Spatial distribution and associated factors of iron supplementation use among pregnant women in Ethiopia; Ethiopian Demographic and Health Survey 2016 data: spatial and multilevel logistic regression analysis

Chilot Desta Agegnehu (chilotdesta@gmail.com)
University of Gondar College of Medicine and Health Sciences

Getayeneh Antehunegn Tesema
University of Gondar College of Medicine and Health Sciences

Achamyeleh Birhanu Teshale
University of Gondar College of Medicine and Health Sciences

Adugnaw Zeleke Alem
University of Gondar College of Medicine and Health Sciences

Yigizie Yeshaw
University of Gondar College of Medicine and Health Sciences

Sewnet Adem Kebede
University of Gondar College of Medicine and Health Sciences

Alemneh Mekuriaw Liyew
University of Gondar College of Medicine and Health Sciences

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Abstract

Background

Although the World Health Organization recommends for all pregnant women taking iron tablet should be a routine activity, more than 50% of anemia in pregnant women was occurred due to lack of iron supplementation and remains global public health problem and varies with in country. Lack of iron tablet supplementation during pregnancy leads to maternal anemia, which intern increases the risk of maternal death, obstetric complications, preterm birth and low birth weight. Therefore, studying spatial distribution and determinants of iron supplementation use among pregnant women in Ethiopia is vital to design appropriate maternal health services and preventing the determinants earlier.

Method:

A stratified two-stage cluster sampling technique was used in the Ethiopian Demographic Health Survey in 2016 data. A total of a weighted sample of 7589 pregnant women were included for analysis. Bernoulli model was used to explore the purely spatial clusters of pregnant women using SaTScan version 9.6 and ArcGIS version 10.3. A multi-level logistic regression model was used to identify determinant factors of iron supplementation use among pregnant women.

Results

Spatial distribution of iron supplementation use among pregnant women was non-random in the country with Moran’s index 0.3 (p < 0.001). The primary cluster was in Southwest Somali and Central part of the Oromia region (LLR = 66.69, P < 0.001). ANC visit (AOR = 3.66, 95%CI: 3.21, 417), community education (AOR = 1.31, 95%CI, 1.07, 1.59), media exposure (AOR = 1.33, 95%CI: 1.15, 1.53), distance to health facility (AOR = 1.32, 95%CI: 1.16, 1.50), region and household wealth index were significantly associated with iron supplementation use among pregnant women in Ethiopia.

Conclusion

Spatial distribution of iron supplementation use among pregnant women varies across the country. ANC visit, region, household wealth index, media exposure, distance to the health facility, and community education were significant predictors of iron supplementation use among pregnant women. Therefore, it needs great interventions in the hot spot areas and maternal health services should be delivered in all areas of our country.

Background
Globally, it is estimated that 41.8% of pregnant women were anemic among this burden at least 50% is associated with due to iron deficiency (1). The demand for iron in pregnancy women becomes increases due to the maternal supply of iron to the fetus and iron loss is due to blood loss at delivery in addition to the expanding blood volume of the mother (2). Iron deficiency anemia (IDA) is one of the most frequently observed and preventive nutritional deficiencies in developing countries particularly in pregnant women (1, 3). For pregnant women the recommended iron supplementation to be 20 mg per day which indicates higher than 50% from required for non-pregnant women (4). The amount of iron absorbed from the diet is not sufficient to meet many individual requirements especially during pregnancy and infancy (5).

According to the recommendation of World Health Organization (WHO), all pregnant women irrespective of their hemoglobin level status should get iron and folic acid supplementation (6).

More than 50% of anemia in pregnant women was due to a lack of iron supplementation (7). Studies revealed that about 20% of maternal deaths are caused by anemia and this anemia has a contribution of 50% of all maternal deaths (8, 9). Regarding to maternal anemia during pregnancy, different studies documented that maternal anemia increases the risk of maternal death, obstetric complications, preterm birth and low birth weight (10, 11). Especially in 2nd trimester, maternal anemia during pregnancy affects postnatal infant growth (12) and leads to an increased risk for low birth weight and preterm birth (11). All this indicates iron supplementation for women during pregnancy timely and appropriately prevents low birth weight and preterm birth (13, 14).

Previous studies have identified factors associated with iron supplementation includes advanced maternal age (15, 16), parity (16), knowledge of anemia and diagnosis of anemia (16, 17), use of other food supplements (18) were found to be associated with iron supplementation use among pregnant women. Daily oral iron and folic acid supplementation are an integral part of antenatal care to reduce postpartum hemorrhage, preterm birth and the current recommendation of six months of regimen are 60 400 mg, respectively (6).

Even though studies were not done about spatial distribution of anemia among pregnant women, spatial distribution of anemia among reproductive age women sat scan result indicated that high spots of anemia among reproductive age women were in eastern (Somali, Hareri, Dire Dawa and in the North eastern Afar part of the country where as cold spot areas (low prevalence of anemia) were observe in Northern (Tigray, Amhara), Addis Ababa and Western Benshangul-Gumuz parts of the country (19).

