Trends and Spatial Variation of Female Genital Mutilation among Reproductive Age Women in Ethiopia based on 2000, 2005, and 2016 Ethiopian Demographic and Health Surveys: Spatial-temporal and Multivariate Decomposition Analysis

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Abstract

Introduction: Even if FGM has been declined dramatically in the world, the rate of decline is far below the rate needed to achieve SDG in Ethiopia. FGM remains as a serious public health concern in Ethiopia and the prevalence has varied across and within countries. Therefore, this study aimed to assess the trends and geographic variation of FGM practice in Ethiopia based on EDHSs. Methods: The study used the data from the three DHSs conducted in Ethiopia. Trend and Logistic based decomposition analysis technique was used for analyzing the change in FGM practice overtime and factors contributing to the change in FGM practice. STATA 14 was used for data management and analysis. The Bernoulli model was fitted using spatial scan statistics version 9.6 to identify hotspot areas and ArcGIS version 10.6 to explore the spatial distribution FGM. Results : The prevalence of FGM practice was decreased from 79.9% in 2000 to 70.4% in 2016. The decomposition analysis indicated that about 95% of the overall decrease in FGM practice was due to the difference in the change in the behavior of FGM practice among urban residents, orthodox and Muslim followers, self-employed, education, and media exposure were significant factors contributed to the change in FGM over the study period. The SaTScan analysis identified 141 most likely clusters (LLR=711.9, p<0.001) in 2000, 175 (LLR=576.4, p<0.001) in 2005, and 220 (LLR= 243.6, p<0.001) in 2016 which was located in Somali, Somali, Harari, and border areas of Somali consistently over the three surveys. Conclusions: These results showed that FGM practice has been declined in Ethiopia. The decrease in FGM practice could be attributable to the difference in the change in effects of residence, media exposure; religion, region, and educational status. The spatial analysis provides further insight into differences in FGM practice within the country and highlights primary and secondary clusters. This could enable efficient and timely spatial targeting of hotspot areas of FGM practice to achieve the goals of eliminating FGM practice in Ethiopia by 2025 and the government should scale up the public health programs to improve the rate of reduction.

Background

According to World Health Organization (WHO), Female Genital Mutilation (FGM) is defined as partial or total removal of the external female genitalia or other injuries to the female genital organs for non-

medical reasons that have no health benefits for girls and women (1). FGM is widely practiced in Africa, Asia, Middle East and some countries in South America and it has strong cultural beliefs that are linked to women's sexuality and their reproductive role in the society and is recognized internationally as a violation of the human rights of girls and women (2). Globally, more than 200 million girls and women undergo female genital mutilation, of these 125 million were occurred in Africa (3). Despite efforts to eradicate the FGM practice, an estimated 3 million girls are at risk of undergoing female genital mutilation every year and exposed to the health consequences of FGM and the parents allow their daughters to conform to the social tradition (4).

Female genital mutilation remains a major public health problem worldwide (2, 5). It is highly practiced in Africa, mostly in the north-eastern region of Africa: Djibouti, Eritrea, Ethiopia, and Somalia (6). The trend of girls undergoing female genital mutilation has reduced dramatically in Africa. According to the systematic analysis based on DHS data from 29 African countries and 2 west Asian countries, the prevalence of female genital mutilation has varied greatly between countries and regions and also varied within countries over time. The rates of FGM have been decreased in North Africa from 57.7% in 1990 to 14.1% in 2015. In West Africa, the trends of FGM have decreased from 73.6% in 1996 to 25.4% in 2017. Whereas, the trends of FGM in East Africa has been reduced from 71.4% in 1995 to 8% in 2016 (7). Countries with the highest prevalence of FGM among women aged 15 to 49 are Somalia at 98 percent, Guinea at 97 percent, Djibouti 93 percent and Egypt at 87 percent (8).

Eliminating FGM is the focus of governments and NGOs all over the world. The Ethiopian government has prioritized sustainable development goal 5.3 as one of the national development targets and it outlined strategic measures to reduce FGM practice that can contribute to the elimination of FGM in Ethiopia (9, 10). In Ethiopia, FGM has been decreased from 79.9 in 2000 to 65% in 2016 (11-13). Despite this progress, FGM remains a serious public health problem in Ethiopia and has affected 23.8 million women and girls, making Ethiopia the second-highest FGM practice in Africa (14). Despite a significant reduction in FGM nationally over the past decades, the UNICEF report from the 2011 Welfare and Monitoring Survey one in every four girls are subjected to the practice and the risk varies

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across regions with the highest prevalence in Somali and Afar regions (15).

FGM has serious physical and psychological consequences to women, risking their lives at the time of circumcision, at marriage, during birth and decrease their attendance and performance in schools (16). The practice has been associated with significant health consequences such as complications during pregnancy and childbirth, menstrual abnormality, post-traumatic stress disorder, recurrent pelvic and vaginal infection (17).

Although there are studies conducted on the prevalence of female genital mutilation in different parts of Ethiopia (18-24) and one study done on Geographic variation of FGM based on nationally representative EDHS data (21) and the result of these studies showed that there is geographic variability of the prevalence of FGM practice within the country but this study only explore the spatial distribution of prevalence of FGM in Ethiopia, they did not conducted Spatial autocorrelation, Hotspot analysis, interpolation, SaTScan analysis and trend analysis since this is important to identify significant hotspot areas and change in FGM practice across areas which is important for designing effective public health interventions and to identify the factors contributing for the decline in FGM practice over time in Ethiopia which is important to evaluate already implemented policies and programmers and to work on it.

Even if the prevalence of FGM has been decreased overtime in Ethiopia (11-13), still there are areas with a high prevalence of FGM in different parts of the countries. Therefore having information on the trend of FGM among women is necessary for the development of public health policies for the prevention of FGM practice in the identified hotspot areas of FGM, and would help policymakers to work on factors contributing to the change in FGM overtime and design public health interventions. The ultimate aim of this study is to inform decision and policymakers to design effective public intervention across geographic regions. To fill this research gap, we therefore used the three consecutive Ethiopian Demographic and Health Survey (EDHS) 2000, 2005 and 2016 data sets to assess the trends and spatial variation of FGM in Ethiopia using a multivariate decomposition and spatial analysis to identify the determinants factors contributing for the decline in FGM from 2000 to 2016. Thus, the government gives more attention to the most significant contributing factors and

design and implement appropriate interventions for further decline of FGM in Ethiopia. Understanding the trends and geographic variations of FGM also would help public health planners, policymakers, programmers, and partners to design effective strategies and interventions to reduce FGM practice in Ethiopia.

Methods

Study design and Study settings

Repeated cross-sectional study design was employed using Ethiopian Demographic and Health surveys (EDHSs) in 2000, 2005, and 2016 to explore the trend and spatial variation of FGM. Since EDHS 2011 FGM data was not collected, EDHS 2011 was not used for this study. Ethiopia is located in the horn of Africa and it has been divided into nine regions and two city administrations (Figure 1). Ethiopia is an agrarian country and agriculture accounts for 43 percent of the gross domestic product (GDP) and 84% of the population lives in rural areas. More than 80 percent of the country's total population lives in the regional states of Amhara, Oromia, and SNNPRs (25). In 2016, the population was 102 million of which 43.47% the population ages less than 14 years with birth rate of 36.5 births per 1000 population and fertility rate of 4.46, Ethiopia is the13th in the world and 2nd in Africa most populous country Ethiopia has 3 tiers health systems, Primary health care unit (Primary hospital, health center, health post, primary clinic, and medium clinic); Secondary health care (General hospital, specialty clinics and specialty centers); and Tertiary health care (Specialized hospital). The number of hospitals varies from region to region in response to differences in population size. The most populous region, Oromia has 30 hospitals. The other two predominant regions Amhara and SNNPR have 19 and 20 respectively with Tigray in fourth place with 16 hospitals, Gambela has only one hospital and Benishangul-Gumuz two had two hospitals (26).

Sample and Source population

The source population was all reproductive-age women within five years before the survey in Ethiopia and all reproductive-age women in the selected enumeration areas within five years before the

survey were the study population. The EDHS used a stratified two-stage cluster sampling technique selected in two stages using the 1994 population and housing census frame for EDHS 2000 and 2005, and the 2007 Population and Housing Census frame for EDHS 2016 as a sampling frame. Stratification was achieved by separating each region into urban and rural areas. In total, 21 sampling strata have been created because the Addis Ababa region is entirely urban. In the first stage, 539 Enumeration Areas (EAs) (138 EAs in urban) for EDHS 2000, 540 EAs (145 in urban area) for EDHS 2005, and 645 EAs (202 in urban area) for EDHS 2016 were selected with probability proportional to the EA size and with independent selection in each sampling stratum. At the second stage, because the time has passed since the PHC, a complete household listing operation was carried out in all selected EAs before the start of fieldwork and on average 27 to 32 households were systematically selected. A total weighted sample of 15,367 in EDHS 2000, 14,070 in EDHS 2005 and 7,248 reproductive-age women were used for analysis. The detailed sampling procedure was presented in the full EDHS report (11, 12, and 27).

Study variables

Outcome variables

The EDHS asked women to answer to the question "having experiencing Female genital mutilation?". The response variable of this study was whether circumcised or not. The response variable for the ith mother is represented by a random variable Y_i with two possible values coded as "yes" and "No". So, the response variable of the ith mother Y_i was measured as a dichotomous variable with possible values Y_i = Yes if ith mother had experienced circumcision and Y_i = No if mother did not experience circumcision.

Independent variables

Independent factors that were considered to affect the practice of female genital mutilation like the place of residence, religion, geographic region, age of women, maternal education, women occupation, media exposure and wealth status were included for the study.

Data collection procedure

The study was conducted based on EDHS data by accessing from the DHS program official database (www.measuredhs.com) after permission was granted through an online request by explaining the objective of our study. The raw data was collected from all parts of the country on childbearing aged women using a structured and pre-tested questionnaire (11-13). We used the women data set and extracted the outcome and independent variables. Geographic coordinate data (longitude and latitude coordinates) was taken at the cluster level/ enumeration area level.

Data management and analysis

Before the actual data collection, the Pre-test was conducted which consisted of in-class training, biomarker training, and field practice days. The questionnaires were pretested in all three local languages (Amharic, Oromia, and Tigrigna) to make sure that the questions were clear and could be understood by the respondents. The data were weighted using sampling weight, primary sampling unit, and strata before any statistical analysis to restore the representativeness of the survey and to tell the STATA to take into account the sampling design when calculating standard errors to get reliable statistical estimates. Cross tabulations and summary statistics were conducted to describe the study population. Descriptive and summary statistics were done using STATA version 14 software. Data from EDHS 2000, 2005 and 2016 were appended together after extracting important variables for trend and decomposition analysis.

Trend and Decomposition analysis

The trend was assessed using descriptive analyses stratified by selected respondent characteristics and was assessed separately for the periods 2000-2005, 2005-2016, and 2000-2016. Logit based decomposition analysis technique was used for the analysis of factors contributing to the change in FGM over the period to identify the sources of changes in stillbirth rate in the last 16 years.

The changes of FGM over time can be attributed to compositional changes between surveys and

changes in the effects of the selected explanatory. Hence, the observed difference in FGM between surveys is additively decomposed into a characteristics (or endowments) component and a coefficient (or effects of characteristics) component.

