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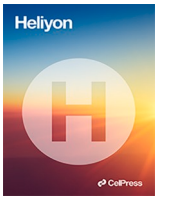

Research article

Trends, spatiotemporal variation and decomposition analysis of pregnancy termination among women of reproductive age in Ethiopia: Evidence from the Ethiopian demographic and health survey, from 2000 to 2016

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ABSTRACT

Background: Pregnancy termination is a major public health problem, and complications of unsafe abortion are among the proximate and major causes of maternal mortality. Mapping the trend and spatiotemporal variation and identifying factors that are responsible for the changes in pregnancy termination help achieve the sustainable development goal of reducing maternal mortality in Ethiopia by understanding the epidemiology and regional variations.

Methods: Data from the 2000–2016 Ethiopian Demographic and Health Survey were analyzed with a total weighted sample of 40,983 women of reproductive age. Variables with a p-value <0.05 in a logit multivariable decomposition analysis were considered significant predictors of the decline in pregnancy termination over time. Spatial analysis was used separately for each survey to show the changes in regional disparities in pregnancy termination in Ethiopia.

Results: The magnitude of pregnancy termination among women of reproductive age decreased by 39.5 %, from 17.7 % in 2000 to 10.7 % in 2016. The difference in the effects of literacy, working status, marital status, age at first intercourse, age at first cohabitation, knowledge about contraceptives, and knowledge of the ovulatory cycle were the significant predictors that contributed to the change in pregnancy termination over time. Significant clusters of pregnancy terminations were observed in central and northern Ethiopia (Addis Ababa, eastern Amhara, and Tigray regions).

Conclusions: Despite the substantial decrease in terminated pregnancies over time in Ethiopia, the magnitude is still high. The government should focus on promoting education for girls and

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women, providing reproductive health education, including access to contraceptives, and raising the minimum age for girls to engage in sexual activities or marriage by implementing policies.

Statement of significance

Problem

There is limited evidence on the trends and spatiotemporal variations in pregnancy termination in Ethiopia. Little is known about how terminated pregnancies change over time and the factors that contribute to this change.

What is already known

Studies have been conducted to identify factors associated with pregnancy termination, and regional variation has been identified in Ethiopia.

What this paper adds

The trend of pregnancy termination decreased from 17.7 % to 10.7 %. Variables contributing to the decrease in pregnancy termination were literacy, working status, marital status, age at first intercourse, age at first cohabitation, knowledge about contraceptives, and ovulatory cycle.

1. Introduction

A pregnancy may terminate or result in a live birth. A pregnancy is considered terminated when it ends because of a miscarriage (often referred to as spontaneous abortion), induced abortion, or stillbirth [1]. Miscarriage and stillbirth are pregnancy losses occurring before and after 20 weeks of gestation, respectively, whereas induced abortion is an intentional pregnancy termination [2–4]. Pregnancy termination is one of the main issues affecting the health of mothers and children worldwide and can have a negative impact on a woman's physical and emotional health, such as stress, depression, anxiety, fear of pregnancy, and weakened relationships with spouses [5,6].

The World Health Organization (WHO) has estimated the average global rate of stillbirth to be April 18, 1000 births, and in SSA, the rate has been March 28, 1000 births [7,8]. Every year, around 23 million miscarriages and 73 million induced abortions occur worldwide [9,10]. Approximately 45.1 % of abortions occurring globally are unsafe, primarily in developing countries where accessing safe abortions is difficult. Developing countries accounted for 24.3 million (97 %) of these unsafe abortions. About 75 % of all abortions in Latin America and Africa are considered unsafe. In Africa, nearly 50 % of all abortions occur under the least safe conditions [11,12].

Nigeria and Ethiopia have the largest number of abortions, at 3.5 and 2.7 million abortions per year, respectively [13]. In Ethiopia, the rate of unintended pregnancies declined by 33 % between 1990–94 and 2015–19. However, the rate of unintended pregnancies ending in abortion has increased from 19 % to 31 % [14]. According to previous studies, educational status, residence, religion, wealth status, age, media exposure, parity, age at first intercourse, age at first marriage, contraceptive behavior, literacy, type of work, and marital status were found to be significantly associated with abortion [15–17]. Ethiopia has the seventh highest rate of stillbirths worldwide, with a significant burden of stillbirths among those who reside in rural areas, who have a poor wealth index, and who are marginalized [18,19].

The Sustainable Development Goal (SDG) aims to reduce the maternal mortality ratio (MMR) to less than 70 per 100,000 live births (LB) by 2030 [20]. In 2020, the global MMR was estimated to be 223 per 100,000 LB, with an annual rate of reduction of only 2.1 % from the 2000 estimate. The 2016 Ethiopian Demographic and Health Survey (EDHS) reported that the MMR was 412 per 100,000 LB in Ethiopia [21]. There is a large gap in achieving global targets, as little time is left to meet SDG targets. Abortion accounts for 7.9 % of global maternal deaths [22], and complications of unsafe abortion are one of the proximate and major causes of maternal mortality, especially in low-resource settings [23,24]. Within ten years of legalizing abortion in Ethiopia, the proportion of maternal mortality caused by unsafe abortion decreased from 32 % to 10 %. However, there is still a lack of public awareness regarding the legal status of abortion [25].

As an element of abortion and post-abortion care, family planning counseling and services have been provided in Ethiopia based on free and informed choices by expanding health facilities that are eligible to provide services [26,27]. When contraceptive options continue to grow, although this will not completely eradicate the need for abortions, they may eventually lower it. All these efforts have caused a change in pregnancy termination. However, to our knowledge, there are no studies demonstrating how pregnancy termination changes according to geographical location over time, or how each factor contributes to the observed changes over the first four survey years of the EDHS.

One study showed the presence of a regional variation in pregnancy termination among women of reproductive age in Ethiopia and revealed that pregnant women residing in the northern parts of the Tigray region were more likely to experience abortion [15]. Yet, they did not show whether regional variations changed over time. Some studies have also been conducted to identify factors associated

with pregnancy termination using a single wave of EDHS [28,29]. However, no study has investigated how these factors contribute to changes in the magnitude of pregnancy termination. Hence, this study was conducted to address this gap. We utilized multivariate decomposition logistic regression analysis to identify factors that contributed significantly to the change in pregnancy termination. The use of spatial analysis enables us to examine how pregnancy termination varies over time and place among women of reproductive age in different regions of Ethiopia. It also aimed to explore the spatial distribution and spatial clusters with high and low prevalences of pregnancy termination. Therefore, this study aimed to investigate the trends, spatiotemporal variations, and factors associated with changes in the trend of pregnancy termination through decomposition analysis among women of reproductive age in Ethiopia from 2000 to 2016.

2. Materials and methods

2.1. Study design, setting, and period

We used four consecutive datasets from the 1st, 2nd, 3rd, and 4th EDHS surveys, which are nationally representative studies, conducted in 2000, 2005, 2011, and 2016, respectively [21,30–32]. The surveys were cross-sectional studies conducted every five years. Ethiopia is the second most populous country in Africa and the 11th most populous country in the world, with a total fertility rate of 4 LB per woman [33,34]. The nation is situated in the Horn of Africa and is subdivided into nine regional states, along with two administrative cities. A two-stage cluster sampling method with a stratified approach was used for all EDHS surveys, where the first stage involved the selection of clusters, and the second stage involved the selection of households per enumeration area (EA). Geographical coordinates (latitude and longitude) were acquired for the selected EAs. An Ethiopian district delineation shape file was obtained from the Central Statistical Agency. Details of the study design and sampling procedure can be obtained from the EDHS reports [21,30–32].

