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Factors affecting anaemia among women of reproductive age in Nepal: a multilevel and spatial analysis

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ABSTRACT

Objective The main objective of this study was to explore the factors affecting anaemia among women of reproductive age (WRA) in Nepal using spatial and multilevel epidemiological analysis.

Design This cross-sectional study analysed data from the 2016 Nepal Demographic and Health Survey. Spatial analysis was performed using ArcGIS software V.10.8 to identify the hot and cold spots of anaemia among WRA (15–49 years). Data were analysed using multilevel mixed-effect logistic regression analysis.

Setting Nepal.

Participants A total of 6414 WRA were included in the analysis.

Main outcome measure Anaemia defined by WHO as haemoglobin level less than 120 g/L in non-pregnant women and less than 110 g/L in pregnant women.

Results The spatial analysis showed that statistically significant hotspots of anaemia were in the southern Terai region (four districts in province 1, eight districts in province 2, one district in Bagmati province, two districts in province 5 and one district in Sudurpaschim province) of Nepal. At the individual level, women who underwent female sterilisation (adjusted OR, aOR: 3.61, 95% CI 1.10 to 11.84), with no education (aOR: 1.99, 95% CI: 1.17 to 3.39), and from middle socioeconomic class families (aOR: 1.65, 95% CI: 1.02 to 2.68) were more likely to be anaemic, whereas, older women (≥35 years) (aOR: 0.51, 95% CI: 0.26 to 0.97) and those women who were using hormonal contraceptives (aOR: 0.63, 95% CI: 0.43 to 0.90) were less likely to be anaemic. At the community level, women from province 2 (aOR=2.97, 95% CI: 1.52 to 5.82) had higher odds of being anaemic.

Conclusion WRA had higher odds of developing anaemia, and it varied by the geographical regions. Nutrition-specific and nutrition-sensitive interventions can be tailored based on the factors identified in this study to curb the high burden of anaemia.

Strengths and limitations of this study

- ► This study uses comprehensive, and nationally representative data with haemoglobin level.
- ► The combined statistical methods including multilevel and spatial analysis were applied, which takes into account the role of geographical risk profile and determinants of anaemia among women of reproductive age in Nepal.
- ► Due to the cross-sectional design, it was difficult to determine the cause-and-effect relationships between the predictors and outcome variable (anaemia).
- ► Other potential confounding factors of anaemia such as nutrient intake, worm infestations, other non-modifiable risk factors and other qualitative factors were beyond the scope of this study.
- ► This study could not distinguish the types of anaemia such as nutritional, genetic and infectious.

INTRODUCTION

Anaemia remains a significant public health problem in developing countries despite advances made in health sciences.[1] Approximately one-third of the population is affected by anaemia globally.[2 3] South and Southeast Asian countries account for the largest burden of anaemia with estimated prevalence of 52.5% among women of reproductive age (WRA).[4] The highest prevalence over the past 26 years was 55.2% in 1990.[5] Despite the implementation of a '1000 days nutrition programme' among various other programmes, targeted to a mother with newborn babies in South Asia, the reduction in anaemia among pregnant women has not been significant.[6] To accelerate reduction of anaemia, the World Health Assembly has set a target of achieving a 50% reduction of anaemia among WRA by 2025 relative to 2010.[7] However, not a single South Asian country is on the way to achieve the 2025 targets.[8]

The Government of Nepal has set targets in line with various global and national indicators such as Multi-Sectoral Nutrition Plan II (2018–2022), and Sustainable Development Goals 2030 for the reduction of anaemia.[9 10] Despite the historical efforts in preventing anaemia through the implementation of national nutrition programmes and policies including iron-folic acid supplementation across the country, the prevalence of anaemia among WRA has been increasing steadily from 35% in 2011 to 41% in 2016.[11 12] These figures suggest that anaemia continues to be a serious public health problem in Nepal.[13]

Anaemia in WRA is associated with multiple conditions and consequences such as preterm delivery,[14] miscarriage,[15] low birth weight,[16] child growth faltering, impairment of cognitive function, increased susceptibility to infection and poverty.[17 18] It is also associated with increased risk of prenatal and maternal mortality.[16 19] Approximately 20% of maternal deaths are caused by anaemia and it is also considered as an additional risk factor for 50% of all maternal deaths.[20 21]

Contributing factors and distribution of anaemia include a complex interplay of political, ecological, social and biological factors.[22] In Nepal, anaemia among WRA is associated with various socioecological factors. In the southern Terai of Nepal, low community education status, gender based-inequality, poor health seeking behaviour,[23–25] inadequate dietary intake during pregnancy,[26–28] lack of diversified diet,[12 27 29] high burden of hookworm infection and malaria,[30–32] and high amount of arsenic in potable water[33] were identified as factors contributing to anaemia. High prevalence of anaemia in the mountainous region were attributed to among others, food insecurity and low dietary diversity,[12 27 34] poor health services,[25] illiteracy and gender-based inequality.[23 24]

To decrease the burden of anaemia, it is necessary to generate adequate evidence in terms of the role and contribution of individual, household and the community level factors along with the geographical risk profile of anaemia. Only a few studies in the past have explored factors affecting anaemia among WRA using nationally representative Nepal Demographic and Health Survey (NDHS) data.[35–37] So far, no studies have used spatial data to explore the geographical hotspots (high prevalence) of anaemia among WRA using cluster sampling of the NDHS data. In addition, population in Nepal has diverse characteristics in terms of their culture, ethnicity and geographical locations. Within the latitude of 193 km (North to South), Nepal bears tropical/subtropical landscape on the south, and temperate to alpine in the North, with an elevation ranging from 70 m to the summit of Mount Everest (8848 m).[38] The distinct characteristics such as dietary habit, lifestyle and socioeconomic status linked to the geographical regions of Nepal are unique and pose risk of developing anaemia. Exploring spatial patterns and factors affecting anaemia by geographical region is therefore critical to inform the plans and policies for targeted anaemia control and prevention programmes.[39] The main objective of this study was to explore the spatial distribution and contributing factors of anaemia among WRA in Nepal.