For logistic regression, the Logit or log-odd of FGM is taken as:

Logit (A) - Logit (B) = F (XAβA) - F (XBβB)

= [F (XAβA) - F (XBβA)] + [F (XBβA) - F (XBβB]

E C

The E component refers to the part of the differential owing to differences in endowments or characteristics. The C component refers to that part of the differential attributable to differences in coefficients or effects.

The equation can be presented as:

Logit (A) - Logit (B) = [β0A - β0B] + ΣXijB * [βijA- βijB] + ΣβijB * [XijA - XijB]

- XijB is the proportion of the jth category of the ith determinant in the DHS 2000,

- XijA is the proportion of the jth category of the ith determinant in DHS 2016,

- $BijB$ is the coefficient of the jth category of the ith determinant in DHS 2000,

- $BijA$ is the coefficient of the jth category of the ith determinant in DHS 2016,

- $B0B$ is the intercept in the regression equation fitted to DHS 2000, and

- $B0A$ is the intercept in the regression equation fitted to DHS 2016.

The recently developed multivariate decomposition for the non-linear model was used for the decomposition analysis of stillbirth using mvdcmp STATA command (28).

Spatial analysis

For the spatial analysis ArcGIS version 10.6 software and SaTScan version 9.6 software.

Spatial autocorrelation analysis

The spatial autocorrelation (Global Moran's I) statistic measures whether FGM patterns were dispersed, clustered or randomly distributed in the study area (29). Moran's I is a spatial statistics used to measure spatial autocorrelation by taking the entire data set and produce a single output

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value which ranges from -1 to +1. Moran's I Values close to −1 indicate FGM dispersed, whereas Moran's I close to +1 indicate FGM clustered and disease distributed randomly if I value is zero. A statistically significant Moran's I (p < 0.05) leads to rejection of the null hypothesis (FGM is randomly distributed) and indicates the presence of spatial autocorrelation.

Hot spot analysis (Getis-OrdGi* statistic)

Getis-OrdGi* statistics were computed to measure how spatial autocorrelation varies over the study location by calculating GI* statistic for each area. Z-score is computed to determine the statistical significance of clustering, and the p-value computed for the significance. Statistical output with high GI* indicates "hotspot" whereas low GI* means a "cold spot"(30).

Spatial interpolation

It is very expensive and laborious to collect reliable data in all areas of the country to know the burden of a certain event. Therefore, part of a certain area can be predicted by using observed data using a method called interpolation. The spatial interpolation technique is used to predict stillbirth on the un-sampled areas in the country based on sampled EAs. There are various deterministic and geostatistical interpolation methods. Among all of the methods, ordinary Kriging and empirical Bayesian Kriging are considered the best method since it incorporates the spatial autocorrelation and it statistically optimizes the weight (31). Ordinary Kriging spatial interpolation method was used for this study for predictions of FGM in unobserved areas of Ethiopia.

Spatial scan statistical analysis

Spatial scan statistical analysis Bernoulli based model was employed to test for the presence of statistically significant spatial clusters of FGM using Kuldorff's SaTScan version 9.6 software. The spatial scan statistic uses a circular scanning window that moves across the study area. Women are circumcised were taken as cases and women who are not circumcised were taken as controls to fit the Bernoulli model. The numbers of cases in each location had Bernoulli distribution and the model

required data for cases, controls, and geographic coordinates. The default maximum spatial cluster size of <50% of the population was used, as an upper limit, which allowed both small and large clusters to be detected and ignored clusters that contained more than the maximum limit.

For each potential cluster, a likelihood ratio test statistic and the p-value were used to determine if the number of observed FGM cases within the potential cluster was significantly higher than expected or not. The scanning window with maximum likelihood was the most likely performing cluster, and the p-value was assigned to each cluster using Monte Carlo hypothesis testing by comparing the rank of the maximum likelihood from the real data with the maximum likelihood from the random datasets. The primary and secondary clusters were identified and assigned p-values and ranked based on their likelihood ratio test, based on 999 Monte Carlo replications (32).

Ethical approval and consent to participate

The study was based on secondary analysis of existing survey data with all identifying information removed. Permission for data access was obtained from measure demographic and health survey through an online request from http://www.measuredhsprogram.com. Prior to the actual interview, each woman was asked if she agreed to participate in the study. The GIS data were obtained through explaining the purpose of using GPS data and approval from Measure DHS. Informed consent was obtained from the participants, their guardian or household heads.

Results

Characteristics of respondents

About one-third of the respondents in all three surveys were found in the Oromia region. Based on the place of residence, there was a slight increment of respondents residing in urban areas from 18.2% in 2000 to 23.0% in 2016. According to maternal educational status, in survey 2000 more than three quarters (75.2%) of women's were not educated, while it was decreased to 65.9% and 47.0% in EDHS 2005 and 2016 respectively and the proportion of women with higher education has been increased from 0.5% in 2000 to 6.2% in 2016. Besides the proportion of women who had media exposure has been increased from 34% in 2000 to 43.3% in 2016. Except for religion, maternal age, region and

wealth index, all other variables listed in the table showed changes in the composition of women, when comparing the sample population in the years 2000, 2005 and 2016 (Table 1).

Trends of female genital mutilation from EDHS 2000 to 2016 in Ethiopia

Figure 2 presents the trends in female genital mutilation among reproductive-age women during the period 2000-2016. With regard to the overall trends of FGM, Ethiopia has shown a significant decline in female genital mutilation over the study period, from 79.9% (95% CI: 79.3, 80.5) in 2000 to 74.3% (95% CI: 73.5, 74.9) in 2005 to 70.4% (95% CI: 69.3, 71.4) in 2016.

Trends in female genital mutilation among reproductive-age women by selected characteristics 2000, 2005, and 2016 Ethiopian Demographic and Health Surveys

The trend period was divided into three phases, 2000-2005, 2005-2016, and 2000-2016, to see the difference in decreases in FGM overtime. The rate of female genital mutilation practice has been decreased over time. The largest decline was seen in the third phase of the study period (2000-2016) with a 9.5 percentage point change in FGM compared with 5.6 percentage point change in the first phase (2000-2005) and 3.9 percentage point change in FGM in the second phase (2000-2016).

The trends in female genital mutilation among women showed variation with respect to their characteristics. Major decreases in FGM were observed in some of the selected variables.

Four regions such as Tigray, Harari, Addis Ababa, and Dire-Dawa showed the greatest decline in FGM practice between 2000 and 2016 but the prevalence of FGM in the Somali region remains high (Figure 3).

Among urban residents, the largest decline in FGM practice has been observed during the third phase of the study period (2000-2016), at 24.3 percentage point decrease as compared with 11.3 percentage point decrease during the first phase (2000-2005) and a 13.0 percentage point decrease during the second phase (2005-2016). Young age women (15-19 years) showed a larger decrease in FGM by 19.1 percentage point change during the overall study period (2000-2016). Reproductive age women with secondary and higher education showed a 34.8 percentage point decrease during the

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third phase of the study period (2000-2016) (Table 2).

Decomposition analysis

The decomposition analysis revealed that about 95% of the overall percentage change in FGM practice among reproductive-age women in Ethiopia was due to difference in coefficient (effects of characteristics) and the remaining 5% was due to the difference in characteristics (compositional factors or endowment) but the difference was not significant (Table 3). After controlling for the roles of compositional changes, a significant decrease in FGM practice was associated with the change in effects of residence, region, educational status, religion, occupation, and media exposure. About 20% of the decrease in FGM practice over the last 16 years was attributable to the change in effect among the urban population. As compared to the Somali region, the change in the effect of FGM practice among the Tigray population contributes about 12.2% of the overall decrease in FGM over the study period. Other factors such as a decrease in the effects of higher education women, Muslim and orthodox religious followers, media exposure were significantly contributed to the change in FGM practice in Ethiopia for the last 16 years (Table 4).

Spatial distribution of FGM practice

Spatial variation of FGM practice was found across regions and was non-random (Figure 4). Of the interviewed 15,367 in EDHS 2000 women, 12,280 (79.9%) women were circumcised, of 14,070 interviewed women in EDHS 2005, 10,448 (74.3%) women were circumcised and of 7,248 women interviewed women in EDHS 2016, 5,103 (70.4%) women were circumcised. The highest FGM practice was spatially clustered in Somali, Harari, east Benishangul Gumuz, Amhara, Oromia, east SNNPRs and southern Afar regions consistently overtime, while Gambella, Tigray, northeast Amhara, west SNNPRs and northeast Benishangul Gumuz regions showed the lowest FGM practice (Figure 5).

The spatial pattern of FGM practice

Based on EDHS 2000, 2005 and 2016 sampled data, the hotspot analysis using Getis Ord Gi statistics

revealed that significant hot spot areas were located in southeast Amhara, south Afar, East SNNPRs, Harari, Dire Dawa, and northeast Somali regions in EDHS 2000, whereas in EDHS 2005 hotspot areas were located in east Amhara, south Afar, northeast Somali, Dire Dawa, Harari, Central Oromia and east SNNPRs and in 2016 the hotspot areas consistently located in eastern border areas of Amhara, Benishangul Gumuz, east SNNPRs, Harari, Diredawa, Afar, and Somali region (Figure 6). In EDHS 2000, spatial scan statistics identified 427 significant primary and secondary clusters. Of these, 141 clusters were the most likely clusters (primary clusters) and the spatial window was located in north Somali, Harari, Dire Dawa, south Afar, and southeast Amhara region centered at 9.867651 N, 43.086403 E with 348.25 km radius, a Relative Risk (RR) of 1.35, and Log-Likelihood Ratio (LRR) of 711.9, at p-value<0.001. It showed that women within the spatial window had 1.35 times higher risk for being circumcised as compared to women outside the spatial window (Table 5), whereas the secondary clusters were located in Amhara, Tigray, Benishangul Gumuz, SNNPRs, and Oromia regions (Figure 7).

In EDHS 2005, a spatial scan statistics identified a total of 468 significant primary and secondary clusters. Of these, 175 clusters were the most likely clusters (primary clusters) and the spatial window was located in the entire Somali region and border areas of Somali regions, centered at 9.774395 N, 43.208576 E with a radius of 484.13 km, a Relative Risk (RR) of 1.42, and Log-likelihood (LLR=576.4, p-value<0.0001) (Table 6). It showed that women within the spatial window had 1.42 times higher risk of being circumcised as compared to women outside the spatial window and the secondary clusters were located in Benishangul, Amhara, Oromia, and Gambella regions (Figure 7).

In EDHS 2016, a spatial scan statistics identified a total of 581 significant primary and secondary clusters. Of these, 220 clusters were the most likely clusters (primary clusters) and the spatial window was located in the entire Somali, Afar and border areas of Somali, centered at 7.717178 N, 46.991580 E with a radius of 900.49 km, a Relative Risk (RR) of 1.42, and Log-likelihood (LLR=243.6, p-value<0.0001) (Table 7). It showed that women within the spatial window had 1.42 times higher risk of circumcision as compared to women outside the spatial window (Figure 7).

