Non-comunicable disease

Spatial distribution and determinant factors of anemia among women age 15-49 years in Burkina Faso; using mixed-effects ordinal logistic regression model

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Keywords

Anemia • Women • Spatial analysis • Mixed-effects ordinal logistic regression

Summary

Background. *Anemia is a condition in which the number of healthy red blood cells/ hemoglobin (Hgb) level (and consequently their oxygen-carrying capacity) is insufficient to meet the body's physiologic needs. Thus, the current study is aimed to assess the spatial distribution and determinant factors of anemia among women aged 15-49 in Burkina Faso.*

Methods. *A secondary data analysis was done based on 2021 Burkina Faso; Demographic and Health Surveys. Total weighted samples of 5655 women's were included. Data processing and analysis were performed using STATA 14; ArcGIS 10.1 and SaTScan 9.6 software.*

Result. *The spatial distribution of anemia in Burkina Faso among women aged 15-49.was found to be clustered (Global Moran's I = 0.25, p value < 0.0001). In the multivariable mixed-effect ordinal regression analysis; Age 25-29 years [AOR = 1.31 ; 95% CI: 1.06 1.61], rich wealth status [AOR = 1.32 ; 95% CI: 1.08 1.62], regions Cascades [AOR = 1.62 ; 95% CI: 1.16 2.25],Hauts-bassis [AOR = 1.40; 95% CI: 1.06 1.84], Plateau central [AOR = 0.72 ; 95% CI: -0.54 0.96 and Sahel[AOR = 0.42 ; 95% CI: 0.28 0.63], were significant predictors of anemia among women aged 15-49.*

Conclusions. *A significant clustering of anemia among women aged 15-49 were found in Burkina Faso. Age, wealth index, regions Cascades, Hauts-bassins, Plateau central, and Sahel were significant predictors of anemia.*

Introduction

Anemia is a condition in which the number of healthy hemoglobin (Hgb) level (and consequently their oxygen-carrying capacity) is insufficient to meet the body's physiologic needs [1]. Anemia is diagnosed when a blood hemoglobin concentration is 120 g/dL for non-pregnant women and below 110 g/dL in pregnant women [2].

The magnitude of anemia differs according to geographic areas, Sub-Saharan Africa (SSA) and South Asia had the highest prevalence of anemia in all age groups. Women of 15-49 years are physiologically more susceptible to anemia because of continues menstrual blood loss and the demands of frequent pregnancy [3]. In eastern Africa, the prevalence of anemia in women of 15- 49 years age is higher, which ranges from 19.2% in Rwanda to 49% in Zambia [1].

According to different studies done worldwide; age [4, 5], educational level [6-8], wealth status [6, 7, 9, 10], type of toilet facility and source of drinking water [6, 10], current pregnancy status [5, 7, 10], and residence [2, 11], are associated with anemia in women of 15- 49 years.

Previous studies have reported pregnancy status [11, 12], lower nutritional status [13], repeated childbearing [14] haemoglobin < 11 g/dl for pregnant women, lactation/ breastfeeding [12], helminths infection [15] and malaria [16]frequently leading to anaemia. Plasmodium falciparum causes the most severe and profound anaemia, with a significant risk of death. This cannot be explained simply by the direct destruction of parasitized red blood cells at the time of release of merozoites, a process shared by all these species. In this review, Clara Menendez, Alan Fleming and Pedro Alonso focus on recent advances in our knowledge of the pathophysiology, epidemiology, management and prevention of anaemia from falciparum malaria. Copyright (C were found to be important causes of anemia among women age 15-49 years.

However, the progress made in decreasing the magnitude of anemia is far less than the expected and its socioeconomic burden, particularly in resource-poor countries, is still a major concern [17]. To achieve the World Health Organization global nutrition targets 2025 and nutrition targets of the Sustainable Development Goals-2030, it is important to generate adequate evidence on contextual determinants of anemia to contribute to the development of timely interventions in anemia prevention.

In addition, assessing the geographic distributions of anemia and its determinant factors across the regions in Burkina Faso can inform the national policy in designing prevention and intervention programmes to address anemia. More-over, mapping the spatial distribution of anemia by regions can help focus resources for prevention and treatment in the hot spot areas that is areas with elevated incidence or prevalence of anemia among women age 15-49 years in Burkina Faso.
Although previous studies have attempted to estimate the prevalence of anemia in Burkina Faso, no studies in Burkina Faso have utilized nationally representative data to investigate the spatial distribution and determinant factors of anemia among women age 15-49 years in Burkina Faso. Therefore, this study aims to assess the spatial distribution and determinant factors of anemia in Burkina Faso among women aged 15–49.

Methods

Study setting and data source

Burkina Faso is one of the sub-Sahara African countries which contained thirty National, Regional states: namely Boucle du mouhoun,Cascades,Centre,Centre Est,Centre Nord,Centre Ouest,Centre Sud,Est,Hauts-bassins,Nord,Plateau central,Sahel and Sud-Ouest This study was a secondary data analysis based on 2021 Burkina Faso Demographic and Health Surveys (BFDHS). The 2021 BFDHS provides reliable estimates at the national level, for urban and rural areas, and for each of the 13 regions [18]. The BFDHS 2021 applied a stratified two-stage cluster sampling technique. Stratification was realized by separating each region into urban and rural areas. In the BFDHS 2021, Blood specimens for anemia testing were collected from women aged 15-49 that voluntarily consented to be tested. Blood samples were drawn from a drop of blood taken from a finger prick and collected in a micro cuvette. Hemoglobin analysis was carried out on site using a battery-operated portable HemoCue analyzer. The full sampling procedure and the Anemia testing data are accessible in the full 2021 BFDHS report [18]. The total weighted samples of 5655 women aged 15–49 were included in this study.

Study variables

The outcome variable for this study was hemoglobin level in the blood, a key indicator for Anemia. Age, place of residence, region, wealth index, and type of toilet facility were included as independent variables in this study (Tab. I).

Operational definition

Wealth index

It is the percent distribution of population by wealth quintiles. It was classified as Poorest, Poorer, Middle, and Richer & Richest.

Improved sanitation facility

Includes flush or pours flush toilets flowing to a piped sewer system, septic tank, or latrine, ventilated pit latrine, pit latrine with slab, and compositing toilet. Based on the type of sanitation facility, a household was classified as having or not having an improved sanitation facility [19, 20].

