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Geographical disparities and determinants of adherence to iron folate supplementation among pregnant women in Ethiopia: spatial and multilevel analysis of the Ethiopian Mini Demographic and Health Survey of 2019

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ABSTRACT

Objective This study aimed to investigate geographic disparities and determinants of adherence to iron and folate supplementation among pregnant women in Ethiopia.

Method A secondary data analysis was performed using data from the Ethiopian Mini Demographic and Health Survey 2019. A total of 2235 pregnant women aged 15–49 years were included in the analysis. ArcGIS V.10.8 and SaTScan V.9.6 were used for spatial analysis. Multilevel logistic regression analysis was used to determinants.

Result Of the total number of participants, 80.3% of pregnant mothers took iron and folate supplements for less than the recommended days. Adherence to iron folate supplementation among pregnant women in Ethiopia was spatially clustered with Moran's global I=0.15868. The SaTScan analysis identified the most likely significant clusters found in the eastern Tigray, northeast Amhara and northwest Afar regions. Multivariable multilevel analysis showed that mothers who were living apart from their partner (adjusted OR (AOR)=10.05, 95% CI 1.84 to 55.04), had antenatal care (ANC) visits at least four times (AOR=0.53, 95% CI 0.41 to 0.69), a higher education level (AOR=0.39, 95% CI 0.25 to 0.63), big distance from health facilities (AOR=1.7, 95% CI 1.51 to 1.97) were significant factors of adherence to iron-folate supplementation. Mothers living in the Amhara and Addis Ababa regions were 0.35 (AOR=0.35, 95% CI 0.19 to 0.621), and 0.29 (AOR=0.29, 95% CI 0.15 to 0.7) times lower iron-folate supplementation intake than mother's in Tigray region.

Conclusion In this study, 8 out of 10 pregnant women did not take iron and folate supplements during the recommended period. As a result, health education activities were necessary to raise awareness among women and the community about the importance of iron folate supplementation during pregnancy, and public health programmes should increase iron folate supplementation through women's education, ANC visits and mothers living in low-iron areas.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Used large population-based data with a large sample size, which is representative of all regions of the country.
⇒ Combining statistical methods (spatial analysis and multilevel logistics analysis) allowed an understanding of contextual and geographical factors associated with anaemia among women of reproductive age.
⇒ Due to the cross-sectional nature of the data, it was not possible to establish a cause/effect and temporal relationship.
⇒ Dietary intake and behavioural factors were unable to be included in the analysis.
⇒ Those who lived in areas without coordinates (longitude and latitude) were not included in the spatial analysis, which may affect generalisability.

INTRODUCTION

Fundamentally anaemia can be caused by poor health and nutrition status. Nutritional deficiencies like iron, folate, vitamin B12 and vitamin A can cause anaemia.[1] If anaemia is common in pregnant women (40% or more), supplementation should be continued for 3 months after delivery. All severely anaemic women treated with iron-folate received a 2-week follow-up to assess clinical progress, test results and compliance, followed by a 4-week follow-up.[2 3] Micronutrient deficiency is a major cause of morbidity and mortality in children. Micronutrients are found in food and can be obtained through direct supplementation. Breast fed babies benefit from the supplements given to their mothers.[2] Iron-folate supplementation was used to improve maternal and perinatal health by preventing and treating iron deficiency anaemia in women during pregnancy and the postpartum period.[4,5]

Iron deficiency anaemia is the most common micronutrient deficiency worldwide, affecting more than 2 billion people. It contributes to low birth weight, decreased resistance to infection, poor cognitive development and decreased work capacity. Pregnant and postpartum women, as well as children, are generally the most affected groups.[6,7] It is very common in low-income and middle-income countries where, in addition to poor nutrition, parasitic and bacterial infections can contribute to iron depletion. Iron folate promotes the growth of maternal and fetal tissues as well as the expansion of a pregnant woman's blood volume.[8–10]

During the first 4 weeks of pregnancy, the WHO recommends that all pregnant women receive standard care. As early as possible in the first trimester of pregnancy, start taking 30–60 mg of iron and 400 µg of folic acid.[11] As a result, national guidelines for the control and prevention of micronutrient deficiencies in Ethiopia emphasise the importance of daily iron supplementation for at least 6 months during pregnancy and 3 months after delivery.[12] Women are said to be adhering to an iron/folic acid supplement if they have taken 65% or more of the supplement, which is equivalent to taking the supplement at least 4 days per week.[13] Many factors hinder the use of oral iron and folate supplements, including poor adherence to regimens, frequent side effects, gastroenteritis, inadequate tablet supplies and a lack of guidance from healthcare professionals.[12,13] In pregnant women, experts suggest a solution that requires 1000 mg of iron per day for the mother and fetus during pregnancy based on the use of tablets, possible side effects, misusing antenatal care (ANC) services and not knowing how to use iron folate tablets.[12,14,15]