Kriging interpolation of FGM practice

Based on EDHS 2000 sampled data, Kriging interpolation predict that the highest FGM practice was detected in the entire Somali, Oromia, Harari, Dire Dawa, Addis Ababa, Benishangul Gumuz, southeast Afar, southeast Amhara, and east SNNPRs. In contrast, relatively low FGM practice areas were predicted in the entire Tigray, Gambella, southwest Oromia, north Benishangul, northwest Amhara and north Afar (Figure 8). Based on EDHS 2005, Kriging interpolation predict that the highest FGM practice was detected in east SNNPRs, most of Oromia, west Benishangul, some parts of Oromia, southeast Amhara, and most of Afar regions. In contrast, predicted low FGM practices were detected in Tigray, northwest Gambella, north Afar, and west SNNPRs (Figure 8). From EDHS 2016 data, Kriging interpolation predicted that most parts of Oromia, entire Somali, Dire Dawa, Harari, Afar, and west Benishangul contained the highest FGM practice while most parts of Amhara, Tigray, Gambella and West SNNPRs contained relatively low FGM practice (Figure 8)

Discussion

Even if the United Nations Sustainable Development Goals (SDGs) and Ethiopia efforts to eliminate female genital mutilation by criminalizing the practice, still FGM practice remains a major public health concern in Africa including Ethiopia. The trend in FGM practice has been significantly declined in Ethiopia. It is in line with studies done in Ghana (33), Oromia (34), Nigeria (35), Burkina Faso (36) and Gambia (37). This could be due to systematic efforts of government and non-governmental organizations for the elimination of FGM by engaging the community to accelerate the abandonment of the practice of FGM, engaging programmers to work with the communities, increase health education and health promotion to the communities (38).

The rate of FGM practice in Ethiopia has been declined from 79.9% in 2000 to 70.4% in 2016 with the annual rate of reduction of 0.9%. Even though the prevalence of FGM has been dropped, the rate of decline is far below to achieve the sustainable development goal 5. which is slower than systematic study in, east Africa which was reduced from 71% to 8% within 20 years with annual rate of reduction of 3.2%, west Africa which was reduced from 73.6% to 25.4% within 21 years with annual rate of reduction of 2.3% and North Africa from 57.7% to 14.1% within 23 years with annual rate of reduction

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of 1.9% (38). This could be due to that FGM practice in Ethiopia is deeply rooted in traditions and persisted as a social norm for a long period and lack of resource allocation to provide health education to the communities (39). Therefore much progress is needed to achieve the SDG goals. The multivariate decomposition analysis identified the determinants contributing to the change in FGM practice over the last 16 years. Hence, understanding the factors contributing to the decline in FGM practice in Ethiopia has public health importance. The decomposition analysis revealed that about 95% of the decrease in FGM practice in Ethiopia over the past 16 years is due to the difference in effects of characteristics (coefficient) but the change due to the difference in endowment (composition) was not significant. One of the findings was, about 20.6% of the decrease in FGM practice in Ethiopia was due to the change in FGM practice among the urban population. This is in line with a study done in Egypt (40), this might be due to improvement better access of information and education over time and this could favor urban residents, and aware of the negative health consequences of FGM relative to rural residents and this could contribute for the decrease in FGM (41).

Also, the change in the effect of Muslim and orthodox religious followers contributes to the change in FGM practice over time, it is supported by the previous study (42) and this showed the behavior of religious followers towards FGM practice has been improved. The change could be due to the engagement of faith leaders by the government to improve awareness of the community towards the consequence of FGM in Ethiopia (38). The other contributing factors for the change in FGM practice over the last 16 years were due to the change in the effect of women's occupation, women, education, Tigray residents, and media exposure. This could be due to the improvement in media exposure; job opportunity and access to education significantly contribute to women empowerment and their capacity to fight against harmful traditional practices such as FGM and child marriage. Therefore, women's education, media exposure and creating job opportunities were significantly contributing to the decline in FGM practice.

GIS-based spatial and SaTScan analysis showed that FGM practice was non-random. This was supported by a spatial study done in Nigeria (43), and Kenya (44). The hotspot and SaTScan analysis

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identified significant hotspot areas across the three EDHS surveys which were consistently located in the entire Somali, Afar, Harari and border areas of Somali regions. Even though there is a coordinated effort by engaging faith and community organizations to accelerate the abandonment of FGM practice in Ethiopia, Afar, and Harari and Somali regions were significant hot spot areas of FGM practice. This could be due to deeply rooted strong belief, attitudes and behaviors towards FGM practice in these regions and the belief that if a girl not get circumcised, the daughter may not get married and this makes the community female circumcision to get social acceptance(45). There is also evidence that hence FGM is deeply rooted in their tradition, there is resistance to abandoning FGM practice in Somali and afar region. This implies that the government needs to strengthen efforts to reduce the FGM practice in these regions by highly engaging the community leaders, civil society, school, media, faith leaders and females.

Strengths And Limitations

This study had several strengths. First, the study was based on nationally representative large datasets, and thus it had adequate statistical power. Second, the estimates of the study were done after the data were weighted for the probability sampling and non-response, to make it representativeness at national and regional levels: therefore, it can be generalized to all women in Ethiopia. Third, multivariate decomposition analysis was applied to understand the source of change in FGM practice. Fourth, the use of GIS and SaTScan statistical tests helped to detect similar and statistically significant hotspot areas of FGM practice across the surveys and to design effective public health programs.

Limitation, variables were not consistently collected in all EDHS surveys like FGM were not collected in EDHS 2011 and wealth index in EDHS 2000 and this variable was not used for the decomposition analysis. The other limitation was, the SaTScan detect only circular clusters, and irregularly shaped clusters were not detected. Furthermore, the EDHS survey did not incorporate community-level variables like community norm, culture, and beliefs rather it relied on mothers or caregivers report and might have the possibility of social desirability and recall bias since FGM is not socially acceptable though CSA claim that strong effort was made to minimize it mainly through extensive training of

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data collectors, recruiting experienced data collectors and supervisors this might underestimate our finding.

Conclusions

Female genital mutilations among women aged 15-49 years have shown a dramatic decrease in FGM over the last 16 years in Ethiopia. About 95% of the overall change in FGM practice among reproductive-age women over the last 16 years was due to the differences in the effect of characteristics (coefficient) between the 2000 and 2016 EDHS. Mainly the decrease in FGM practice over the study period was attributed to the change in effects of residence, religion, region, media exposure, occupational status, and women education. But, the change in FGM practice due to the difference in endowment or composition between the surveys was not significant.

This study identified significant spatial clusters of FGM practice in Somali, Afar, Harari and border areas of Somali as significant hotspot areas consistently over the three surveys. These results provide further insight into identifying the reason why FGM practice highly concentrated in these regions consistently over the three surveys and dig the deeply rooted factors about the continued experience of FGM practice. Besides, it would help policymakers, programmers and NGOs to design effective public health interventions and enabling efficient and timely spatial targeting to identify significant hotspot areas to achieve the SDGs.

Abbreviations

CI; Confidence Interval, CSA; Central Statistical Agency, DHS; Demographic Health Survey, EA; Enumeration Area, EDHS; Ethiopian Demographic Health Survey, FGM; Female Genital Mutilation, GDP; Gross Domestic Product, GIS;   Geographic Information System, LLR; log-likelihood Ratio, LR; Likelihood Ratio, PHC; Population and Housing census, SNNPRs; Southern Nations and Nationality People Regional state, WHO; World Health Organization

Declarations

Ethical approval and consent to participate

The study was based on secondary analysis of existing survey data with all identifying information removed. Permission for data access was obtained from measure demographic and health survey through an online request from http://www.measuredhsprogram.com. Prior to the actual interview,

each woman was asked if she agreed to participate in the study. The GIS data were obtained through explaining the purpose of using GPS data and approval from Measure DHS. Informed consent was obtained from the participants, their guardian or household heads

Consent for publication

Not applicable since the study was a secondary data analysis already collected by CSA

Availability of data and materials

Data is available online and you can access it from www.measuredhs.com.

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Tables

Table 1: percentage distribution of characteristics of women in 2000, 2005 and 2016 Ethiopian Demographic and Health Surveys

Variables	EDHS 2000	EDHS 2005	EDHS 2016
	Weighted frequency (%)	Weighted frequency (%)	Weighted fre
Region			
Tigray	969 (6.3)	919 (6.5)	462 (6.4)
Afar	177 (1.2)	146 (1.0)	67 (0.9)
Amhara	3,820 (24.9)	3,482 (24.7)	1,702(23.5)
Oromia	5,937 (38.6)	5,009 (35.6)	2,748 (37.9)
Somali	175 (1.1)	486 (3.5)	228 (3.2)
Benishangul	160 (1.0)	124 (0.9)	68 (0.9)
SNNPRs	3,285 (21.4)	2,995 (21.3)	1,433 (19.8)
Gambella	40 (0.3)	44 (0.3)	15(0.2)
Harari	41 (0.3)	39 (0.3)	18 (0.3)
Addis Ababa	684 (4.4)	756 (5.4)	461 (6.3)
Dire Dawa	79 (0.5)	69 (0.5)	45 (0.6)
Place of residence			
Urban	2,791 (18.2)	2,499 (17.8)	1,665(23.0)
Rural	12,576 (81.8)	11,571 (82.2)	5,583 (77.0)
Religion			
Orthodox	7,763 (50.5)	6,920 (49.2)	3,157 (43.6)
Muslim	4,456 (29.0)	4,009 (28.5)	2,287 (31.6)
Catholic	175 (1.1)	189 (1.3)	52 (0.7)
Protestant	2,432 (15.8)	2,654 (18.9)	1,674 (23.1)
Traditional	503 (3.3)	189 (1.3)	55 (0.8)
Others	37 (0.2)	124 (0.9)	24 (0.3)
Age of women (in years)			
15-19	3,710 (24.1)	3,266 (23.2)	1,523 (21.0)
20-24	2,859 (18.6)	2,547 (18.1)	1,193 (16.5)
25-29	2,585 (16.8)	2,517 (17.9)	1,356 (18.7)
30-34	1,841 (12.0)	1,808 (12.9)	1,124 (15.5)

35-39	1,716 (11.2)	1,602 (11.4)	939 (12.9)
40-44	1,392 (9.2)	1,187 (8.4)	610 (8.4)
45-49	1,264 (8.2)	1,143 (8.1)	502 (6.9)
Maternal Education			
No education	11,551 (75.2)	9,271 (65.9)	3,406 (47.0)
Primary	2,425 (15.8)	3,123 (22.2)	2,505 (34.5)
Secondary	1,304 (8.5)	1,481 (10.5)	889 (12.3)
Higher	87 (0.5)	194 (1.4)	448 (6.2)
Maternal occupation			
Not working	5,671 (36.9)	9,312 (66.2)	3,516 (48.5)
Professional	107 (0.7)	181 (1.3)	198 (2.7)
Clerical	88 (0.6)	56 (0.4)	71 (1.0)
Sales	2,038 (13.3)	1,494 (10.6)	1,127 (15.6)
Agriculture employee	5,687 (37.0)	2,484 (17.7)	1,496 (20.6)
Services	197 (1.3)	15 (0.1)	275 (3.8)
Skilled manual	1,472 (9.6)	289 (2.1)	285 (3.9)
Unskilled manual	103 (0.7)	238 (1.7)	280 (3.9)
Media exposure			
Yes	5,222 (34.0)	6,511 (46.3)	3,141 (43.3)
No	10, 115 (66.0)	7,559 (53.7)	4,107 (56.7)
Wealth status			
Poorest		2,427 (17.3)	1,127 (15.5)
Poor		2,643 (18.8)	1,284 (17.7)
Middle		2,732 (19.4)	1,408 (19.4)
Rich		2,646 (18.8)	1,445 (19.9)
Richest		3,621 (25.7)	1,984 (27.4)