Improved water sources

If a household used piped water (in to dwelling, compound, yard or plot, piped to neighbor, public tap/standpipe), tube well/borehole, protected well, protected spring and rain water collection for drinking purposes.it is considered as using improved water sources [20, 21].

Data source and extraction

First, authorization was obtained through online request after submitting the objectives of our study. Then, the data was accessed from the demography heath survey (DHS) program official database www.measuredhs.com and we have extracted the outcome and independent variables.

Data processing and management

Data processing and analysis were performed using STATA 14; ArcGIS 10.1 and SaTScan 9.6 software. Cross tabulations and summary statistics were conducted to describe the study population.

Ethics approval and consent to participate

The study does not contain the collection of information from subjects. We sent a one-page proposal abstract of the study to the DHS program office. They gave permission to access the data.

Spatial analysis

Spatial autocorrelation analysis

In this study, the existence of spatial autocorrelation was checked using Global Moran's index (Moran's I). Global Moran's index (Moran's I) was used to identify the presence of spatial auto correlation. Moran's I value ranges from-1 to 1 [22]. A value close to 1 shows a strong positive spatial autocorrelation (disease/event clustered), whereas a value close to -1 shows a

Tab. I. Measurement of outcome variable used in the Analysis.

Pregnancy status	Anemia status			
	Mild anaemic	Moderate anaemic	Sever anaemic	Not anaemic
Pregnant women	10.0-10.9 g/dl	7.0-9.9 g/d	< 7.0 g/dl	≥ 11.0 g/dl
Non Pregame women	11 and 11.9 g/dL	8 and 10.9 g/dL	<8 g/dL	≥ 12.0 g/dl,

strong negative spatial autocorrelation (disease/event dispersed). If Moran's I is close to 0, it indicates that there is no spatial autocorrelation. A statistically significant Moran's I ($p < 0.05$) led to the rejection of the null hypothesis (anemia is randomly distributed) and showed the presence of spatial autocorrelation. Hot- spot analysis was made using Gettis-OrdGi*statistics.

Spatial scan statistical analysis

Spatial scan statistics were applied to identify a significant Primary (most likely) and secondary cluster of anemia using Kuldorff's SaTScan software. SaTScan™ works with a moving window and requires fixing of the window size that moves across the study area. Since the dependent variable (anaemic and not anaemic) has a Bernoulli distribution, the Bernoulli model was employed for purely spatial analysis. To fit the Bernoulli model, women age 15-49 years who were anaemic (mild, moderate, and severe) were considered as cases and those who were not anaemic were considered as controls. The default maximum spatial cluster size of < 50% of the population was considered as an upper limit, which permitted both small and large clusters to be identified and ignored clusters that contained more than the maximum limit. Areas with high Log Likelihood Ratio and significant p-value were taken as high anemic areas compared to areas outside of the window.

Statistical analysis

Since the BFDHS data have a hierarchical nature, women 15-49 years age within a cluster may be more similar to each other than with women 15-49 years age in another cluster. Due to this, the assumption of independence of observations and equal variance across clusters might be violated. Therefore, an advanced statistical model is required to take into account the between cluster variability to get a reliable standard error and unbiased estimate. Furthermore, by taking the ordinal nature of the outcome variable into account, ordinal logistic regression and mixed effect ordinal logistic were fitted. Model comparison was done based on Akaike and Bayesian Information Criteria (AIC and BIC). Mixed effect model with the lowest Information Criteria (AIC and BIC) was selected**.** Adjusted Odds Ratio (AOR) with a 95% Confidence Interval (CI) and *p*-value 0.05 in the multivariable model was declared as determinant factors of anemia. The assumption of proportional odds was checked and the results tell that the assumption of proportional odds is plausible at 5% level of significance for all considered covariates in the model.

Clusters were accounted in the analysis using mixed-effect ordinal logistic regression, by including region in random effect model and all other variables in fixed effect model.

Results

Characteristics of study population

In this study, a total of 5655 women 15-49 years age were included. Among these respondent, more than half of them were uneducated (67.1%) and poorest (17.0%) in wealth index and more than half (64.7%) of them were rural residents. Four hundred ninety three (8.9%) of the study participants were in the age range of 15 to 19 years. Concerning the marital status, 5025 (90.8%) respondents were married while 100 (1.8%) respondents were never married. Five hundred eighty eight (10.6%) of the study participants were from Hauts-bassins region. 3676 (66.4%) of the respondents had improved toilet facility, whereas 3349 (60.5%) of the study participants used improved drinking water (Tab. II). Regarding, the current pregnant, majority of women (90.4%) were not pregnant or don't know whether they are pregnant or not.

Spatial analysis of anemia

Spatial distribution of anemia

The highest number of anemia cases were found in Centre and Hauts-bassins regions (Fig. 1).

The spatial distribution of anemia in Burkina Faso among women age 15-49 years was identified to be clustered (Global Moran's I = 0.25, p value < 0.0001). Given the z-score of 10.9016137606, there is a less than 1% likelihood that this clustered pattern could be the result of random chance (Fig.2).

Gettis-OrdGi statistical analysis of anemia

Based on the Gettis-OrdGi statistical analysis, this study identified hotspots and cold spot areas of anemia in Burkina Faso among women aged 15–49. Accordingly, the red colors indicate the significant hotspot area (higher cluster of anemia), which were found in Boucle du mouhoun, Centre, Hauts-bassins,Nord, Centre Ouest, Plateau central, and Centre Est regions. In contrast, the blue color indicates significant cold spot areas (low cluster of anemia), located in Sahel and Cascades regions (Fig. 3).

Interpolation of space

For the prediction of anemia prevalence in untested women age 15-49 years in different locations of, Burkina Faso. We employed standard Kriging interpolation. Based on geostatistical Kriging analysis, Boucle du mouhoun, Centre Ouest, Centre Sud, Centre and Cascades regions is 3.91-4.77 number of cases, border of Boucle du mouhoun, Hauts-bassins, border of Sahel and Plateau central regions the predicted anemia prevalence for untested women age 15-49 years is 7.35-8.21 number of cases and for inside Boucle du mouhoun, Centre Ouest, Centre and Centre Sud regions the predicted anemia prevalence for untested women age 15-49 years is highest which is 9.93-10.79 number of cases (Fig. 4).