According to the report of the Demographic and Health Survey of 22 low-income and middle-income countries, 81% of all pregnant women received iron folic acid (IFA) tablets. Only 8% of those who received IFA tablets consumed 180 or more AFI (Iron folic acid) tablets.[16] The overall prevalence of 90-day adherence to iron supplementation during pregnancy in sub-Saharan African countries was 28.7%.[17] The consumption of foods rich in iron and folate among Ethiopian children remains low. The percentage of women taking iron supplements for 90 days or more has increased from 5% in 2016 to 11% in 2019, but remains below the recommended level. During the same period, the percentage of women not taking iron supplements dropped from 58% to 40%.[18,19] According to the 2019 Ethiopian Mini Demographic and Health Survey (EMDHS), 40% of women who had a child in the previous 5 years did not take iron tablets during their most recent pregnancy. Only 11% of women took iron supplements for 90 days or more.[19]

Therefore, in Ethiopia, iron-folate supplementation is one of the strategies provided to all pregnant women during pregnancy and iron supplementation coverage during pregnancy is still low and does not meet WHO standard recommendations. Therefore, it would be essential to identify regional variation in iron-folate supplementation and its determinants in high-risk groups, such as pregnant women, for evidence-based intervention. Consequently, this study aimed to investigate geographic disparities and the determinants of adherence to iron-folate supplementation among pregnant women in Ethiopia based on data from the 2019 EMDHS.

METHODS

Study design, setting and periods

Data for this study were obtained from secondary data analysis based on the EMDHS 2019 and access data from the official database of the DHS programme (https://dhsprogram.com/). It is the second mini demographic and health survey conducted in Ethiopia from March to June 2019. All women age 15–49 who were usual members of the selected households and those who spent the night before the survey in the selected households were eligible to be interviewed in the survey. The survey was carried out in nine Ethiopian regional states, namely Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, Southern Nations Nationalities and Peoples (SNNP), Gambela and Harari, as well as two city administrations (Addis Ababa and Dire Dawa). Then reviewing the account permission was given via email. A cross-sectional study design using secondary data from 2019 intermediate Ethiopian demography and health survey was conducted.

Sample and populations

The 2019 EMDHS is the second EMDHS in the country and the fifth DHS. The survey used a nationally representative sample to provide estimates at the national, regional and urban/rural levels. On a nationally representative sample of 8663 families, the survey interviewed 8855 women of reproductive age (age 15–49). The basic characteristics of the respondents, determinants of fertility, marriage, knowledge and use of family planning methods, infant feeding practices, infant nutritional status, infant mortality and height and the weight of babies from 0 to 59 months have been extensively studied. The DHS samples are separated by region, as well as by urban or rural areas within each region. Initially, the enumeration areas (EAs) was selected from each stratum using a proprietary scale. As a result, the sample was stratified and chosen in two stages.[19]

A total of 305 EAs were chosen for the survey (93 in urban areas and 212 in rural areas) with probability proportional to the size of the AE and with independent selection in each sampling stratum. Second, from the newly created list of families, a fixed number of 30 families per group was chosen with a systematic selection of equal probability.[19]

In EMDHS 2019, a total of 9150 households were selected for the sample. Of the 8794 employed families, 8663 were successfully interviewed, obtaining a response rate. A total of 8885 interviews were completed with women out of a total of 9012 eligible women, resulting in a 99% response rate. Overall, there was little variation in response rates by residence; however, the rates were slightly higher in rural than in urban areas.[19] This study included 2235 pregnant women who had received iron-folate supplements and asked how many days they consumed iron tablets/syrups during their most recent pregnancy.

Measurement of variables

Dependent variable

Our outcome variable was the adherence to iron/folate supplementation during pregnancy, split into pregnant women adhering to iron folic acid supplementation (IFAS) (women who took iron tablets/syrups during their most recent pregnancy for 90 days or more) coded as '0' and pregnant women who did not adhere to IFAS (women took iron tablets/syrups during their most recent pregnancy for less than 90 days) coded as '1'.

Independent variable

To assess the adherence to iron/folate supplementation among pregnant women in the country, explanatory variables were used at the individual and community levels.

Individual-level independent variables include maternal sociodemographic factors, maternal health service and related factors, and child factors.

1. *Sociodemographic factors* such as maternal age, age of household, sex of household head, maternal education, marital status, religion, family size, media exposure, wealth quantile.
2. *Maternal health service and related factors* such as parity, ANC visits, distance from health facilities
3. *Child-related factors* such as total children ever born, birth interval.

Community-level independent variables

Community-level factors in this study were residence and contextual regions.

Data collection procedures

This study was done based on the 2019 EMDHS, which was accessed from the official database of the DHS programme (https://dhsprogram.com/). Online registration and applications were done to grant permission for the use of these data sets. Geographic coordinate (longitude and latitude) data were taken at EAs/cluster level.

Data management and analysis

The STATA V.14 software was used to generate descriptive and summary statistics. STATA V.14, ArcGIS V.10.8 and SaTScan V.9.6 were used in the analysis.