Table 2. The trend in FGM practice among reproductive age women by selected characteristics, 2000, 2005, and 2016 Ethiopian Demographic and Health Surveys

Characteristics	EDHS 2000	EDHS 2005	EDHS 2016	Point difference in prevalence of FGM	
				Phase 1 (2005-2000)	Phase 2 (2016-2005)
Place of residence					
Urban	79.8	68.5	55.5	-11.3	-13.0
Rural	79.9	75.5	74.8	-4.4	-0.7
Religion					
Orthodox	76.8	67.5	58.8	-9.5	-8.7
Muslim	91.8	88.9	84.9	-2.9	-4.0
Catholic	66.9	76.9	73.7	10.0	-3.2
Protestant	71.9	71.3	73.2	-0.6	1.9
Traditional	66.8	49.2	62.1	-17.6	11.9
Age of women					
15-19	70.7	62.2	51.6	-8.5	-10.6
20-24	78.3	73.0	63.3	-5.3	-9.7
25-29	81.4	77.6	73.4	-3.8	-4.2
30-34	86.2	78.0	82.2	-8.2	4.2
35-39	83.6	81.2	80.8	-2.4	-0.4
40-44	85.8	81.6	77.2	-4.2	-4.4
45-49	86.8	80.8	81.5	-6.0	0.7
Maternal education					
No education	80.4	77.3	81.0	-3.1	3.7
Primary	78.4	70.8	66.3	-7.6	-4.5
Secondary	77.7	65.1	50.7	-12.6	-14.4
Higher	85.5	55.6	50.7	-29.9	-4.9
Women occupation					
Not working	79.6		74.2	72.9	-5.4	-1.3
Professional	85.5		65.2	61.9	-20.3	-3.3
Clerical	73.5		65.8	44.8	-7.7	-21.0
Sales	83.8		74.6	69.6	-9.2	-5.0
Agricultural employee	77.6		78.0	70.5	0.4	-7.5
Services	86.2		67.5	72.2	-18.7	4.7
Skilled manual	83.9		68.1	63.0	-15.8	-5.1
Unskilled manual	80.6		55.9	58.2	-24.7	2.3
Media exposure					
Yes	80.5		72.8	62.9	-7.7	-9.9
No	79.7		75.5	76.5	-4.2	1.0
Wealth status					
Poorest			73.0	75.6	2.6	
Poor			75.9	73.2	-2.7	
Middle			75.4	77.1	1.7	
Rich			77.6	73.6	-4.0	
Richest			70.6	58.5	-12.1	
Total	79.9		74.3	70.4	-5.6	-3.9

Table 3. The overall decomposition analysis of change in FGM practice in Ethiopia, 2000 to 2016

Female genital mutilation	Coef.	[95% conf.Interval]	P
E	-0.0053	[-0.014, 0.0037]	5.
C	-0.099	[-0.114, -0.084]**	9
R	-0.104	[-0.115, -0.093]	

Table 4. The detailed decomposition analysis of the change in FGM practice in Ethiopia, 2000 to 2016

Female Genital Mutilation		Difference due to characteristics (E)		Difference d
		Coef.	Pct.	Coef.
Residence	Rural	0		0
	Urban	0.003 (-0.006, 0.011)	-2.7	0.02 [0.01, (
Region	Somali	0		0
	Afar	0.003 [-0.006, 0.012]	-2.8	-0.0006[-0.0
	Amhara	-0.005 [-0.02, 0.01]	4.9	0.013 [-0.00
	Oromia	-0.015 [-0.06, -0.029]	14.1	0.006 [-0.02
	Tigray	0.013 [-0.025, 0.05]	-12.2	0.01 [0.0008
	Ben-Gumuz	0.0029 [-0.0058, 0.012]	-2.8	0.007 [-0.00
	SNNPRs	-0.0046[-0.018, -0.009]	4.4	0.01 [-0.009
	Gambella	0.004 [-0.009, 0.017]	-4.1	0.007 [-0.00
	Harari	-0.0004 [-0.002, 0.0008]	0.37	0.003 [-0.00
	Addis Ababa	-0.005 [-0.02, 0.01]	4.9	0.011 [-0.00
	Dire Dawa	0.001 [-0.002, 0.004]	-1.0	-0.0013 [-0.(
Women age (in years)	15-19	-0.0018 [-0.007, 0.004]	1.7	-0.007 [-0.0?
	20-24	-0.0001[-0.00002, 0.00001]	0.005	-0.002 [-0.0(
	25-29	0.0003 [-0.0006, 0.0012]	-0.28	-0.002 [-0.0(
	30-34	0.0001 [-0.0006, 0.001]	-0.1	0.0007 [-0.0
	35-39	0		0
	40-44	-0.0001 [-0.0003, 0.0002]	0.07	-0.001 [-0.0(
	45-49	00002 [-0.0008, 0.0013]	-0.2	0.0006 [-0.0
Educational status	No education	0		0
	Primary	0.0019[-0.007, 0.01]	-1.8	-0.002 [-0.0(
	Secondary	0.0005 [-0.001, 0.002]	-0.5	-0.001 [-0.0(
	Higher	0.008 [-0.02, 0.033]	-7.6	-0.0008 -0.00006]**
Occupation	Not working	0		0
	Gov't employee	-0.0013 [-0.0012, 0.0009]	0.1	-0.0006 0.0003]
	Self employee	0.0007 [-0.003, 0.005]	0.7	-0.02 [-0.03,
Religion	Orthodox	-0.0018 [-0.011, 0.007]	1.8	-0.06 [-0.11,
	Muslim	-0.006 [-0.025,0.012]	5.8	-0.05 [-0.08,
	Protestant	0.0007 [-0.0043, 0.0056]	-0.6	-0.003 [-0.0?
	Traditional	-0.0038 [-0.015, 0.0075]	3.6	-0.002 [-0.0(
	Catholic	0		0
Media exposure	Yes	-0.0006 [-0.0025,0.0014]	0.5	-0.012 -0.003]**
	No	0		0
Constant				0.02 [-0.15,

Table 5. SaTScan analysis result of FGM practice in Ethiopia, 2000

Clusters	Enumeration areas(EAs)/ clusters detected	Coordinates/radius	Population	Cases	R
1(141)	255, 256, 260, 274, 257, 258, 259, 251, 253, 250, 273, 272, 252, 249, 254, 262, 248, 244, 261, 275, 506, 264, 263, 265, 218, 246, 425, 507, 424, 426, 422, 423, 509, 515, 421, 432, 505, 427, 431, 420, 438, 434, 447, 514, 436, 450, 435, 439, 440, 448, 437, 452, 441, 442, 443, 449, 451, 444, 453, 445, 446, 429, 513, 242, 433, 219, 428, 430, 538, 539, 537, 36, 521, 510, 522, 535, 523, 531, 534, 528, 533, 529, 530, 527, 519, 532, 517, 524, 526, 518, 516, 511, 540, 512, 508, 247, 220,224, 245, 221, 223, 222, 213, 57, 56, 53, 52, 54, 55, 1, 214, 217, 81, 64, 212, 215, 61, 60, 75, 59, 58, 62, 78, 74, 77, 79, 216, 76, 80, 69, 82, 71, 83, 66, 73, 70, 72, 68, 67, 65, 63	(9.867651 N, 43.086403 E) / 348.25 km	3807	3704	1
2 (62)	175, 186, 236, 187, 315, 176, 321, 170, 177, 185, 322, 237, 178, 377, 172, 191, 168, 320, 323, 182, 316, 325, 188, 169, 326, 179, 167, 311, 181, 192, 183, 380, 184, 180, 317, 166, 331, 173, 319, 318, 358,324, 164, 333, 190, 332, 334, 235, 352, 351, 200, 470, 471, 373, 328, 189, 502, 468, 171, 494, 501, 461	(8.527592 N, 37.185362 E) / 177.79 km	2034	1899	1
3(49)	129, 128, 100, 130, 98, 142, 131, 99, 132, 101, 158, 116, 117, 139, 109, 96, 135, 97, 36, 115, 143, 138, 140, 95, 105, 106, 154, 133, 141, 110, 144, 134, 118, 93, 155, 94, 37, 194, 193, 120, 238, 114, 119, 104, 148, 111, 102, 95, 147	(11.086446 N, 38.158578 E) / 155.51 km	1267	1150	1
4(18)	304, 293, 305, 313, 295, 306, 301, 280, 282, 298, 302, 292, 296,281, 297, 160, 303, 299	(10.329109 N, 35.159160 E) / 75.37 km	492	477	1
5(7)	346, 347, 345, 339, 228, 342, 343	(6.495022 N, 38.853737 E) / 46.64 km	187	181	1
6(5)	266, 268, 276, 243, 267	(5.134748 N, 40.418175 E) / 180.04 km	26	25	1
7(6)	361, 362, 364, 363, 357, 353	(6.520039 N, 37.390891 E) / 57.41 km	166	154	1
8 (4)	234, 270, 233, 271	(3.992650 N, 38.343911 E) / 112.67 km	92	88	1
9(3)	413, 419, 412	(7.215608 N, 35.321323 E) / 5.17 km	61	60	1
10 (11)	38, 39, 40, 48, 42, 43, 36, 41, 37, 146, 145	(12.823525 N, 39.374479 E) / 64.31 km	256	229	1

Table 6. SaTScan analysis result of FGM practice in Ethiopia, 2005

clusters	Enumeration areas(EAs)/ Clusters detected	Coordinates/radius	Population	Cases
1 (175)	176, 538, 52, 58, 127, 50, 241, 374, 108, 466, 508, 221, 43, 494, 4,438, 313, 404, 253, 197, 183, 106, 41, 25, 375, 208, 453, 524, 272,155, 89, 169, 141, 429, 95, 3, 525, 318, 306, 285, 476, 358, 478,509, 228, 275, 117, 345, 294, 378, 493, 114, 133, 386, 469, 391, 440,79, 63, 85, 321, 495, 422, 366, 473, 521, 301, 173, 91, 300, 320,456, 121, 446, 79, 92, 287, 371, 166, 369, 38, 196, 425, 198, 379,232, 138, 314, 233, 78, 297, 460, 174, 407, 242, 247, 515, 227, 186,248, 486, 100, 344, 6, 33, 18, 59, 413, 148, 47, 137, 290, 55, 54,265, 385, 443, 410, 492, 481, 498, 246, 70, 442, 513, 377, 383, 82,57, 16, 88, 142, 56, 334, 103, 101, 250, 505, 29, 516, 14, 402, 111,278, 309, 522, 31, 187, 128, 397, 291, 330, 165, 439, 298, 87, 225,392, 96, 261, 51, 382, 218, 181, 470, 32, 528, 288, 74, 147, 216,458, 308, 295, 243	(9.774395 N, 43.208576 E) / 484.13 km	4252	3826
2 (116)	320, 321, 79, 38, 473, 521, 446, 366, 495, 173, 301, 196, 85, 121,166, 91, 92, 371, 300, 422, 287, 456, 369, 425, 198, 378, 379, 179,141, 63, 169, 208, 233, 318, 306, 294, 386, 138, 272, 524, 469, 493, 3, 114, 95, 275, 228, 375, 345, 285, 476, 117, 89, 478, 358, 391,525, 155, 429, 440, 133, 314, 453, 25, 509, 297, 78, 232, 460, 183, 197, 313, 404, 466, 108, 174, 242, 494, 43, 221, 247, 58, 241, 374,50, 127, 52, 538, 508, 344, 176, 6, 486, 100, 106, 438, 253, 407, 41, 4, 33, 148, 137, 54, 265, 492, 443, 290, 515, 18, 498, 227, 55	(9.687251 N, 41.857767 E) / 206.04 km	2782	2544
3 (88)	94, 269, 512, 328, 273, 209, 465, 519, 395, 131, 283, 193, 487, 514,373, 504, 219, 235, 432, 255, 336, 387, 105, 533, 279, 420, 170, 365,323, 45, 499, 342, 224, 497, 168, 202, 35, 210, 436, 517, 464, 286,292, 266, 199, 67, 419, 230, 340, 537, 389, 245, 441, 151, 46, 534,434, 122, 467, 126, 324, 184, 12, 474, 276, 252, 44, 343, 380, 394,8, 363, 30, 361, 482, 69, 13, 7, 49, 201, 80, 535, 65, 355, 239	(8.028170 N, 37.259328 E) / 188.46 km	2287	2051
4(37)	128, 278, 96, 516, 225, 402, 102, 103, 288, 382, 330, 29, 262, 528,277, 101, 216, 70, 187, 57, 246, 152, 82, 261, 145, 147, 399, 513, 51, 481, 428, 385, 74, 149, 410, 56, 250	(11.545679 N, 39.640334 E) / 119.59 km	873	771
5(11)	158, 416, 175, 26, 341, 449, 37, 10, 143, 267, 439	(3.998656 N, 41.240691 E) / 333.74 km	249	235