Spatial SaTScan analysis of Anemia (Bernoulli based model)

A spatial scan statistical analysis recognized a total of 123 significant primary and secondary clusters. Among these, 116 clusters were primary (most likely) clusters

Tab. II. Characteristics of women 15-49 years age in Burkina Faso, 2021 (N = 5,655)

Variables	Anemia level (weighted frequency)				Total	Weighted percent
	Severe	Moderate	Mild	Not anemic		
Age						
15-19	5	165	102	221	493	8.9%
20-24	6	257	207	412	882	15.9%
25-29	9	238	236	476	959	17.3%
30-34	11	250	252	485	998	18.0%
35-39	12	259	211	424	906	16.4%
40-44	11	210	183	322	726	13.1%
45-49	10	185	143	233	571	10.3%
Marital; status						
Never married	3	25	21	51	100	1.8%
Married	54	1428	1219	2324	5025	90.8%
Widowed	6	86	73	157	322	5.8%
Divorced	1	25	21	41	88	1.6%
Educational level						
No education	53	1101	919	1639	3712	67.1%
Primary, secondary, Higher	11	452	411	911	1785	32.2%
Don't know	0	11	4	23	38	0.7%
Type of place of residence						
Urban	19	494	458	981	1952	35.3%
Rural	45	1070	876	1592	3583	64.7%
Region						
Boucle du mouhoun	6	141	119	214	480	8.7%
Cascades	1	70	51	183	305	5.5%
Centre	9	171	140	361	681	12.3%
Centre Est	0	150	124	236	510	9.2%
Centre Nord	8	112	95	144	359	6.5%
Centre-Ouest	4	136	113	234	487	8.8%
Centre Sud	4	102	85	188	379	6.8%
Est	5	84	76	131	296	5.3%
Hauts-bassins	5	119	151	313	588	10.6%
Nord	5	136	116	184	441	8.0%
Plateau central	5	157	109	140	411	7.4%
Sahel	8	82	47	43	180	3.3%
Sud-Ouest	4	104	108	202	418	7.6%
Wealth index						
Poorest	20	290	250	381	941	17.0%
Poorer	15	302	261	425	1003	18.1%
Middle	11	346	276	485	1118	20.2%
Richer	8	319	246	630	1203	21.7%
Richest	10	307	301	652	1270	22.9%
Type of toilet facility						
Improved	33	1029	851	1763	3676	66.4%
Not Improved	31	535	483	810	1859	33.6%
Source of drinking water						
Not Improved	27	644	522	993	2186	39.5%
Improved	37	920	812	1580	3349	60.5%
Currently pregnant						
No/don't know	57	1388	1206	2314	4965	90.4%
Yes	6	168	118	233	525	9.6%

which were located in the Plateau central, Centre Nord, half of Est, half of Nord, and Sahel regions at 14.122803 N, 0.062321 W, with 228.21 km radius, a Relative Risk (RR) of 1.32, and Log-Likelihood Ratio (LRR) of 51.483251, at p-value < 0.01 (Tab. III). This tells us that women's within the spatial window had 1.32 times higher risk of experiencing anemia as compared to women's outside the spatial window. The secondary cluster were found in half of Boucle du mouhoun, border of Centre Ouest, and border of Nord regions at

Fig. 1. Spatial distribution of anemia across regions among women age 15-49 years in Burkina Faso, 2021.

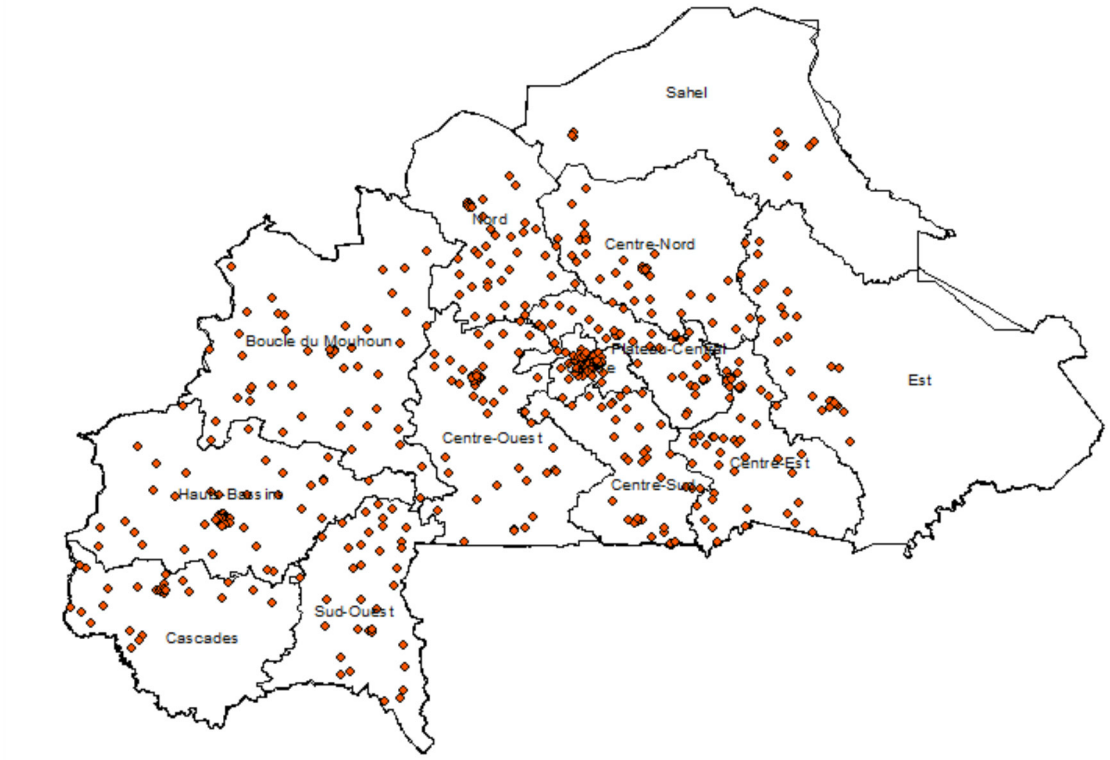


Fig. 2. Spatial autocorrelation analysis of anemia among women age 15-49 years in Burkina Faso, 2021.

