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Giving birth in Ethiopia: a spatial and multilevel analysis to determine availability and factors associated with healthcare facility births

Running head: Giving birth in Ethiopia

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Abstract

Objective: To assess spatial variations in the use of healthcare facilities for birth and to identify associated factors.

Design: Cross-sectional analysis of population- and healthcare facility-based data.

Setting: Ethiopia Demographic and Health Survey (EDHS 2016) linked to Service Provision Assessment data (SPA 2014).

Population: 6,954 women who gave birth in the five years preceding the 2016 DHS and 717 healthcare facilities providing delivery care.

Methods: Secondary data analysis of linked population and health facility data was conducted. Multilevel and spatial analyses were conducted to identify key determinants of women's use of health facilities for birth and to assess spatial clustering of facility births.

Main outcome measure: Health facility birth.

Results: A one-unit increase in the mean score of health facilities' readiness to provide basic emergency obstetric care (EmOC) was associated with a two-fold increase in the odds of facility birthing (Adjusted Odds Ratio [AOR] = 2.094, 95% CI 1.187–3.694). Women's attendance for at least four antenatal care visits was significantly associated with facility birth (AOR = 8.863, 95% CI 6.748–11.640). Distance to a healthcare facility was inversely related to women's use of facility birthing (AOR = 0.967, 95% CI 0.944–0.991). Women in the richest wealth quintile were also more likely to have facility births (AOR = 2.892, 95% CI 2.199–3.803).

Conclusion: There were geographic variations in facility births in Ethiopia, revealing critical gaps in service availability and readiness. It is important to ensure that health facilities are in a state of readiness to provide EmOC service.

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Keywords: Health facility births, health facility delivery, institutional delivery, spatial analysis, multilevel analysis

Tweetable abstract: Failure to ensure health facility readiness is associated with failure to give birth at a healthcare facility.

Introduction

Globally, healthcare facilities are not evenly distributed in terms of geography and population. The distribution of EmOC facilities varies significantly between low and high-income countries.[1] Even within a country, rural areas have the least access to EmOC services.[1-4] EmOC is grouped into two categories: basic and comprehensive EmOC.[5] There should be at least five basic EmOC facilities, including one comprehensive EmOC facility, per 500,000 population.[5] Previous studies have shown that countries with high and moderate numbers of maternal deaths had an insufficient number and/or poor distribution of EmOC facilities. Furthermore, the available EmOC facilities did not provide a full range of services.[2, 6] Due to inequality in the distribution of healthcare facilities, utilization of healthcare services varies across and within countries.[7-9] In Ethiopia, for instance, utilization of maternal healthcare services varies across regional states, and urban and rural areas.[10-13]

An extensive body of literature can be found on factors that influence the place of childbirth.[14-18] The majority of past studies have focused on the demand-side determinants that operate at the individual, household or community levels, such as women's education, parity and distance to EmOC facilities.[19-23] The effect of the supply-side, the characteristics of healthcare offered in health facilities, such as EmOC availability and facilities' service readiness has largely been overlooked to date.[18, 24] This is mainly due to the lack of service-provision data availability. However, with the increasing availability of georeferenced health facility [25] and population [13] data, it is possible to link these datasets. Supply-side data from a health facility can be linked to

population data in order to investigate the relationship between service-provision and service uptake, including health facility births.

A geographically linked analysis of health facility and population data is valuable to map where women attend for childbirth and to identify inequalities in service provision and uptake. This is very important for informed decision-making. It is a valuable way of looking *'what is where'* on the Earth's surface, such as where the health facilities providing EmOC are located in relation to the population distribution. It allows health planners and healthcare professionals to understand the distribution and range of specific health services in a given geographic location.

This study aimed to assess the spatial variations in births at a health facility over a five-year period in Ethiopia. It also aimed to identify the potential factors associated with health facility births using linked population and health facility data.