In Ethiopia until now the coverage of iron supplementation among pregnant women is low and doesn't achieve WHO standard recommendations. The important of studying spatial distribution of iron supplementation use among pregnant women used for policy makers for resource allocation, planning maternal health care services, to evaluate programs and to design interventions in major hot spot areas. Since, targeting interventions based on vulnerability of the community would help to maximize the benefit from interventional programs through optimal utilization of scarce resources and based on the magnitude of the problem and managing factors of iron supplementation among pregnant women is very important. Therefore, this study aimed to investigate spatial variation and associated factors of Iron supplementation use among pregnant women in Ethiopia using 2016 Ethiopian Demographic and Health Survey data.
Methods

Study setting

The study was conducted in Ethiopia (3°-14° N and 33° – 48°E), situated at the eastern horn of Africa. The country covers 1.1 million square kilometers and has a great geographical diversity, which ranges 4550 meters above sea level down to the Afar depression to 110 meters below sea level. There are nine regional states and two city administrations subdivided into 68 zones, 817 districts and 16,253 kebeles (lowest local administrative units of the country in the administrative structure of the country) (20).

Study Design and Participants

A community-based cross-sectional study was conducted in Ethiopia from January 18 to June 27, 2016. All pregnant women in the selected enumeration areas within five years before the survey were considered as study participants.

Sampling Technique And Sampling Procedure

Ethiopian Demographic and Health Survey 2016 used a two-stage stratified cluster sampling technique selected from population and housing census frame for EDHS 2016 (21). Stratification was done by separating in each region into urban and rural areas. A total of 21 sampling strata has been done because of Addis Ababa is entirely urban. In the first stage, 645 Enumeration Areas (EAs) (202 in an urban area and 443 from urban areas) 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 24–32 households were systematically selected. For this study the women data set was used. A weighted sample of 7,589 pregnant women were used for the final analysis.

Aggregated Community-level Variables

Community women's education

was defined as the proportion of women who attended primary, secondary and higher education within the cluster. The aggregate of individual women's primary, secondary and higher educational attainment can show the overall educational status of women within the cluster. They were categorized into two categories as a higher proportion of women's education within the cluster and the lower proportion of women education based on the national median value.
Data Collection Procedure And Quality Control

The study was conducted based on EDHS data by accessing from the DHS program database www.measuredhs.com, permission was secured after explaining the purpose of the study. The outcome and independent variables were extracted from EDHS 2016 women data set. XY coordinate data was also taken from the selected enumeration areas. A structured and pre-tested questionnaire was used as a tool for data collection. Data were recoded based on kinds of literature and cleaned by running frequencies and cross-tabulations. For spatial distribution, those EAs with 0 geographic coordinates were dropped.

Data Management and Analysis

After downloading the data from the DHS program official database (www.measuredhsprogram.com), editing, recording, and analysis were done using STATA 14, ArcGIS 10.3 and SaTscan version 9.6. Just before any statistical analysis, the data were weighted using sampling weight in primary sampling unit, and strata to restore the representativeness of the survey and introduce STATA to take into account the sampling design during calculation of standard errors to get reliable statistical estimates. Descriptive, spatial distribution and multilevel analysis were done to identify associated factors of iron supplementation among pregnant women in Ethiopia, using data from the 2016 EDHS.

Spatial Data Analysis

The coordinate data and weighted frequency of outcome variable with cluster numbers were extracted and merged in STATA 14 and exported to Excel. EAs with longitude and latitude data having 0 were dropped. ArcGIS 10.3 was used for Analysis. Among 645 EAs two of them were not included initially from the DHS coordinate file. From 643 EAS 622 were included from our analysis the rest 21 EAS were excluded due to dropped the zero GPS cells. Global Moran's I was used to check the presence of spatial autocorrelation across the country and local Moran's I with P-value was reported. To check patterns of iron supplementation use among pregnant women Moran's I value closest to -1 (Dispersed), Moran's I value closest to +1 (Clustered) or when Moran's I value zero (randomly distribute). Moran's I p-value < 0.05 indicates spatial autocorrelation.

Anselin local Moran's I used to identify the local level of clustering of iron supplementation use among pregnant women. Furthermore, local Moran's index shows the correlation of clusters whether positively correlated (High-High and Low-Low) clusters or negatively correlated (High-Low and Low-high) clusters that mean an outlier cluster.

Hot spot analysis using Getis-OrdGi* statistics to measure how spatial autocorrelation varies over the study location by calculating GI Bin for each area. Z-score (confidence interval) and P-value are used to determine the statistical significance of clusters. Statistical output with high GIBin* indicates "hotspot" whereas low GI* means a "cold spot."
We also conduct Ordinary kriging spatial interpolation was used to predict unobserved from observed measurements and make a suitable environment to estimate the burden of iron supplementation use among pregnant women in Ethiopia.

Spatial SaTscan analysis was conducted using SaTscan version 9.6 software to identify most likely clusters. Bernoulli model was used by applying the kulldorff method for purely spatial analysis to identify most likely clusters. Pregnant women who don't take iron tablets are cases whereas those taking iron tablets considered as controls and fitted in 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. The null hypothesis was stated that there is no risk difference within and outside the scanning window. Areas with a high log likely hood ratio (LLR) and p-value < 0.05 were considered to have high risk as compared to the outside the window. Finally significant and most likely clusters with LLR, RR and P-value were reported. To know the location where the most likely clusters were found by using ArcGIS 10.3

**Multi-level Analysis**

Model comparison was conducted using deviance.

To measure the variation between clusters ICC (Intra-class correlation), MOR (median odds ratio) and PCV (proportional change in variance) were computed. To calculate this parameters based on this formula

\[
 ICC = \frac{\hat{\sigma}^2}{\hat{\sigma}^2 + \frac{\pi^2}{3}} \quad (22), \quad \text{MOR} = \exp \left( \sqrt{2 \times \hat{\sigma}^2 \times 0.6745} \right) \quad \approx \text{MOR} = \exp (0.95 \times \hat{\sigma}) \quad (23) \quad \text{and}
\]

\[
 \text{PCV} = \frac{\text{var (null model)} - \text{var (full model)}}{\text{var (null model)}}
\]

Two-level multilevel Multivariable logistic regression was used to analyze factors associated with iron supplementation use among pregnant women at two levels, at individual and community (cluster) levels.