2.2. Population

The source population was all pregnant women of reproductive age within 5 years preceding each survey, regardless of whether it was their most recent pregnancy. The study population consisted of women in all reproductive age groups with any pregnancy who lived in the selected EAs within the 5 years preceding each survey. Individual women's data (IR) were obtained from all surveys to extract the variables. The study comprised a total weighted sample of 40,983 women aged 15–49 years, 10,089 from the 2000 EDHS, 9627 from the 2005 EDHS, 10,717 from the 2011 EDHS, and 10,550 from the 2016 EDHS, with the sample weighted accordingly.

2.3. Variables

Dependent variable: The outcome variable, pregnancy termination, was taken from the EDHS question "Have you ever had a pregnancy termination?" It is defined as any pregnancy that ends in stillbirth, abortion, or miscarriage. The responses were coded into a binary outcome as yes = 1 if a woman ever had a pregnancy termination and no = 0 otherwise [15,35].

Independent variables: The explanatory variables used in this study were: religion, residence, age, educational status, literacy, marital status, occupation, wealth index, media exposure, sex of household head, parity, knowledge about contraceptives, contraceptive utilization, knowledge about ovulation period, age at first sex, and age at first marriage [15–17,35–38].

Women who could read whole or parts of a sentence or who attended school above the secondary level were categorized as literate. Women of reproductive age are considered to have knowledge about contraceptives if they know at least one contraceptive method (traditional or modern). Contraceptive utilization was categorized as yes if women currently used contraceptive methods. Women who answered in the middle of two menstrual periods for the question "When is the time a woman is more likely to become pregnant when she has sexual relations?" were deemed to have accurate knowledge of the ovulation period [21]. We combined three variables to generate variable media exposure: listening to the radio, watching TV, and reading newspapers or magazines. If a woman answered yes to any one of the questions, it was assumed that she had experienced media exposure.

Since the EDHS 2000 has no wealth index variable, we generate a wealth index using principal component analysis (PCA) by assembling household asset data. The asset variables included in the PCA were: variables that assess ownership of assets, source of drinking water, type of toilet facility, main floor material, main roof material, and type of cooking fuel. Each variable was dichotomized into binary variable and coded 1 for yes (available) and 0 for no (absent). Individuals were categorized into the wealth quintile as poorest, poorer, middle, richer, or richest [39].

2 4. Data management and analysis

The data were cleaned and analyzed using STATA version 17. To obtain reliable statistical estimates, the representativeness of the survey was restored by weighting the data using sample weight, primary sampling unit, and strata before conducting any statistical analysis. Subsequently, dependent and independent variables were extracted, cleaned, and coded. The frequencies and percentages of the study variables were computed for each survey to characterize the participants.

2.5. Trend and decomposition analysis

We analyzed the trend of pregnancy termination separately in four phases for the periods 2000–2005, 2005–2011, 2011–2016, and 2000–2016. To conduct a multivariate decomposition analysis of the change in pregnancy termination over the last 16 years, the EDHS 2000 and 2016 datasets were combined.

To identify explanatory variables that contributed significantly to the decrease in pregnancy termination over the last 16 years

Table 1
Distribution of characteristics of reproductive age group women by frequency and percentage in 2000, 2005, 2011, and 2016 EDHS.

Variables		Weighted frequency of characteristics (percentage %)			
		EDHS 2000 (N = 10,089)	EDHS 2005 (N = 9625)	EDHS 2011 (N = 10,717)	EDHS 2016 (N = 10,550)
Age	15–19	314 (5.1)	498 (5.2)	429 (4.0)	394 (3.7)
	20–24	1701 (16.9)	1526 (15.9)	1642 (15.3)	1571 (14.9)
	25–29	2090 (20.7)	2150 (22.3)	2654 (24.8)	2428 (23.0)
	30–34	1695 (16.8)	1685 (17.5)	1869 (17.4)	2153 (20.4)
	35–39	1592 (15.8)	1538 (15.9)	1785 (16.7)	1797 (17.0)
	40–44	1312 (13.0)	1134 (11.8)	1192 (11.1)	1241 (11.8)
	45–49	1185 (11.7)	1097 (11.4)	1147 (10.7)	967 (9.2)
Religion	Orthodox	5176 (51.3)	4559 (47.4)	4824 (45.0)	4322 (41.0)
	Muslim	2943 (29.2)	2995 (31.1)	3203 (29.9)	3585 (34.0)
	Protestant	1508 (14.9)	1738 (18.1)	2368 (22.1)	2378 (22.5)
	Others	463 (4.6)	336 (3.5)	323 (3.0)	265 (2.5)
Literacy	Illiterate	8190 (81.2)	7758 (80.6)	7914 (73.8)	7541 (71.5)
	Literate	1895 (18.8)	1871 (19.4)	2803 (26.2)	3009 (28.5)
Education level	No education	8385 (83.1)	7560 (78.5)	7198 (67.2)	6683 (63.3)
	Primary	1139 (11.3)	1461 (15.2)	2879 (26.9)	2911 (27.6)
	Secondary and above	566 (5.6)	607 (6.3)	641 (6.0)	957 (9.1)
Working status	Not working	3461 (34.3)	6377 (66.2)	4435 (41.4)	5234 (49.6)
	Working	6628 (65.7)	3252 (33.8)	6283 (58.6)	5316 (50.4)
Marital status	Single	1499 (14.9)	1367 (14.2)	2059 (19.2)	1332 (12.6)
	Married	8590 (85.1)	8262 (85.8)	8658 (80.8)	9218 (87.4)
Contraceptive knowledge	No	1355 (13.4)	1184 (12.3)	250 (2.3)	141 (1.3)
	Yes	8735 (86.6)	8445 (87.7)	10468(97.7)	10409(98.7)
Contraceptive use intention	Using modern method	618 (6.1)	1241 (12.9)	2716 (25.4)	3244 (32.5)
	Using traditional method	154 (1.5)	66.4 (0.69)	109 (1.0)	60 (0.57)
	Non-user and intend to use	4137 (41)	4099 (42.6)	4140 (38.6)	3198 (30.3)
	Does not intend to use	5181 (51.4)	4222 (43.9)	3751 (35.0)	3869 (36.7)
Knowledge of ovulatory cycle	No	8810 (87.3)	8613 (89.5)	9037 (84.3)	8112 (76.9)
	Yes	1278 (12.7)	1015 (10.5)	1681 (15.7)	2439 (23.1)
Age at 1st intercourse	< = 15	2388 (23.7)	2766 (28.7)	1174 (10.9)	4775 (45.3)
	>15	7698 (76.3)	6863 (71.3)	9544 (89.1)	5776 (54.7)
Age at 1st cohabitation	<18	7426 (74.1)	6852 (71.7)	7187 (67.7)	6752 (64.6)
	≥ 18	2600 (25.9)	2709 (28.3)	3431 (32.3)	3699 (35.4)
Parity	Nulliparous	221 (2.2)	176 (1.8)	181 (1.7)	223 (2.1)
	Primiparous	1348 (13.4)	1297 (13.5)	1624 (15.2)	1699 (16.1)
	Multiparous	3831 (38.0)	3736 (38.8)	4407 (41.1)	4292 (40.7)
	Grand multiparous	4689 (46.5)	4420 (45.9)	4506 (42.0)	4336 (41.1)
Wealth index	Poor	2913 (50.4)	3897 (40.5)	4377 (40.8)	4179 (39.6)
	Middle	1140 (19.7)	1936 (20.1)	2091 (19.5)	2110 (20.0)
	Rich	1722 (29.8)	3796 (39.4)	4249 (39.6)	4261 (40.4)
Media exposure	No	7928 (78.6)	6275 (65.2)	6004 (56.0)	6784 (64.3)
	Yes	2161 (21.4)	3354 (34.8)	4714 (43.9)	3766 (35.7)
Sex of household head	Male	8205 (81.3)	7949 (82.6)	8529 (79.6)	8474 (80.3)
	Female	1885 (18.7)	1680 (17.5)	2188 (20.4)	2076 (19.7)
Residence	Urban	1426 (14.1)	1191 (12.4)	2047 (19.1)	1792 (17.0)
	Rural	8663 (85.9)	8438 (87.6)	8671 (80.9)	8758 (83.0)
Region	Tigray	664 (6.6)	635 (6.6)	717 (6.7)	760 (7.2)
	Afar	122 (1.2)	104 (1.1)	102 (0.96)	92 (0.87)
	Amhara	2768 (27.4)	2510 (26.1)	2827 (26.4)	2404 (22.8)
	Oromia	3771 (37.4)	3459 (35.9)	4046 (37.8)	4140 (39.2)
	Somali	121 (1.2)	382 (3.9)	238 (2.2)	334 (3.2)
	Benishangul	108 (1.07)	95 (0.98)	123 (1.2)	114 (1.2)
	SNNPR	2149 (21.3)	2050 (21.3)	2148 (20.0)	2208 (20.9)
	Gambella	28 (0.28)	33 (0.35)	43 (0.4)	31 (0.29)
	Harari	25 (0.24)	23 (0.23)	30 (0.28)	26 (0.25)
	Addis Ababa	291 (2.89)	296 (3.1)	403 (3.8)	388 (3.7)
	Dire Dawa	42 (0.42)	41 (0.43)	41 (0.38)	53 (0.51)