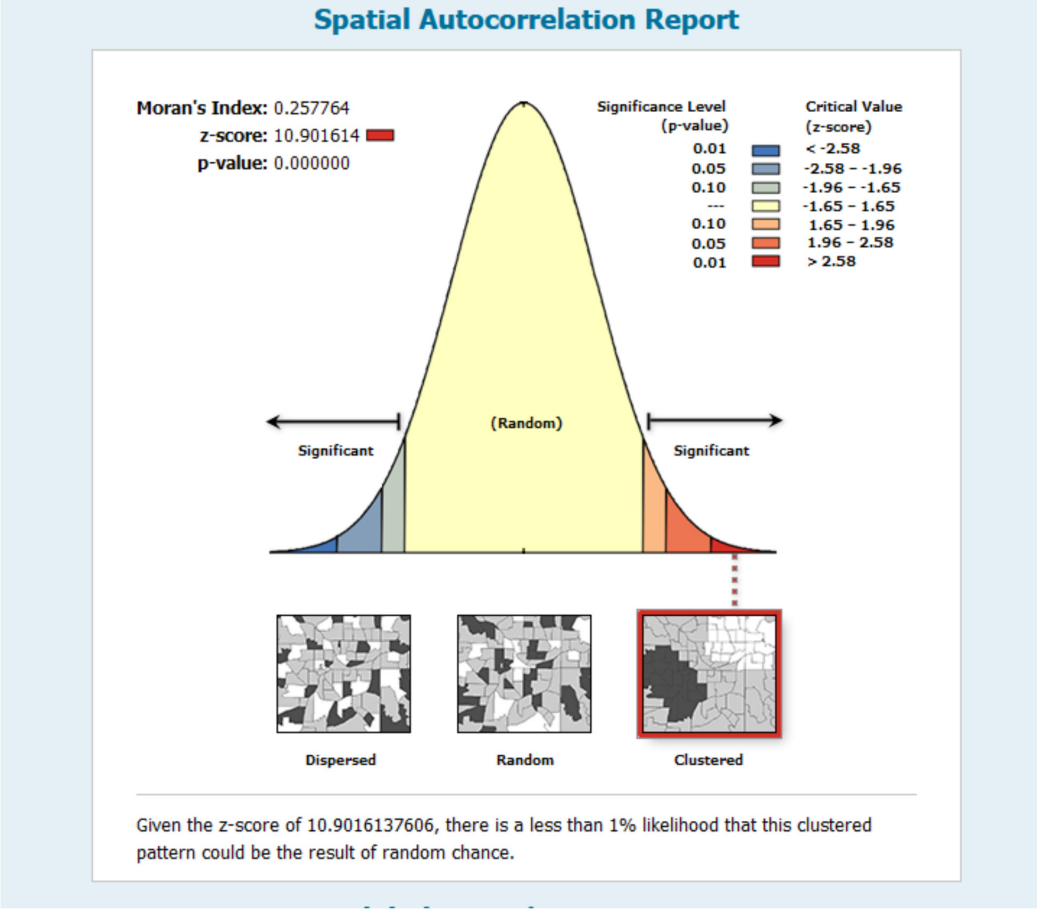


Fig. 3. Hotspot and Cold areas of anemia across regions among women age 15-49 years in Burkina Faso, 2021.

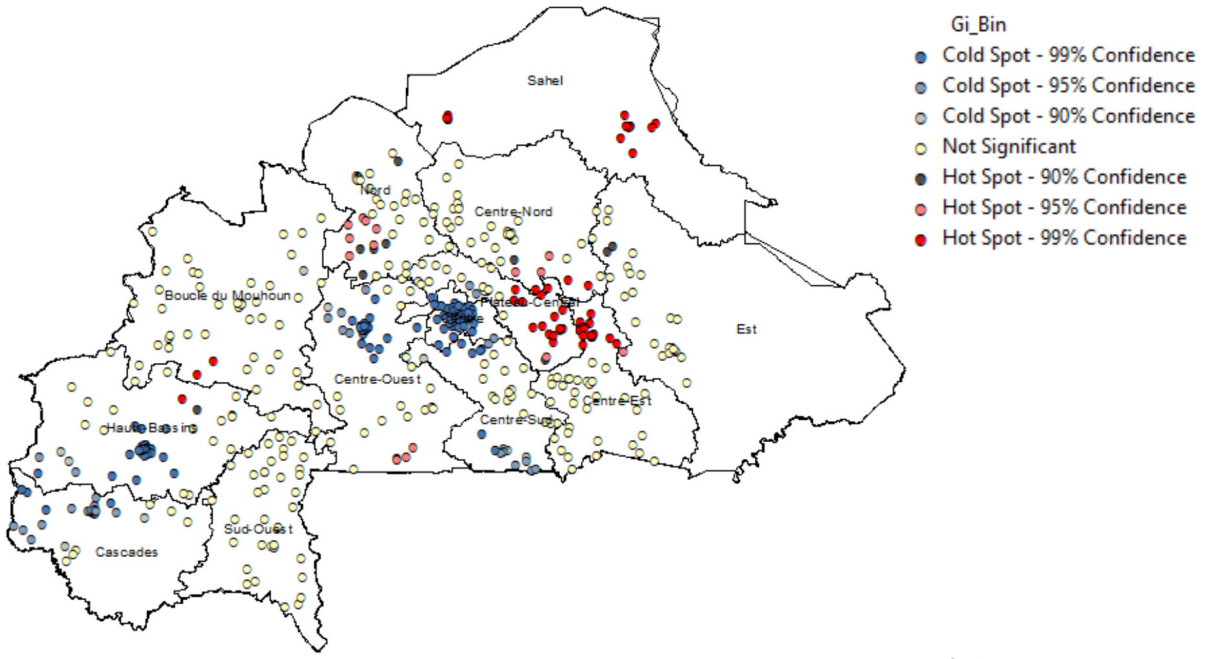
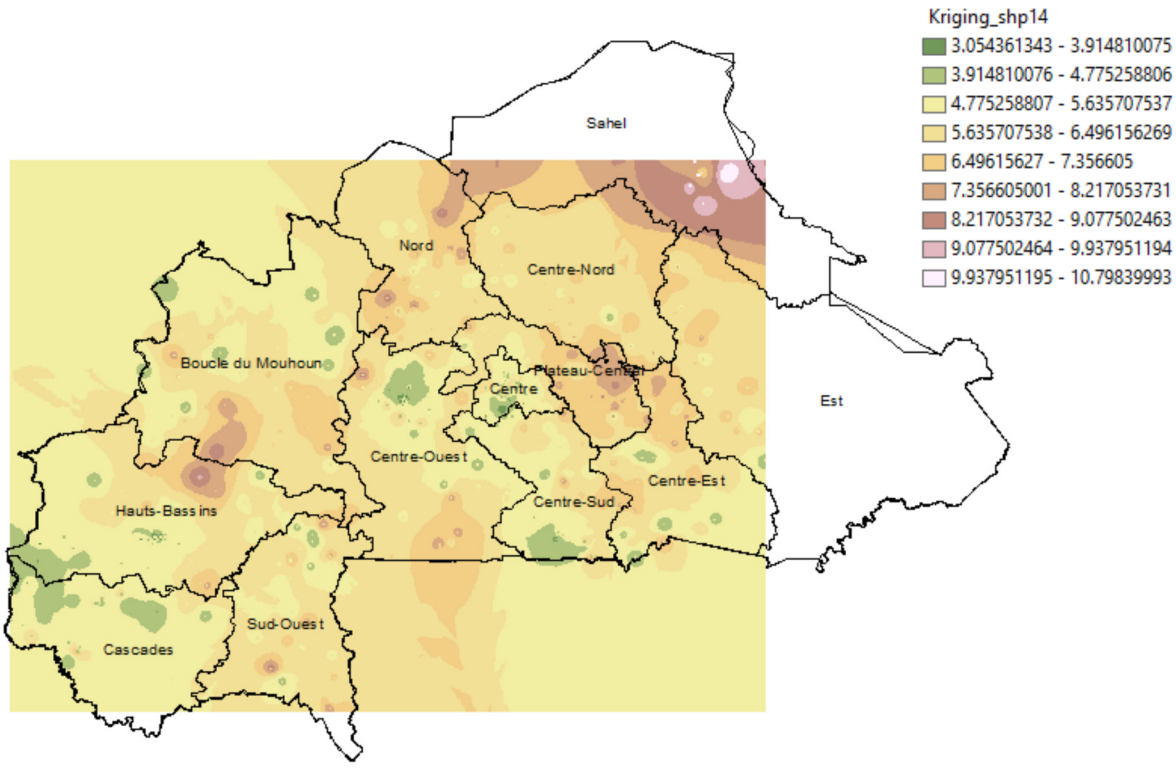


