Geographically vary determinants of High-Risk Fertility Behavior among Reproductive age women in Ethiopia. Geographically Weighted Regression Analysis

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Zemenu Tessema Tadesse
University of Gondar
zemenu1979@gmail.com Corresponding Author
ORCiD: https://orcid.org/0000-0003-3878-7956

Melkalem Mamuye Azanaw
Debre Tabor University

Yeaynmarsh Asmare
University of Gondar

Kassahun Alemu Gelaye
University of Gondar

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Abstract

Background

Maternal and child mortality is the main public health problem worldwide and it is the major health concern in developing countries such as Africa and Asia. Fertility behavior of women characterized in relation to maternal age, birth spacing, and order which has an impact on the health of women and children. The aim of this study was to assess the geographically vary Risk factors of High-Risk Fertility Behavior(HRFB) among reproductive-age women in Ethiopia.

Methods

A total of 11,022 reproductive-age women were included in this study. The data was cleaned and weighted by STATA 14.1 software. Bernoulli based spatial scan statistics were used to identify the presence of purely spatial clusters HRFB using Kulldorff’s SaTScan version 9.6 software. ArcGIS 10.7 was used to visualize spatial distribution for HRFB. Geographical weighted regression analysis was employed by Multiscale Geographical weighted regression version 2.0 software. A P-value of less than 0.05 was used to declare statistically significant predictors locally.

Results

Overall, 76% with 95% confidence interval of 75.60 to 77.20 of reproductive age women were faced with High-Risk Fertility problems in Ethiopia. High-Risk Fertility Behavior was highly clustered at the Somali, and Afar regions of Ethiopia. SaTScan identified 385 primary spatial clusters (RR= 1.13, P < 0.001) located at Somali, Afar, and some parts of Oromia Regional State of Ethiopia. Women live in primary clusters were 13% more likely venerable HRFB than outside the cluster. In geographically weighted regression not contraceptive use, and home delivery were statistically significant spatially vary risk factors affecting HRFB.

Conclusion

In Ethiopia, HRFB had to vary geographically across regions. Statistically, a significant-high hot spot of HRFB was identified at Somali and Afar. This study showed that predictor variables for HRFB were varied spatially in Ethiopia. Not use a contraceptive, and home delivery were statistically significant predictors locally in different regions of Ethiopia. Therefore, policymakers and health planners should
design an effective intervention program at Somali, and Afar to reduce HRFB and Special attention needs about health education on the advantage of contraceptive utilization and health facility delivery to reduce HRFB.

**Background**

Maternal and child mortality is the main public health problem worldwide and it is the major health concern in developing countries such as Africa and Asia(1). Globally, 830 women die from preventable causes related to pregnancy and childbirth, of which 99% of all deaths occur in developing countries(2). Ethiopia one of the countries with the highest maternal mortality ratio with 412 deaths per 100,000 live births according to 2016 EDHS reports, of which most of the deaths were attributed to high-risk fertility behavior(3). The maternal mortality issue is under a sustainable development goal (SDG) targeted to reduce below 70 deaths per 100,000 live births at the end of 2030(4).

The global population is rapidly increasing and according to the 2016 report, the total fertility was 2.5 and 4.8 per woman globally and Ethiopia, respectively (5). Fertility behavior of women characterized evidence maternal age, birth spacing, and order which has an impact on the health of women and children (6,7). High-risk fertility behavior associated with numerous unfavorable child and maternal health outcomes such as chronic undernutrition, anemia, and child mortality(8–10). Different studies showed that high-risk fertility behaviors are associated with chronic undernutrition and anemia among under-five children. In addition, these behaviors are associated with adverse birth outcomes such as stillbirth, low birth weight and prematurity(9,11–13). As the birth interval got narrower (less than 24 months) the chance of child morality increased sharply compared to long spaced birth intervals (14). The risk of infant mortality from teenage mothers was increased by 30% compared to those women who gave birth between the age of 20 and 30 years. The problem is higher in developing countries where health care services are inaccessible, low socio-economic conditions and high unmet family planning needs (8,11–13,15,16). In addition, early age marriage is also another problem for high-risk fertility problems in Ethiopia and other low and middle-income countries (15). Different factors are associated with high-risk fertility behavior such as socio-demographic characteristics (residence, religion, level of education and marital status) and reproductive health
characteristics such as history of child death, facility delivery, and family panning utilizations are factors associated with high-risk fertility behavior (10-13, 15-18). Government and stakeholders made tremendous efforts such as increasing health services accessibility and coverage, providing maternal health services free of charge and postnatal care follow up for mothers for halting high-risk fertilities (19). Although, different studies conducted to assess the magnitude and effects of high-risk fertility behaviors No national studies have accounted for geographical variability risk factors of High-Risk Fertility Behavior.