Table 2
Trends in pregnancy termination among women of reproductive age by characteristics in 2000, 2005, 2011, and 2016 EDHS.

Variables	Prevalence of pregnancy termination				Point difference in prevalence of pregnancy termination			
	EDHS							
	2000	2005	2011	2016	Phase1 (2005–2000)	Phase2 (2011–2005)	Phase3 (2016–2011)	Phase4 (2016–2000)
Overall	17.7	9.5	11.9	10.7	−8.2	2.4	−1.2	−7
Age								
15–19	8.1	2.7	5.1	3.6	−5.4	2.4	−1.5	−4.5
20–24	10.6	6.4	6.0	6.1	−4.2	0.4	0.1	−4.5
25–29	12.4	7.0	10.7	7.9	−5.4	3.7	−2.8	−4.5
30–34	16.7	10.3	10.5	10.8	−6.4	0.2	0.3	−5.9
35–39	20.8	10.4	13.8	12.7	−10.4	3.4	−1.1	−8.1
40–44	26.3	14.5	17.3	16.0	−11.8	2.8	−1.3	−10.3
45–49	29.3	13.9	19.5	17.6	−15.4	5.6	−1.9	−11.7
Religion								
Orthodox	15.5	10.4	10.8	12.2	−5.1	0.4	1.4	−3.3
Muslim	21.3	8.8	13.8	10.0	−12.5	5	−3.8	−11.3
Protestant	18.1	8.1	11.7	9.7	−10	3.6	−2	−8.4
Others	18.5	10.5	12.6	5.8	−8	2.1	−6.8	−12.7
Literacy								
Illiterate	18.5	9.2	12.5	10.4	−9.3	3.3	−2.1	−8.1
Literate	14.2	10.5	10.2	11.5	−3.7	−0.3	1.3	−2.7
Education level								
No education	18.4	9.6	13.0	10.8	−8.8	3.4	−2.2	−7.6
Primary	15.1	8.5	9.2	10.9	−6.6	0.7	1.7	−4.2
Secondary and above	12.4	10.9	11.6	9.3	−1.5	0.7	−2.3	−3.1
Working status								
Not working	17.3	9.1	10.5	9.2	−8.2	1.4	−1.3	−8.1
Working	17.9	10.2	12.9	12.2	−7.7	2.7	−0.7	−5.7
Marital status								
Single	16.6	8.1	9.5	9.7	−8.5	1.4	0.2	−6.9
Married	17.9	9.7	12.5	10.9	−8.2	2.8	−1.6	−7
Contraceptive knowledge								
No	16.0	5.5	11.3	4.3	−10.8	5.8	−7	−11.7
Yes	17.9	10.0	11.9	10.8	−7.9	1.9	−1.1	−7.1
Contraceptive use intention								
Using modern method	16.3	11.5	8.5	8.8	−4.8	−3	0.3	−7.5
Using traditional method	16.1	13.8	8.8	19.0	−2.3	−5	10.2	2.9
Non-user and intend to use	15.5	9.2	11.9	9.9	−6.3	2.7	−2	−5.6
Does not intend to use	19.7	9.1	14.4	12.9	−10.6	5.3	−1.5	−6.8
Knowledge of ovulatory cycle								
No	17.1	9.4	11.8	10.8	−7.7	2.4	−1	−6.3
Yes	21.7	10.1	12.3	10.6	−11.6	2.2	−1.7	−11.1
Age at 1st intercourse								
< = 15	17.3	10.8	12.1	12.1	−6.5	1.3	0	−5.2
>15	17.9	8.9	11.9	9.6	−9	3	−2.3	−8.3
Age at 1st cohabitation								
<18	18.8	9.9	12.4	10.7	−8.9	2.5	−1.7	−8.1
≥ 18	15.1	8.5	11.0	10.9	−6.6	2.5	−0.1	−4.2
Parity								
Nulliparous	13.2	5.6	8.3	6.1	−7.6	2.7	−2.2	−7.1
Primiparous	11.9	7.7	8.4	8.0	−4.2	0.7	−0.4	−3.9
Multiparous	13.4	7.7	10.4	9.9	−5.7	2.7	−0.5	−3.5
Grand multiparous	23.1	11.6	14.9	12.8	−11.5	3.3	−2.1	−10.3
Wealth index								
Poor	18.3	9.0	12.1	10.3	−9.3	3.1	−1.8	−8
Middle	17.7	8.6	12.9	10.8	−9.1	4.3	−2.1	−6.9
Rich	16.9	10.4	11.3	11.1	−6.5	0.9	−0.2	−5.8
Media exposure								
No	17.6	9.1	12.1	10.2	−8.5	3	−1.9	−7.4
Yes	18.3	10.2	11.6	11.7	−8.1	1.4	0.1	−6.6
Sex of household head								
Male	17.7	9.4	11.9	10.6	−8.3	2.5	−1.3	−7.1
Female	17.7	10.0	12.0	11.4	−7.7	2	−0.6	−6.3
Residence								
Urban	16.8	12.3	10.2	11.3	−4.5	−2.1	1.1	−5.5
Rural	17.9	9.1	12.3	10.6	−8.8	3.2	−1.7	−7.3

(2000–2016), we employed multivariate decomposition analysis. Multivariate decomposition for nonlinear response models (MVDCMP) uses a logit-based approach to analyze and decompose nonlinear response models. Given the binary nature of the outcome, the analysis uses the results from a logistic regression model to break down the observed variation in pregnancy termination over time across the surveys into distinct components. The variations in pregnancy termination rates between the surveys can be a result of differences in endowments or characteristics (labeled E) and differences in coefficients or effects (labeled C). To conduct the decomposition analysis of pregnancy termination, the "mvdcmp" Stata command was used [40]. Variables with a p-value <0.2 in the bi-variable multivariate decomposition analysis were added to the multivariable multivariate decomposition analysis. Variables with a p-value <0.05 in the multivariable multivariate decomposition analysis were considered significant factors for the decline in pregnancy termination over time.

