Exploring Geographical Variation in Iron Supplementation among Ethiopian Women Aged 15 to 49 Who Have Had a Child in the Last Five Years: a Spatial Analysis of the Ethiopian Demographic and Health Survey 2016-2019

Kaleab Tesfaye Tegegne[1*], Eleni tesfaye Tegegne[2], Mekibib Kassa Tessema[3], Teshale Belayneh[1], Berhanu Bifato[1], Kebebush Gebremichael[1] and Belayneh Feleke Weldeyes[1]

[1]Department of Public Health, Hawassa College of Health Science, Hawassa, Ethiopia

[2]Department of Medicine and Health Science, University of Gondar, Gondar, Ethiopia

[3]Department of Oncology, University of Gondar, Gondar, Ethiopia

Corresponding Author*

Kaleab Tesfaye Tegegne
Department of Public Health,
Hawassa College of Health Science,
Hawassa, Ethiopia,
E-mail: kaleabtesfaye35@gmail.com

Received: March 29, 2022, Manuscript No. JBTW-22-58792; **Editor assigned:** Mar 31, 2022, Pre QC No. JBTW-22-58792 (PQ); **Reviewed:** April 14, 2022, QC No. JBTW-22-58792; **Revised:** May 30, 2022, Manuscript No. JBTW-22-58792 (R); **Published:** June 06, 2022, DOI: 10.4172/ 2322-3308.11.4.007

Abstract

Background: Anemia among women of childbearing age is a major public health concern globally, particularly in low and middle-income countries. The most common type of anemia worldwide is nutritional anemia mainly due to iron, foliate, and vitamin B_{12} deficiencies. Iron deficiency anemia is the most common cause of anemia, with over 50% of anemia being due to iron deficiency Designing and evaluating effective intervention programs necessitates investigating regional variations in iron supplementation among women.

As a result, from 2016 to 2019, this study aimed to investigate the regional variance in iron supplementation among Ethiopian women aged 15 to 49 who had a child in the previous five years.

Methods: The Ethiopian Demographic and Health Surveys from 2016 and 2019 were used. To identify geographical risk areas for iron supplementation coverage, researchers used spatial autocorrelation analysis, hotspot analysis, spatial interpolation, and spatial scan statistics. The spatial pattern and significant hotspot locations for iron supplementation among women were investigated using ArcGIS V.10.3 and SaTScan V.10.0 statistical software.

Results: Iron supplementation coverage was spatially clustered in Ethiopia at the regional level (Global Morans=-0.517864 (p=0.033744)). The purely SaTScan spatial analysis identified a total of 7 significant clusters in Ethiopia. The most likely SaTScan cluster of low iron supplementation coverage was identified in Oromia (LLR=164.51, p<0.01) and Somalia (LLR=12.01, p<0.01). In 2016 and the most likely SaTScan cluster of low iron supplementation coverage was identified in Somalia (LLR=82.34, p<0.01), Oromia (LLR=14.10, p<0.01) and SNNPRS (LLR4.81, p<0.01) in 2019 The Space-Time SaTScan analysis identified a total of 3 significant clusters. The most likely SaTScan cluster of low iron supplementation coverage was identified in Oromia (LLR=162.13, p<0.01) and SNNPRS (LLR 3.24, p<0.01) during the period from 2016/6/27-2017/6/28.

Conclusion: Women in the Harar, Dire Dawa, Gambella, Somalia Oromia, and Southern Nation Nationalities and Peoples Regions had a low likelihood of receiving iron supplements.

As a result, when developing efficient Antenatal care strategies to enhance iron supplementation among women to lower the burden of anemia and its effects among pregnant women in Ethiopia, these regions should be considered.

Keywords: Iron supplementation • Spatial analysis

Introduction

Anemia among women of childbearing age is a major public health concern globally, particularly in low and middle-income countries [1,2]. Though anemia is prevalent among pregnant women, it affects women of all age groups. In 2019, anemia prevalence was 29.9% in women of reproductive age, and 36.5% in non-pregnant women of reproductive age globally. The most common type of anemia worldwide is nutritional anemia mainly due to iron, foliate, and vitamin B_{12} deficiencies. Iron deficiency anemia is the most common cause of anemia, with over 50%of anemia being due to iron deficiency [3,4]. Iron deficiency is common in women of reproductive age because of their high demand for iron during pregnancy, lactation, menstrual blood loss, and nutritional deficiencies during their reproductive cycle [5,6].