Spatial autocorrelation and hot spot analysis

Spatial autocorrelation (Global Moran's I) is a statistic used to assess spatial heterogeneity in iron/folate supplementation adherence among pregnant women. Moran's I values close to −1 indicate dispersed adherence to iron/folate supplementation, close to +1 indicates clustered adherence and Moran's I values 0 indicate randomly distributed adherence.[20] A statistically significant Moran I value ($p<0.05$) had the potential to reject the null hypothesis, indicating the presence of spatial autocorrelation. In addition, incremental spatial autocorrelation was used to determine the distance band where the spatial processes that promote clustering were the most pronounced. Hot spot analysis (Getis-Ord Gi* statistic), z-scores and significant p values provided features with hot or cold spot values for the clusters spatially.[21]

Spatial interpolation

For unsampled areas of the country, the spatial interpolation technique was used to predict adherence to iron/folate supplementation among pregnant women. We used geostatistical empirical Bayesian Kriging spatial interpolation techniques with ArcGIS V.10.8 software to predict unsampled EAs. Empirical Bayesian kriging relaxes the assumption that the observed semivariogram in the input data has a Gaussian distribution, which rarely holds in practice. Bayes' rule was used to determine the weight of the new simulated semi-variogram.[22]

Spatial scan statistics

Using Kuldorff's SaTScan V.9.6 software, we used Bernoulli-based model spatial scan statistics to determine the geographical locations of statistically significant clusters for poor iron/folate supplementation adherence among pregnant women.[23] The scanning window that moves throughout the study area, with pregnant women with low iron/folate supplementation intake as cases and those with adequate intake as controls to fit the Bernoulli model. The default maximum spatial cluster size of less than 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. The most likely clusters were identified using p values and log-likelihood ratio (LLR) tests based on 999 Monte Carlo replications.

Multilevel mixed-effects logistic regression analysis

As a result of the hararichial nature of the EMDHS dataset, the observations within the cluster are correlated (dependent), which violates the independence assumption.[24] The intraclass correlation (ICC) value identifies the correlation within the cluster. The following formula was used to calculate the ICC, which is a measure of the variability within the cluster and between individuals within the same cluster: $ICC = \frac{V_A}{V_A+\frac{\pi^2}{3}} = \frac{V_A}{V_A+3.29}$, where V_A is the estimated variance in each model described elsewhere.[25] At each model, the total variation attributed to factors at the individual or community level was measured using a proportional change in variance (PCV) calculated as: $PCV = \frac{V_A-V_B}{V_A}$, where V_A=variance of the initial model and V_B=variance of the model with more terms.[26] The MOR is the median OR that compares two people from two different randomly chosen clusters and measures unexplained cluster heterogeneity, as well as variation between clusters by comparing two people from two different randomly chosen clusters. It was determined using the following formula: $MOR = \exp(\sqrt{2 \times V_A \times 0.6745}) \approx \exp(0.95\sqrt{V_A})$, where V_A is the cluster level variance. The MOR measure is always greater than or equal to 1. If the MOR is 1, there is no variation between clusters.[27] To identify community and individual level factors associated with pregnant women taking iron-folate supplementation, multilevel models were fitted. The first model (model I or the empty model) lacked explanatory variables. Instead, it was fitted to decompose total variance into individual and community-level components. The second model included individual-level factors. Household level factors were included in the third model. Community-level factors were included in the fourth model. Finally, the fourth model included individual and community-level factors. The deviance information criteria, Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) were used to compare models (BIC).[28]

Patient and public involvement

No patients or public were involved in this study.

RESULT

Sociodemographic characteristics of pregnant mother

This study included 2235 currently pregnant women ranging in age from 15 to 49 years and taking iron-folate supplementation during pregnancy at the time of the survey. Of the total number of pregnant mothers; 1222 (54.7%) were between the ages of 20 and 29 years old, 1530 (68.5%) lived in rural areas, 2050 (91.7%) had gotten married, 943 (42.2%) had not attended formal education, 1588 (71.1%) had delivered at a health institution and 423 (18.9%) had the poorest wealth index. However, the majority, 1319 (59%) of the mothers had four or more follow-ups of ANC during the index pregnancy. In terms of media exposure, 1553 (69.5%) had no media exposure to the iron-folate supplementation intake for the recommended period. Around 1668 (74.6%) of all respondents were mothers with at least one[1–4] child. Similarly, the adherence to iron-folate supplementation was 1776 (79.5%) and 874 (39.1%) among pregnant mothers with a male house head and mothers with a husband aged 30–39, respectively (table 1).

Incremental spatial autocorrelation

A peak in the graph represents the distance at which the clustering is most pronounced. The statistical significance of the z-score values is indicated by the colour of each point on the graph. The incremental spatial autocorrelation showed that with 10 distance bands starting at 319.64 km, the adherence to iron-folate supplementation among pregnant women clustered at 319.64 km. A significant z-score (14.435773) indicates that the spatial

Table 1 Sociodemographic and economic characteristics of pregnant mothers in 2019 Ethiopian Mini Demographic and Health Survey (N=2235)

Predictor variables with categories	Frequency (n=2235)	Percentage
Region		
Tigray	281	12.6
Afar	180	8.1
Amhara	281	12.6
Oromia	259	11.6
Somalia	57	2.6
Benishangul	212	9.5
SNNPR	240	10.7
Gambela	175	7.8
Harari	202	9
Addis Abeba	167	7.5
Dire Dawa	181	8.1
Residence		
Urban	705	31.5
Rural	1530	68.5
Religion		
Orthodox	884	39.6
Protestant	402	18
Muslim	919	41.1
Others	30	1.3
Current marital status		
Single	37	1.7
Married	2050	91.7
Widowed	18	0.8
Divorced	86	3.8
Separated	44	2
Wealth quantile		
Poorest	423	18.9
Poorer	384	17.2
Middle	364	16.3
Richer	353	15.8
Richest	711	31.8
Education level of mother		
No education	943	42.2
Primary	827	37
Secondary	290	13
Higher	175	7.8
Age of mother		
15–20 years	120	5.4
20–29 years	1222	54.7
30–39 years	741	33.2
40–49 years	152	6.8