2.6. Spatial analysis

The spatial analysis was conducted using ArcGIS version 10.7 and SaTScan version 9.6 software. Spatial autocorrelation was conducted to test for the existence of an identifiable spatial pattern using the global Moran's index statistics. It was used to measure whether patterns of pregnancy termination among women of reproductive age in Ethiopia were randomly distributed, dispersed, or clustered with Moran's I values close to 0, -1, and 1, respectively. When the Moran's I value is statistically significant (p-value <0.05), the null hypothesis (random distribution of pregnancy termination) is rejected , indicating the occurrence of spatial autocorrelation [41–43].

2.6.1. Hot spot analysis

Hotspot analysis was conducted, and Getis-Ord Gi* was calculated to determine the presence of significantly higher or lower concentrations. It creates an output feature class with a z-score, p-value, and confidence level bin field (Gi_Bin). The Gi_Bin field identifies statistically significant hot- and cold-spot areas of pregnancy termination with 99 %, 95 %, and 90 % confidence levels. For a feature to be a statistically significant hotspot, it must have a high value surrounded by other features with high values. Similarly, for a feature to be a statistically significant cold spot, it must have a low value surrounded by other features with low values [44,45].

2.6.2. Spatial interpolation

The spatial interpolation method was used to forecast pregnancy termination among women aged 15–49 years in the unsampled areas of Ethiopia based on the sampled EAs. We applied ordinary Kriging spatial interpolation, as it includes spatial autocorrelation and statistically optimizes the weights. Additionally, it also yields the lowest mean square error and highest R2 value [46].

2.6.3. Spatial scan analysis

We employed spatial scan statistics to identify statistically significant spatial clusters with high and low prevalences of pregnancy termination in Ethiopia. It uses a circular scanning window that moves across the study area. Considering the binary nature of the outcome variable (yes or no), the Bernoulli-based model was employed using Kuldorff's SaTScan version 9.6 software. The presence of pregnancy termination was taken as a case, and its absence was considered a control. The data files for the cases, controls, and

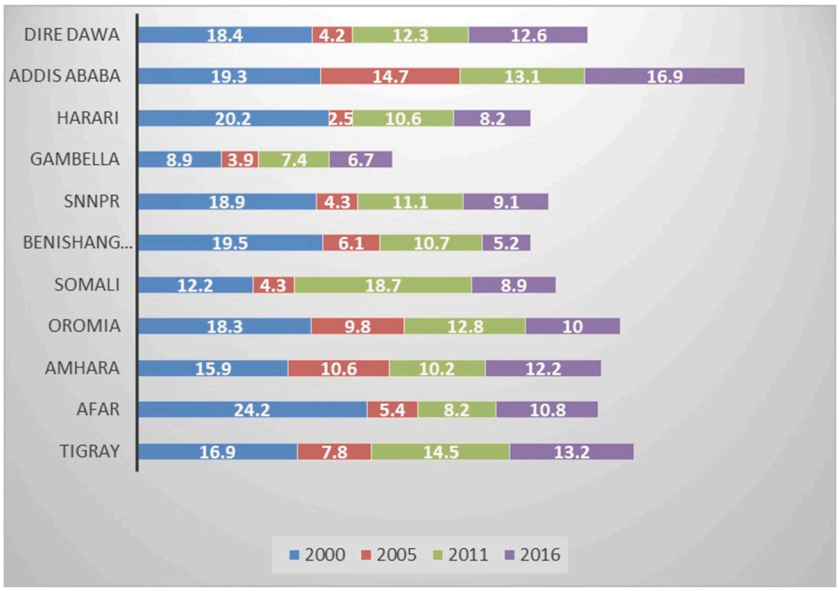

Fig. 1. Trends in pregnancy termination among women of reproductive age across regions in Ethiopia, 2000–2016.

coordinates were imported into the software to determine the locations of significant clusters. To avoid missing very small and very large-sized clusters, a default maximum spatial cluster size of <50 % of the population was used. The most likely or primary clusters were identified using p-values and likelihood ratio tests. The cluster with the largest likelihood ratio contains the primary cluster [47].

3. Results

3.1. Characteristics of the study population

In this analysis, we included weighted data on 40,983 women of reproductive age from the first four consecutive surveys. The majority of the participants (>80 %) in all four surveys were rural residents. Among the 11 regions of Ethiopia, the largest and smallest number of respondents were from the Oromia and Harari regional states, respectively across all surveys. The mean age of the reproductive age women was 32.3 (SD = 8.6) years in 2000, 31.7 SD = 8.6) years in 2005, 31.6 (SD = 8.2) years in 2011, and 31.8 (SD = 8.1) years in 2016. Literacy increased from 18.8 % in 2000 to 28.5 % in 2016. The percentage of married women increased from 85.1 % in 2000 to 87.4 % in 2016. Regarding contraceptive-related knowledge, the percentage of women with knowledge about contraceptives rose from 86.6 % in 2000 to 98.7 % in the 2016 survey year (Table 1).

3.2. The trend of pregnancy termination in Ethiopia

The trend of pregnancy termination among women of reproductive age decreased from 17.7 % (95 % CI: 16.9, 18.5) in the 2000 EDHS to 10.7 % (95 % CI: 10.1, 11.3) in the 2016 EDHS, indicating a decline in the prevalence of pregnancy termination over time. The percentage of pregnancy termination decreased by 5.5 and 7.3 points among urban and rural residents from 2000 to 2016, respectively. In terms of literacy, there was a decline in pregnancy termination among both illiterates (8.1 point percentage) and literates (2.7 point percentage) in phase 4 (Table 2). The greatest decline in pregnancy termination over the 16 years was observed in the Benishangul, Afar, and Harari regions, with a percentage point decrease of 14.3, 13.4, and 12.0, respectively (Fig. 1).

3.3. Decomposition analysis

The decomposition analysis revealed that 103 % of the overall decrement in pregnancy termination among women of reproductive age was a result of the difference in the 'C' coefficient (effect of characteristics) between the surveys. However, the overall decrease in pregnancy termination due to the difference in 'E' endowment (difference in the composition of the women) was not significant (Table 3).