In Africa, based on the 2019 World Bank Report, about 41% of women of reproductive age are anemic [7]. Based on the 2016 Ethiopian demographic health survey report, 24% of reproductive age group women were anemic, ranging from 16% to 59% across different parts of the country [8]. According to WHO standards, anemia is a severe public health problem in Ethiopia [3,8].

Anemia in women of reproductive has a lot of negative health effects, such as increased susceptibility to infection, loss of productivity due to reduced work capacity, cognitive impairment, stillbirth/miscarriage, and maternal mortality [9,10]. Furthermore, anemia in women of reproductive age can result in poor fetal-neonatal outcomes such as low birth weight, depletion of the iron stores of the newborn, preterm birth, and it may end up with infant/child mortality [9,11,12].

Findings from different studies show that; iron supplementation during pregnancy, educational status of the mother, economic status of the households, sex of household head, maternal age, antenatal care visit, cesarean delivery, history of a terminated pregnancy, maternal occupation, religion, marital status, maternal Body Mass Index (BMI, source of drinking water, parity, place of delivery, current modern contraceptive use, duration of breastfeeding, number of births within the past 5 years, birth interval, region, and place of residence are associated with anemia among women of reproductive age [13-15].

Anemia among women of childbearing age, as indicated in WHO's reports, both in developed and developing nations is remains high. The severity of the problem in deprived countries like Ethiopia is pervasive and associated with different factors of the population. Despite the wider scope of the problem, no sufficient research has been done using spatial analysis which helps to determine a variation of the problem at different clusters. Exploring spatial variations in iron supplementation among women is vital to designing and monitoring effective intervention programs. Therefore, this study aimed to explore the spatial variation in iron supplementation among women aged 15 to 49 who have had a child in the last five years from 2016-to 2019 in Ethiopia.

Materials and Methods

Study design, setting, and period

The Ethiopian Demographic and Health Survey (EDHS) is a community-based cross-sectional survey that was done on June 27, 2016, and the mini Ethiopian Demographic and Health Survey (EDHS) was conducted on June 28, 2019. Ethiopia has two administrative cities (Addis Ababa and Dire Dawa) and nine regional states (Tigray, Amhara, Afar, Oromia, Benishangul-Gumuz, Gambela, Harari, Somalia, and Southern Nations, Nationalities, and People's Region (SNNPR)). Ethiopia is mostly an agricultural country, with agriculture accounting for 43% of GDP. The regional states of Amhara, Oromia, and SNNPR are home to more than 80% of the country's population [16].

Ethiopia is the world's 13th most populous country and Africa's second. Ethiopia now has three health-care tiers: primary (hospitals, health centers, health posts, primary clinics, and medium clinics), secondary (general hospitals, specialty clinics, and specialty centers), and tertiary (hospitals, specialty clinics, and specialty centers) (specialized hospital). The number of hospitals varies from region to region, mainly due to population size disparities. Oromia, the most populous region, contains 30 hospitals. Amhara and SNNPR, the other two most populated areas, each have 19 and 20 hospitals, while Tigray, the fourth most populous region, has 16 hospitals. Gambela only has one hospital, while Benishangul-Gumuz has two [17].

Sample population and variable measurement

The EDHS used a stratified two-stage cluster sampling technique with the 2007 population and Housing Census (PHC) as the sampling frame, which was selected in two phases. Each region was stratified by dividing it into urban and rural sections. Because the Addis Ababa region is fully urban, 21 sampling strata were established in total. In the first stage, 645 survey clusters (202 in the city) were chosen with a probability proportionate to the size of the survey cluster and independent selection in each sampling stratum.

Because time had passed since the PHC, the second stage included a comprehensive home listing operation in all selected survey clusters before the start of field activity, with an average of 28 families being methodically picked. Finally, the study included 18 008 families and 4453 children. The full EDHS 2016 and 2019 report includes a detailed sampling technique [16].

The status of iron supplementation was classified as yes or no. For additional spatial analysis, the fractions of women who take iron supplements were used. The geographical coordinates XY data (latitude and longitude coordinates) for each GBS region were also gathered *via* a Google search. After justifying the purpose of data access and being deemed an authorized user, the survey data sets and location data were accessed through the international demographic and health survey program website.