Continued

Table 1 Continued

Predictor variables with categories	Frequency (n=2235)	Percentage
Family size		
1–4	800	35.3
5–9	1333	59.6
≥10	102	4.6
Parity		
1–4	1668	74.6
5–9	531	23.8
≥10	36	1.6
Gravidity (total children ever born)		
1–4	1597	71.5
≥5	638	28.5
ANC visit		
0–3 times	916	41
≥ 4 times	1319	59
Birth interval		
1–2 years	1017	45.5
3–4 years	580	26
≥5 years	638	28.5
Distance from health facilities		
Not-big problem	647	28.9
Big problem	1588	71.1
Sex of household head		
Male	1776	79.5
Female	459	20.5
Media exposure		
Not have exposure	1553	69.5
Had exposure	682	30.5
Age of household head		
15–19	17	0.8
20–29	526	23.5
30–39	874	39.1
39+	818	36.6

ANC, antenatal care; SNNPR, Southern Nations Nationalities and Peoples Region.

clustering of iron-folate supplementation adherence was most pronounced at 319.64 km distance (figure 1).

Spatial pattern of poor adherence to iron-folate supplementation among pregnant women

The spatial distribution of adherence to iron and folate supplementation among pregnant women in Ethiopia was clustered with Global Moran's I=0.15868 (z-score=9.38047, p value 0.001). This demonstrated the presence of spatial hotspot and cold spot clustering in Ethiopian regions. With a z-score of 9.38047, there was less than a 1% chance that this high-clustered pattern was due to random chance. The tails' bright red and blue colours indicate a higher level of significance (figure 2).

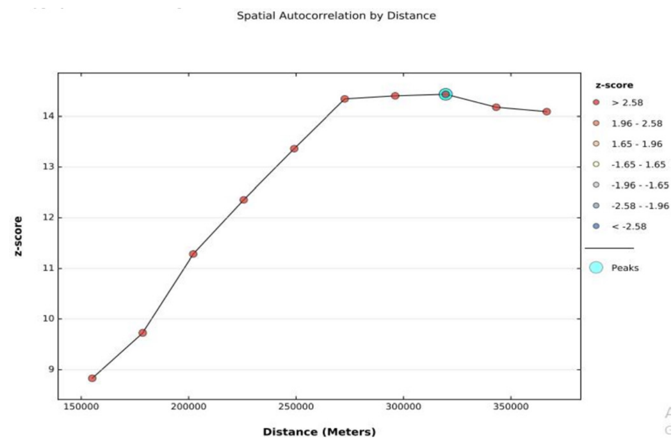

Figure 1 Incremental spatial autocorrelation analysis of poor adherence to iron-folate supplementation among pregnant women in Ethiopia, 2019 Ethiopian Mini Demographic and Health Survey.

Hot spot analysis (Getis-Ord-Gi*) of poor adherence to iron-folate supplementation among pregnant women

Significant hotspot areas (areas with low iron-folate supplementation intake below the recommended period) were identified in the Getis Ord Gi*statistical analysis in the regional states of Tigray, northern Amhara and north-western Afar. The significant cold spot areas (areas with high adherence to iron folate supplementation) were found in eastern Oromia, central and northern Somalia, southern Afar, Harari and Dire Dawa regional states (figure 3).

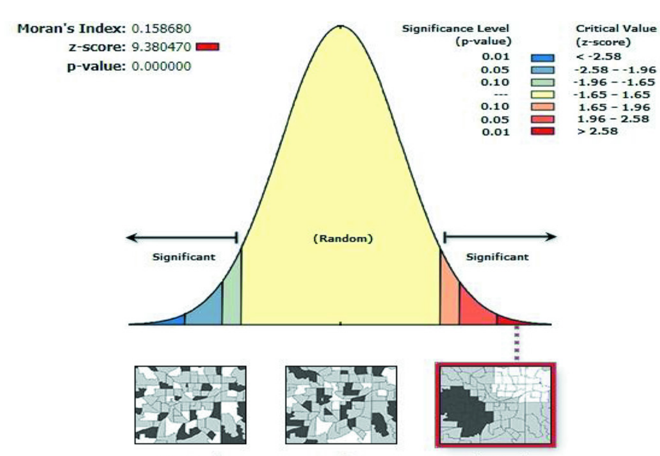

Figure 2 Spatial autocorrelation analysis poor adherence to iron-folate supplementation among pregnant women in Ethiopia, 2019 Ethiopian Mini Demographic and Health Survey. Given the Z-score of 9.38046964797, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