In the detailed decomposition analysis, the variables that contributed significantly to the decrease in pregnancy termination from 2000 to 2016 attributed to the difference in coefficients were: literacy, working status, marital status, age at first intercourse, age at first cohabitation, knowledge about contraceptives, and knowledge of ovulatory cycle. About 40 %, 36 %, 84 %, 31 %, and 167 % of the decrease in pregnancy termination over 16 years was a result of the difference in effects of being literate (β = −0.02, 95 % CI: 0.04, −0.004), working (β = −0.02, 95 % CI: 0.04, −0.005), married (β = −0.05, 95 % CI: 0.09, −0.008), age at first marriage ≥18 (β = −0.02, 95 % CI: 0.03, −0.002), and knowing any method of contraceptives (β = −0.09, 95 % CI: 0.17, −0.02), respectively. Women with age at first intercourse >15 (β = 0.04, 95 % CI: 0.014, 0.05) and women who know their ovulatory cycle (β = 0.01, 95 % CI: 0.003, 0.02) contributed significantly to the increment of pregnancy termination by 58 % and 23 %, respectively (Table 4).

3.4. Spatial analysis

3.4.1. Spatial variation of pregnancy termination in Ethiopia

A significant spatial variation in pregnancy termination was observed across the nation in all four survey years with positive and significant global Moran's Index values (0.14 in 2000, 0.08 in 2005, 0.05 in 2011, and 0.11 in 2016). This shows that pregnancy termination among reproductive age women was clustered (Fig. 2).

3.4.2. Hotspots of pregnancy termination in Ethiopia

In the 2000 EDHS, hotspots of pregnancy termination were identified in Southeast Amhara, southern Afar, Northeast Oromia, and northern SNNPR (Fig. 3A). In the 2005 EDHS, the hotspot areas were concentrated in the central parts of Ethiopia (Addis Ababa, central Oromia, parts of northern SNNPR, and southern Amhara). In the 2011 EDHS, the hotspot areas of pregnancy termination shifted to the Tigray region, some parts of central Oromia, Addis Ababa, and the southern Somali region. In the 2016 EDHS, the Tigray,

Table 3
Decomposition analysis of the decline in pregnancy termination among women of reproductive age in Ethiopia, 2000–2016.

Pregnancy termination	Coefficient	95 % confidence interval	Percentage
E	−0.00159	(-0.01979, 0.01661)	−2.77
C	0.05914	(0.03540, 0.08287)	102.77
R	0.05754	(0.04209, 0.07300)	

C: Coefficient, E: Endowment, R: Residual.

Table 4
Decomposition analysis of the decline in pregnancy termination rates among women of reproductive age in Ethiopia, 2000 to 2016.

Variables	Difference due to Endowment (E)		Difference due to coefficient (C)	
	Coefficient	Pct	Coefficient	Pct
Literacy				
Illiterate	0		0	
Literate	−0.00046(-0.0066, 0.0057)	−0.80	−0.0228(-0.042, −0.00398)[a]	−39.6
Education level				
No education	0		0	
Primary	−0.00025(-0.0034, 0.0029)	−0.44	0.00224(-0.0163, 0.02077)	3.89
Secondary and above	−0.00022(-0.0030, 0.0026)	−0.37	0.00165(-0.0064, 0.00973)	2.86
Age at first birth	0.00007(-0.00086, 0.0010)	0.12	−0.0606(-0.1609, 0.03964)	−105
Working status				
Not working	0		0	
Working	0.00001(-0.00054,0.00055)	0.01	−0.0209(-0.0373, −0.0045)[a]	−36.3
Marital status				
Single	0		0	
Married	−0.00018(-0.0026, 0.0022)	−0.32	−0.04822(-0.088, −0.0081)[a]	−83.8
Contraceptive knowledge				
No	0		0	
Yes	0.00043(-0.0053, 0.00614)	0.74	−0.097(-0.1696, −0.0244)**	−168
Contraceptive use intention				
Using modern method	0		0	
Using traditional method	−0.00007(-0.0010, 0.00086)	−0.13	−0.00031(-0.0011, 0.00046)	−0.54
Non-user and intend to use	−0.00026(-0.0032, 0.00264)	−0.45	−0.00178(-0.0194, 0.0158)	−3.1
Does not intend to use	−0.00109(-0.0144, 0.01223)	−1.89	−0.0076(-0.0296, 0.01442)	−13.2
Knowledge of ovulatory cycle				
No	0		0	
Yes	0.00084(-0.01022, 0.0119)	1.47	0.01304(0.00294, 0.0231)[a]	22.6
Age at 1st intercourse				
< = 15	0		0	
>15	−0.00052(-0.0071, 0.0060)	−0.90	0.0334(0.01407, 0.0527)**	58.0
Age at 1st cohabitation				
<18	0		0	
≥ 18	−0.00077(-0.0107, 0.00919)	−1.35	−0.01783(-0.034, −0.0019)[a]	−31.0
Wealth index				
Poor	0		0	
Middle	−0.00001(-0.00013, 0.0001)	−0.02	−0.0038(-0.0124, 0.0048)	−6.55
Rich	−0.00003(-0.00068, 0.0006)	−0.05	−0.00047(-0.0192, 0.0183)	−0.81
Residence				
Urban	0		0	
Rural	0.0000(-0.00003, 0.00004)	0.00	0.0199(-0.02749, 0.06724)	34.5

[a] P-value <0.05, ** P-value <0.01, Pct = Percentage.

Addis Ababa, and central Oromia region continued to be hotspot areas (Fig. 3).

3.4.3. Spatial interpolation of pregnancy termination in Ethiopia

By employing the ordinary kriging interpolation, the geographical variations in pregnancy termination in Ethiopia were predicted in areas without observations based on the observed data. The green color showed the predicted areas with a lower proportion of pregnancy termination while the red color showed predicted areas with a higher proportion of pregnancy termination. The white spaces were areas from which data were not collected. According to the sampled data from the 2000 EDHS, kriging interpolation predicts that the highest prevalence of pregnancy termination was identified in western Tigray, eastern Benishangul, central and southern Afar; eastern, central western, and a part of southern Oromia and eastern part of the SNNPR. Based on the 2005 EDHS, the highest pregnancy termination prevalence was detected in central and southern Amhara, Addis Ababa, central and eastern Oromia, and parts of the northern SNNPR. In the EDHS 2011, the highest pregnancy termination was predicted in the northern and central parts of Somali and central Tigray. As per the 2016 EDHS northern Tigray, Addis Ababa and some parts of central Oromia contained the predicted highest proportion of pregnancy termination (Fig. 4).

3.4.4. Sat scan analysis

In the sat scan analysis, the most probable primary and secondary clusters of pregnancy termination among women of reproductive age were detected in the EDHS from 2000 to 2016. The primary cluster's spatial window in the 2000 EDHS was located in the southern part of Afar and some parts of the eastern Amhara region, with a relative risk (RR) of 2.12, a log-likelihood ratio (LLR) of 13.1, and a p-value <0.001. The results revealed that reproductive age women in this spatial window had a 2.12 times higher risk of experiencing pregnancy termination than women outside the window. The primary cluster's spatial window in the 2005 EDHS was located in Addis Ababa and the central and western parts of the Oromia region, with a RR of 1.39, LLR of 9.06, and p-value of 0.026. This implies that women aged 15–49 in this spatial window were 1.39 times more likely to experience pregnancy termination compared to those outside