Methods

Data sources

This study used two nationally representative sets of population and health facility-based survey data. The main source of the population data was the 2016 Ethiopian Demographic and Health Survey (EDHS). The 2016 EDHS was a cross-sectional household survey that aimed to provide up-to-date estimates of key demographic and health indicators. For instance, population's health data include health service use, such as timing of first antenatal care (ANC) visits, the total number of ANC visits, and the place of childbirth.[13]

The 2016 EDHS used a two-stage stratified sampling procedure.[13] In the survey, 16,583 women aged 15-49 years were identified where only 15,683 women were interviewed.[13, 26] Of the 15,683 women, 7,193 women gave birth in the five years preceding the survey. Among 7,193 women, only 6,954 women were included in this study. Due to missing geographic coordinates, 239 women from 23 DHS clusters or EAs were excluded from this analysis. The geographic coordinates of DHS clusters were captured using the global positioning system (GPS) receivers.[27]

The health facility data were obtained from the 2014 Ethiopian Service Provision Assessment Plus (ESPA+) survey.[25] The ESPA+ survey data was obtained from the Ethiopian Public Health Institute (EPHI). In addition to other health facility characteristics, the ESPA+ data had

information on health service availability and readiness, including EmOC availability and facility service readiness.[25]

The 2014 ESPA+ survey used the list of 23,102 formal health facilities operating in the country. A combination of census and simple random sampling techniques were used to select health facilities.[25] The survey included all hospitals, including newly identified hospitals. A representative sample of health centres, health posts and clinics was included using the simple random technique. In total, 1,327 health facilities, including 321 health posts and 10 newly identified hospitals, were included. However, data were collected only from 1,165 health facilities.[25] Teams of data collectors visited and interviewed healthcare providers and administrative staff.[25] For this analysis, data were included from 717 facilities that reported provision of delivery care services. Among these facilities, 200 were hospitals and 517 were sampled health centres, health posts and clinics.

Data linking

The population and health facility data were linked using the relevant government administrative boundary link. This method links a DHS cluster with all health facilities that fall within a particular geographic boundary.[26] Ethiopia's highest administrative boundaries (city administrations and administrative regions) were used for this administrative boundary linking method. Ethiopia's administrative boundaries were obtained from Natural Earth.[28]

Health service environment

In this study, four service environment variable scores were created using principal component analysis.[26] These were average straight-line distance to the nearest basic emergency obstetric care (BEmOC) facility, general service readiness, and BEmOC service availability and readiness. These scores were created using the World Health Organization's 'Service Availability and Readiness Indicators' (SARA).[29, 30] Service availability and readiness scores were computed for the nearest BEmOC facility. The distance used in this study was the average straight-line distance between DHS clusters and BEmOC facilities.[26] First, within defined administrative boundaries, the average straight-line distance between each DHS cluster and BEmOC facility was calculated. Second, based on the computed average straight-line distance, the nearest BEmOC facility was identified. Finally, the average straight-line distance was calculated for each administrative boundary.

The principal component analysis resulted in nine dimensions of general service readiness scores.[26] Average general service readiness scores were computed for each administrative boundary using the SCORE procedure in SAS. Two general service readiness scores (health facility management system and infrastructure) were computed using the first two principal components (Table S1). In general, the highest the scores, the more likely each health facility to provide EmOC services.

Indices of basic obstetric care availability and readiness were created for healthcare facilities reported as providing basic obstetric care services. One BEmOC service availability score (BEmOC signal functions) was created using seven variables [26] (Table S1).

Similarly, three BEmOC readiness scores (skilled personnel, medicine and commodities, and delivery equipment) (Table S1)[26] were created using 12 variables: staff trained in delivery and newborn care; skilled delivery care providers (with 24-hour coverage); examination lights; delivery packs; suction apparatuses (mucus extractors); manual vacuum extractors; vacuum aspiration (dilatation and curettage kit); neonatal bags and masks; blank partographs; antibiotic eye ointment for newborns (e.g., tetracycline); injectable antibiotics (e.g., Ceftriaxone); and IV solution (i.e., Ringer's lactate and Normal saline) with infusion set.

A pregnant woman was considered to have had a health facility birth if she reported having her most recent birth, in the five years preceding the survey, at a health facility.