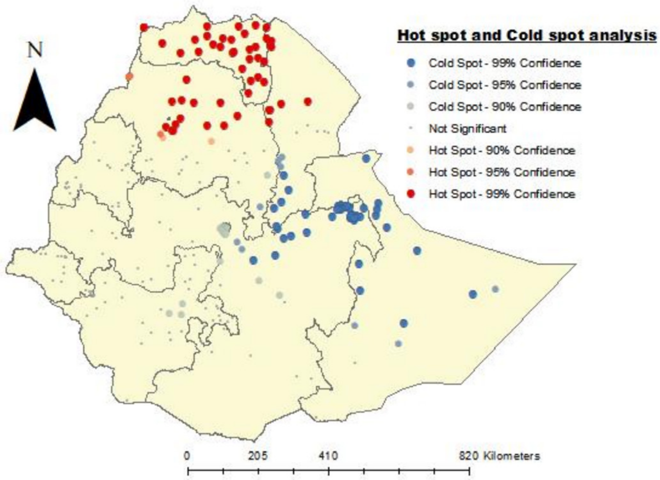

Figure 3 Hot spot analysis of poor adherence to iron-folate supplementation among pregnant women in Ethiopia, 2019 Ethiopian Mini Demographic and Health Survey.

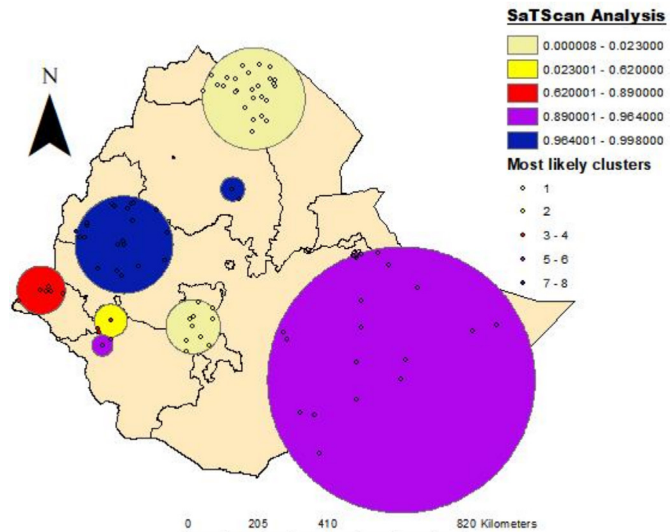

Figure 4 SaTScan analysis for poor adherence to iron-folate supplementation among pregnant women in Ethiopia, 2019 Ethiopian Mini Demographic and Health Survey.

Spatial SaTScan analysis of poor adherence to iron-folate supplementation among pregnant women

Spatial scan statistics revealed a total of 36 significant clusters, 26 of which were primary clusters (most likely). Primary clusters were found in the eastern Tigray, north-eastern Amhara and northwest Afar regions, was centred at (13.476454N, 39.457342E)/150.73 km, with a relative risk (RR) of 1.17 and an LLR of 17.37 with p value <0.0001. It was discovered that pregnant women who lived within the most likely cluster were 17% more likely vulnerable to poor adhering to iron-folate supplementation than women who did not live within the spatial window (table 2 and figure 4).

Spatial interpolation of poor adherence to iron-folate supplementation among pregnant women

Empirical Bayesian interpolation shows predicted risk areas, and pregnant mothers living in these areas were more likely to have a low iron-folate supplementation intake below the recommended period. In the first panel, Tigray, northern Amhara and northwestern Afar were predicted to be more dangerous areas than other regions. Afar, southern and eastern Oromia, SNNP, Gambela, Benishangule Gumuz, Harari and western Somalia were identified as risk areas (figure 5).

Multilevel logistic regression analysis for determinant factors associated with iron-folate supplementation adherence among pregnant women

Random-effects measures of variation

The results of the random effects revealed a statistically significant variation in the adherence to iron-folate supplementation between pregnant mothers in clusters (table 3). The ICC within the null model revealed that community-level variability accounted for 13.3% of the variability in iron-folate supplementation. Additionally, the null model's MOR of 1.96 indicates that there was variation in iron-folate supplementation adherence between clusters. When pregnant mothers were randomly selected from two different groups, those in the cluster with the highest iron-folate supplementation had 1.96 times the odds of adhering to iron-folate supplementation than those in the group with lower iron-folate supplementation. Furthermore, as demonstrated by PCV in the final model, both individual and community factors explained approximately 48% of the variability in iron-folate supplementation.

Table 2 Significant SaTScan spatial scan clusters of adherence to iron-folate supplementation among pregnant women in Ethiopia, 2019 mini Demographic and Health Survey

Most likely clusters	Significant enumeration areas (clusters) detected	Population (n)	Cases (n)	RR	LL	Coordinates/radius	P value
Primary	5, 25, 17, 23, 3, 36, 14, 2, 24, 20, 38, 27, 35, 16, 11, 19, 37, 13,18, 12, 10, 15, 39, 7, 1, 9	297	273	1.17	17.37	(13.476454N, 39.457342E)/ 150.73 km	<0.0001
Secondary	180, 179, 177, 178, 189, 203, 176, 184, 190, 205	80	77	1.21	9.2	(7.415238N, 37.827222E)/80.08 km	0.023

LL, log-likelihood; RR, relative risk.