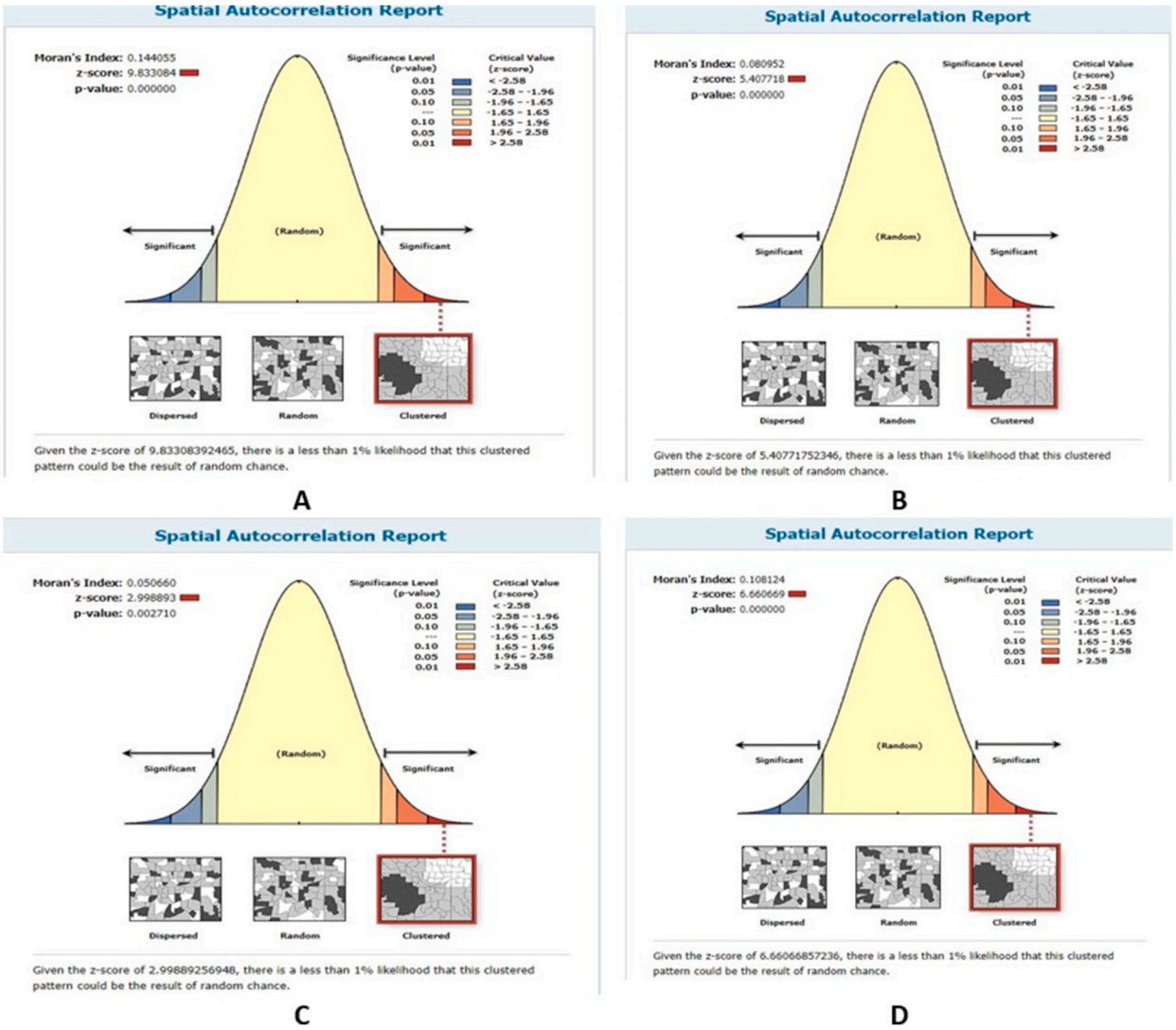

Fig. 2. Global spatial autocorrelation of pregnancy termination among women of reproductive age in Ethiopia; 2000 (**A**), 2005 (**B**), 2011 (**C**), and 2016 (**D**).

the window. In the 2011 EDHS, the spatial window of the primary cluster had a RR of 4.05, LLR of 8.65, and p-value of 0.063. This clustering is more likely to be formed by chance, as the insignificant p-value failed to rule out that the cluster was formed by chance. Based on the 2016 EDHS, the primary or most likely cluster was found in the Tigray, Afar, Amhara, central and northern Oromia, and northern Somali regions, with a RR of 1.33, LLR of 12.5, and a p-value of 0.002. This shows that women within this spatial window had a 1.33 times greater likelihood of experiencing pregnancy termination compared to those outside this window. (Fig. 5) (Supplementary Table 1).

4. Discussion

Pregnancy termination has been recognized as a serious public health problem for more than 50 years by the WHO [48]. Despite the decrease in abortion-related maternal mortality in Ethiopia, it is still a major public health problem in the country [49,50]. This study determined the trend, spatial distribution, and factors responsible for the change in pregnancy termination in Ethiopia over the past 16 years.

Between 2000 and 2016, pregnancy termination among women of reproductive age in Ethiopia declined by 39.5 %. A possible explanation might be due to improved access to contraceptives specifically uptake of modern contraceptive methods [51], a decrease in unintended pregnancy [52], increased healthcare services that are attributable to improved healthcare coverage, and decreased healthcare access challenges [53,54], and government initiatives by improving access to reproductive health services including family planning [55]. Additionally, since antenatal care (ANC) services have a crucial role in reducing adverse pregnancy outcomes including

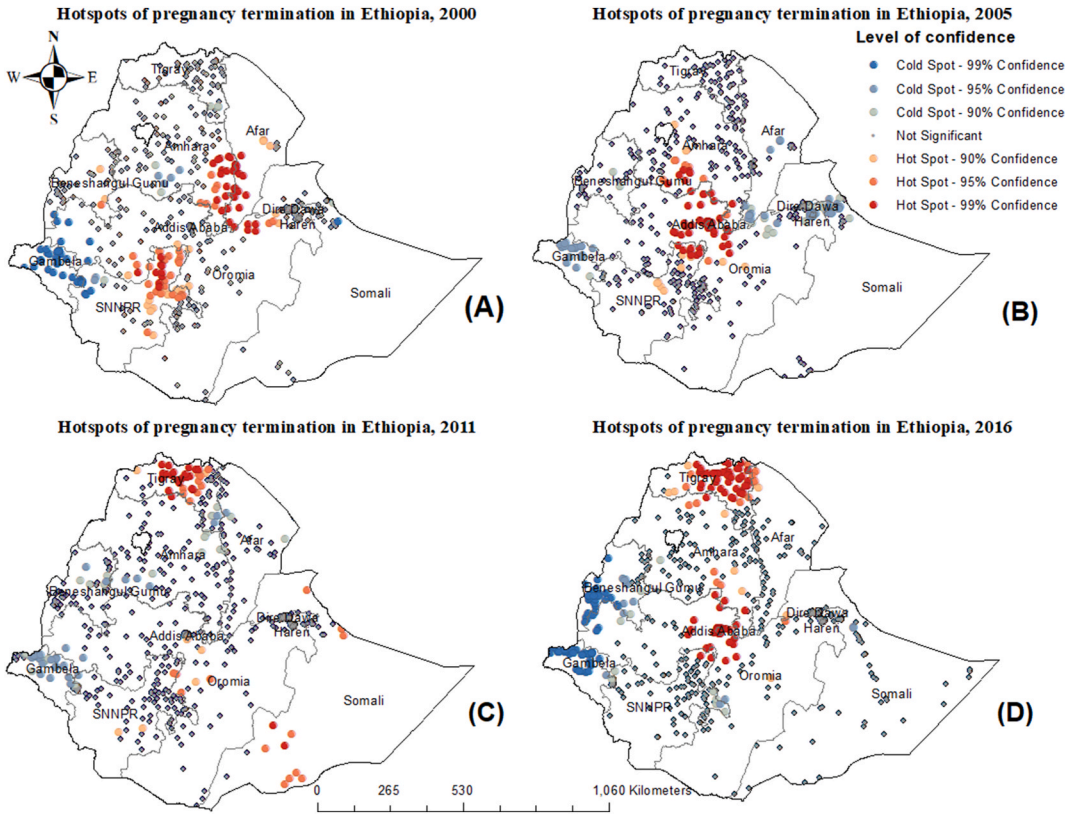

Fig. 3. Hotspots of pregnancy termination among women of reproductive age in Ethiopia using Getis-Ord Gi statistics; 2000 (**A**), 2005 (**B**), 2011 (**C**), and 2016 (**D**).