Statistical analysis

Multilevel analysis

DHS data are nested. To account for this nesting, a two-level generalized linear mixed model was used. This study had binary outcomes: health facility births, and, out-of- health-facility-births. We were interested in the probability of health facility birth and factors associated with health facility birth. The equation used to estimate the two-level hierarchical model is discussed elsewhere.[26]

Binary data were modelled using a binary distribution with the logit link function. The GLIMMIX procedure in SAS was used to estimate this hierarchical model.[31] Four model building processes were followed. Model fitness was checked using the Laplace estimation. Model building was started with an empty model without covariates. The variance estimate from this model was used

to calculate the intra-class correlation coefficient (ICC).[31] Details of these computations are discussed elsewhere.[26, 32] Improvements in model fit were used to build complex models.[31]

Spatial analysis

ArcGIS 10.6.1 was used to carry out the spatial analysis. The flattened map of Ethiopia was prepared using the Ethiopian Polyconic Projected Coordinate System.[26] Hot spot analysis was carried out to identify geographic clustering of health facility births. DHS clusters were the units of spatial analysis.

Hot spot analysis is a spatial statistic used to test a statistically significant local clustering of high and/or low values of a particular phenomenon.[26, 33, 34] Statistically significant local clustering of high values of a particular phenomenon are called hot spots. Cold spots are a statistically significant clustering of low values in a particular geographic area. [35] Three spatial analysis procedures were followed as discussed elsewhere.[26] First, the Global Moran's I statistic, which is a global measure of spatial autocorrelation was carried out.[33] Second, based on the Global Moran's I statistic, incremental spatial autocorrelation was carried out to determine the critical distance at which there was maximum clustering.[26] The maximum distance at which clustering of health facility delivery peaked was at 95 kilometres. Third, hot spot analysis was carried out using the Getis-Ord Gi* statistic. This was used to identify statistically significant geographical clusters of high and low rates of facility births.[26] Multiple and spatial dependence tests were also accounted for by applying a False Discovery Rate correction.[26, 36] The *Z*-scores and *P*-values were used to determine statistically significant geographical clustering of health facility birthing.[26]

Patient involvement

This study was conducted without patient involvement.

Funding

There was no additional funding for the study. The Ethiopian government, the United States Agency for International Development (USAID), the Netherlands government, the Global Fund, Irish Aid, the World Bank, the United Nations Population Fund (UNFPA), the United Nations Children's Fund (UNICEF), and UN Women, funded the 2016 EDHS. USAID, the World Bank,

UNICEF, Irish Aid and the World Health Organization (WHO) financially supported the 2014 ESPA+ survey.

Results

Sociodemographic characteristics

The mean age of women was 29.3 (±6.8) years. About 60% of women had no education. In terms of wealth, 32.6% of the women were grouped in the poorest quintile. About 78% of the women were from rural areas (Table S2).

Women's obstetric characteristics

The mean age at first childbirth was 19.2 (±3.7) years. About 36% of the women had five or more births. Among 6954 women, 2351 (33.8%) had no ANC visits for their most recent pregnancy (Table 1).

Health facilities characteristics

In the ESPA+ survey, data were collected from 1165 health facilities. Among these facilities, 717 (61.5%) provided EmOC services. The national average distance from EmOC facilities to the 2016 EDHS clusters was 12.8 kilometres. The DHS clusters sampled in the Somali region had the longest distance (27.1 km) from EmOC facilities, while DHS clusters in Addis Ababa were 1.1 kilometres from EmOC facilities (Table S1).

In Ethiopia, each region and city administration had a different mean of health facilities service availability and readiness scores. For example, for Addis Ababa, the average value of health facility infrastructure was 0.78, while the Somali region had the lowest mean value of –0.62. Regarding facilities service readiness measured in terms of medicine and commodities, health facilities in the Tigray region had the highest readiness score of 0.47, while the Harari region had the lowest mean value of -0.78 (Table S1). In general, the highest the scores each health facility has, the more likely to provide EmOC services.