Four models were constructed for the multi-level logistic regression. The first model was an empty model without any explanatory variables, to calculate the extent of cluster variations on iron supplementation use among pregnant women. The second model was adjusted with individual-level variables, the third model was adjusted for community-level variables while the fourth was fitted with both individual and community level variables simultaneously. The fourth model was the best-fitted model since it had lower deviance and higher likelihood.

In the multivariable multilevel logistic regression analysis variables with a p-value of < 0.05 were considered as statistically significant. Adjusted Odds Ratio (AOR) with their corresponding 95% confidence interval was determined to identify factors associated with iron supplementation use among
pregnant women. After comparing all models a model with low deviance was considered as a fitted model. Multi-collinearity was also checked using the variance inflation factor (VIF). Accordingly, all variables had VIF < 5 and tolerance greater than 0.1 indicating that there is no multi-collinearity.

Results

Socio-demographic characteristics of study participants

A total of 7589 respondents were included in the study. More than one fourth 2,165 (28.5%) of the respondents were in the age range of 25–29. Of all the respondents, 662 (87.2%) were rural dwellers. Regarding to region, about 3129 (41.2%) were Oromia whereas 33 (0.4%) were Dire Dawa. Among the total 1654(21.8%) were in the poorer wealth quantile category and 4799(63.2) were lowered community education. More than half, 4406(58%) of the respondents had a big problem to reach health facility whereas only 2414 (32%) had ANC visit more than 4 + times. According to media exposure, 2564(33.8%) the study participants had media exposure [Table 1].
Table 1
Percentage distribution of characteristics of respondents in 2016 Ethiopian Demographic and Health Surveys.

| Characteristics | Weighted frequency | Percentage |
|-----------------|--------------------|------------|
| **Age**         |                    |            |
| 15–19           | 339                | 4.5        |
| 20–24           | 1,465              | 19.3       |
| 25–29           | 2,165              | 28.5       |
| 30–34           | 1,661              | 22         |
| 35–39           | 1,206              | 16         |
| 40–44           | 546                | 7          |
| 45–49           | 207                | 2.7        |
| **Residence**   |                    |            |
| Rural           | 6620               | 87.2       |
| Urban           | 969                | 12.8       |
| **Religion**    |                    |            |
| Orthodox        | 2,882              | 38         |
| Protestant      | 1,651              | 21.8       |
| Muslim          | 2,824              | 37.2       |
| Others*         | 232                | 3          |
| **Marital status** |                |            |
| Single          | 144                | 2          |
| Married         | 7020               | 92.5       |
| Widowed         | 95                 | 1.2        |
| Divorced        | 233                | 3          |
| Separated       | 97                 | 1.3        |
| **Region**      |                    |            |
| Somali          | 269                | 3.5        |
| Tigray          | 537                | 7.1        |

*key: others- traditional, catholic
| Characteristics                  | Weighted frequency | Percentage |
|---------------------------------|-------------------|------------|
| Afar                            | 71                | 1          |
| Amhara                          | 1,632             | 21.5       |
| Oromia                          | 3,129             | 41.2       |
| Benishangul-Gumuz               | 81                | 1.1        |
| SNNPR                           | 1,600             | 21.1       |
| Gambelia                        | 21                | 0.3        |
| Harari                          | 17.4              | 0.2        |
| Addis Ababa                     | 198.3             | 2.6        |
| Dire dawa                       | 33.3              | 0.4        |
| **Wealth index**                |                   |            |
| Poorest                         | 1,651             | 21.7       |
| Poorer                          | 1,654             | 21.8       |
| Middle                          | 1,588             | 21         |
| Richer                          | 1,427             | 18.8       |
| Richest                         | 1,269             | 16.7       |
| **Community women's education** |                   |            |
| Lower community education       | 4799              | 63.2       |
| Higher community education      | 2790              | 36.8       |
| **Occupational status**         |                   |            |
| Not working                     | 4,078             | 53.7       |
| Working                         | 3,511             | 46.3       |
| **Distance to health facility** |                   |            |
| A big problem                   | 4,406             | 58         |
| Not a big problem               | 3,183             | 42         |
| **Parity**                      |                   |            |
| 0–4                             | 4,624             | 61         |
| 5–9                             | 2,732             | 36         |

*key: others- traditional, catholic*
### Characteristics

| Characteristics | Weighted frequency | Percentage |
|-----------------|--------------------|------------|
| 10+             | 233                | 3          |
| **Family size** |                    |            |
| 1–4             | 2331               | 31         |
| 5–9             | 4,875              | 64         |
| 10+             | 383                | 5          |
| **ANC visit**   |                    |            |
| 0–3 times       | 5,175              | 68         |
| 4+ times        | 2,414              | 32         |
| **Media exposure** |                |            |
| Not have media exposure | 5025 | 66.2 |
| Have media exposure | 2,564 | 33.8 |

*key: others- traditional, catholic*

### Regional Prevalence Of Iron Supplementation Among Pregnant Women

The prevalence of iron supplementation among pregnant women varies across the country. The highest and lowest prevalence of Iron supplementation among pregnant women was observed in Tigray (77.2%) and in Somali (27.7%) regions respectively [Figure 1].