Spatial data analysis

Excel was used to extract data on coordinates and weighted frequency of outcome variables with cluster numbers. For the analysis, ArcGIS V. 10.3 was employed. The geographical autocorrelation revealed that iron supplementation was dispersed, concentrated, or randomly distributed in this study area. By collecting the whole data set and providing a single output value that spans from 1 to +1, the Global Moran's I spatial statistics were utilized to measure spatial autocorrelation.

Moran's I values close to 1 suggest scattered iron supplementation coverage, whereas Moran's I values close to +1 imply clustered iron supplementation coverage, and an I value of 0 shows iron supplementation coverage that is randomly distributed. A statistically significant Global Moran's I (p=0.05) reveals the presence of spatial autocorrelation and rejects the null hypothesis (iron supplementation coverage is randomly distributed).

Hotspot analysis (Getis-Ord Gi* statistics)

The degree of spatial autocorrelation varies depending on the study context. This variance was calculated for each location using Getis-Ord Gi* statistics and the GiBin statistic. The z-score (CI) and p-value were also calculated to determine the statistical significance of clustering [18]. Statistical output with a high GiBin* suggests a 'hotspot,' or various geographical locations with low iron supplementation coverage, whereas a low Gi* shows a 'cold spot,' or places with high iron supplementation coverage, among Ethiopian women aged 15 to 49 [19-21].

Spatial interpolation

Interpolation algorithms forecast iron supplementation coverage in unseen areas based on available data in both deterministic and probabilistic ways. Ordinary kriging, universal kriging, and empirical Bayesian kriging are the most commonly used probabilistic types of interpolation methods for prediction.

We conducted and compared the three procedures utilizing residuals and root mean square error based on this evidence. We picked ordinary kriging as the interpolation technique for this study since it has the lowest residuals and root mean square error value based on the parameters. Kriging spatial interpolation is a technique that uses observable measures to anticipate the percentage of iron supplementation coverage among women aged 15 to 49 in unstamped parts of the country [22].

Finally, because it contains spatial autocorrelation and statistically optimizes the weight, the ordinary kriging spatial interpolation approach was used to forecast iron supplementation coverage among women aged 15 to 49 years in unobserved areas of Ethiopia [23].

Spatial scan statistical analysis

The spatial scan statistical approach is generally recommended, and it does a good job of identifying local clusters and has more power than other spatial statistical methods [24].

Using Kulldorff's SaTScan V.10.0 software, spatial scan statistical analysis was used to look for statistically significant geographical hotspots (clusters with low iron supplementation coverage) [25].

Women who took iron supplements were termed cases, while those who did not take iron supplements were called controls and were put into the Bernoulli model. The number of cases in each place was distributed according to a Bernoulli distribution, and the model required data on cases, controls, and geographic coordinates. The default maximum spatial cluster size of 50% of the population was utilized as an upper limit, allowing tiny and big clusters to be found while clusters with more than the maximum limit were ignored.

The null hypothesis was that there is no risk difference between the scanning windows and the rest of the country when compared to areas outside the window, places with a high log-like Lihood Ratio (LLR) and p=0.05 were judged high risk. Finally, significant and most likely clusters were identified using LLR, relative risk, and p-value. The place where the most likely clusters can be discovered was determined using ArcGIS V. 10.3. Based on 999 Monte Carlo replications, the primary and secondary clusters are discovered, given p values, and ordered based on their likelihood ratio test.

Results

The spatial distribution of Iron supplementation coverage among women aged 15–49 years was found to be clustered (non-random) in Ethiopia, with Moran's index of -0.517864 (p=0.033744) (Figure 1).

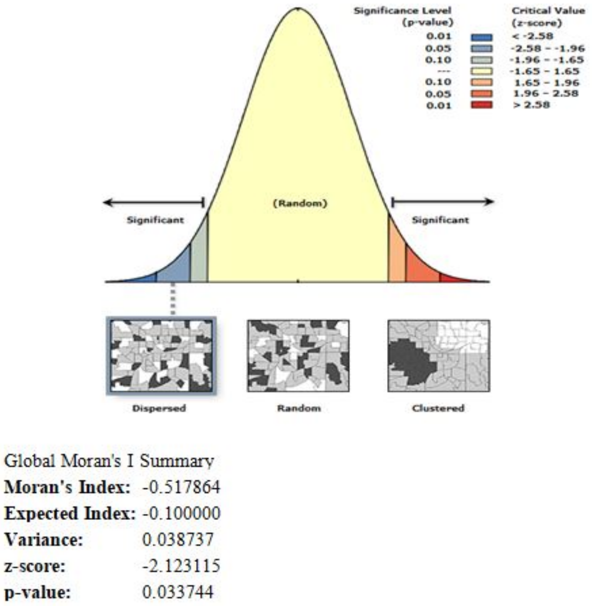

Figure 1. Spatial autocorrelation analysis of iron supplementation coverage among women 15-49 years age, EDHS2016-2019.