Health facility birth rate

In Ethiopia, health facility birth rate was found to be 38.3% (urban 83.1%, 25.9% rural) with variation across the country; the highest rate was reported in Addis Ababa (95.5%) followed by Dire Dawa (64.6%) and Tigray region (62.6%) (Figure 1).

Spatial epidemiology of health facility births

There is strong evidence to support spatial clustering in the utilization of a health facility for birth (Global Moran's I = 0.028; Z-score = 3.41; P-value < 0.0001). All of the hot spot areas were located in the Tigray region. The Getis-Ord Gi* statistic finding supported this clustering (Figure 2).

Determinants of birth at a health facility

The calculated ICC was 32.6%. This indicated that 32.6% of the variability in giving birth at a health facility was accounted for by region. The probability of giving birth at any particular health facility in a typical region was estimated at 49.6%.

In the bivariate analysis, it was observed that women's and their spouses' education, wealth quintile, parity, women's autonomy on healthcare decision-making, nature of pregnancy, age at first childbirth, and the number of ANC visits were individual-level predictors of health facility birth. Similarly, residence, general service readiness (health facility infrastructure), BEmOC service readiness (measured in terms of medicines and commodities, and delivery equipment), and average distance to the nearest BEmOC facility were cluster-level predictors of health facility birth.

However, in the multilevel analysis, it was found that women's and their spouses' education, wealth quintile, parity, age at first childbirth and number of ANC visits were strong individual-level predictors of health facility birth. A woman who attained a higher level of education was five times more likely to give birth at a health facility compared to a woman who had no education. The adjusted odds ratio of health facility births increased with having more ANC visits. A one-year increase in a woman's age at first childbirth was associated with a 16.1% increase in health facility birth. On the other hand, multiparous women were 18.8% less likely to have facility births (Table 2).

Furthermore, four regional-level variables were significantly associated with health facility births. Pregnant women who were living in rural areas were 66.5% less likely to give birth at a health facility compared to urban women. A one-unit increase in the mean score of health facilities'

readiness to provide BEmOC services in a typical region was associated with a two-fold increase in the odds of health facility birth (AOR = 2.094, 95% CI 1.187–3.694). An increase in distance or living away from a health facility able to provide BEmOC was associated with a reduced odds of giving birth at this facility (AOR = 0.967, 95% CI 0.944–0.991) (Table 2).

Discussion

Main findings

In this analysis, it was demonstrated that substantial geographic variation exists in health facility births. Giving birth in a health facility was significantly associated with ANC attendance, BEmOC facility's service readiness and distance to BEmOC facility.

Strengths and limitations

This study identified the demand and supply-side determinants of facility-based birthing using population and health facility data. Most previous studies have studied these separately. In addition to multilevel analysis, a spatial analysis was used to identify geographic variations in the level of facility births.

This study had several methodological limitations.[26] Due to missing geographic coordinates, 23 DHS clusters were excluded. Excluding these clusters might under or overestimate the study findings. Due to the lack of road-network data, this study used 'straight-line' distance, which might not reflect true travelling-distance. There could be also other factors not included in the available datasets that could influence the place of childbirth, such as cultural practices and the availability of maternity waiting homes. Maternity waiting homes increase women's access to a health facility at the time of birth.[37, 38] DHS provides an average weight (hv005 or v005); however, the GLIMMIX procedure requires weights at each level. Due to this issue, DHS weights were not applied in the multilevel analysis.

Interpretation

In Ethiopia, the overall facility birth rate was estimated to be 38.3% with variations across urban-rural areas and region of residence. For instance, the two largest regions, the Amhara and Oromia regions, had a facility birth rate below the national average of 38.3%, while Addis Ababa, Dire Dawa, Harari and the Tigray regions had a facility birth rate of 60% and above.[10-13] The local inaccessibility of EmOC facilities might be attributed to these variations.[23]