### Spatial Analysis

**Spatial analysis of Iron supplementation among pregnant women**

A total of 622 clusters were included in the spatial analysis of iron supplementation. Each point on the map characterizes one enumeration area with the proportion of iron supplementation in each cluster. The yellow color indicates areas with a high proportion of iron supplementation whereas the red color indicates enumeration areas with a low proportion of iron supplementation. The higher proportion of iron supplementation has occurred in a majority of the Tigray region, Northeast part of Amhara, west part of Beneshangul Gumuz, North east part of SNNPR and the entire part of Addis Ababa. Whereas the low proportion of iron supplementation was accumulated in Somali, Afar, South west part of Oromia, West part of Gambella and South west part of Addis Ababa [Figure 2].
Spatial Autocorrelation

The spatial distribution of iron supplementation among pregnant women was found to be non-random in Ethiopia with Global Moran's 0.30 (p < 0.001). The clustered patterns (on the right sides) show high rates of iron supplementation occurred over the study area. Given the z-score of 10.6 indicated that there is less than 1.5% likelihood that this clustered pattern could be the result of chance. The bright red and blue colors to the end tails indicate an increased significance level [Figure 3].

Cluster and outlier analysis of iron supplementation among pregnant women

Cluster and outlier analysis was conducted to identify the nature of clustering by using local Moran's I. The red color (low-low cluster) indicates that iron supplementation hot spot areas means low rate of iron supplementation surrounded by low rate of iron supplementation, the green (high-high cluster) color indicates iron supplementation cold spot areas mean high rate of iron supplementation surrounded by high rate of iron supplementation and the pink (High outlier) means high rate of iron supplementation surrounded by low rate of iron supplementation and dark yellow (Low outlier) colors indicates low rate of iron supplementation surrounded by high rate of iron supplementation. Significant clusters were found in Tigray, Amhara, Gambela, SNNPR, Oromia, Somali, Addis Ababa, and Drie Dawa. Hot spot areas for iron supplementation were found in south east Somali, Northwest Gambela, and south west Somali, Northwest SNNPR, East Afar While the cold spot regions were found in Northwest Amhara, East part of Addis Ababa, and Northeast Gambella. Outliers were found in the central and southern parts of Amhara, south east Afar, Benshangul Gumuz, and central Somali regions, Dire Dawa, Hareri, east Oromia, east part of Addis Ababa and North East Part of SNNPR [Figure 4].

Hot Spot Analysis Of Iron Supplementation Among Pregnant Women

The red color indicates that significant hot spot areas (low iron supplementation) and found in Northeast Somali, South Afar, North West Gambela, West and east part of SNNPR and Southwest Oromia regions (P < 0.01). Whereas the yellow color indicates those significant more on non-risk areas (Cold spot areas) found in Tigray, North part of Amhara, East part of Addis Ababa, North West hareri regions (Fig. 5).

Interpolation of Iron Supplementation Among Pregnant Women

North West Gambela, east Somali, southwest Somali, North West Oromia, Northeast Afar were identified as predicted more risky areas of iron supplementation as compared to other regions. Whereas Tigray,
North West Amhara, Northeast Addis Ababa, West Beneshangul Gumuz, Northeast Addis Ababa and North SNNPR were found predicted low-risk areas [Figure 6].

**Spatial Sat Scan analysis of iron supplementation (Bernoulli based model).**

Spatial scan statistics were done using SaTScan\textsuperscript{v9.6} to identify most likely clusters, and a total of 10 significant clusters with 271 enumeration areas were identified. Among the total, 1 of them was most likely (primary) clusters and 9 were secondary clusters. The primary clusters spatial window red color was located in southwest Somali and central part of Oromia region which was centered at 5.330795 N, 41.837597 E of geographic location with 441.87 km radius, and Log-Likelihood ratio (LLR) of 66.68, at $p < 0.001$ which was detected as the most likely cluster with maximum LLR. It showed that pregnant women within the spatial window had 1.35 times higher risk of low iron supplementation than pregnant women outside the window. The other secondary clusters were described as detail in the table [Table 2] [Figure 7].
Table 2
Sat Scan analysis of iron supplementation use among pregnant women in Ethiopia, 2016