6(9)	251, 518, 254, 144, 520, 118, 305, 107, 457	(10.223275 N, 34.605020 E) / 49.29 km	233	209
7(14)	298, 522, 397, 165, 32, 243, 308, 392, 14, 536, 332, 295, 87, 454	(8.550956 N, 39.299797 E) / 71.70 km	405	340
8(13)	304, 354, 231, 461, 182, 115, 97, 351, 1, 338, 415, 479, 99	(11.075622 N, 37.699792 E) / 62.45 km	334	284
9(4)	145, 277, 262, 428	(12.172298 N, 39.074809 E) / 49.37 km	88	81
10(1)	502	(13.163256 N, 39.926912 E) / 0 km	30	30

Table 7: SaTScan analysis result of FGM practice in Ethiopia, 2016

clusters	Enumeration areas(EAs)/ Clusters detected	Coordinates/radius	Population	Cases
1 (220)	630, 269, 629, 77, 146, 92, 490, 543, 171, 492, 198, 95, 497, 458, 588, 553, 521, 138, 214, 33, 573, 251, 239, 116, 85, 358, 22, 164, 527, 568, 277, 439, 64, 57, 278, 210, 8, 186, 566, 1, 318, 622, 436, 212, 454, 501, 68, 187, 357, 419, 483, 194, 513, 321, 587, 288, 580,44, 534, 307, 240, 387, 58, 418, 381, 500, 133, 257, 29, 157, 396,495, 397, 56, 179, 228, 238, 28, 329, 60, 115, 393, 614, 383, 443,607, 173, 610, 642, 473, 242, 523, 281, 311, 166, 202, 453, 352, 613,514, 493, 519, 444, 27, 471, 185, 535, 5, 385, 224, 273, 390, 631,74, 151, 606, 380, 30, 111, 467, 282, 363, 190, 644, 43, 101, 140,546, 594, 557, 441, 25, 556, 372, 93, 480, 520, 333, 491, 412, 286, 476, 506, 75, 452, 4, 208, 472, 596, 245, 289, 529, 366, 632, 440,122, 394, 135, 564, 37, 336, 39, 71, 49, 51, 230, 319, 334, 178, 499, 123, 205, 102, 283, 484, 570, 276, 620, 547, 295, 377, 213, 624, 562,55, 427, 201, 637, 524, 368, 125, 149, 121, 254, 310, 348, 619, 290, 40, 191, 438, 26, 571, 345, 389, 422, 611, 518, 18, 303, 189, 241, 34, 544, 599	(7.717178 N, 46.991580 E) / 900.49 km	2384	2033
2 (183)	33, 527, 277, 568, 116, 22, 239, 573, 251, 214, 439, 64, 57, 210, 8, 458, 553, 588, 521, 186, 566, 1, 622, 436, 212, 497, 501, 307, 454, 68, 357, 419, 288, 321, 194, 483, 381, 587, 44, 534, 495, 387, 240,580, 513, 58, 396, 418, 257, 157, 500, 329, 29, 397, 133, 56, 238, 228, 60, 179, 28, 393, 614, 383, 115, 443, 610, 173, 607, 642, 473,242, 523, 281, 95, 311, 166, 202, 352, 613, 514, 493, 27, 444, 185, 519, 471, 224, 385, 5, 535, 390, 273, 606, 631, 74, 151, 380, 111, 467, 363, 30, 282, 198, 190, 453, 644, 101, 140, 43, 546, 594, 171, 557, 25, 441, 93, 372, 543, 490, 491, 333, 92, 492, 412, 506, 476, 75, 278, 318, 596, 4, 187, 135, 37, 440,	(9.191989 N, 43.573399 E) / 456.66 km	2043	1750

	632, 336, 39, 85, 564, 358, 245, 629, 122, 529, 164, 51, 230, 49, 71, 146, 334, 283, 102, 366, 286, 499, 178, 276, 484, 570, 452, 620, 205, 547, 138, 77, 630, 480,295, 269, 472, 319, 55, 624, 123, 637, 201, 368, 289, 427, 254			
3 (63)	272, 223, 331, 537, 297, 41, 577, 271, 360, 502, 388, 420, 373, 359,174, 142, 14, 565, 609, 633, 126, 204, 162, 262, 113, 347, 227, 53,578, 54, 148, 308, 391, 20, 447, 522, 306, 216, 139, 486, 408, 180, 589, 12, 141, 215, 217, 365, 432, 434, 634, 438, 576, 23, 118, 619,26, 313, 76, 468, 445, 485, 406, 62	(7.631441 N, 37.861459 E) / 152.62 km	816	713
4(44)	502, 577, 331, 142, 272, 227, 41, 174, 223, 360, 447, 537, 126, 271,486, 565, 297, 113, 388, 359, 262, 373, 306, 420, 432, 204, 162, 14,53, 609, 633, 347, 141, 20, 180, 76, 62, 54, 118, 139, 434, 148, 489, 578	(7.701180 N, 37.486551 E) / 128.59 km	569	515
5(24)	6, 433, 416, 165, 203, 317, 595, 17, 581, 508, 563, 407, 209, 409, 374, 335, 395, 324, 462, 569, 275, 65, 193, 285	(9.942940 N, 34.629272 E) / 67.68 km	239	209
6(4)	235, 585, 127, 362	(13.750028 N, 39.991260 E) / 16.33 km	56	55
7(33)	249, 488, 344, 332, 351, 455, 97, 442, 200, 241, 544, 128, 389, 449,599, 348, 189, 300, 136, 143, 79, 478, 571, 401, 496, 392, 191, 511,130, 591, 66, 410, 172	(12.335896 N, 39.851758 E) / 103.48 km	345	283
8(7)	313, 468, 576, 405, 634, 445, 215	(6.620913 N, 38.626887 E) / 38.40 km	89	83
9(3)	130, 511, 172	(13.169308 N, 39.987117 E) / 10.69 km	39	39