To our knowledge, we provide this first geographically weighted analysis on high-risk fertility behavior and geographically vary risk factors among reproductive-age women in Ethiopia. This study could help health care planners and policymakers for evidence-based interventions and appropriate allocation of resources in hot spot areas.

Methods

Study design, area and period:

This study is a community-based cross-sectional study was conducted using a nationally representative Ethiopian Demographic and Health Survey (EDHS) dataset 2016. Ethiopia is situated in the Horn of Africa from 3° to 14° and 33° to 48°E.

Sources and study populations:

The source population was all reproductive age group, women, five years preceding the survey. A total of 15,683 women aged 15-49 years were interviewed and 11,023 women included in the analysis. In the 2016 EDHS, a total of 645 clusters (EAs) (202 urban and 443 rural) were selected with a probability proportional to each EAs size and independent selection in each sampling stratum (urban = 1,215 and rural = 9,807). Among a total selected clusters that coordinate data not obtained and missing data were excluded for the analysis. Finally, a total of (185 urban and 413 rural) clusters were used for this study. Among the selected clusters a total of 11,023 (urban = 1,215 and rural = 9,807) weighted women were included in this study. The recorded data were accessed at www.measuredhs.com on request with the help of ICF International, Inc.

Data collection tools and procedures:
Ethiopian Demographic and Health Survey data were collected by two-stage stratified sampling. Each region of the country was stratified into urban and rural areas, yielding 21 sampling strata. In the first stage, 645 EAs were selected with probability proportional to Enumeration Area size by independent selection in each sampling stratum. In the second stage of selection, a fixed number of 28 households per cluster were selected with an equal probability systematic sampling from the newly created household listing. The detail sampling procedure was available in the Ethiopian Demographic and Health Survey reports from Measure DHS website (www.dhsprogram.com).

Outcome Variable
For this study, we considered three parameters, maternal age at the time of delivery, birth order and birth interval, to define the high-risk fertility behaviors. Three exposure variables were defined for this analysis. Any high-risk fertility behavior versus non-risk coded as 1/0 respectively. The presence of any of the following four conditions was termed high-risk fertility behavior: (i) mothers aged less than 18 years at the time of delivery; (ii) mothers aged over 34 years at the time of delivery; (iii) latest child born less than 24 months after the previous birth; and (iv) latest child of order three or higher. We applied the definition of ‘high-risk fertility behaviors’ adopted by the 2016 EDHS(3). The dependent variable in this analysis was high-risk fertility behavior (proportion in the cluster).

Predictor variables:
From the 2016 EDHS datasets, independent variables such as proportion of rural, proportion of male sex, the proportion of religion, the proportion of education, the proportion of occupation, proportion of anemia, proportion of wealth index, proportion of ANC visit, proportion of home delivery, proportion of media exposure and proportion of wanted pregnancy.

Data management and analysis:
The data was cleaned by STATA version 14.1 software and Microsoft excel. Sample weighting was done for further analysis.

Spatial autocorrelation and hot spot analysis:
Spatial autocorrelation (Global Moran’s I) statistic measure was used to assess whether HRFB among reproductive-age women were dispersed, clustered, or randomly distributed in Ethiopia. Moran’s I
values close to −1 indicates the low proportion of HRFB and dispersed, close to +1 indicates clustered, and if Moran’s I value zero indicates randomly distributed(20). A statistically significant Moran’s I value (p < 0.05) had a chance to rejection of the null hypothesis which indicates the presence of spatial autocorrelation. Hot Spot Analysis (the Getis-Ord Gi* statistic) of the z-scores and significant p-values tells the features with either hot spot or cold spot values for the clusters spatially.