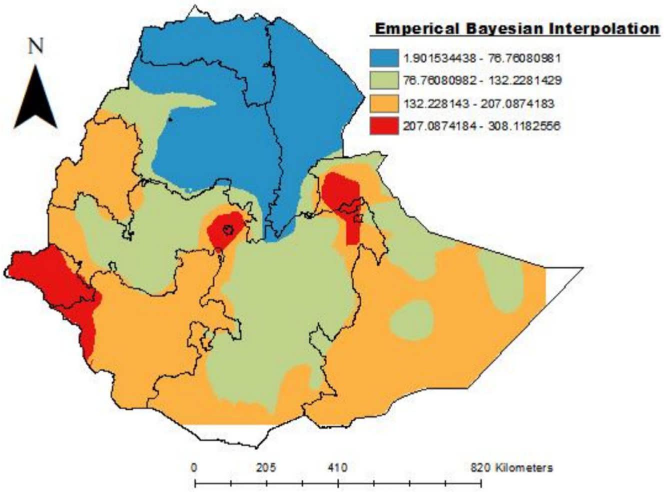

Figure 5 Empirical Bayesian interpolation of poor adherence to iron-folate supplementation among pregnant women in Ethiopia, 2019 Ethiopian Mini Demographic and Health Survey.

Fixed effect analysis results

Individual level factors

The results of the multivariable multilevel binary logistic regression model both individual and community-level variables were summarised in table 4. The model comparison result revealed that model III is a better fit for the data as compared with other reduced models, since it has the smallest AIC, BIC and deviance statistic (table 3). In this model, all factors at the individual and community levels are included (table 4). Individual-level factors such as women's marital status of women, ANC visits, women's education and distance from the health facility were found to be significantly associated with iron-folate supplementation intake during pregnancy.

When compared with married mothers, the odds of failing to take iron-folate supplements for the recommended period were 10.05 times higher among mothers who lived apart from their partner (adjusted OR (AOR)=10.05, 95% CI 1.84 to 55.04). Mothers who attended the minimum four ANC visits recommended by WHO were nearly four times most likely to take iron-folate supplementation for the recommended period than those who did not attend the minimum recommended ANC follow-ups during the index pregnancy (AOR=0.53; 95% CI 0.41 to 0.69). Pregnant women with a higher level of education were more likely to follow iron-folate supplementation than pregnant women without education (AOR=0.39, 95% CI 0.25 to 0.63). In terms of perceived distance from health facilities, mothers who perceived distance from health facilities were 1.7 (AOR=1.7, 95% CI 1.51 to 1.97) times less likely to follow iron-folate supplementation than pregnant women who did not perceive distance from health facilities (table 4).

Community-level factors

Among the community-level covariates, region was significantly related to iron-folate supplementation. Pregnant mother's in Afar, Amhara, Oromia, Benishangul-Gumuz, Gambelia, Harari, Dire Dawa and Addis Ababa regions were 0.41 (AOR=0.41, 95% CI 0.19 to 0.87), 0.35 (AOR=0.35, 95% CI 0.19 to 0.621), 0.35 (AOR=0.35, 95% CI 0.183 to 0.663), 0.48 (AOR=0.48, 95% CI 0.25 to 0.94), 0.36 (AOR=0.36, 95% CI 0.174 to 0.74), 0.29 (AOR=0.29, 95% CI 0.15 to 0.57), 0.35 (AOR=0.35, 95% CI 0.17 to 0.69) and 0.29 (AOR=0.29, 95% CI 0.15 to 0.7) times lower iron-folate supplementation intake below the recommended period than that of pregnant mother's in Tigray region, respectively (table 4).

DISCUSSION

Iron-folate supplements should be given to pregnant women on a regular basis in almost all circumstances.[29] However, iron-folate supplementation during pregnancy is still unpopular in Ethiopia. This study found that 80.3% of pregnant mothers took iron-folate supplements for less than the recommended period (<90 days). This finding outperforms studies conducted in 22 sub-Saharan African countries (71.3%),[17] Ethiopian (82.9%),[30 31] Ethiopia

Table 3 Measure of variation on individual and community level factors associated with iron folate supplementation adherence among pregnant women in Ethiopia, 2019 Ethiopian Mini Demographic and Health Survey

	Models			
Measure of variation	**Null model**	**Model I**	**Model II**	**Model III**
Community variance (SE)	0.5 (0.133)	0.4 (0.12)	0.274 (0.101)	0.26 (0.1032)
ICC (%)	13.3	10.75	7.7	7.3
PCV (%)	1	20	45.2	48
MOR	1.96	1.824	1.644	1.623
Model fit statistics				
−2*LL (DIC)	2183.68	2080.35	2126.75	2043.376
AIC	2187.669	2144.35	2152.75	2129.376
BIC	2199.093	2327.133	2227.004	2374.992

AIC, Akaike's information criterion; BIC, Bayesian information criterion; DIC, deviance information criteria; ICC, intraclass correlation; MOR, median OR; PCV, proportional change in variance.