Figures
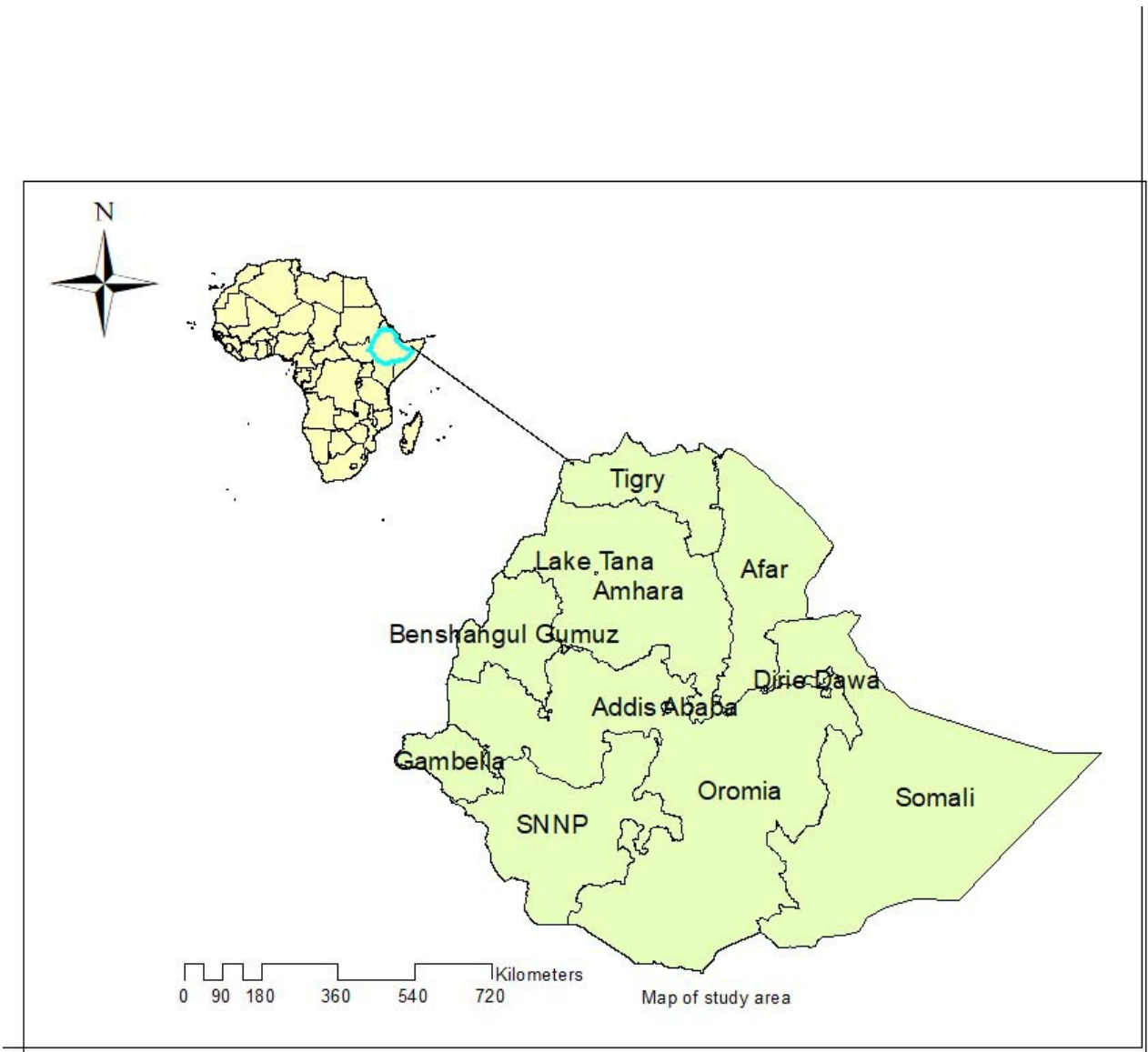
Figure 1

Trends of FGM practice among reproductive age women in Ethiopia, based on EDHS 2000,
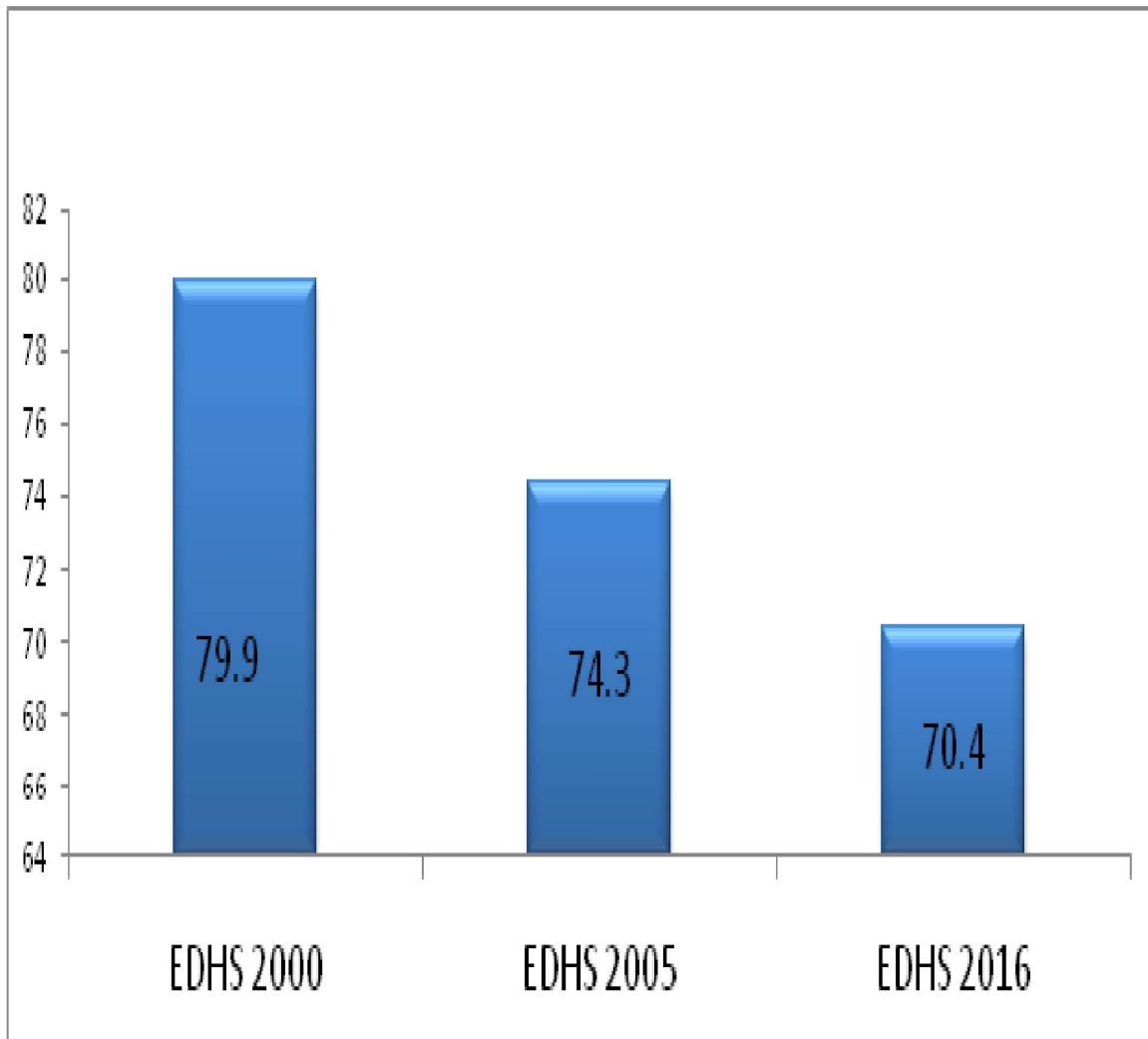
2005 and 2016

Figure 2

Trends of FGM practice among reproductive age women across regions in Ethiopia, based on

EDHS 2000, 2005 and 2016
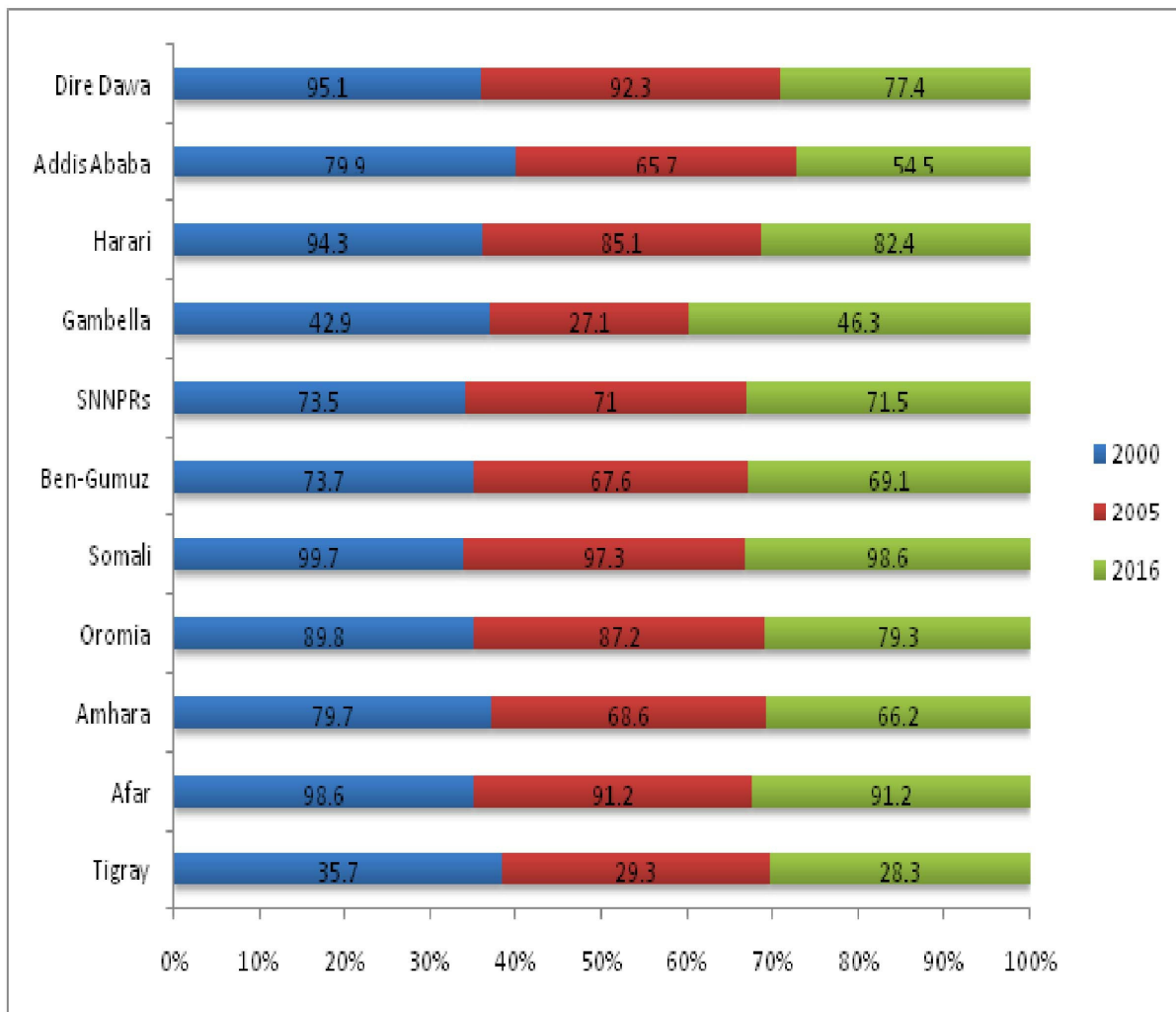
Figure 3

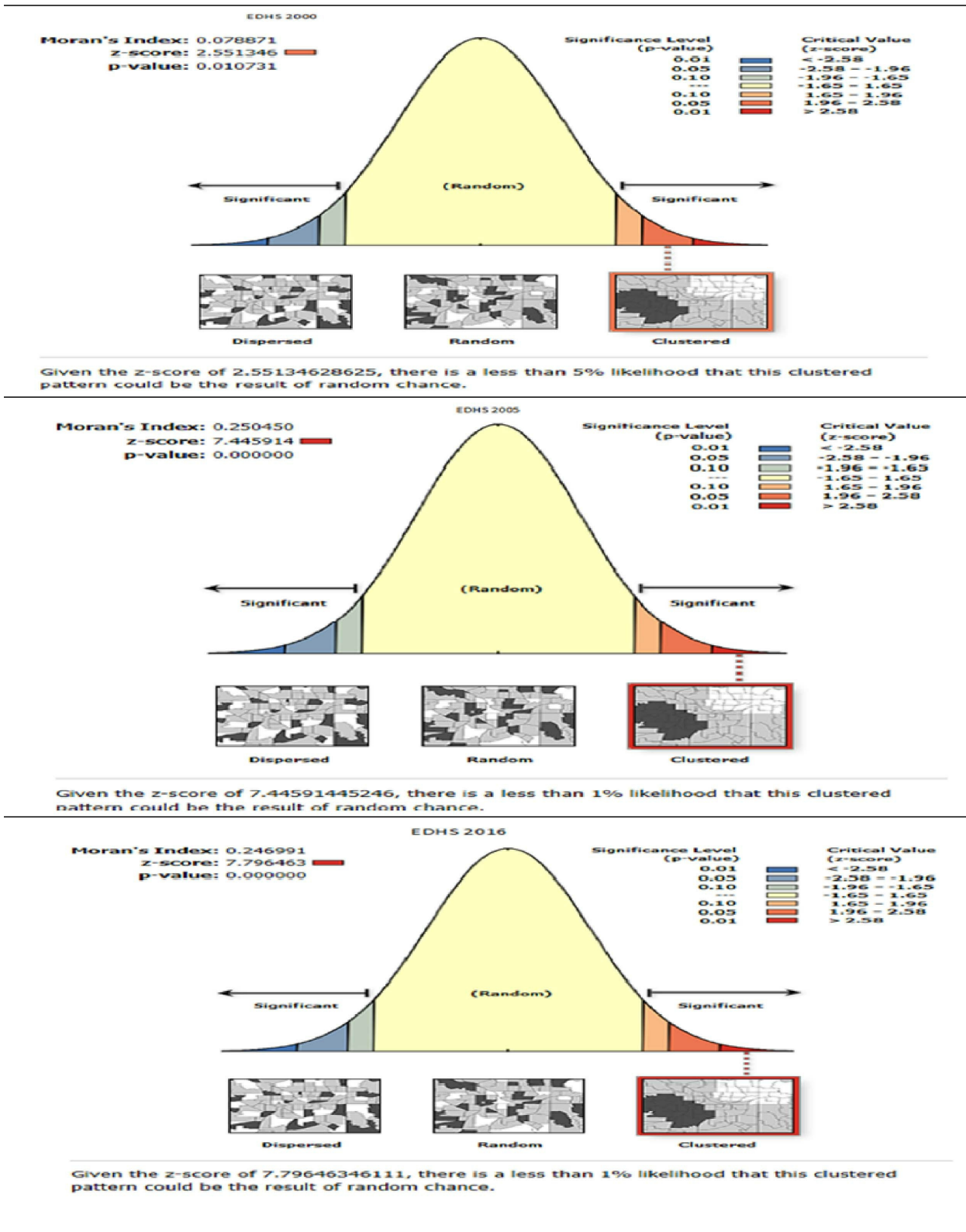Map of the study area (Source; Shape file from CSA, 2013)