Fig. 4. Spatial interpolation of anemia across regions among women age 15-49 years in Burkina Faso, 2021.



11.845827 N, 3.836225 W), with 39.61 km radius, a Relative Risk (RR) of 1.50, and Log-Likelihood Ratio (LRR) of 12.782125, at p-value = 0.0019. This tells us that women's within the spatial window had 1.50 times higher risk of experiencing anemia as compared to women's outside the spatial window (Fig. 5).

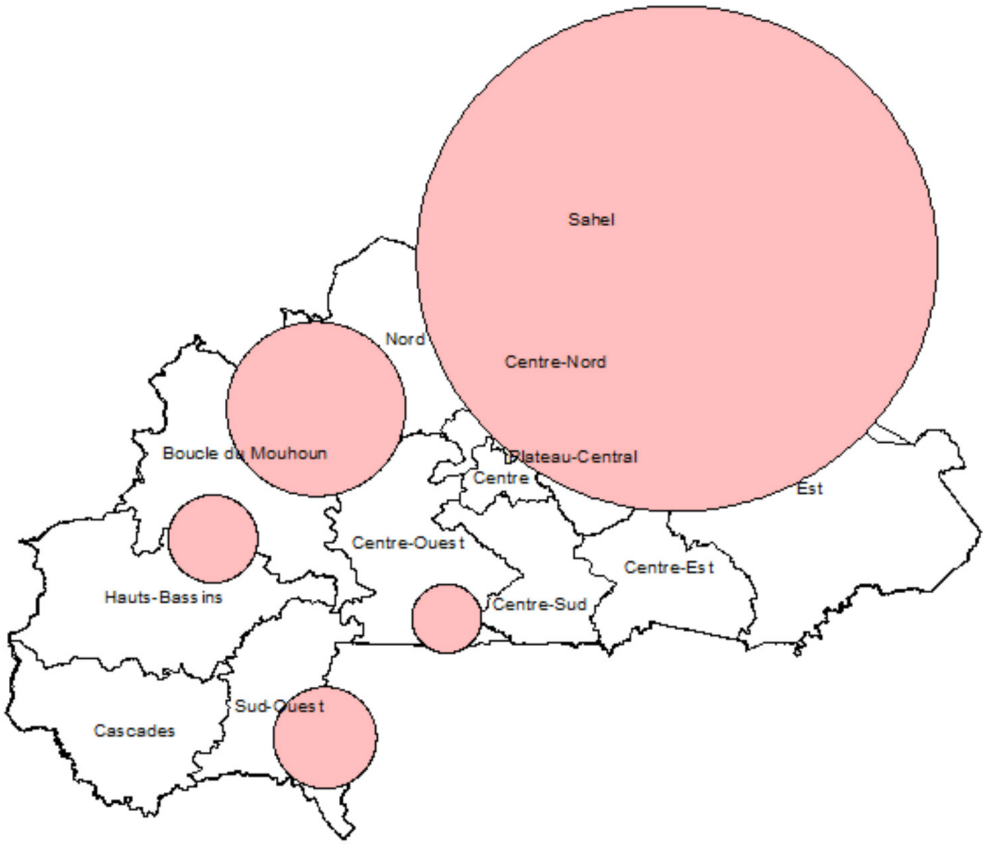
Determinant factors of anemia

Based on multivariable mixed-effects ordinal logistic regression model, Age, wealth index, regions Cascades, Hauts-bassins, and Plateau central were significantly associated with the level of anemia among women age 15-49 years in Burkina Faso at p-value 0.05 (Tab. IV).