Table 4 Multivariate multilevel logistic regression analysis of individual and community-level factors associated with adherence to iron and folate supplementation among pregnant women in Ethiopia, 2019 Ethiopian Mini Demographic and Health Survey

Individual and community level variables	Models			
	Null model	Model I	Model II	Model III
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Region				
Tigray			1	1
Afar			0.51 (0.27 to 0.982)*	0.41 (0.19 to 0.87)*
Amhara			0.39 (0.22 to 0.685)**	0.35 (0.19 to 0.621)***
Oromia			0.37 (0.21 to 0.65)**	0.35 (0.183 to 0.663)**
Somalia			0.99 (0.36 to 2.75)	0.76 (0.25 to 2.28)
Benishangul			0.42 (0.23 to 0.771)**	0.48 (0.25 to 0.94)*
SNNPR			1.2 (0.61 to 2.36)	1.1 (0.52 to 2.32)
Gambela			0.42 (0.22 to 0.78)**	0.36 (0.174 to 0.74)*
Harari			0.31 (0.12 to 0.571)***	0.29 (0.15 to 0.57)***
Addis Abeba			0.33 (0.17 to 0.65)**	0.35 (0.17 to 0.69)**
Dire Dawa			0.28 (0.15 to 0.51)***	0.29 (0.15 to 0.57)***
Residence				
Urban			1	1
Rural			1.34 (0.97 to 1.85)	0.99 (0.63 to 1.54)
Religion				
Orthodox		1		1
Protestant		0.87 (0.6 to 1.27)		0.87 (0.56 to 1.35)
Muslim		0.7 (0.53 to 0.95)*		0.86 (0.61 to 1.22)
Others		1.57 (0.412 to 5.93)		1.73 (0.45 to 6.7)
Current marital status				
Single		1		1
Married		1.69 (0.697 to 4.09)		1.8 (0.74 to 4.4)
Widowed		2.54 (0.432 to 14.98)		2.83 (0.48 to 16.64)
Divorced		1.4 (0.5 to 3.75)		1.4 (0.51 to 3.88)
Separated		9.44 (1.73 to 51.6)*		10.05 (1.84 to 55.04)*
Wealth quantile				
Poorest		1		1
Poorer		1.27 (0.823 to 1.94)		1.31 (0.84 to 2.042)
Middle		0.86 (0.56 to 1.31)		0.89 (0.57 to 1.37)
Richer		1.53 (0.96 to 2.44)		1.57 (0.97 to 2.52)
Richest		1.01 (0.66 to 1.56)		1.27 (0.74 to 2.2)
Education level of mother				
No education		1		1
Primary		0.83 (0.61 to 1.12)		0.83 (0.614 to 1.13)
Secondary		0.74 (0.49 to 1.12)		0.74 (0.49 to 1.13)
Higher		0.38 (0.24 to 0.62)***		0.39 (0.25 to 0.63)***
Age of mother				
15–20 years		1		1
20–29 years		0.95 (0.53 to 1.72)		0.9 (0.5 to 1.6)

Continued

Table 4 Continued

Individual and community level variables	Models			
	Null model	Model I	Model II	Model III
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
30–39 years		0.91 (0.47 to 1.76)		0.87 (0.45 to 1.68)
40–49 years		0.85 (0.38 to 1.92)		0.83 (0.37 to 1.89)
Family size				
1–4		1		1
5–9		1.11 (0.81 to 1.52)		1.13 (0.82 to 1.55)
≥10		1.15 (0.61 to 2.16)		1.15 (0 .61 to 2.15)
Parity				
1–4		1		1
5–9		1.05 (0.56 to 1.993)		1.02 (0.55 to 1.92)
≥10		0.98 (0.38 to 2.49)		0.98 (0.39 to 2.5)
Gravidity (total children ever born)				
1–4		1		1
≥5		1.22 (0.62 to 2.4)		1.14(0.59 to 2.23)
ANC visit				
0–3 times		1		1
≥ 4 times		3.35 (2.41 to 4.7)***		0.53 (0.41 to 0.69)***
Birth interval				
1–2 years		1		1
3–4 years		1.04 (0.74 to 1.47)		0.98 (0.69 to 1.4)
≥5 years				
Distance from health facilities				
Not Big problem		1		1
Big problem		0.72 (0.53 to 0.991)*		1.7 (1.51 to 1.97)*
Sex of household head				
Male		1		1
Female		1.2 (0.83 to 1.61)*		1.16 (0.83 to 1.63)
Media exposure				
Not have exposure		1		1
Had exposure		1.01 (0.79 to 1.29)		1.03 (0.8 to 1.31)
Age of household head				
15–19		1		1
20–29		0.9 (0.21 to 3.74)		0.98 (0.24 to 4.05)
30–39		0.8 (0.18 to 3.34)		0.87 (0.21 to 3.7)
39+		0.77 (0.18 to 3.35)		0.86 (0.201 to 3.69)

*Significant at p value<0.05; **p value<0.01; ***p value <0.001.
ANC, antenatal care; AOR, adjusted OR; SNNPR, Southern Nations Nationalities and Peoples Region.