Spatial interpolation:
The spatial interpolation technique is used to predict HRFB proportion among reproductive-age women for unsampled areas in the country based on sampled EAs. For the prediction of unsampled EAs, we used deterministic and geostatistical Empirical Bayesian Kriging spatial interpolation techniques. Ordinal Kriging method of Gaussian distribution was used(21).

Spatial scan statistics:
We employed Bernoulli based model spatial scan statistics to determine the geographical locations of statistically significant clusters for HRFB using Kuldorff’s SaTScan version 9.6 software(22). The scanning window that moves across the study area in which HRFB was taken as cases and no HRFB were taken as controls to fit the Bernoulli model. The default maximum spatial cluster size of < 50% of the population was used as an upper limit, allowing both small and large clusters to be detected, and ignored clusters that contained more than the maximum limit with the circular shape of the window. Most likely clusters were identified using p-values and likelihood ratio tests on the basis of the 999 Monte Carlo replications.

Geographically weighted regression analysis:
Ordinary Least Square regression (OLS) model is a global model, which estimates only one single coefficient per explanatory variable over the entire study area. Global models assume factors that affect HRFB were stationary geographically. The assumption of geographical independence may bias the parameter estimates. The assumption of geographical independence relaxes by geographically weighted regression analysis. A geographically weighted regression model is an extension of the OLS regression model and gives local parameter estimates to reflect changes over space in the association between an outcome and explanatory variables (23).
For the interest of geographically weighted regression analysis, the aggregated proportion of HRFB among reproductive-age women and all the predictor variables were calculated for each cluster. To determine the predictor variables for HRFB among reproductive-age women, we used a geographically weighted regression model. To check the assumption of spatial dependency explanatory analysis was performed first by Arc GIS 10.7 software. Statistically significant (P < 0.01) Koenker (BP) statistic indicates that the relationships modeled are not consistent (either due to non-stationarity or heteroskedasticity). Multicollinearity (Variance Inflation Factor < 7.5) was checked to exclude redundancy among explanatory variables. In the case of spatial dependency, the coefficient of predictor variable varies locally as well the predictor variables may or may not significant locally. The model structure of geographically weighted regression written as,

$$Y_i = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) X_{ik} + \epsilon_i$$

Where $Y_i$ is the response variable, $(u_i, v_i)$ denotes the coordinates of the $i^{th}$ point in space, $\beta_0$ is the intercept at the $(u_i, v_i)$ coordinate, $\beta_k$ is the coefficient of the covariate $X$ at the $(u_i, v_i)$ coordinate, and $\epsilon_i$ is the random error term.

Calibration of the model: we used Multiscale Geographically Weighted Regression (MGWR) version 2.0 software to calibrate the parameter estimates of the Geographically Weighted Regression model(24). The new version of GWR is termed Multiscale Geographically Weighted Regression (MGWR), which was potentially providing a more flexible and scalable framework in which to examine multiscale processes. Adaptive bi-square kernels were used for geographical weighting to estimate local parameter estimates. The ‘golden section search ‘method was used to determine the best bandwidth size based on corrected Akaike’s Information Criterion (AICc) and the bandwidth with the lowest AICc was used to determine the best fit model for local parameter estimates.

Geographical variability for each coefficient can be assessed by comparing the AICc between the GWR model and the global OLS regression model. The corrected Akaike’s Information Criterion (AICc) was
obtained by minimizing the Akaike Information Criteria (AIC) which is;

\[ AIC_c = 2n \log_e (\sigma^2) + n \log_e (2\pi) + \left\{ \frac{(n + tr(s))}{(n - 2 - tr(s))} \right\} \] ............(23)

where \( n \) is the sample size, \( \sigma^2 \) is the estimated standard deviation of the error term, and \( tr(S) \) denotes the trace of the hat matrix which is a function of the bandwidth. Finally, local parameter estimates were plotted on Arc GIS 10.7 (ESRI Inc., Redlands, CA, USA, version 10.7) software.