In the hot spot analysis, we found high rates of facility birth clustered in the Tigray region. This could be attributed to variations in political commitment and facility service readiness. The Tigray region had the highest service readiness score in Ethiopia (Table S1). We also note that community mobilization is part of the Ethiopian Health Sector Transformation Plan.[39] The Ethiopian Ministry of Health uses the Health Development Army (HDA), one-to-five community networks, to organize community and health workers.[39, 40] However, this is not fully functioning throughout Ethiopia, except the Tigray region. In this region, the HDA organize monthly meetings for pregnant women aiming at 'home-delivery-free villages'.[41] Furthermore, the cultural adaptation of birthing services [41] and maternity waiting homes [37] are in use. Maternity waiting homes may improve maternal and neonatal health outcomes, for instance, in reducing obstructed labor and stillbirth rates.[37] At health facilities, to better-suit women's personal and cultural needs, certain culturally accepted and important practices are also made available. For instance, in the Tigray region, a cultural practice is that a mother is expected to eat porridge immediately after birth. To encourage facility births and help women to feel more 'at home', health facilities provide porridge and also practice the traditional coffee ceremony for delivering mothers.[41] Further research is needed to establish whether these interventions have increased service uptake.

Different individual and regional-level factors were significantly associated with facility birth. Among the region-level variables, it was found that a one-unit increase in facilities BEmOC readiness was significantly associated with a two-fold increase in the odds of facility birth (AOR = 2.094, 95% CI 1.187–3.694). In Haiti, facility EmOC readiness was significantly associated with higher odds of health facility birth (AOR = 2.74, 95% CI 1.34–5.60). EmOC availability was significantly associated with facility births.[42] Healthcare facilities need to be staffed, and well-equipped with key signal functions in place.

For every one-kilometre increase in distance to the nearest BEmOC facility, there was a 3.3% reduction in facility births (AOR = 0.967, 95% CI 0.944–0.991). A systematic review found that every one-hour and/or one-kilometre increase in travel time and distance were associated with about a 20.0% reduction in facility birthing.[23] Similarly, having EmOC access within a five-kilometre distance [21, 23] and/or 60-minute walk [23] was associated with higher odds of facility births. This indicates that making EmOC facilities accessible to the population, in terms of

geography, needs to be given more attention. Improving road infrastructure and transport systems might enhance women's access to EmOC facilities and thus increase facility births.

Rural residence was found to be negatively associated with facility births. A meta-analysis found that women living in urban areas were more likely to have facility births compared to rural women.[21] In Ethiopia, the majority of BEmOC facilities are concentrated in urban areas. In Ethiopia, it was reported that maternity waiting homes were associated with a significant reduction in maternal and perinatal mortality.[38] Using maternity waiting homes could be one strategy to increase facility births in areas with limited access to EmOC facilities.

Among the individual-level factors, both women's and their spouses' education were significantly associated with facility births. This is consistent with systematic reviews conducted in sub-Saharan Africa [43] and Ethiopia [21]. Women's [21, 43, 44] and husbands' [21, 45, 46] educational attainment was significantly associated with facility births. This indicates that educated women and spouses might have information access, better knowledge on health services, and control over resources, which could improve facility births.

The odds of having a facility birth were significantly associated with increases in the number of ANC visits. Women who had ANC4+ visits had higher odds of facility birth (AOR = 8.863, 95% CI 6.748–11.640). A meta-analysis found that ANC visits were significantly associated with higher odds of facility births.[19] In Ethiopia, about 37% of women had ANC4+ visits.[34] Therefore, promoting women's use of ANC services should be emphasized.

Women in the richest wealth quintile were three times more likely to have facility births. In Ethiopia, cost was reported as among the major constraints of facility births.[47] Legally, maternal health services are free of charge in Ethiopia.[48] However, transportation and other opportunity costs, such as time spent on travel for the woman and accompanying families are known to deter woman's use of a health facility.[43, 44, 49] Interventions targeting poor women, such as maternity waiting homes,[37] cash assistance,[50] conditional cash transfer,[51] and voucher and equity funds [52] are known to help increase the rate of facility births.

A single-year increase in women's age at first childbirth was significantly associated with facility birth. This could be related to obstetric complications that increase with age and thus increases

facility births.[18, 53-55] On the other hand, having more livebirths was negatively associated with facility births in other studies.[20, 56] Previous uncomplicated pregnancy and delivery experience might influence facility births.