Tab. III. Significant spatial clusters with high rate of Anemia among women age 15-49 years in Burkina Faso, 2021

	Cluster Enumeration area (cluster) identified	Coordinate (radius	Population	Case	RR	LLR	P- value
1	473, 469, 467, 466, 468,470, 474, 472, 471, 313, 315, 314, 318, 312, 204, 311, 309, 209, 310, 201, 316, 199, 306, 215, 203, 317, 216, 211, 212, 213, 205, 210, 214, 188, 208, 477, 475, 476, 78, 200,202, 221, 308, 190, 207, 307, 206, 220, 195, 192,193, 194, 432, 218, 217, 191, 197, 222, 219, 437,458, 166, 457, 189, 433,446, 196, 330, 198, 331,332, 175, 170, 439, 418 434, 438, 176, 392, 179,177, 450, 178, 456, 455, 403, 171, 453, 440, 454, 442, 414, 174, 167, 172, 444, 441, 173, 436, 419, 452, 391, 415, 448, 169, 420, 435, 449, 320, 428, 416, 443, 447, 451, 445, 115	14.122803 N, 0.062321 W) / 228.21 km	1281	843	1.32	51.483251	< 0.001
3	10, 9, 380, 367, 381, 37, 17	11.845827 N, 3.836225 W) / 39.61 km	84	67	1.50	12.782125	0.0019

Fig. 5. Primary and secondary clusters of Anemia among women age 15-49 years in Burkina Faso, 2021.



Making other variables constant, the likelihood of experiencing severe anemia among among women that were in age group of 25-29 years (relative to moderate, mild or non-anemic) were 1.31 times higher than those in the age group of 15-19 years [AOR = 1.31 ; 95% CI: 1.06 1.61]. The likelihoods of rich women aged 15 to 49 developing severe anemia (compared to moderate, mild or non-anemic) were 1.32 times higher than poor women aged 15–[AOR = 1.32 ; 95% CI: 1.08 1.62] while holding other variables constant. Regarding region, the odds of severe anaemic (opposed to moderate, mild or non-anemic) were increased by 62%, and 40% among women aged 15-49 residing in Cascades and Hauts-bassins respectively as compared with women aged 15-49 residing in Boucle du mouhoun and the odds of severe anaemic (opposed to moderate, mild or non-anemic) were decreased by 72%, and 42% in Plateau central and Sahel respectively as compared with women aged 15-49 residing in Boucle du mouhoun.

Discussion

This study is aimed to investigate the spatial distribution and determinants of anemia among women age 15-49 in

Tab. IV. Bi-variable and multivariable mixed-effects ordinal logistic regression model of anemia among women age 15-49 in Burkina Faso, 2021 (N = 5,655).

Variables		Crude odds ratio				Adjusted odds ratio			
		OR	95% CI		P-value	OR	95% CI		P-value
Region									
1)	Boucle du mouhoun	Ref	Ref		Ref	Ref	Ref		Ref
2)	Cascades	1.82	1.31	2.53	< 0.001	1.62	**1.16**	**2.25**	**0.004**
3)	Centre	1.49	1.14	1.93	0.003	1.22	0.93	1.60	0.145
4)	Centre Est	1.10	0.83	1.46	0.485	1.04	0.79	1.37	0.754
5)	Centre Nord	0.88	0.65	1.20	0.443	0.86	0.64	1.16	0.344
6)	Centre Ouest	1.11	0.84	1.47	0.442	1.10.	0.83	1.46	0.472
7)	Centre Sud	1.20	0.89	1.63	0.215	1.21	0.90	1.64	0.201
8)	Est	0.99	0.72	1.38	0.993	1.01	0.73	1.39	0.940
9)	Hauts-bassins	1.55	1.18	2.03	0.001	1.40	**1.06**	**1.84**	**0.015**
10)	Nord	0.89	0.67	1.19	0.462	0.88	0.66	1.17	0.382
11)	Plateau central	0.71	0.53	0.96	0.026	0.72	**0.54**	**0.96**	**0.027**
12)	Sahel	0.47	0.31	0.70	< 0.001	0.42	**0.28**	**0.63**	**< 0.001**
13)	Sud-Ouest	1.16	0.86	1.55	0.316	1.17	0.87	1.56	0.285
Type of place of residence									
Urban		Ref	Ref		Ref				
Rural		0.74	0.65	0.84	< 0.001	0.87	0.74	1.03	0.120
Toilet facility									
Yes		Ref	Ref		Ref				
No		0.86	0.77	0.97	0.015	1.04	0.91	1.19	0.480
Wealth index									
1)	Poorest	Ref	Ref		Ref				
2)	Poorer	1.03	0.86	1.22	0.733	1.00	0.84	1.19	0.951
3)	Middle	1.06	0.89	1.26	0.338	1.001	0.83	1.20	0.988
4)	Richer	1.48	1.25	1.77	< 0.001	1.32	**1.08**	**1.62**	**0.007**
5)	Richest	1.53	1.28	1.84	< 0.001	1.24	0.97	1.59	0.075
Age									
1)	15-19	Ref	Ref		Ref				
2)	20-24	1.13	0.91	0.24	0.243	1.09	0.88	1.34	0.403
3)	25-29	1.34	1.09	1.65	0.005	1.31	**1.06**	**1.61**	**0.011**
4)	30-34	1.19	0.97	1.47	0.088	1.16	0.95	1.43	0.140
5)	35-39	1.08	0.88	1.34	0.432	1.07	0.87	1.32	0.491
6)	40-44	1.02	0.82	1.27	0.817	1.03	0.83	1.28	0.770
7)	45-49	0.87	0.69	1.10	0.262	0.87	0.69	1.10	0.266
Random intercept									
Var (cons)		--	--		--	0.12	0.08	0.20	--

AOR: Adjusted Odd ratio; COR: Crude Odd Ratio; CI: Confidence interval.

Burkina Faso. The spatial analysis result showed that the spatial distribution of anemia among women age 15-49 was significantly varied across the country. In multivariable mixed-effect ordinal regression analysis; Age, wealth index, regions Cascades, Hauts-bassins, Plateau central, and Sahel were significant predictors of the level of anemia among women age 15-49 in Burkina Faso.