Results

Prevalence of High-risk fertility behavior

A total of 11,022 women were included, with 643 of clusters nested in 11 regions. This study reveals that the magnitude of HRFB among women was 76.3% with 95% CI: (75.6, 77.2). The prevalence of HRFB among an urban and rural place of residence of women was 66.51% and 77.59% respectively (Table 1).

Table 1

| Variables                   | Description                                               | Proportion |
|-----------------------------|-----------------------------------------------------------|------------|
| Place of residence          | Proportions of women with Rural place of residence        | 0.89       |
| Sex                         | Proportions of males                                      | 0.52       |
| Religion                    | Proportions of women of Orthodox Christian religion followers | 0.34       |
|                            | Proportions of women of Muslim religion followers         | 0.41       |
|                            | Proportions of women of protestant religion followers     | 0.21       |
| Educational status of women | Proportions of women with no Education                    | 0.66       |
| Occupation of women         | Proportions of women with no work                         | 0.56       |
| Anemia status               | Proportions of women with Anemia                          | 0.30       |
| Wealth status               | Proportions of women with low economic status             | 0.46       |
| Antenatal follow up         | Proportions of women with no ANC follow up                | 0.25       |
| Place of delivery           | Proportions of women with home delivery                    | 0.72       |
| Media exposure status       | Proportions of women with no media exposure               | 0.09       |
| Wanted pregnancy            | Proportions of not wanted pregnancy                       | 0.25       |

Spatial autocorrelation of High-Risk Fertility Behavior in Ethiopia

This study revealed that the spatial distribution of HRFB was found to be non-random in Ethiopia with Global Moran’s I 0.113 (p < 0.001) (Fig. 1)
The clustered patterns (on the right sides) show high rates of HRFB occurred over the study area. The outputs have automatically generated keys on the right and left sides of each panel. Given the z-score of 3.78 indicated that there is less than 1% likelihood that this clustered pattern could be the result of random chance. The bright red and blue colors to the end tails indicate an increased significance level. The table shows that the observed value is greater than the expected value and P-value is < 0.05, it is statistically significant

Incrementa Spatial I Autocorrelation among reproductive-age women in Ethiopia.

To determine spatial clustering for HRFB, global spatial statistics were estimated using Moran’s I value. As shown in the figure below a statistically significant z-scores indicate at 166 Km distances where spatial processes promoting clustering are most pronounced. The incremental spatial Autocorrelation indicates that a total of 10 distance bands were detected with a beginning distance of 121813 meters. The spatial distribution of HRFB among reproductive-age women in Ethiopia was found non-random with a Global Maran’s I was 0.11 and p-value 0.0001. The z-score of 3.77, there is a less than 1% likelihood that this high-clustered pattern could be the result of random chance. (Fig. 2)

Hot spot (Getis-Ord Gi) analysis:

As shown in the figure below, the red color indicates the more intense clustering of high (hot spot) proportion HRFB preceding the survey period. A high proportion of HRFB was clustered at the Somali and Afar region of Ethiopia. Whereas, Amhara, SNNPR and Addis Ababa regions of Ethiopia were less risk area. (Fig. 3)

Spatial Sat Scan analysis of High-risk fertility behavior among women across regions of Ethiopia, 2016

Most likely (primary clusters) and secondary clusters of HRFB were identified. A total of 383 significant clusters were identified. Of these, 181 of them were most likely (primary) clusters and 102 were secondary clusters. The primary clusters' spatial window was located in the Somali, Eastern Oromia, Dire Dawa and Harari region which was centered at 5.848373 N, 43.527981 E with 569.73 km radius, and Log-Likelihood ratio (LLR) of 65.24, at p < 0.001. It showed that women within the spatial window had 1.13 times higher risk of HRFB than women outside the window. The secondary clusters'
spatial window was typically located in the central part of the Amhara region. Which was centered at 11.287790 N, 38.406887 E with 71.42 km radius, and LLR of 9.46 at p-value 0.032? It showed that women within the spatial window had a 1.16 times higher risk of HRFB than women outside the window (Fig. 4 and Table 2).