Conclusion

In Ethiopia, there were wide geographical variations in the rate of facility births. Giving birth in a health facility was significantly associated with ANC attendance, a healthcare facility service readiness and distance to a health facility. This study has several implications for policy and practice. The importance of ensuring that health facilities are in a state of readiness to provide EmOC should be emphasized. Health facilities need to be staffed, and well-equipped and with key signal functions in place. Geographic access needs to be taken into account with an equitable distribution of health facilities. ANC providers can then continue to counsel pregnant women about the potential benefits of giving birth at a healthcare facility.

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Disclosure of interests

The authors declared that they have no competing interests. Completed disclosure of interest forms are available to view online as supporting information.

Contributions to authorship

TKT, CC, RS, DL conceptualized the design of the analysis. TKT developed and drafted the manuscript. CC, RS and DL participated in critically revising the intellectual contents of the manuscript. TG provided expertise in the SPA data. All authors read, provided feedback and approved the final manuscript.

Ethics approval

Ethical approval was obtained from the Human Research Ethics Committee, The University of Newcastle on March 20, 2018 with a reference number H-2018-0066. We also got the Ethiopian Public Health Institute (EPHI) and the Measure DHS program approval to access the datasets.

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Table 1: Obstetric characteristics of reproductive age women in Ethiopia, 2016 (N = 6954).

Variable		Frequency	Percentage
Parity	1 – 4	4430	63.70
	>= 5	2524	36.30
Number of living children	0	64	0.92
	1 – 4	4757	68.41
	>= 5	2133	30.67
Age at 1st childbirth	<= 19 year	4250	61.12
	20 – 24 year	2087	30.01
	>= 25 year	617	8.87
Number of ANC visits for the last	0	2351	33.81
pregnancy	1 – 3	2045	29.41
	>=4	2558	36.78
Autonomy in own personal	Respondent alone	1134	16.31
healthcare decision making	Joint decision	4063	58.43
	Husband/partner alone	1757	25.27
Last pregnancy wanted	Yes	5516	79.32
	Later	982	14.12
	Not at all	456	6.52
Timing of 1st ANC check (n = 4603)	1st Trimester	1786	38.80
	2nd Trimester	2396	52.05

Table 2. Factors associated with health facility birthing among pregnant women in Ethiopia (N = 6,954).

Predictors		N	Adjusted odds ratio (95% CI)
Level-1 predictor variables			**Health facility delivery**
Women's education	No education	4171	1
	Primary	1903	**1.564 (1.293, 1.891)**
	Secondary	567	**2.992 (2.156, 4.152)**
	Higher	313	**4.790 (2.679, 8.565)**
Husbands' or partners education	No education	2997	1
	Primary	2108	1.087 (0.920, 1.285)
	Secondary	726	**1.860 (1.431, 2.417)**
	Higher	1123	**1.490 (1.163, 1.910)**
Wealth quintile	Poorest	2264	**1**
	Poor	1157	**1.671 (1.352, 2.065)**
	Meddle	1007	**1.767 (1.418, 2.201)**
	Rich	895	**2.039 (1.622, 2.563)**
	Richest	1631	**2.892 (2.199, 3.803)**
Parity	1 – 4	4430	**1**
	>4	2524	**0.812 (0.687, 0.960)**
Autonomy on their own healthcare decision making	Respondent alone	1134	1
	Joint decision	4063	0.823 (0.675, 1.002)
	Husband/partner alone	1757	0.831 (0.658, 1.050)
Nature of pregnancy	Wanted pregnancy	5516	1
	Unwanted pregnancy (Later and/or No more)	1438	0.960 (0.798, 1.155)
Number of antenatal care visits	No ANC visit	2351	1
	1 – 3 visits	2045	**5.292 (3.997, 7.005)**
	>=4 visits	2558	**8.863 (6.748, 11.640)**
Age at first childbirth			**1.161 (1.034, 1.304)**
Level-2 predictor variables			
Residence	Urban	1512	**1**
	Rural	5442	**0.335 (0.252, 0.445)**
General service readiness (Health facility infrastructure)			0.638 (0.312, 1.302)
BEmOC service readiness (Medicines and commodities)			**1.920 (1.180, 3.122)**