miscarriage and stillbirth, several steps have been taken to expand ANC, such as: setting a national target, introducing a health extension program, providing free ANC services and implementing a health sector development program [56].

The decomposition analysis showed that changes in coefficients contributed more than changes in endowments to the decline of pregnancy termination and explained approximately 103 % of the reduction in pregnancy termination over 16 years (2000–2016). The variables that significantly contributed to the change were: literacy, working status, marital status, age at first intercourse, age at first cohabitation, knowledge about contraceptives, and knowledge of the ovulatory cycle.

Being literate contributes to the decrease in pregnancy termination. This may be because literacy is associated with improved access to information, particularly regarding sexual and reproductive health. It also enhances the understanding of available contraceptive methods and enables individuals to make informed decisions about family planning and reproductive health overall [57]. Being a working woman also resulted in a decline in pregnancy termination. The possible justification might be that working women have better economic stability and can support their children financially additionally they have better access to reproductive health services and contraception [58]. Being a married woman had an impact on the decline of pregnancy termination. This could be due to most of the pregnancies being wanted, having better access to contraceptives, and having adequate social, familial, and financial support to provide for their children [59].

Although early sexual initiation has been found to be a significant predictor of induced abortion by different studies [60,61], this study revealed that women aged >15 at first intercourse contribute to the increment in pregnancy termination compared to those who initiate their first intercourse before the age of 15. This is because most sexual activities and pregnancies occur after the age of 15, and early-aged teenagers may not be aware of contraceptive preferences or even abortion. Age of marriage ≥18 years contributed to the decline in pregnancy termination. The possible reason is that women who are engaged in marriage at a younger age (<18) may achieve their desired number of children sooner, which could increase the chance of unintended pregnancy which might end up in induced abortion compared to those who marry after 18 years of age [62,63].

Women who know about any contraceptive methods contribute to the decline in pregnancy termination. This is because knowledge of family planning is the first step in adopting contraceptive methods, and similarly, a lack of awareness and poor knowledge of contraceptives are common among women seeking abortion [64,65]. Knowledge of ovulatory cycles, which form the foundation of natural family planning techniques, is usually used to delay pregnancy. Studies show that a lack of accurate knowledge about it leads to unintended pregnancies followed by abortion [66]. However, in our study, women who have knowledge about their fertility period during the ovulatory cycle were found to have an effect on the increment of pregnancy termination. This can be explained by the fact that women might have a chance of miscalculating their fertility period and fail to use contraception by relying on this natural method.

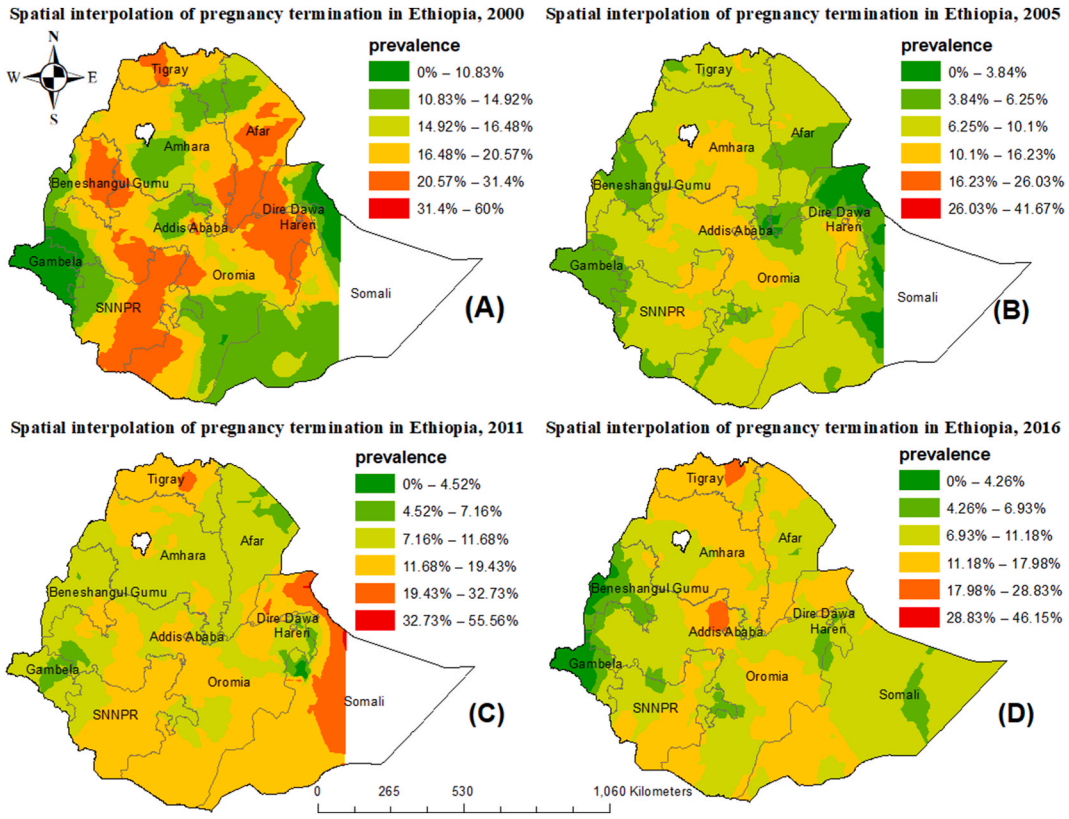

Fig. 4. Spatial interpolation of pregnancy termination among women of reproductive age in Ethiopia using Kriging interpolation; 2000 (**A**), 2005 (**B**), 2011 (**C**), and 2016 (**D**).

This paves the way for unintended pregnancies to occur, some of which may result in abortion. This implies that comprehensive sex education, specifically focusing on fertility and contraception, is crucial.

The spatial analysis showed that pregnancy termination among women of reproductive age exhibited significant spatial variation in Ethiopia over time. The Moran's I statistics confirmed this by showing the presence of spatial heterogeneity in pregnancy termination across the country. This is supported by previously conducted spatial analysis in Ethiopia [15]. This spatial variation might be attributable to access to reproductive health services, including healthcare infrastructures, which might vary across different regions of the country, socioeconomic factors, and knowledge about contraceptives [15,67].