Table 2
SaTScan analysis of high-risk fertility behavior among women in the last five years in Ethiopia, 2016.

| Cluster type | Significant Enumeration Areas(clusters) detected | Coordinates/Radius | Populations | Cases | RR  | LLR   | P-value |
|--------------|-----------------------------------------------|-------------------|-------------|-------|-----|-------|---------|
| Primary      | 164, 358, 85, 138, 278, 492, 92, 543, 490, 146, 318, 187, 171, 198, 95, 556, 497, 520, 480, 521, 588, 553, 458, 208, 77, 214, 251, 394, 573, 239, 116, 629, 22, 286, 568, 277, 289, 33, 472, 452, 527, 377, 64, 439, 186, 57, 8, 210, 454, 513, 436, 501, 68, 212, 580, 483, 133, 587, 115, 500, 240, 194, 418, 58, 29, 622, 321, 44, 179, 534, 607, 257, 387, 56, 397, 137, 228, 28, 614, 393, 60, 396, 443, 173, 357, 566, 238, 419, 269, 363, 329, 495, 288, 381, 610, 372, 1, 473, 453, 378, 630, 242, 523, 281, 166, 642, 311, 557, 441, 30, 594, 202, 613, 74, 380 | (5.848373 N, 43.527981 E) / 569.73 km | 3450       | 2870 | 1.13 | 64.24 | < 0.001 |
| Secondary | (6.273056 N 42.688145 E) | 1684 | 1457 | 1.16 | 61.29 | < 0.001 |
|-----------|--------------------------|------|------|------|-------|---------|
| 278, 318, 187, 358, 89, 164, 556, 480, 492, 543, 138, 490, 92, 198, 171, 95, 497, 521, 588, 146, 553, 286, 458, 520, 394, 289, 472, 214, 452, 251, 208, 573, 239, 116, 22, 568, 377, 277, 372, 454, 513, 186, 527, 33, 68, 501, 580, 436, 64, 133, 115, 212, 483, 8, 500, 587, 240, 29, 418, 58, 439, 607, 179, 194, 44, 321, 534, 257, 56, 397, 210, 157, 228, 387, 28, 614, 57, 393, 60, 396, 173, 443, 622, 238, 383, 357, 329, 419, 495, 581, 568 |
Interpolation of high-risk fertility behavior

The predicted high-risk fertility behavior over the area increases from green to red-colored areas. The red color indicates high-risk areas of predicted HRFB and the green color indicates the predicted low fertility behavior risk areas. The Somali region, the Afar region, Eastern parts of the Oromia region, and center parts of the Beneshangul Region were predicted as more risky areas compared to other regions. Continuous images produced by interpolating (Kriging interpolation method) HRFB among women. The red color indicates the predicted high-risk areas and green color indicates fewer risk areas of HRFB (Fig. 5).

Geographically weighted regression Analysis:

Selected predictor variables fitted in the geographically weighted regression model. For model compression, both Ordinary Least Square (OLS) model with Geographical Weighted Regression (GWR) model was fitted. The bandwidth corrected Akakian Information Criteria (AICc), and loglikelihood was considered. Comparing the global model, the GWR model best fits the model with AICc of 1652 compared with 1655 least AICc best approach. As well, the GWR model best explained by the predictor variables log-likelihood also supports this. (Table 3).

| Variable       | GLR  | GWR  |
|----------------|------|------|
| AICc           | 1655 | 1652 |
| Residual sum of squares | 510.9 | 502.5 |
| Log likelihood  | -821.4 | -816.3 |

NB: AICc = corrected Akakian Information Criteria.

Ordinary Least Square (OLS) model Result

From the OLS model, we found two spatially vary risk factors that affect HRFB among reproductive age group women in Ethiopia. The Global beta coefficients for the Proportion of home delivery and not use family planning were statistically (home delivery beta coefficient = 0.08 p-value < 0.001, not use family planning beta coefficient 0.10 p-vale < 0.001 ). When the Koeker test is statistically significant, it indicates relationships between some or all of your explanatory variables and your dependent
variable are non–stationary (Koenker (BP)Statistics = 47.8 p-vale < 0.001). Breusch–Pagan statistic is used to test for heteroskedasticity in a linear regression model (75.5; p-value < 0.001) since the test statistic has a p-value below an appropriate threshold (p < 0.05) then the null hypothesis of homoskedasticity is rejected and heteroskedasticity assumed (Table 4).