BEmOC service readiness (Delivery equipment)	**2.094 (1.187, 3.694)**
Average distance to the nearest obstetric health facility	**0.967 (0.944, 0.991)**
Random effects (Error variance)	
Var (Women's education)	**0.010 (0.002, 2.282**)
Var (Husbands' or partners' education)	0.000
Var (Wealth quintile)	0.000
Var (Autonomy on their own healthcare decision making)	0.000
Var (Nature of pregnancy)	0.000
Var (Number of ANC visits)	**0.027 (0.008, 0.499)**
Var (Age at first childbirth)	**0.003 (0.001, 59.675)**
Var (constant) - level-2 variance	**0.001**
Rho – Intra-class correlation	0.000228
Fit statistics (-2 Log Likelihood)	5742.86

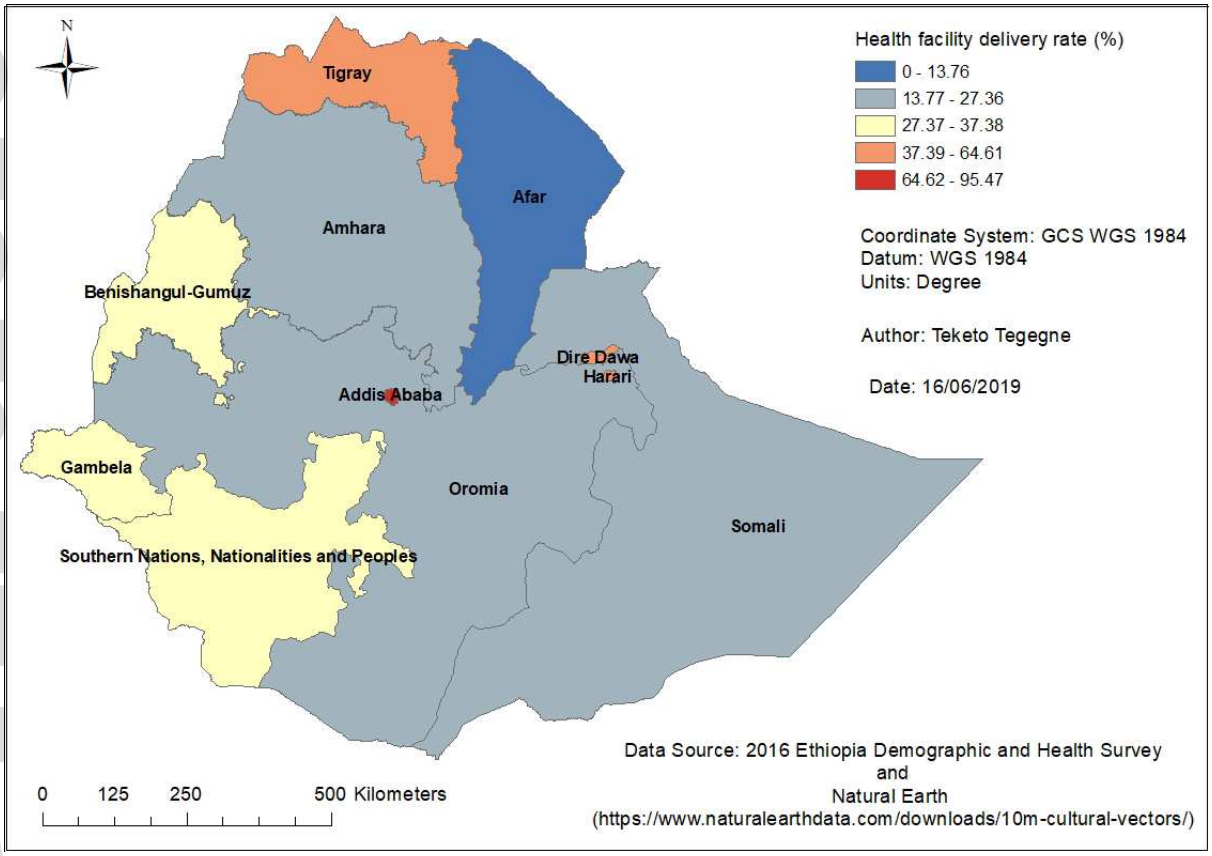

Figure 1. Health facility birthing among pregnant women in Ethiopia, 2016

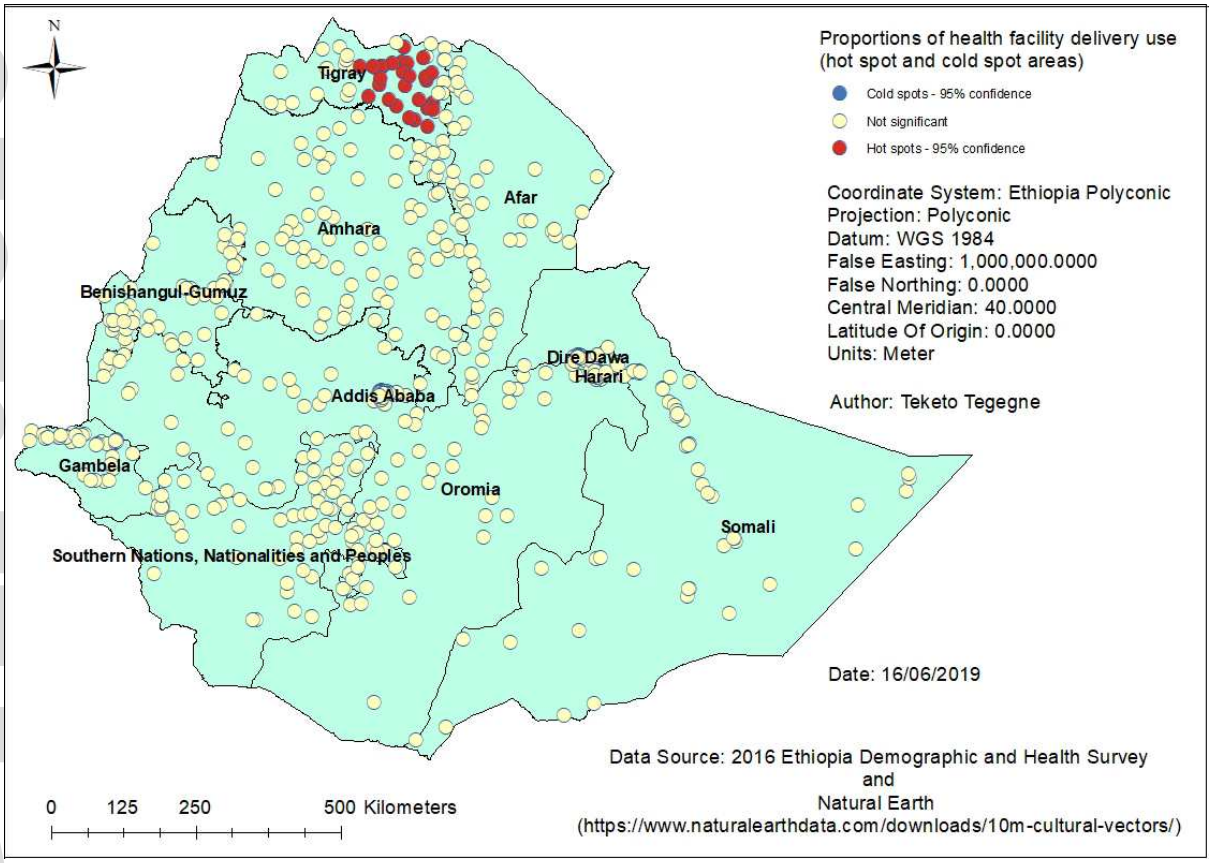

Figure 2. Clusters of health facility birthing in Ethiopia, 2016