Hotspot identification of iron supplementation among women aged 15–49 years: The dark red color indicates significant (p<0.001) clusters of high iron supplementation (non-risk areas), whereas the green color, indicates significant (p<0.001) clusters of low iron supplementation (risky areas). Addis Ababa was identified to have high iron supplementation (hotspot areas) from 2016-to 2019 (Figure 2).

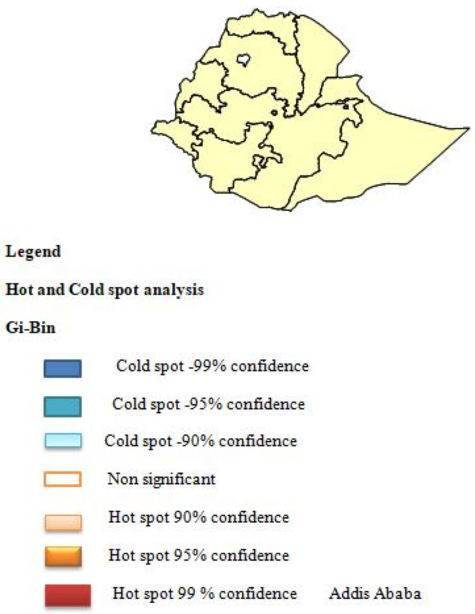

Figure 2. Hotspot analysis of iron supplementation coverage among women 15-49 years age, 2016 and 2019 Ethiopian Demographic and Health Survey. CSA, Central Statistics Agency.

Interpolation of iron supplementation coverage among women aged 15–49 years: Harar, Dire Dawa, and Gambella were identified as the more risky areas for iron supplementation coverage or with low iron supplementation coverage. However, Amhara and Oromia were found to be low-risk areas for iron supplementation coverage (Figure 3).

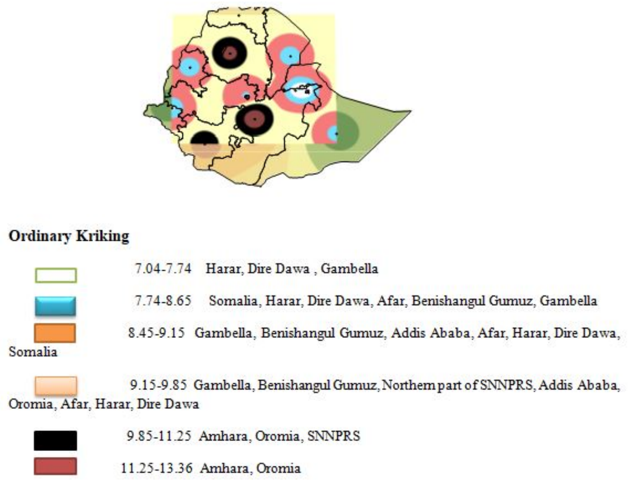

Figure 3. Spatial interpolation of iron supplementation coverage among women 15-49 years age, 2016 and 2019 Ethiopian Demographic and Health Survey. CSA, Central Statistics Agency.

Spatial SaTScan analysis of iron supplementation coverage (Bernoulli-based model): Spatial scan statistics were done using SaTScan V.10.0 to identify the most likely clusters, and a total of 7 significant clusters, were identified. From the identified clusters, 1 was a primary (most likely) cluster and 6 were secondary clusters. The primary cluster's spatial window was located in Tigray, Afar, Amhara, Benishangul Gumuz, Addis Ababa, Hrara, and Dire Dawa and was centered at 14.032334 N,38.316573 E in geographical location, with 673.06 km radius, with an LLR 223.452644 at p<0.001, and was identified as the most likely cluster with maximum LLR. It showed that women within the spatial window had 1.76 times higher iron supplementation coverage than women outside the window. Women within the Secondary Cluster 1 Oromia had 0.59 times lower iron supplementation coverage than women outside the window. Women within the Secondary Cluster 5 Somalia had 0.65 times lower iron supplementation coverage than women of other regions the other secondary clusters are described in detail in (Table 1 and Figure 4).

Table 1. SaTScan analysis of Iron Supplementation among women age 15-49 years with a child born in last 5 years in Ethiopia, 2016.