Table 4
Global beta coefficients of the GWR model Summary results for best non-spatial linear regression model for the proportion of HRFB behavior among reproductive-age women in Ethiopia, 2016

| Variable                        | Coefficient | Std error | P-value   | Robust Std error | Robust P-value | VIF |
|---------------------------------|-------------|-----------|-----------|------------------|----------------|-----|
| Intercept                       | 0.60        | 0.014     | 0.000000* | 0.017            | 0.000000*      | .....|
| Home delivery                   | 0.08        | 0.03      | 0.0006*   | 0.026            | 0.001*         | 2.6 |
| Not using family planning       | 0.10        | 0.026     | 0.0001*   | 0.028            | 0.0004*        | 1.9 |

Geographical Weighted Regression (GWR) model Result

In a Geographically weighted regression model, the predictor variables of the GLR model (Anemia, home delivery, no using family planning, not educated women proportion) were incorporated into a geographically weighted regression model. To determine the number of neighboring clusters for local regression the bandwidth with the lowest AICc was chosen. The bi-square adaptive kernel function looks at an adaptive number neighbors and the influence of these neighbors decays following a Gaussian distribution so that closer observations have the most weight. So local regression for clusters that have few data points adjacent, will include clusters farther away. Comparing the global and the local model shows that the GWR model performs better than the GLR model.

Not use contraceptives among women had different statistical significance in different parts of Ethiopia for HRFB among reproductive-age women. The coefficients of not contraceptives vary spatially between 0.137 is Amhara and Region into 0.171 Somali indicating that the effect of association different in different parts of Ethiopia. In the significant parts of Ethiopia, a 1% increase in not use of contraceptives among women will increase the prevalence of HRFB by 70%. Not
contraceptive was significant across Ethiopia (Fig. 6).

Home delivery among women had different statistical significance in different parts of Ethiopia for HRFB among reproductive-age women in Ethiopia. The geographically vary risk factors of home delivery ranges from 0.221 in Tigray to 0.228 in Somali(Fig. 7)

Discussion
This study revealed that 76% of women had high-risk fertility behavior with a 95% confidence interval of 75.6–77.20%. This finding was lower than a study conducted in the Afar region of Ethiopia (86.3%) (25). However, this finding was higher than of the 2011 EDHS report 58% (3), 34% in Bangladesh DHS, 38.3% in Nepal, and 44.9% in India(26). The possible explanation for the observed discrepancies might be due to the fact that socio-demographic characteristics changes and increased intention of fertility in society. Specifically, when compared with Asian countries such as Nepal the socio-demographic characteristics are quite different and also the health system variations could be the reason. In addition, in Ethiopia, child marriage is higher which might be responsible for the increased magnitude of high risky fertility behavior (27).

This study revealed that the spatial distribution of HRFB was nonrandom in Ethiopia. Significant HRFB highly clustered at Somali and Afar. In line with this high proportion clustering, spatial scan statistics analysis revealed that 385 significant clusters were identified. A high proportion of HRFB observed in Somali and Afar and a low proportion of HRFB observed at Amhara, Addis Ababa, Oromia, and SNNP. The observed geographical variation of HRFB across regions of Ethiopia might be due to the regional variation health system infrastructure and this result is supported Ethiopian demographic survey report(3).

Geographically weighted regression gave local parameter estimates of the predictor variables of the model fit vary spatially in Ethiopia. Home delivery and not use contraceptives were local statistically significant predictor variables for HRFB among reproductive-age women in Ethiopia.

One of the obstacles to tackle maternal and child mortality is High-risk fertility. This high-risk fertility is indirectly associated with home delivery due to the reason that women who deliver at home with high-risk fertility had low service utilization of counseling about the benefit of optimal birth spacing(14).

Across regions of Ethiopia, the estimates of high-risk fertility behavior for women who deliver at home varied
between 0.221 and 0.228 and this variation in coefficients of high-risk fertility for those women who are delivering at home varied from region to region. Home delivery is a relatively stronger significant factor for high-risk fertility behavior in Amhara, Tigray, Afar, and Oromia regions than other regions. The statistically significant variation in estimates of high-risk fertility behavior across regions in Ethiopia is might be the reflection of the diverse socio-cultural setting differently responding to factors affecting fertility and child survival in the country than the perception of given community members to the issue in their own settings.

