.92, 3.52)
AIC	2363.69	1440.17	1392.79
SBA, skilled birth attendant; AOR, adjusted odds ratio; hh, Household; #, optimal ANC if 4 or more visit during pregnancy; @, cluster level factor; CrI, credential interval; MOR, median odds ratio; CI, confidence interval; Secondary education is if one complete grade 12 or more,			
*: <0.05, **: <0.01, ***: <0.001			

Figures

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Figure 1

Trends of skilled birth attendant education, order of birth, wealth index and maternal health service and regional states of Ethiopia.

Figure 2

Spatial autocorrelation of skilled birth attendant across the regions of Ethiopia, EDHS 2005, EDHS 2011, and EDHS 2016.

Figure 3

Spatial scan statistics of skilled birth attendant across the regions of Ethiopia in EDHS 2005.

Figure 4

Spatial scan statistics of skilled birth attendant across the regions of Ethiopia in EDHS 2011

Figure 5

Spatial scan statistics of skilled birth attendant across the regions of Ethiopia, in EDHS 2016