| Cluster | Enumerated area (cluster identified) | Coordinate/radius | Population | Case | RR  | LLR  | p-value  |
|---------|------------------------------------|-------------------|------------|------|-----|------|----------|
| 1(89)   | 556, 394, 480, 187, 520, 318, 278, 208, 164, 358, 377, 85, 289, 286, 472, 138, 452, 7, 492, 422, 543, 92, 490, 198, 171, 95, 34, 146, 82, 497, 518, 123, 405, 562, 521, 588, 553, 26, 468, 316, 458, 601, 213, 398, 319, 576, 313, 619, 529, 365, 600, 21, 245, 445, 232, 589, 12, 214, 372, 634, 251, 32, 182, 573, 476, 391, 574, 524, 239, 122, 308, 216, 578, 215, 116, 22, 408, 148, 438, 522, 412, 513, 454, 506, 580, 68, 115, 133, 501, 453, 607, 568 | (5.33079 5 N, 41.83759 7 E) / 441.87 km | 1240 | 852 | 1.35 | 66.68 | < 0.001 |
| Cluster | Enumerated area (cluster) identified | Coordinate/radius | Population | Case | RR  | LLR  | p-value |
|---------|-------------------------------------|------------------|------------|------|-----|------|---------|
| 2 (37)  | 377, 394, 422, 7, 34, 289, 480, 398, 316, 601, 82, 556, 405, 21, 518, 468, 232, 472, 600, 208, 313, 182, 445, 574, 32, 576, 286, 634, 26, 365, 452, 520, 12, 215, 216, 408 | (5.20323 4 N, 40.01973 2 E) / 261.38 km | 510 | 391 | 1.47 | 60.01 | < 0.001 |
| 3 (12)  | 66, 618, 309, 435, 536, 370, 507, 592, 104, 260, 233, 69 | (8.38974 7 N, 33.25855 7 E) / 71.61 km | 146 | 132 | 1.7  | 46.72 | < 0.001 |
| 4 (49)  | 630, 378, 269, 629, 77, 146, 92, 490, 543, 171, 492, 198, 95, 497, 458, 588, 553, 521, 138, 214, 33, 573, 251, 239, 116, 8, 358, 22, 164, 527, 568, 277, 439, 64, 57, 278, 210, 8, 186, 566, 1, 318, 622, 436, 212, 454, 501 | 7.717178 N, 46.99158 0 E) / 555.85 km | 587 | 423 | 1.37 | 43.43 | < 0.001 |
| Cluster | Enumeration area (cluster identified) | Coordinate/radius | Population | Case | RR  | LLR  | p-value |
|---------|--------------------------------------|-------------------|------------|------|-----|------|---------|
| 5(10)  | 1, 566, 622, 186, 307, 436, 212, 8, 210, 419 | (9.50547 N, 42.43862 E) / 33.79 km | 142 | 117 | 1.54 | 25.76 | < 0.001 |
| 6(42)  | 477, 325, 207, 437, 376, 154, 168, 177, 552, 459, 371, 243, 465, 299, 526, 554, 197, 46, 586, 489, 119, 338, 76, 326, 555, 470, 337, 432, 486, 447, 448, 62, 306, 227, 446, 411, 219, 558, 270, 593, 265, 406 | (7.17396 N, 35.80268 E) / 170.61 km | 509 | 343 | 1.27 | 20.07 | < 0.001 |
| 7(7)   | 372, 93, 412, 333, 476, 506, 453 | (8.94935 N, 41.31240 E) / 65.76 km | 105 | 85 | 1.51 | 16.91 | < 0.001 |
| 8(2)   | 544, 599 | (12.3499 N, 40.24239 E) / 29.62 km | 34 | 33 | 1.8  | 16.61 | < 0.001 |
| 9(16)  | 150, 36, 183, 559, 184, 246, 533, 244, 137, 364, 35, 498, 615, 320, 515, 494 | (10.5124 N, 36.12905 E) / 76.33 km | 198 | 139 | 1.31 | 11.04 | 0.011 |
### Multilevel Logistic Regression Analysis

#### Random effect analysis results

The intra class correlation in the null model indicated that 27% of the total variability for iron supplementation was due to differences between clusters/EA, with the UN explained 67% attributable to individual differences.

Furthermore, the median odds ratio revealed that iron supplementation among pregnant women was heterogeneous. The median odds ratio for iron supplementation was 2.9 in the empty model which indicates that there was variation between clusters. If we randomly select pregnant women from two different clusters women at the cluster with favorable iron supplementation had 2.9 times higher odds of experiencing iron supplementation as compared with pregnant women at cluster with lower favorable with iron supplementation.

About 67% of the variability in iron supplementation was explained by the full model (pcv = 67%) [Table 3]. Therefore, the two-level multilevel logistic regression model was used to get an unbiased standard error and to make a valid inference.

| Cluster | Enumerated area (cluster) identified | Coordinate/radius | Population | Case | RR  | LLR  | p-value |
|---------|--------------------------------------|-------------------|------------|------|-----|------|---------|
| 10(7)   | 20, 276, 283, 547, 102, 37, 55       | (10.3819 87 N, 40.26579 6 E) / 75.25 km | 91         | 70   | 1.43| 10.33| 0.019   |
Table 3
Multivariable multilevel logistic regression analysis result of both individual and community level factors associated with iron supplementation in pregnant women Ethiopia, EDHS 2016.

| Community and individual level variables | Null model | Model II | Model III | Model IV |
|------------------------------------------|------------|----------|-----------|----------|
|                                          | AOR(95%CI) | AOR(95%CI) | AOR(95%CI) | AOR(95%CI) |
| Age                                      |            |          |           |          |
| 15–19                                    | 1.27 [0.78–2.06] | 1.38 [0.85–2.23] |          |          |
| 20–24                                    | 1.34 [0.87–2.06] | 1.41 [0.92–2.16] |          |          |
| 25–29                                    | 1.21 [0.80–1.83] | 1.29 [0.85–1.95] |          |          |
| 30–34                                    | 1.01 [0.67–1.52] | 1.06 [0.71–1.59] |          |          |
| 35–39                                    | 0.88 [0.59–1.33] | 0.89 [0.59–1.33] |          |          |
| 40–44                                    | 0.71 [0.46–1.09] | 0.70 [0.45–1.07] |          |          |
| 45–49                                    | 1          | 1        |          |          |
| Residence                                |            |          |           |          |
| Rural                                    | 1          |          |           |          |
| Urban                                    | 1.81 [1.42–2.33] | 1.24 [0.92–1.66] |          |          |
| Region                                   |            |          |           |          |
| Somali                                   | 1          | 1        |           |          |
| Tigray                                   | 9.18 [6.35–13.28] | 5.35 [3.73–7.69]** |          |          |
| Afar                                     | 1.75 [1.22–2.51] | 1.61 [1.13–2.28]** |          |          |
| Amhara                                   | 3.08 [2.19–4.33] | 2.07 [1.47–2.91]** |          |          |
| Oromia                                   | 1.25 [0.89–1.75] | 0.81 [0.58–1.14] |          |          |
| Benishangul-Gumuz                        | 2.37 [1.62–3.46] | 1.37 [0.94–1.99] |          |          |
| SNNPR                                    | 1.91 [1.35–2.71] | 1.13 [0.80–1.59]. |          |          |
| Gambelia                                 | 1.02 [0.68–1.52] | 0.76 [0.52–1.13] |          |          |
| Harari                                   | 2.10 [1.39–3.16] | 1.47 [0.98–2.19] |          |          |
| Addis Ababa                              | 1.92 [1.24–2.96] | 0.90 [0.58–1.38] |          |          |