It should also be noted that there is a considerable variation in actual fertility level estimates across the different regions in the country(3). Therefore, the likelihood of getting exposed to high-risk fertility behavior is observed among regions experiencing high fertility and vice-versa indicating that the desire for more children is a trigger of high-risk fertility(13).

Women who had no ever used contraceptive was associated with an increased occurrence of high-risk fertility behavior compared to those who had used. This finding is supported by other studies and evidence (13,15) and DHS analytical studies(28). One of the purposes of contraceptive use is spacing birth and decreasing unintended pregnancies which might affect the health of mother and child. One of the basic postnatal intervention is family planning service provision for mothers with the aim of spacing birth intervals(18).

The study has some strengths. As Tobler's first law of geography states that "Everything is related to everything else, but near things are more related than distant things" (29). Based on Tobler's first law of geography, HRFB was spatially autocorrelated. In the presence of spatial dependence and heterogeneity, the estimates obtained from the global model would be biased. Therefore, fitting the GWR model and knowing the spatial distribution of HRFB in regions of Ethiopia provides important insight to policymakers and health planners and valuable hot spot maps used to more effective and cost-efficient nutrition intervention.

The study has also limitations: Since the data used in this study was cross-sectional data, which limits the conclusions about the causality of the factors on the dependent variable and Since 21 clusters did not have coordinate data and we did not include in the analysis this may affect the estimated result.

Conclusions
In Ethiopia, High-Risk Fertility Behavior had to vary geographically across regions. Statistically, a significant-high hot spot of High-Risk Fertility Behavior was identified at Somali and Afar. Whereas, Amhara, Addis Ababa, Oromia
and SNNPR regions of Ethiopia were less risk area. This study showed that predictor variables for High-Risk Fertility Behavior were varied spatially in Ethiopia. Not use a contraceptive, and home delivery were statistically significant predictors locally in different regions of Ethiopia. Therefore, policymakers and health planners should design an effective intervention program at Somali, and Afar to reduce High-Risk Fertility Behavior among reproductive-age women and Special attention needs about health education on the advantage of contraceptive utilization and health facility delivery to reduce High-risk fertility Behavior.

Abbreviations
AICc: corrected Akaki Information Criteria ANC: Antenatal Care EAS: Enumeration Areas EDHS: Ethiopian Demographic and Health Survey GWR: Geographically Weighted Regression HRFB: High-Risk Fertility Behavior MGWR: Multiscale Geographically Weighted Regression SNNPR: South Nation Nationalities and People of Regions

Declarations

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Authors’ Contributions
ZTT, M, and YA were involved in this study from the inception to design, acquisition of data, data cleaning, data analysis and interpretation and drafting and revising of the manuscript. KAG was involved in project administration, principal supervision, and revising the final manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The data was available from the corresponding author and we can provide upon request.

Ethics approval and consent to participate
We, authors, submitted a proposal to DHS Program/ICF International Inc, and permission was confirmed from the International Review Board of Demographic and Health Surveys (DHS) program data archivists to download the dataset for this study.
Consent for publication
Not applicable

Competing Interests
The authors declare that they have no competing interests.

Author Details
1 Department of Epidemiology and Biostatistics, Institute of Public Health, College of Medicine and Health Sciences, University of Gondar, Ethiopia.

2 Department of Social and Public Health, College of Health Sciences, Debre Tabor University, Ethiopia

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Figures

Figure 1
Spatial autocorrelation of elevated risk fertility behavior in Ethiopia, 2016
Figure 2
The spatial autocorrelation of HRFB among reproductive age group women in Ethiopia by a function of distance

Figure 3
Hot spot analysis of high-risk fertility behavior among women within 5 years preceding the survey in Ethiopia, 2016
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Figure 6
Geographically varying values of significance and coefficients per cluster for predictor variable not use contraceptive

Figure 7
Geographically varying values of significance and coefficients of home delivery per cluster for HRFB