The hotspot analysis results indicated that the hotspots of pregnancy termination were located in central (including the capital) and northern Ethiopia. This is because in urban areas, particularly in Addis Ababa, there are many private and governmental healthcare providers which give abortion services, since the legalization of abortion in the country in 2005, which drew women from surrounding areas or elsewhere to obtain abortion services [68,69]. In the Tigray region, where significant hotspots of pregnancy termination are spotted, women have a better level of knowledge about availability and where to access facility-based abortion services [70]. Additionally, the region is one of the few administrative regions that has achieved the recommended level of comprehensive abortion care services [27]. The spatial scan statistical analysis was utilized to pinpoint the most likely clusters, which is important to prioritize those areas for an intervention. Therefore, in the spatial scan analysis, the central northern and Northeastern parts of the country were identified as primary clusters (Fig. 5).

4.1. Strength and limitations

This study utilized four extensive nationally representative datasets, providing robust statistical power and enabling the generalization of the findings to women of reproductive age in Ethiopia. To make the data more representative, each dataset was weighted before the estimates were performed. Multivariate decomposition analysis was conducted to identify variables that contribute to the decrease in pregnancy termination among women of reproductive age over time. Lastly, a spatial analysis was applied to take into account the spatial variations in pregnancy termination. However, the study was not free of limitations. Similar to other cross-sectional studies, the ability to establish a cause-and-effect relationship between the dependent and independent variables was not possible. Our variable of interest, pregnancy termination, consisted of spontaneous abortion, induced abortion, and stillbirth. As the dependent variable 'pregnancy termination' was collected based on the respondent's self-reports, social desirability bias is possible and could lead to underreporting.

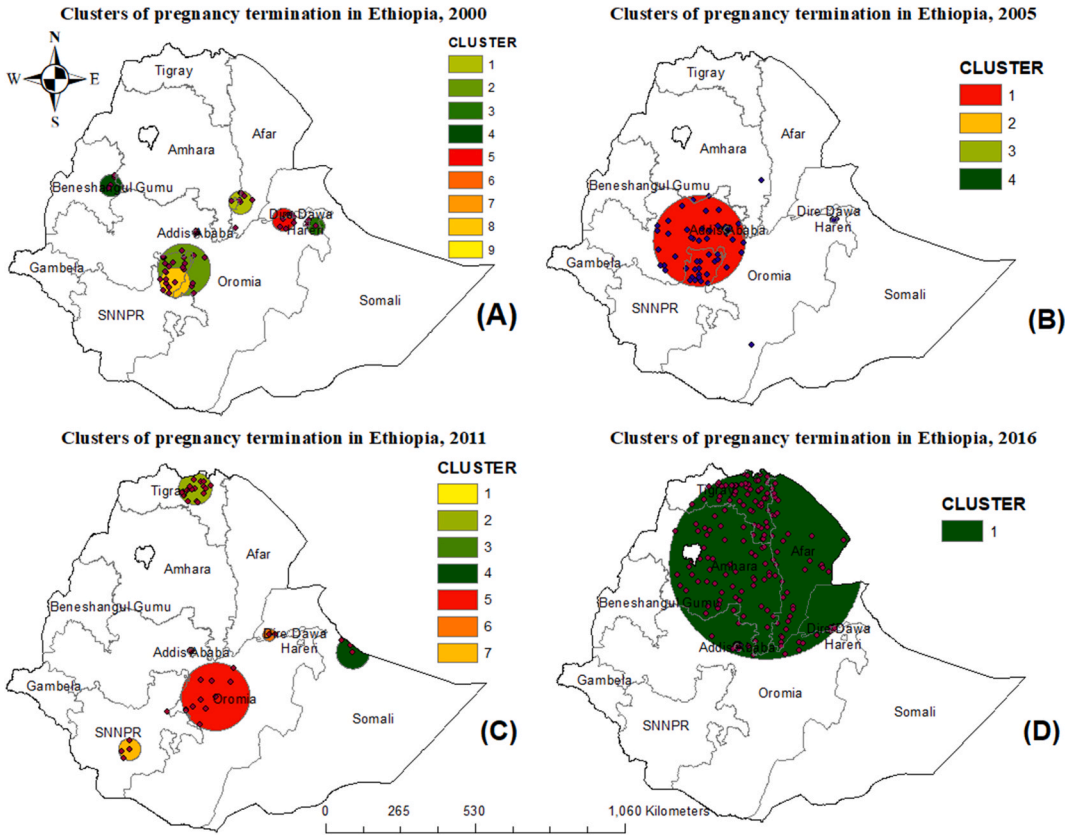

Fig. 5. Clusters of pregnancy termination among women of reproductive age in Ethiopia using SaTScan analysis; 2000 (**A**), 2005 (**B**), 2011 (**C**), and 2016 (**D**).

5. Conclusions

Pregnancy termination among women of reproductive age has declined over 16 years. Approximately 103 % of this reduction can be attributed to differences in the impact of certain characteristics between 2000 and 2016, as found in the Ethiopian Demographic and Health Surveys (EDHS). The decrease in pregnancy termination can be largely attributed to variations in the effects of factors such as literacy, working status, marital status, age at first intercourse, age at first cohabitation, knowledge about contraceptives, and knowledge of the ovulatory cycle. These findings have significant policy implications for the development and implementation of interventions and programs. The government should prioritize initiatives that promote education for girls and women, provide reproductive health education including access to contraceptives, and establish policies that increase the minimum age for girls to engage in sexual activities or marriage.

The surveys (2000-2016) conducted in Ethiopia consistently revealed that the spatial distribution of pregnancy termination was clustered. The primary clusters were identified in the central, northern, and northeastern parts of the country. To achieve the sustainable development goal of reducing abortion-related maternal mortality, the Ministry of Health and regional health bureaus should pay appropriate attention to these identified hotspot areas.

Availability of data and materials

The data are available from http://www.dhsprogram.com.

Ethical approval and consent to participate

This research was a secondary data analysis of a survey data from MEASURE DHS program that was publicly available (EDHS 2000, 2005, 2011 and 2016), therefore it did not require ethical approval and participant consent. We obtained permission from the DHS program and accessed the data for our study from their website http://www.dhsprogram.com.

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CRediT authorship contribution statement

Tsion Mulat Tebeje: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Formal analysis, Conceptualization. **Beminate Lemma Seifu:** Writing – review & editing, Visualization, Validation, Formal analysis. **Binyam Tariku Seboka:** Writing – review & editing, Visualization, Validation, Software, Formal analysis. **Kusse Urmale Mare:** Writing – review & editing, Visualization, Validation, Formal analysis. **Yazachew Moges Chekol:** Writing – review & editing, Visualization, Validation, Formal analysis. **Tigabu Kidie Tesfie:** Writing – review & editing, Visualization, Validation, Formal analysis. **Negalgn Byadgie Gelaw:** Writing – review & editing, Visualization, Validation, Formal analysis. **Mesfin Abebe:** Writing – review & editing, Visualization, Validation, Methodology, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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List of abbreviations

CI	Confidence Interval
EA	Enumeration Area
EDHS	Ethiopian Demographic and Health Survey
IR	Individual Record
LB	Live Births
LLR	Log-Likelihood Ratio
MMR	Maternal Mortality Ratio
PCA	Principal Component analysis
RR	Relative Risk
SSA	Sub-Saharan Africa
SDG	Sustainable Development Goals
SNNPR	Southern Nations, Nationalities and Peoples Region
WHO	World Health Organization

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e34633.

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