Key: AOR: Adjusted odds ratio; CI: confidence interval; ICC: intra-cluster correlation; MOR: median odds ratio; 1: reference group; p-value 0.05 – 0.01 *: p-value < 0.01 **: ANC, antenatal care visit
| Community and individual level variables | Null model | Model II | Model III | Model IV |
|------------------------------------------|------------|----------|-----------|----------|
| **Dire dawa**                            |            |          |           |          |
|                                          |            | 2.95 [1.94–4.48] | 1.54 [1.03–2.33] |          |
| Wealth index                             |            |          |           |          |
| Poorest                                  | 1          |          | 1         |          |
| Poorer                                   | 1.45 [1.21–1.74] | 1.33 [1.15–1.68] |          |          |
| Middle                                   | 1.40 [1.15–1.71] | 1.39 [1.10–1.63] |          |          |
| Richer                                   | 1.49 [1.21–1.84] | 1.42 [1.13–1.76] |          |          |
| Richest                                  | 1.58 [1.26–1.98] | 1.18 [0.89–1.57] |          |          |
| Community women’s education              |            |          |           |          |
| Lower community education                |            |          | 1         |          |
| Higher community education               |            | 1.61 [1.32–1.97] | 1.31 [1.07–1.59] |          |
| Occupational status                      |            |          |           |          |
| Not working                              | 1          |          | 1         |          |
| Working                                  | 1.20 [1.06–1.35] | 1.12 [0.99–1.26] |          |          |
| Distance to health facility              |            |          |           |          |
| A big problem                            | 1          |          | 1         |          |
| Not a big problem                        | 1.43 [1.26–1.61] | 1.32 [1.16–1.50] |          |          |
| Parity                                   |            |          |           |          |
| 0–4                                      | 1          |          | 1         |          |
| 5–9                                      | 1.04 [0.88–1.23] | 1.07 [0.91–1.26] |          |          |
| 10+                                      | 1.05 [0.70–1.56] | 1.10 [0.74–1.65] |          |          |

Key: AOR: Adjusted odds ratio; CI: confidence interval; ICC: intra-cluster correlation; MOR: median odds ratio; 1: reference group; p-value 0.05 – 0.01 *: p-value < 0.01 **: ANC; antenatal care visit
| Community and individual level variables | Null model | Model II | Model III | Model IV |
|----------------------------------------|------------|----------|-----------|----------|
|                                        | AOR(95%CI) | AOR(95%CI) | AOR(95%CI) | AOR(95%CI) |
| Family size                            |            |          |           |           |
| 1–4                                    | 1          |          | 1         |           |
| 5–9                                    | 0.98 [0.85–1.13] | 1.01 [0.87–1.16] |          |           |
| 10+                                    | 0.97 [0.73–1.29] | 1.06 [0.80–1.41] |          |           |
| ANC visit                              |            |          |           |           |
| 0–3 times                              | 1          |          | 1         |           |
| 4+ times                               | 3.9 [3.43–4.44] | 3.66 [3.21–417]** |          |           |
| Media exposure                         |            |          |           |           |
| Not have exposure                      | 1          |          | 1         |           |
| Have exposure                          | 1.39 [1.20–1.61] | 1.33 [1.15–1.53]** |          |           |
| Constant                               | 0.88 [0.80–98] | 0.28 [0.18–0.44] | 0.24 [0.18–0.31] | 0.16 [0.10–0.27] |
| Model comparison and random effects    |            |          |           |           |
| ICC                                    | 0.27 [0.24-31] |          |           |           |
| Log likelihood (LL)                    | -4552.55   | -4213.56 | -4373.57  | -4113.25 |
| Deviance                               | 9105.1     | 8427.12  | 8747.14   | 8226.5   |
| PCV                                    | Ref        | 0.41     | 0.59      | 0.67     |
| MOR                                    | 2.9(2.65,3.2) | 2.27(2.09,2.49) | 1.97(1.84,2.5) | 1.84(1.70,2.00) |

Key: AOR: Adjusted odds ratio; CI: confidence interval; ICC: intra-cluster correlation; MOR: median odds ratio; 1: reference group; p-value 0.05 − 0.01 *: p-value < 0.01 **: ANC; antenatal care visit

The Fixed Effect Analysis Result

Bi-variable multilevel logistic regression analysis was done to identify variables for multivariable multilevel logistic analysis and Variable with a p-value less than 0.2 were considered for multivariable analysis.
The combined multilevel logistic regression model (model 4) was the best-fitted model for this data because this model had high likelihood and low deviance and in addition LR test vs. logistic model: chibar2 (01) = 141.94, Prob > = chibar2 = 0.0000 the likelihood ratio test indicates that multilevel logistic regression with individual and community level factors was the best-fitted model to handle the data.