Figure 4

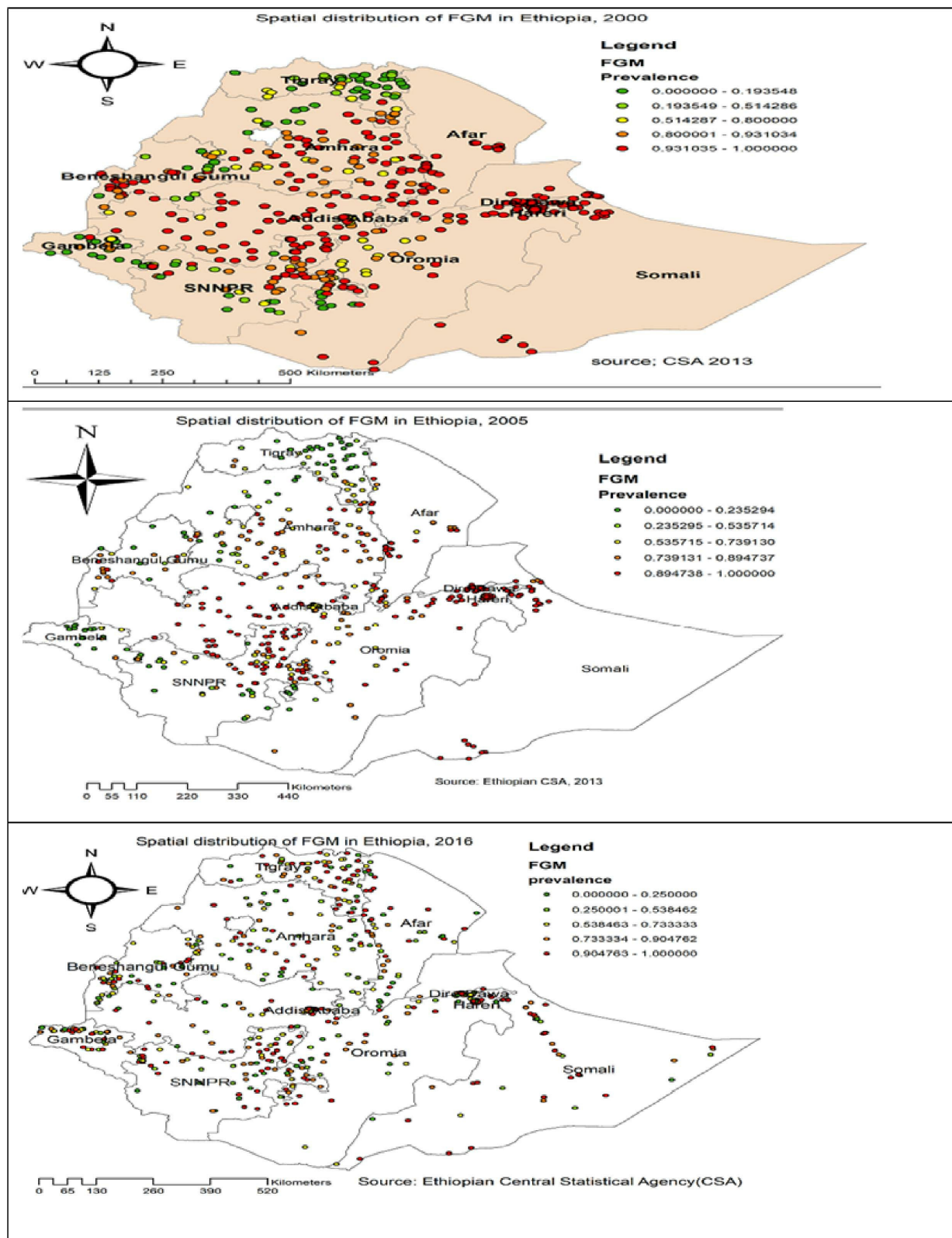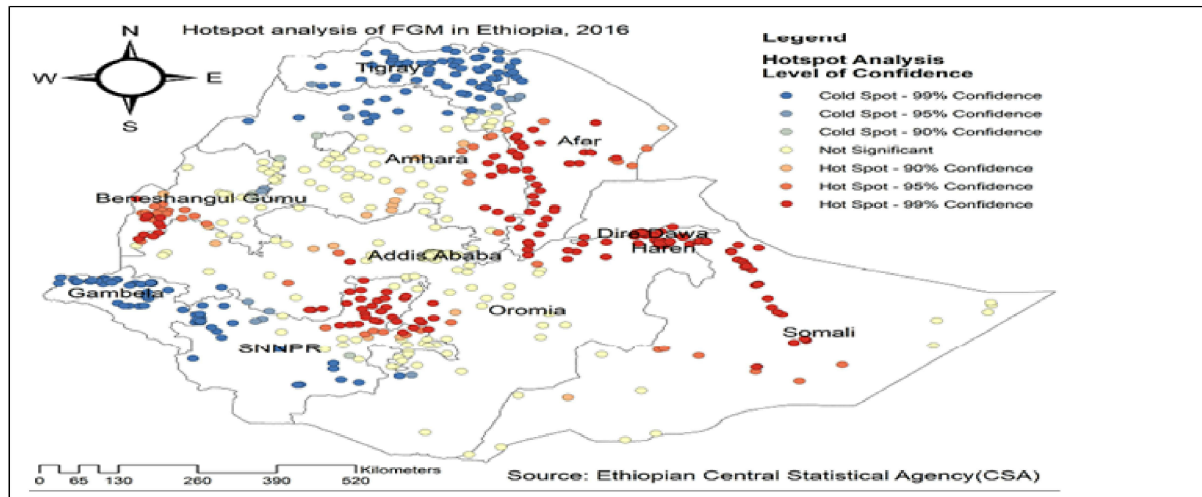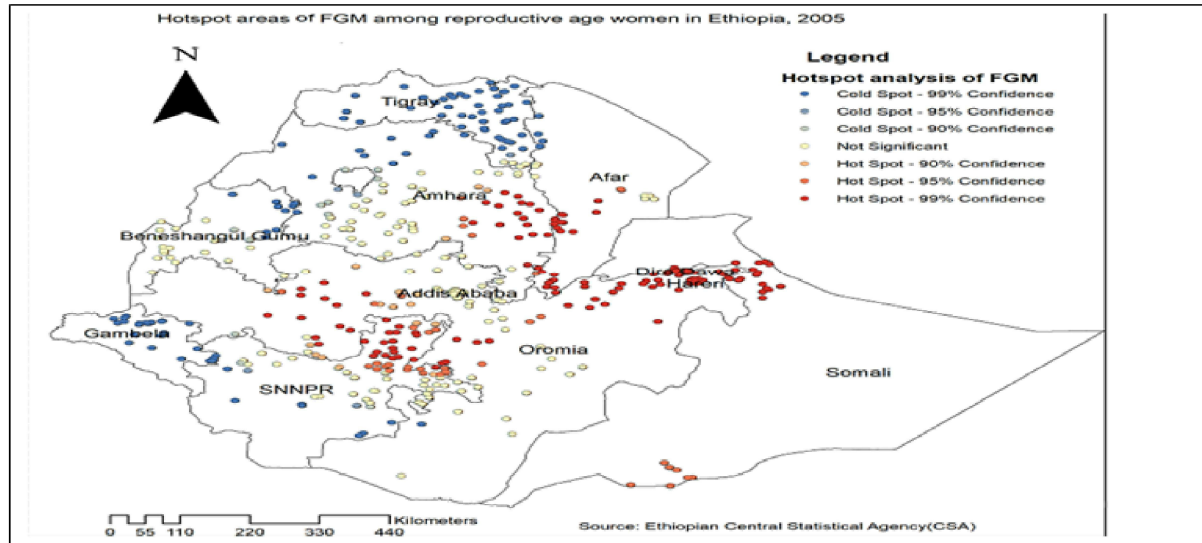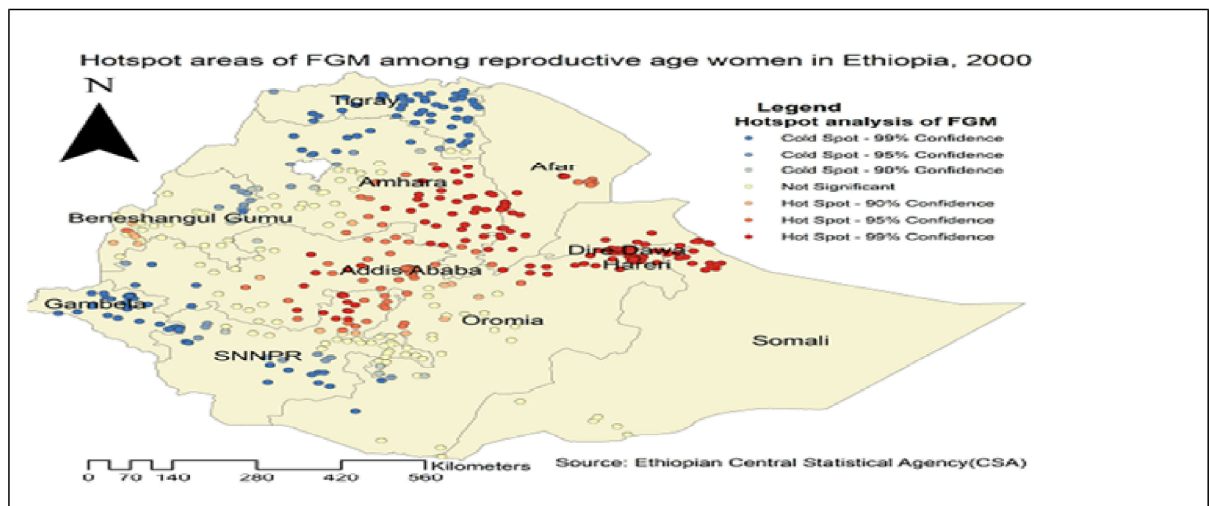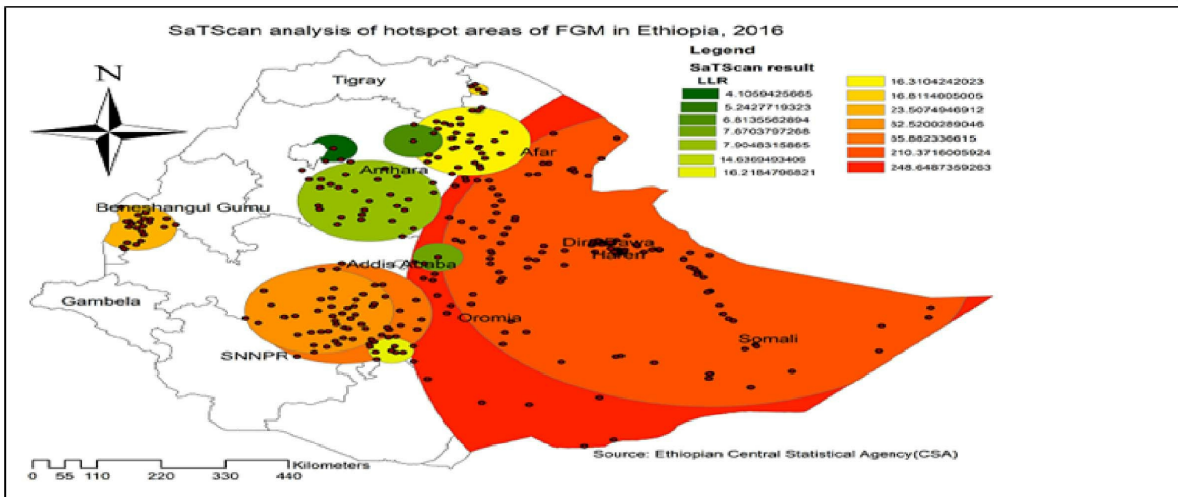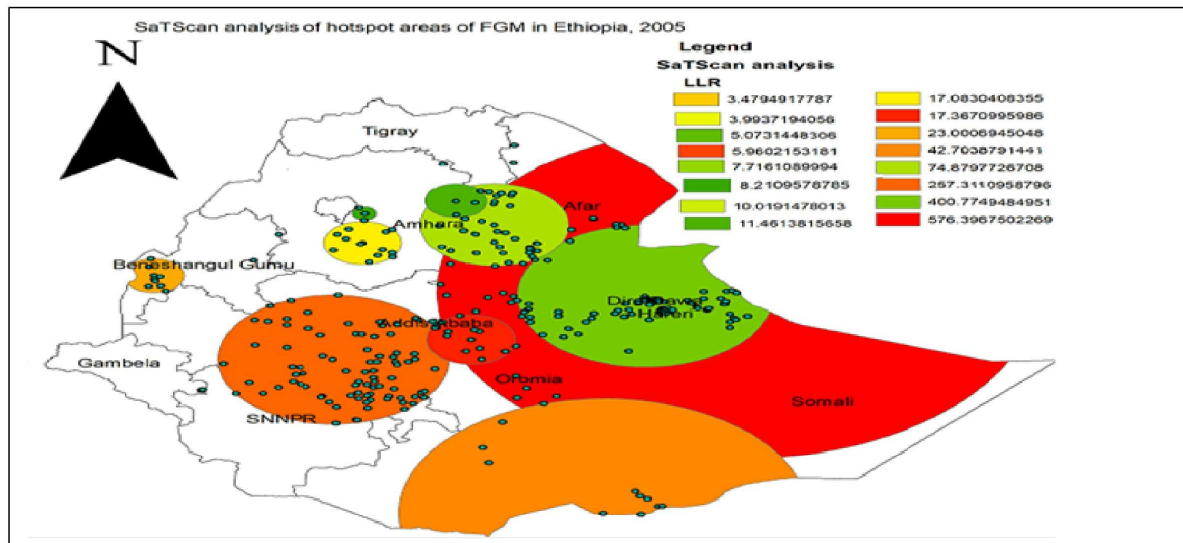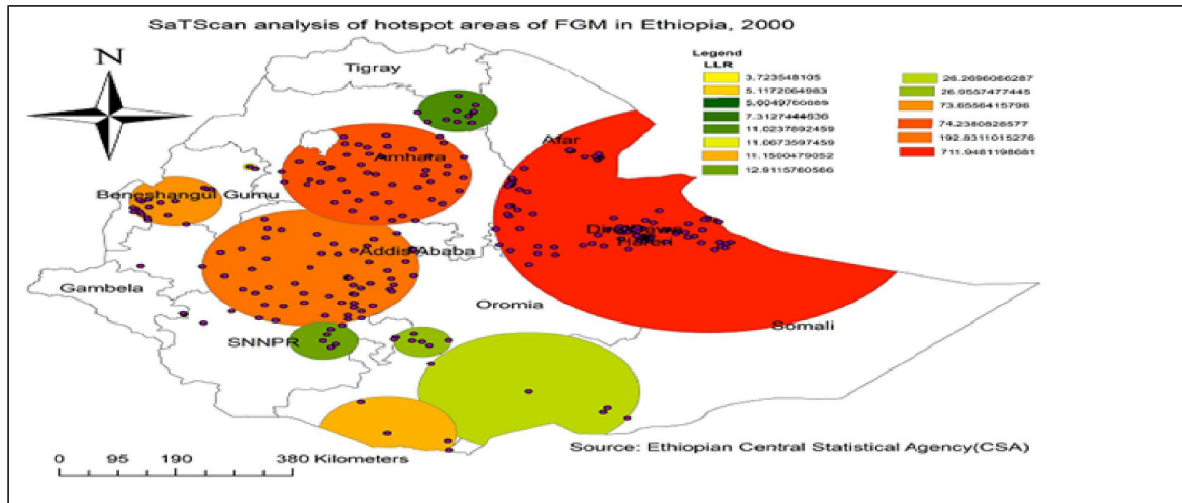Global spatial autocorrelation of FGM practice across the surveys (Source; Shape file from CSA, 2013)