Cluster Type	Coordinates/ Radius	N	Cluster Regions	Observed Case	Expected Case	RR	LLR	P-value
Most likely Cluster	14.032334 N, 38.316573 E/ 673.06 km	7	Tigray, Afar, Amhara, Benishangul Gumuz, Addis Ababa, Hrara, and Dire Dawa	1511	1080.21	1.76	223.4526	0.001
Secondary Cluster 1	7.592062N, 39.225225E/0 km	1	oromia	935	1315.67	0.59	164.5186	0.001
Secondary Cluster 2	14.032334 N, 38.316573 E/0 km	1	Tigray	415	225.8	1.96	148.8266	0.001
Secondary Cluster 3	11.485999 N, 41.245999 E/ 373.28 km	4	Afar, Amhara,Harar, Dire Dawa	931	737.1	1.37	56.65861	0.001
Secondary Cluster 4	9.005401 N, 38.763611E/0 km	1	Addis ababa	126	83.25	1.53	19.16417	0.001
Secondary Cluster 5	6.661229N, 43.790845E/0 KM	1	Somalia	75	113.11	0.65	12.01946	0.001
Secondary Cluster 6	8.247190N, 34.591597 E/ 301.06 km	2	Gambela, Benishangul Gumuz	48	42.89	1.12	0.527961	0.99

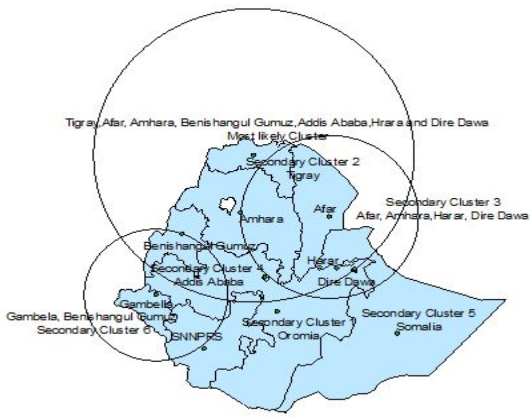

Figure 4. Spatial SaTScan analysis iron supplementation coverage among women 15-49 years ago, 2016 Ethiopian Demographic and Health Survey. CSA, Central Statistics Agency; LLR, log-likelihood ratio; SNNPR, Southern Nations, Nationalities, and People's Region.

Spatial SaTScan analysis of iron supplementation coverage (Bernoulli-based model): Spatial scan statistics were done using SaTScan V.10.0 to identify the most likely clusters, and a total of 7 significant clusters, were identified. From the identified clusters, 1 was a primary (most likely cluster and 6 were secondary clusters. The primary cluster's spatial window was located in Amhara, Benishangul Gumuz, Addis Ababa, Tigray and was centered at 11.663240N,37.821903E in geographical location, with 312.78 km radius, with an LLR 107.777690 at p<0.001, and was identified as the most likely cluster with maximum LLR. It showed that women within the spatial window had 1.46 times higher iron supplementation coverage than women outside the window women within the Secondary Cluster 1 Somalia had 0.30 times lower iron supplementation coverage than other region women within the Secondary Cluster 4 Oromia had 0.87 times lower iron supplementation coverage than women outside the window women within the Secondary Cluster 6 SNNPRS had 0.90 times lower iron supplementation coverage than other regions. The other secondary clusters are described in detail in Table 2 and Figure 5.

Table 2. SaTScan analysis of Iron Supplementation among women age 15-49 years with a child born in last 5 years in Ethiopia, 2019.

Cluster Type	Coordinates/ Radius	N	Cluster Regions	Observed Case	Expected Case	RR	LLR	P-value
Most likely Cluster	11.663240N, 37.821903E/ 312.78 km	4	Amhara, Benishangul Gumuz, Addis Ababa, Tigray	988	780.13	1.46	107.7777	0.001
Secondary Cluster 1	6.661229N, 43.790845E/0 km	1	Somalia	41	130.82	0.3	82.34661	0.001
Secondary Cluster 2	11.663240N, 37.821903E/0 km	1	Amhara	624	503.49	1.33	47.93455	0.001
Secondary Cluster 3	14.032334N, 38.316573E/0 km	1	Tigray	242	172.23	1.45	42.94771	0.001