In multivariable multilevel logistic regression analysis individual-level factors such as wealth index ANC visit, and media exposure were found to be significantly associated with the odds of iron supplementation. Whereas, in community factors region, community education and distance to health facilities were significantly associated with iron supplementation.

With adjusting other covariates, women's in Tigray, Afar, Amhara and Dire Dawa regions were 5.35 (AOR = 5.35, 95%CI: 3.73, 7.69), 1.61 (AOR = 1.61, 95%CI: 1.13, 2.28), 2.07 (AOR = 2.07, 95%CI: 1.47, 2.91) and 1.54 (AOR = 1.54, 95%CI: 1.03, 2.33) times higher iron supplementation use than that of women's in Somali region, respectively.

Based on WHO recommendation, women who attended the minimum four ANC visit 3.66 times (AOR = 3.66, 95%CI: 3.21, 417) more likely to take the iron tablet as compared to those who didn't attend minimum requirement ANC visit.

Those mothers who were in poorer, middle and richer wealth quantile categories were 1.33 (AOR = 1.33, 95%CI: 1.15, 1.68), 1.39 (AOR = 1.39, 95%CI: 1.10, 1.63) and 1.42 (AOR = 1.13, 95%CI: 1.131.76) times higher iron supplementation use than that of women's in poorer wealth quantile.

Community educational level of women was significantly associated with iron supplementation use. Women having higher community education 1.31 times [AOR = 1.31, 95%CI, 1.07, 1.59) more likely to take iron supplementation as compared to those lower community education.

The odds of iron tablet use was 1.32 times (AOR = 1.32, 95%CI: 1.16, 1.50) higher among women who hadn't a problem to the distance of health facility as compared to their counterparts.

The odds of iron taking during pregnancy were 1.33 times (AOR = 1.33, 95%CI: 1.15, 1.53) higher among those who had media exposure as compared to their counterparts [Table 3].

**Discussion**

The spatial analysis in different methods consistently verified hot and cold spot areas of iron supplementation among pregnant women in Ethiopia. The geospatial analysis indicated that Northeast Somali, South Afar, North West Gambela, West and east part of SNNPR and Southwest Oromia regional states were statistically significant hot spot areas for iron supplementation (low iron supplementation) during pregnancy and SaT scan analysis identifies significant primary (Most likely clusters) in southwest Somali and central part of Oromia region. The possible justification could be is the variation in ANC utilization across regions. Lowest ANC utilization rate was reported in hot spot areas as compared to cold spot areas (21). This could be attributed to the discrepancy in the distribution of maternal health service,
and inaccessibility of infrastructure in the border areas of Somali, and Benishangul regions (24). These regions are also relatively rural and they couldn't access health facilities and women may not have awareness about the iron supplementation program and its benefit during their pregnancy as well. In Different studies also evidence showed that in Somali, Hareri, and Afar regions the prevalence of anemia among reproductive age women were high (19, 25). This makes pregnant women who were live in this regions may not get special consideration during iron supplementation due to lack of resources.

The cold spot clusters are aggregated in Tigray, North part of Amhara, East part of Addis Ababa, North West Hareri regional state of Ethiopia. The justification could be these regions are urban as compared to the hotspot areas. They have good access to the health facilities and mothers may have awareness of the iron supplementation program and its benefits compared to other regions. ANC is one of the major contributing factors to dispense iron tablets for pregnant women. In this study women who had 4 + times, ANC visit had higher odds to receive an iron tablet as compared to those women who had 0–3 visits.

According to multilevel multivariable logistic regression ANC visit, community women's education, region, media exposure, household wealth index and distance to health facility were determinants of iron supplementation use among pregnant women in Ethiopia.

ANC visit has significantly associated with iron supplementation among pregnant women. Pregnant women having a minimum of four ANC visit more than three times taking iron tablets as compared to who hadn't minimum ANC visit. This study is supported by a study done in Ethiopia (15), Tanzania (26), Senegal (17), Pakistan (27), and India (16). The possible justification could be mothers who had adequate ANC visits (four and above 4+) may have information about the importance of iron supplementation and may have a positive attitude towards maternal health services like preterm birth and low birth weight. ANC visit creates a good suitable condition to increase frequent interaction between pregnant mothers and health providers and in every visit pregnant mother's hemoglobin level should be monitored routinely. Hence health providers can disseminate key information regarding the benefits of iron tablets during pregnancy.

Community women's education is one of the important factors for iron supplementation among pregnant women. The odds of having an iron tablet 1.3 times higher among women had higher community education as compared to lower community education. This study was similar to the study done in India (16), Pakistan (27), and Senegal (28). This might be due to education is a vital tool to highly enhance pregnant women about the consequence of iron deficiency and show the ways how to handle these deficiencies from different sources. This indicates educated pregnant women have a great ability to stick to maternal health services like iron supplementation during pregnancy which is a very important service for fetal growth and development as well as to keep the health status of mothers (29–31).

Media exposure is also one of the very important factors of iron supplementation among pregnant women. Pregnant women who were exposed to media 1.33 times more likely taking iron tablets as compared to their counterparts. This study was supported by a study done in Asia (32). Media might help to be aware more likely to take iron tablets during pregnancy and ANC attended. Different maternal health
services including the purpose of Iron taking during pregnancy was given for the community in different Media. Therefore, pregnant women who exposed to media would have a better understanding of the benefits of taking iron tablets.