The present study documented that the spatial distribution of anemia among women age 15-49 significantly varied across the country this implies that anemia is unevenly distributed in all regions of Burkina Faso. Significant hotspot areas of anemia were identified in the Boucle du mouhoun, Centre, Hauts-bassins, Nord, Centre Ouest, Plateau central, and Centre Est regions this implies that

these regions have higher prevalence of anemia than other regions of Burkina Faso. Significant cold spot areas of anemia (low cluster of anemia), located in Sahel and Cascades regions this implies that this regions have low prevalence of anemia than other regions of Burkina Faso.

116 clusters were primary (most likely) clusters which were located in the Plateau central, Centre Nord, half of Est, half of Nord, and Sahel regions at 14.122803 N, 0.062321 W, with 228.21 km radius, a Relative Risk (RR) of 1.32, and Log-Likelihood Ratio (LRR) of 51.483251, at p-value < 0.01 (Tab. III). This tells us that women's within the spatial window had 1.32 times higher risk of experiencing anemia as compared to women's outside the spatial window. The secondary cluster were found in half of Boucle du mouhoun, border of Centre Ouest, and border of Nord regions at 11.845827 N, 3.836225 W), with 39.61 km radius, a Relative Risk (RR) of 1.50, and Log-Likelihood Ratio (LRR) of 12.782125, at p-value = 0.0019. This tells us that women's within the spatial window had 1.50 times higher risk of experiencing anemia as compared to women's outside the spatial window.

Regarding region, the odds of severe anaemic (opposed to moderate, mild or non-anemic) were increased by 62%, and 40% among women aged 15-49 residing in Cascades and Hauts-bassins respectively as compared with women aged 15-49 residing in Boucle du mouhoun (p values < 0.05) and the odds of severe anaemic (opposed to moderate, mild or non-anemic) were decreased by 72%, and 42% in Plateau central and Sahel respectively as compared with women aged 15-49 residing in Boucle du mouhoun (p values < 0.05) This spatial variation might be due to the difference in socioeconomic status, dietary diversity and food security [23]. Infectious disease like Malaria [24, 25] accounting for 18% of all deaths before five years of age. Clinical manifestations of severe falciparum malaria vary according to transmission in-tensity and typically present as one or more life-threatening complications, including: hy-perparasitemia; hypoglycemia; cerebral malaria; severe malarial anemia (SMA, HIV [23].

The likelihoods of rich women aged 15-49 developing severe anemia (compared to moderate, mild or non-anemic) were 1.32 times higher than poor women aged 15 [AOR = ;1.32; 95% CI: 1.08, 1.62, p values < 0.05] while holding other variables constant. This is in contrast with previous studies [2, 6, 7, 9-11] but similar with a study in Nepal [3] which showed that women in poorer wealth status were less likely to be anemic. The possible reasons listed in previous study conducted in Nepal is being an agrarian-based country and the same eating pattern for all. Most of the people consume iron-rich staple foods regardless of wealth status [3] and the same reason might apply to Burkina Faso. This finding may be surprising because maintaining food security is a big issue among poor families [26].

The current study revealed that the chances of women in age group of 25-29 years developing severe anemia (versus moderate, mild or non-anemic) were higher than the chances of women in age group of 15-19 years (p values < 0.05). This is similar with previous studies [4, 5]. The possible explanations for such results might be due to this specific group 25-29 years is in the phase of puberty growth spurt, when there is increasing need for the intake of iron, imposed by the expansion of cellular mass and by the growth of tissues, as well as by menstrual loss, with a direct influence on metabolism and the need for iron [4] as compared to women in age group of 15-19 years. Besides, inadequate intake of iron-rich foods and consequence of unhealthy dietary choices lead to anemia [27]. Therefore, the iron-deficiency intake – associated with menstrual losses and other factors – may lead to higher risks for adolescents to develop iron-deficiency anemia [28].

The current study has some strengths and limitations that need to be kept in mind while interpreting the result. The first strength of the current study was using large population-based data with a large sample size, which is representative at national and regional levels, so it can be generalized to women aged 15-49 years in Burkina Faso. Secondly, the combined use of both ArcGIS and Sat Scan statistical tests facilitated to identify similar and statistically significant areas with a high cluster of anemia (hot spot area). Furthermore, by considering the ordinal nature of the outcome variable and the cluster nature of data, the current study applied an advanced model (mixed effect ordinal logistic regression) to get reliable standard errors and parameter estimates. The first limitation of the present study was using secondary data, some important variable like dietary intake, Plasmodium falciparum parasite rate and hook- worm were not included in the analysis.

Conclusions

A significant clustering of anemia among women aged 15-49 were found in Burkina Faso and the significant hotspot areas with high cluster anemia were identified in Boucle du, mouhoun, Centre, Hauts-bassins, Nord, Centre Ouest, Plateau central, and Centre Est regions. Besides, Age, wealth index, regions Cascades, Hauts-bassins, Plateau central, and Sahel were significant predictors of anemia. Therefore, effective public health intervention and nutritional education should be designed for the identified hotspot areas and risk groups in order to decrease the incidence of anemia.

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Authors' contributions

Conception and design of the work, acquisition of data, analysis, and interpretation of data were done by KTT.

Data curation, drafting the article, revising it critically for intellectual content, validation, and final approval of the version to be published were done by KTT, ETT, MKT, TKW, MTA and AWZ. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets supporting the conclusions of this article are available upon request to the corresponding author.

Ethics approval and consent to participate

The study does not contain the collection of information from subjects. We sent a one-page proposal abstract of the study to the DHS program office. They gave permission to access the data.

Consent for publication

Not applicable.

Conflicts of interest

All authors declare no conflicts of interest.

References

[1] Teshale AB, Tesema GA, Worku MG, Yeshaw Y, Tessema ZT. Anemia and its associated factors among women of reproductive age in eastern Africa: a multilevel mixed-effects generalized linear model. PLoS One 2020;15:e0238957. https://doi.org/10.1371/journal.pone.0238957.

[2] Tusa BS, Kebede SA, Weldesenbet AB. Spatial distribution and determinant factors of anemia among adults aged 15-59 in Ethiopia; using mixed-effects ordinal logistic regression model. BMC Nutr 2021;7:18. https://doi.org/10.1186/s40795-021-00424-4.