Secondary Cluster 4	7.592062N, 39.225225E/0 km	1	Oromia	832	911.55	0.87	14.10679	0.001
Secondary Cluster 5	9.005401N, 38.763611E/0 KM	1	Addis Ababa	93	76.21	1.23	5.024154	0.034
Secondary Cluster 6	6.033103N, 36.433828E/0 KM	1	SNNPRS	434	472.28	0.9	4.810161	0.045

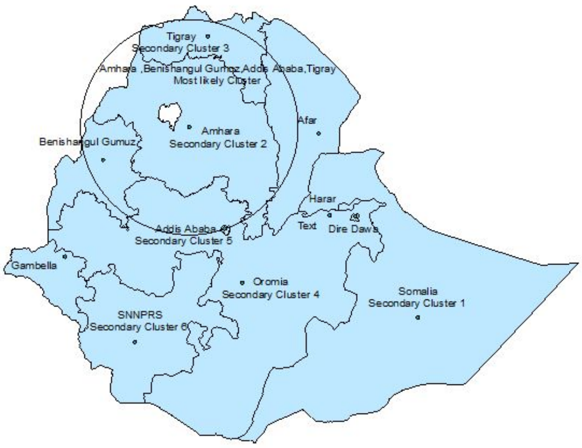

Figure 5. Spatial SaTScan analysis iron supplementation coverage among women 15-49 years ago, 2019 Ethiopian Demographic and Health Survey. CSA, Central Statistics Agency.

The most likely spatiotemporal cluster location include Tigray, Amhara, Afar, Benishangul Gumuz, Harar, Dire Dawa, and Addis Ababa (Figure 6), and the high-iron supplementation coverage period was from 2016/6/27-2017/6/28 (LLR=323.372117, P=0.001).

The area's center was Tigray, which was located at 14.032334 N and 38.316573E, with a radius of 673.06 km (Figure 4) During the period 2016/6/27-2017/6/28, a total of 2548 women who had taken iron supplementation were recorded in this location, with an RR of 1.63 (Table 3).

Table 3: Space Time SaTScan analysis of Iron Supplementation among women age 15-49 years with a child born in last 5 years in Ethiopia, 2016/6/27-2019/6/28.

Cluster Type	Cluster Time Frame	Coordinates/ Radius	N	Cluster Countries	Observed Case	Expected Case	RR	LLR	P-value
Most likely Cluster	2016/6/27-2017/6/28	14.032334 N, 38.316573E/ 673.06 km	7	Tigray, Amhara, Afar, Benishangul Gumuz, Harar, Dire Dawa, Addis Ababa	2548	1903.76	1.63	323.3721	0.001
Secondary Cluster 1	2016/6/27-2017/6/28	7.592062 N, 39.225225 E/0 km	1	Oromia	1767	2239.03	0.69	162.1359	0.001
Secondary Cluster 2	2016/6/27-2017/6/28	6.033103N, 36.433828 E/0 km	1	SNNPRS	1095	1150.35	0.94	3.244717	0.185

During the period from 2016/6/27-2017/6/28, women within the Secondary Cluster 1 Oromia had 0.69 times lower iron supplementation coverage than other regions and women within the Secondary Cluster 2 SNNPRS had 0.94 times lower iron supplementation coverage than other regions.

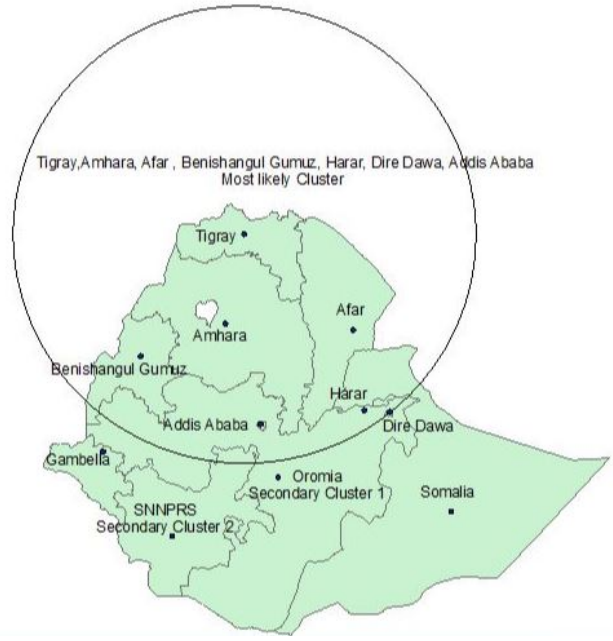

Figure 6. Space Time SaTScan analysis iron supplementation coverage among women 15-49 years ago, 2016-2019 Ethiopian Demographic and Health Survey. CSA, Central Statistics Agency.