The region was significantly associated with iron supplementation among pregnant women. Pregnant women in Tigray, Afar, Amhara, and Dire Dawa regions were 5.35, 1.6, 2 and 1.5 times taking an iron tablet as compared to the Somali region. This might be due to the variation of ANC visit across the country, higher ANC visit was observed in these regions whereas the lowest ANC visits in the Somali region (21). This is the fact that ANC visit is the major route to deliver iron supplementation for pregnant women in Ethiopia. That is why pregnant mothers in Tigray, Afar, Amhara, and Dire Dawa regions had better iron supplementation than the Somali region.

The household wealth index is another important factor of iron supplementation among pregnant women. Mothers who were in poorer, middle and richer wealth quantile categories were nearly 1.4 times taking iron supplementation as compared in the poorest wealth quantile. This study is similar to a study done in Senegal (28). This is the fact that access to health services utilization in Ethiopia mainly depends on out of pocket payment (33). Though the services for ANC are exempted, women are expected to pay for medication and other transportation costs contribute to the high cost of pursuing care and may discourage women from utilizing maternal health services.

Distance to a health facility is significantly associated with iron supplementation among pregnant women. The odds of having taking iron tablets was 1.3 times higher among women who hadn't a problem to the reach health facility as compared to their counterparts. The possible reason could be that pregnant women, especially from urban areas are expected to travel the short distance to reach health facilities and transport issues like money, may not be a big problem for those women to go health facilities. Due to this reason, they are motivated to attend any maternal health services like ANC which leads to pregnant women have awareness about iron supplementation and taking iron tablets more than their counterparts.

The limitation of this study is the possibility of constraining recall bias and shares the limitation of cross-sectional study like doesn't show a temporal relationship.

**Conclusion**

This study investigated that spatial clustering of poor iron supplementation among pregnant women was Northeast Somali, South Afar, North West Gambela, West and east part of SNNPR and Southwest Oromia regions. In this area especially in Somali and Afar the prevalence of anemia among reproductive age women were high (19) and in this study have poor iron supplementation among pregnant women so should be given priority for this regions for the better intervention.

In multivariable multilevel logistic regression analysis Community education, household wealth index, ANC visit, region, media exposure, distance to a health facility, and were significant predictors of iron
supplementation use among pregnant women. To enhance iron supplementation use among pregnant women should be targeted on this identified factors. Particular, different interventions programs need to be prioritized on ANC, education and importance of mass media. To enhance maternal health services about iron tablets for pregnant women should be promote using different mass Medias.

**Abbreviations**

AIC  
Akaike information criteria  
ANC  
Antenatal Care  
AOR  
Adjusted Odds Ratio  
BIC  
Bayesian information criteria  
COR  
Crude Odds Ratio  
EDHS  
Ethiopian Demographic health survey  
ICC  
Intra-Class Correlation  
MOR  
Median Odds Ratio  
PCV  
Proportional Change in Variance

**Declarations**

**Ethics approval and consent to participate**

We were get permission letter for data access was obtained from major demographic and health survey through the online request from http://www.dhsprogram.com. The IRB-approved procedures for DHS public-use datasets do not in any way allow respondents, households, or sample communities to be identified. There are no names of individuals or household addresses in the data files. The geographic identifiers only go down to the regional level (where regions are typically very large geographical areas encompassing several states/provinces). Each enumeration area (Primary Sampling Unit) has a PSU number in the data file, but the PSU numbers do not have any labels to indicate their names or locations. In surveys that collect GIS coordinates in the field, the coordinates are only for the enumeration area (EA) as a whole, and not for individual households, and the measured coordinates are randomly displaced within a large geographic area so that specific enumeration areas cannot be identified.
Consent for publication

It is not applicable

Availability of Data and Materials

As you know this is research paper done based on EDHS 2016 perspective secondary data so you can get relevant data from DHS or and we can upload when you request us the all the relevant information

Competing interest

All authors declare that they have no competing interest final content of the manuscript.

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Author’s Contribution

DC, MA, and AG was involved in the design and conception of the study; the analysis and interpretation of the findings and write the manuscript.

AS, YY, ZA, and BA involved in analysis, interpretation and writes up of the manuscript. All the authors read and approved the manuscript.

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**Figures**
Figure 1: Regional prevalence of iron supplementation among pregnant women in Ethiopia, 2016
Regional prevalence of iron supplementation among pregnant women in Ethiopia, 2016

Figure 2: Spatial distribution of Iron supplementation among pregnant women in Ethiopia, 2016

Figure 2

spatial distribution of iron supplementation among pregnant women in Ethiopia, 2016
Figure 3: Spatial autocorrelation of iron supplementation among pregnant women in Ethiopia, 2016 DHS perspective

Spatial autocorrelation for distribution of iron supplementation among pregnant women in Ethiopia, 2016
Figure 4: Cluster and outlier analysis of iron supplementation among pregnant women in Ethiopia.

Figure 4
Figure 5: Hot spot and cold spot identifications of iron supplementation among pregnant women in Ethiopia, 2016.
Figure 6: Kriging interpolation of iron supplementation among pregnant women in Ethiopia, 2016.

**Figure 6**

Kriging interpolation of iron supplementation among pregnant women in Ethiopia, 2016
Figure 7: Spatial Sat Scan analysis of iron supplementation among pregnant women in Ethiopia, 2016

Figure 7

spatial Sat Scan analysis of iron supplementation among pregnant women in Ethiopia