Demographic and Health Survey report (57.9%),[18] Kenya (67.3%),[31 32] Simada District, Northwest Ethiopia (67.6%),[30] Afar region, northeast Ethiopia (77%)[33] and Khartoum, Sudan (34.6%).[34] Though, this finding is lower than that of studies conducted in eight rural districts of Ethiopia (96.5%),[35] Ethiopia (87.6%)[36] and Northern Ethiopia (89.5%).[37] The physiological requirement for iron during pregnancy is one of the public health challenges that most low-income and middle-income country diets cannot meet.[38 39] The disparities could be explained by differences in the quality of service delivered in the facility over time, sociocultural barriers, women's compliance with the service and women's awareness of the importance of iron-folate supplementation intake for recommended period during pregnancy. Furthermore, differences in access to healthcare facilities and the availability of iron-folate supplementation in nearby health institutions may contribute to these variations. Furthermore, there may be a misunderstanding of the need to take the iron-folate tablets throughout pregnancy due to inadequate counselling and beliefs against consuming medications during pregnancy; that is, the medications may cause too much blood or a large baby, making delivery more difficult.

According to the spatial analysis, the spatial distribution of iron-folate supplementation adherence among pregnant women varied significantly across the country. Significant hotspot areas with low iron-folate supplementation intake below the recommended period were found in the regional states of Tigray, northern Amhara and northwestern Afar and the SaTscan analysis identifies significant primary (most likely clusters) clusters in the regions of eastern Tigray, northeastern Amhara and northwestern Afar. This finding is consistent with previous studies in Ethiopia.[29 39] The possible reason could be that the lowest ANC usage rate was reported in hot spot areas as opposed to cold spot areas covered by the country's lowest ANC service usage in the country's border areas. Another possibility is that in the hot spot regions, the majority of the population lives in rural areas, and the pregnant mother may not receive information from the health centre, and mothers in rural areas are likely to be less educated than those in urban areas, which may have contributed to the lower level than the regional level.

In the current study, one of the important factors for iron-folate supplementation intake below the recommended period among pregnant women is women's education. Pregnant mothers with a higher level of education are more likely to take iron-folate supplements for recommended period than those with no education. This study's findings are similar to those of previous studies in Ethiopia,[40] Pakistan,[41] Senegal,[42] India.[43] This might be because education is a critical tool for increasing pregnant mother's knowledge of the consequences of iron deficiency and demonstrating how to deal with these deficiencies. This means that educated pregnant women are better able to take advantage of maternal health services such as iron-folate supplementation during pregnancy. Furthermore, it is possible that education would increase women's access to information through reading and understanding the benefit of the supplement.

According to this study, women who had four or more ANC visits were 47% times more likely to have iron-folate supplementation intake for recommended period than women who had fewer than four ANC visits. Attending WHO-required ANC (at least four times) was linked to a higher intake of iron-folate during pregnancy. Other studies have found that taking iron tablets during pregnancy is associated with an increased number of ANC visits.[17 33 36 40 44–46] Aside from the fact that more ANC visits mean more interaction with a health provider, this could be because when mothers attended ANC frequently, their haemoglobin level could be continuously monitored. Pregnant mothers should be informed about the signs of complications and tested for them at all ANC visits. This enables the mother to receive iron tablets based on her haemoglobin level. Also, early registration for ANC services may have resulted in greater concern for their pregnancy and more ANC visits, which in turn leads to better medical advice and ultimately, increased knowledge about anaemia, iron and folic acid supplementation.[47]

Women who perceived a short distance to a health facility had a higher likelihood of adherence to iron-folate supplementation than women who perceived a long distance to a health facility. This result was confirmed by other studies.[40 45 48 49] This could be due to the fact that women with easy access to healthcare are more likely to use maternal healthcare services such as ANC follow-ups during the index pregnancy. According to women's current marital status was found to have a significant relationship with iron-folate supplementation adherence for the recommended period. Women who lived apart from their partner were more likely than married women to fail to take iron-folate supplements for the recommended period. The reason could be as a result of spouses fare better adhere than separated women because their husbands closely monitor them.[50 51]

The region is also significantly associated with pregnant mothers' adherence to iron-folate supplementation. Pregnant mothers from Afar, Amhara, Oromia, Benishangul-Gumuz, Gambelia, Harari, Dire Dawa and Addis Abeba had higher iron-folate supplementation intake than those from Tigray. This could be explained by differences in ANC usage coverage across these regions; for instance, lower ANC visits were observed in the Tigray region compared with other regions.[18 19] This is often the case, as ANC visits are the primary method of delivering iron-folate supplementation to pregnant mothers in Ethiopia. That's why pregnant mothers in Afar, Amhara, Oromia, Benishangul-Gumuz, Gambelia, Harari, Dire Dawa and Addis Ababa had better iron-folate supplementation intake than the Tigray region.

CONCLUSION

The finding of the current study revealed that eight out of ten pregnant women were not adhere iron-folate supplementation intake for the recommended period. The spatial clustering of poor adherence to iron-folate supplementation among pregnant women was found in Tigray, northern Amhara and northwestern Afar regional states. The multivariable multilevel model showed that separate mothers from their partners, four or more ANC visits, women education level, perception of distance to a health facility and region were the significant predictors of iron-folate supplementation intake among pregnant women.

Therefore, health education activity was essential to raise awareness among women and the community about the importance of iron-folate supplementation during pregnancy plus public health programmes should increase iron and folate supplementation through women's education, ANC visits and mothers living in low-iron areas.

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