Discussion

The results of this study revealed that iron supplementation coverage among women aged 15 to 49 years in the country was non-random (clustered). A clustering trend in iron supplementation coverage across the country was revealed in the global autocorrelation study (Global Moran's I=-0.517864 (p=0.033744). This suggests that in specific places, almost identical iron supplementation coverage was aggregated. Addis Ababa (p=0.01) was found as the hotspot cluster of high iron supplementation coverage.

One probable explanation is that women in Addis Ababa have a greater understanding of the significance of iron supplementation than mothers in other regions, as well as a higher rate of antenatal care follow-up. As a result, the majority of women require iron supplementation.

Harar, Dire Dawa, and Gambella are at risk of low iron supplementation coverage, according to the iron supplementation coverage map prediction.

This probably is because these locations are border zones and hence have limited access to and use of healthcare services. People in these areas may also have a poorer educational standing and live far away from healthcare facilities [26].

Another factor that may influence iron supplements coverage is a woman's rural residence [27]. Because the majority of these areas are rural, iron supplementation coverage may be poor.

The purely SaTScan spatial analysis, a total of 7 significant clusters, were identified. The most likely SaTScan cluster of low iron supplementation coverage was identified in Oromia (LLR=164.51, p<0.01) and Somalia (LLR=12.01, p<0.01). In 2016 and the most likely SaTScan cluster of low iron supplementation coverage was identified in Somalia (LLR=82.34, p<0.01), Oromia (LLR=14.10, p<0.01) and SNNPRS (LLR4.81, p<0.01) in 2019.

The Space Time SaTScan analyses, a total of 3 significant clusters, were identified. The most likely SaTScan cluster of low iron supplementation coverage was identified in Oromia (LLR=162.13, p<0.01) and SNNPRS (LLR 3.24, p<0.01). During the period from 2016/6/27-2017/6/28.

Apart from sociocultural differences in the community, this could be attributable to inequalities in health service accessibility and consumption. According to studies, women in Afar and other distant locations delivered at home due to a lack of trust in local health practitioners [28]. Furthermore, because pastoralist women primarily live in the Afar and Somali regions, they do not have access to iron supplements during pregnancy.

Limitations of this study include the data being collected at a specific point in time and the retrospective character of the study. Finally, the SaTScan algorithm only discovers circular clusters and ignores irregularly shaped clusters.

Based on the findings of this study, policymakers and programmers in Ethiopia should provide improved interventions in hotspot areas (poor iron supplementation coverage) and develop various techniques to improve iron supplementation coverage among women aged 15 to 49 years.

Conclusion

Women in the Harar, Dire Dawa, Gambella, Somalia Oromia, and Southern Nation Nationalities and Peoples Regions had a low likelihood of receiving iron supplements.

As a result, when developing efficient Antenatal care strategies to enhance iron supplementation among women to lower the burden of anemia and its effects among pregnant women in Ethiopia, these regions should be considered.

Declaration

Ethics approval and consent to participate: Permission for data access was obtained from a major Demographic and Health Survey through an online request at. The data used for this study were publicly available with no personal identifier. Our study was based on secondary data from Ethiopian Demographic and Health Survey and we have secured the permission letter from the main Demographic Health and Survey.

Consent for publication: not applicable

Availability of data and materials: The paper includes

all data.

Competing interests: There are no competing interests stated by the authors.

Funding

There was no financing available for this project

Contributions of the authors: KTT was responsible for the original drafting of the manuscript's conceptualization, analysis, supervision, and development.

Methodology, discussion, and data analysis were all done by KTT, ETT, TB, and MKT.

KTT, ETT, MKT, TB, BB, KG, and BFW assisted with data analysis, critically revised the work, and agreed to be held accountable.

Acknowledgments

We'd like to thank Hawassa College of Health Science for assisting us with this study project and Ethiopian Demographic and Health Survey staff and the main Demographic and Health Survey Program for permitting data access.

References

1. World Health Organization Global Anaemia estimates. Department of Women Health Science (2021).
2. JJ G. The world health report 2002 reducing risks, promoting healthy life. *Educ Health*. 16 (2003): 230.
3. WHO. Iron Deficiency Anemia: Assessment, Prevention, and Control. A Guide for Programme Managers. Geneva: World Health Organization. 2002.