[3] Sunuwar DR, Singh DR, Chaudhary NK, et al. Prevalence and factors associated with anemia among women of reproductive age in seven South and Southeast Asian countries: Evidence from nationally representative surveys. PLoS One 2020;15:e0236449. https://doi.org/10.1371/journal.pone.0236449.

[4] Bezerra AGN, Leal VS, Lira PIC, et al. Anemia and associated factors in women at reproductive age in a Brazilian Northeastern municipality. Rev Bras Epidemiol 2018;21:e180001. https://doi.org/10.1590/1980-549720180001.

[5] Kandala NI, Pallikadavath S, Amos Channon A, et al. A multilevel approach to correlates of anaemia in women in the Democratic Republic of Congo: findings from a nationally representative survey. Eur J Clin Nutr 2020;74:720-31. https://doi.org/10.1038/s41430-019-0524-8.

[6] Habyarimana F, Zewotir T RS. Spatial Distribution and Analysis of Risk Factors Associated with Anemia Among Women of Reproductive Age: Case of 2014 Rwanda Demographic and Health Sur- vey Data. Open Public Health J 2018;11:425-37. https://doi.org/10.2174/1874944501811010425.

[7] Kibret KT, Chojenta C, D'Arcy E, Loxton D. Spatial distribution and determinant factors of anaemia among women of reproductive age in Ethiopia: a multilevel and spatial analysis. BMJ Open 2019;9:e027276. https://doi.org/10.1136/bmjopen-2018-027276.

[8] Lover AA, Hartman M, Chia KS, Heymann DL. Demographic and spatial predictors of anemia in women of reproductive age in Timor-Leste: implications for health program prioritization. PLoS One 2014;9:e91252. https://doi.org/10.1371/journal.pone.0091252.

[9] Hakizimana D, Nisingizwe MP, Logan J, Wong R. Identifying risk factors of anemia among women of reproductive age in Rwanda - a cross-sectional study using secondary data from the Rwanda demographic and health survey 2014/2015. BMC Public Health 2019;19:1662. https://doi.org/10.1186/s12889-019-8019-z.

[10] Nankinga O, Aguta D. Determinants of anemia among women in Uganda: further analysis of the Uganda demographic and health surveys. BMC Public Health 2019;19:1757. https://doi.org/10.1186/s12889-019-8114-1.

[11] Adamu AL, Crampin A, Kayuni N, et al. Prevalence and risk factors for anemia severity and type in Malawian men and women: urban and rural differences. Popul Health Metr 2017;15:12. https://doi.org/10.1186/s12963-017-0128-2.

[12] Lee JO, Lee JH, Ahn S, et al. Prevalence and risk factors for iron deficiency anemia in the Korean population: results of the fifth KoreaNational Health and Nutrition Examination Survey. J Korean Med Sci 2014;29:224-9. https://doi.org/10.3346/jkms.2014.29.2.224.

[13] Harding KL, Aguayo VM, Namirembe G, Webb P. Determinants of anemia among women and children in Nepal and Pakistan: an analysis of recent national survey data. Matern Child Nutr 2018;14:e12478. https://doi.org/10.1111/mcn.12478.

[14] Balarajan YS, Fawzi WW, Subramanian SV. Changing patterns of social inequalities in anaemia among women in India: cross-sectional study using nationally representative data. BMJ Open 2013;3:e002233. https://doi.org/10.1136/bmjopen-2012-002233.

[15] Bethony J, Brooker S, Albonico M, et al. Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. Lancet 2006;367:1521-32. https://doi.org/10.1016/S0140-6736(06)68653-4.

[16] Menendez C, Fleming AF, Alonso PL. Malaria-related anaemia. Parasitol Today 2000;16:469-76. https://doi.org/10.1016/s0169-4758(00)01774-9.

[17] Kassebaum NJ, Jasrasaria R, Naghavi M, et al. A systematic analysis of global anemia burden from 1990 to 2010. Blood 2014;123:615-24. https://doi.org/10.1182/blood-2013-06-508325.

[18] Burkina Faso. 2021; DHS final report. Available at: https://dhsprogram.com/what-we-do/survey/survey-display-562.cfm (Access on: March 24, 2024).

[19] World Health Organization, United Nations Children's Fund. Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs. WHO 2021.

[20] World Health Organization (WHO). Joint monitoring programme for water supply and sanitation. United Nations 2006.

[21] WHO/UNICEF Joint Water Supply, Sanitation Monitoring Programme. Progress on sanitation and drinking water: 2015 update and MDG assessment. WHO 2015.

[22] Waldhör T. The spatial autocorrelation coefficient Moran's I under heteroscedasticity. Stat Med 1996;15:887-92. https://doi.

org/10.1002/(sici)1097-0258(19960415)15:7/9<887::aidsim257>3.0.co;2-e.

[23] Ejigu BA, Wencheko E, Berhane K. Spatial pattern and determinants of anaemia in Ethiopia. PLoS One 2018;13:e0197171. https://doi.org/10.1371/journal.pone.0197171.

[24] Perkins DJ, Were T, Davenport GC, et al. Severe malarial anemia: innate immunity and pathogenesis. Int J Biol Sci 2011;7:1427-42. https://doi.org/10.7150/ijbs.7.1427.

[25] Quintero JP, Siqueira AM, Tobón A, et al. Malaria-related anaemia: a Latin American perspective. Mem Inst Oswaldo Cruz 2011;106:91-104. https://doi.org/10.1590/s0074-02762011000900012.

[26] Ajao KO, Ojofeitimi EO, Adebayo AA, Fatusi AO, Afolabi OT. Influence of family size, household food security status, and child care practices on the nutritional status of under-five children in Ile-Ife, Nigeria. Afr J Reprod Health 2010;14:117-26.

[27] Borges CQ, Silva Rde C, Assis AM, Pinto Ede J, Fiaccone RL, Pinheiro SM. Fatores associados à anemia em crianças e adolescentes de escolas públicas de Salvador, Bahia, Brasil. Cad Saude Publica 2009;25:877-88. https://doi.org/10.1590/s0102-311x2009000400019.

[28] Silva T dos S, Oliveira FM, Santos JM de J. Níveis de Hemoglobina e Consumo de Alimentos Fontes de Ferro em Estudantes do Ensino Médio. Rev Bras Ciências da Saúde 2018;22:307-14. https://doi.org/10.22478/ufpb.2317-6032.2018v22n4.34154.

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