Figure 5

Spatial distribution of prevalence of FGM practice across the surveys (Source; Shape file from CSA, 2013)

Figure 6

Hotspot analysis of FGM practice across the surveys (Source; Shape file from CSA, 2013)

Figure 7
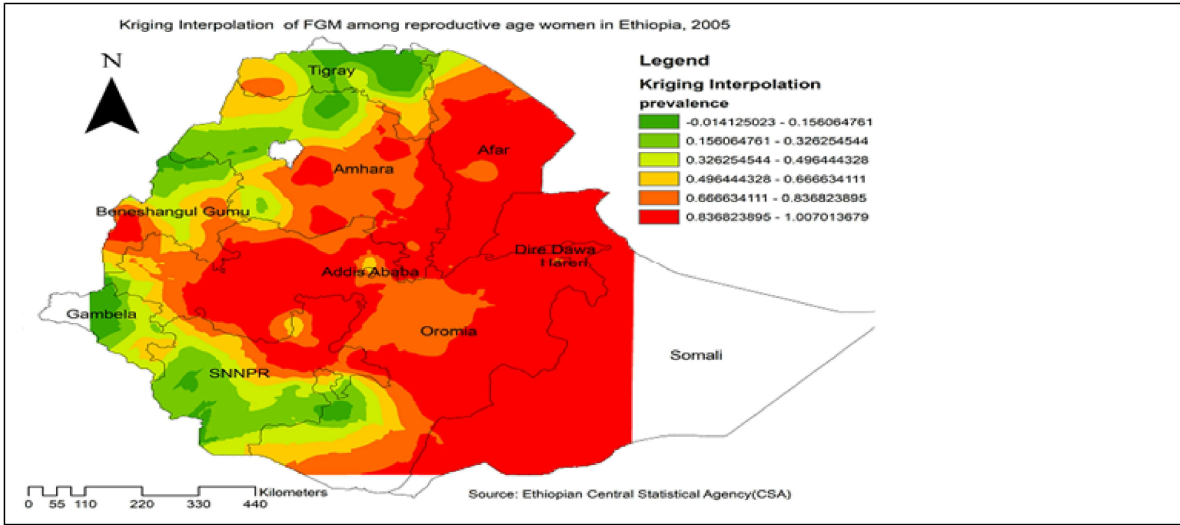
SaTScan analysis of FGM practice across the surveys (Source; Shape file from CSA, 2013)
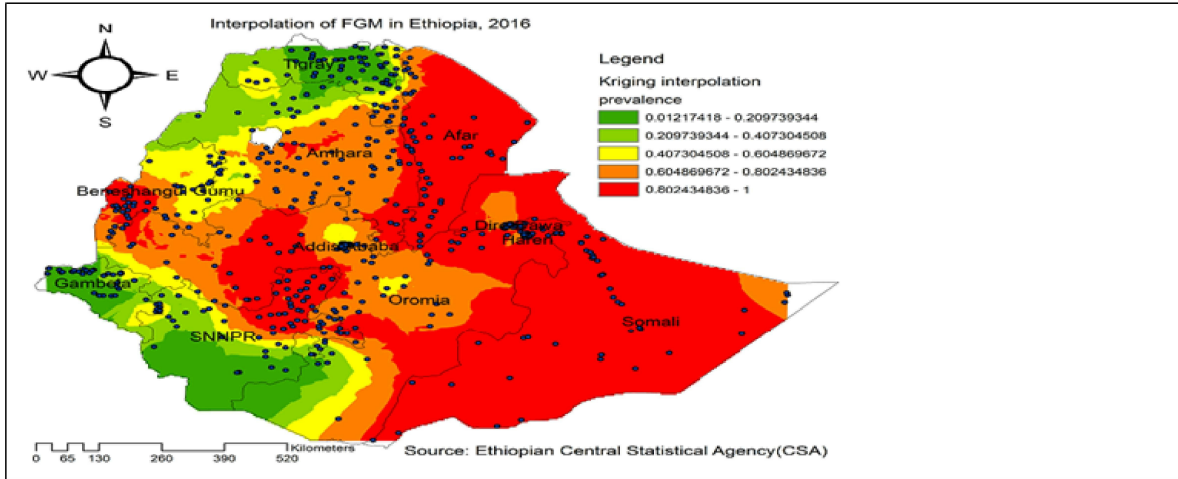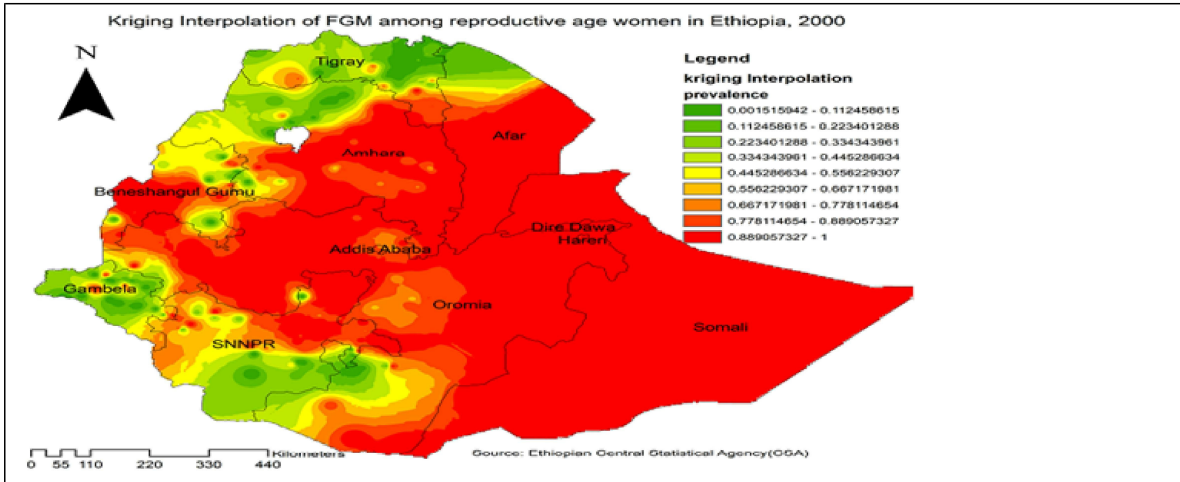
Figure 8

Interpolation of FGM practice across the surveys (Source; Shape file from CSA, 2013)

Supplementary Files

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