4. Nojilana BNR, et al. Estimating the burden of disease attributable to vitamin A deficiency in South Africa in 2000. *S Afr Med J*. 97.8 (2007): 748-753.

5. TH B. Overview and Mechanisms of Iron Regulation. *Nutr Rev*. 53 (1995):237–245.

6. Mawani MAS, et al. Iron deficiency anemia among women of reproductive age, an important public health problem: Situation analysis. *Reprod Syst Sex Disord*. 5.3 (2006):1.

7. Bank W . Prevalence of anemia among women of reproductive age in Sub-Saharan Africa. World Bank Report Google Scholar. 2019.

8. Central Statistical agency EP. Ethiopia Demographic and Health Survey. The DHS Program. 2016.

9. Haas JD BTI. Iron deficiency and reduced work capacity: a critical review of the research to determine a causal relationship. *J Nutr*. 131.2 (2001): 676S-690S.

10. World Health Organization. Global Nutrition Targets 2025: Anemia Policy Brief Geneva: WHO. 2014.

11. Terefe BBA, et al. Effect of maternal iron deficiency anemia on the iron store of newborns in Ethiopia. *Anemia.* 2015.

12. Kumar KJ, et al. Maternal anemia in various trimesters and its effect on newborn weight and maturity: an observational study. *Int J Prev Med*. 4.2 (2013):193.

13. Lakew Y BS, et al. Anaemia prevalence and associated factors among lactating mothers in Ethiopia: evidence from the 2005 and 2011 demographic and health surveys. *BMJ Open*. 5.4 (2015):e006001.

14. Nisar R AS, et al. Food security as the determinant of anemia at household level in Nepal. *J Food Sec*. 1.2 (2002);27-29.

15. Bellizzi SAM. Effect of oral contraception on anemia in 12 low-and middle-income countries. *Contraception.* 97.3 (2018):236-242.

16. Agency CSICF. Ethiopia demographic and health survey 2016: key indicators report. Addis Ababa, Ethiopia, and Rockville, Maryland, USA: CSA and ICF, 2016.

17. Adugna A Health institutions and services. Department of Ethopian Demography and Health (2014).

18. Zulu LC, et al. Analyzing spatial clustering and the spatiotemporal nature and trends of HIV/AIDS prevalence using GIS: the case of Malawi, 1994-2010. *BMC Infect Dis* 2014;14:285.

19. Anselin L, et al. Using exploratory spatial data analysis to leverage social indicator databases: the discovery of interesting patterns. *Soc Indic Res*. 82 (2007):287–309.

20. Krivoruchko K. Empirical Bayesian kriging. ArcUser, fall 2012. Redlands, California: Esri, 2012.

21. Naish S, et al. Hot spot detection and Spatio-temporal dynamics of dengue in Queensland, Australia. ISPRS Technical Commission VIII symposium. Queensland, Australia. *J Photogramm Remote Sens*. 2014.

22. Mitas L, et al. Spatial interpolation. geographical information systems: principles, techniques, management and applications 1999;1.

23. Bhunia GS, et al. Comparison of GIS-based interpolation methods for the spatial distribution of soil organic carbon (soc). *J Saudi Soc Agric Sci*. 2018;17:114–26.

24. Tiwari N, et al. Investigation of geospatial hotspots for the occurrence of tuberculosis in Almora district, India, using GIS and spatial scan statistic. *Int J Health Geogr*. 5 (2006):33.

25. Kulldorff M. Inventor SaTScan-Software for the spatial. Temporal and Space-Time Scan Statistic 2015.

26. Abebe AM, et al. Coverage, opportunity, and challenges of expanded program on immunization among 12-23-Month-Old children in Woldia town, northeast Ethiopia. 2018. *Biomed Res Int*. (2019):1–9.

27. Tsehay AK, et al. Determinants of BCG vaccination coverage in Ethiopia: a cross-sectional survey. *BMJ Open*. 9 (2019):e023634.

28. Ahmed M, et al. Socio-cultural factors favoring home delivery in the afar pastoral community, northeast Ethiopia: a qualitative study. *Reprod Health*. 16 (2019):1–9.

Cite this article: Tegegne KT, et al. "Exploring Geographical Variation in Iron Supplementation among Ethiopian Women Aged 15 to 49 Who Have Had a Child in the Last Five Years: a Spatial Analysis of the Ethiopian Demographic and Health Survey 2016-2019 ". *J Biol Todays World,* 2022,11(4), 1-7.