METHODS

Patient and public involvement

This study used a publicly available data set (NDHS). There were no patients involved.

Data source

This study was based on the data from NDHS 2016, a nationally representative cross-sectional survey. This survey was carried out as part of the DHS programme by New ERA (a private non-profit research organisation based in Kathmandu) under the guidance of the Ministry of Health, Government of Nepal and was supported by ICF international and US Agency for International Development. The study population for this study was WRA from the NDHS 2016.

Study settings and sampling strategy

The sample for the 2016 NDHS was designed to provide estimates of population health, and nutrition indicators including fertility and mortality rates for the overall country, provinces, development regions, urban and rural municipalities, and for the ecological zones: Terai, Hills, and Mountains. The NDHS 2016 used a stratified, two-stage cluster sampling design. The survey used enumeration areas (EAs) which is a primary sampling unit and was selected from 383 wards in both rural (n=199) and urban (n=184) areas with probability proportional to size method. In the second stage, 30 households on average within EAs were selected using a systematic sampling technique. A more detailed methodology of the NDHS has been published elsewhere.[12] All WRA (pregnant and non-pregnant) with complete sociodemographic and nutritional characteristics who were residents or who had slept in the selected households on the night before the survey were eligible for the survey. The details of the sample size selection in the NDHS 2016 are presented in figure 1.

Study variables

Outcome variables

Haemoglobin level was measured using capillary blood by a battery-operated portable HemoCue rapid testing machine and was adjusted for altitude and smoking status.[12] According to the WHO, for non-pregnant and pregnant women aged 15–49 years, any form of anaemia is defined as haemoglobin concentration <120 g/L and <110 g/L, respectively.[40] The categories of anaemia were further dichotomised into ‘anaemic’ and ‘not anaemic’.

Predictor’s variables

Predictors of anaemia were selected based on the literature review.[4 35–37 39] The wide range of sociodemographic, individual, household and community factors were hypothesised to increase the likelihood of anaemia. The predictors of anaemia including both individual-level and community-level factors were included in the analysis. The coding strategy of individual-level and community-level factors are presented in online supplemental table 1.

Individual-level factors

A total of 11 individual-level factors were identified, and that included, for example, respondent’s age, education level, occupation, wealth index, nutritional status,

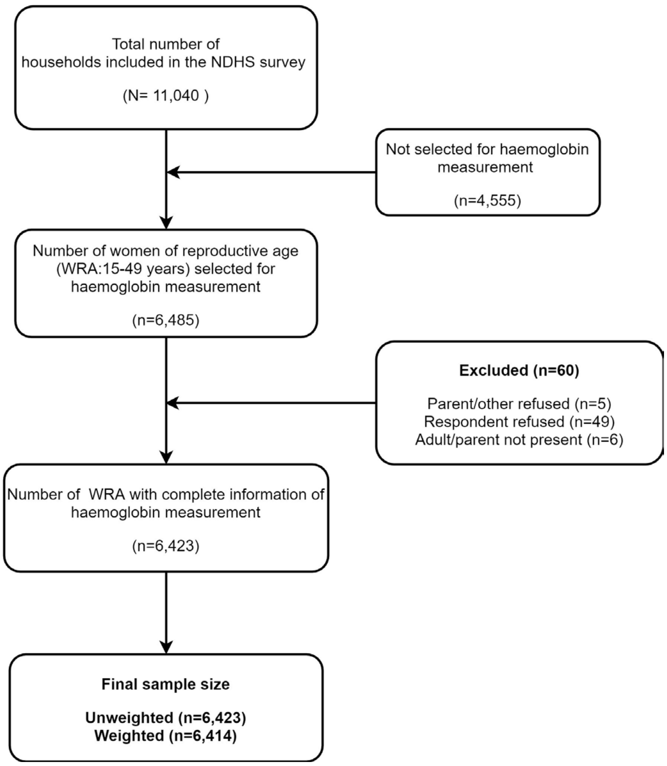

Figure 1 Flow chart for sample size selection. NDHS, Nepal Demographic and Health Survey; WRA, women of reproductive age.

pregnancy status and minimum dietary diversity for WRA (MDD-W). The MDD-W was calculated using the guideline of the modified Food and Nutrition Technical Assistance III (FANTA) project tool developed by the Food and Agriculture Organization of the United Nations.[41]

Community-level factors

The six different factors were included in the community-level factors that included place of residence, province, community wealth, community female education, community safe water access and community toilet facility. The selection of community-level factors were based on the group of women living in similar settings.[39] If more women have shared features such as place of residence, province, type of water source and toilet facility; it was considered to have the same effect on anaemia among WRA.[39] For community level wealth and female education, we constructed the aggregate continuous community-level predictor variables by aggregating individual-level characteristics at the community (cluster) level. We dichotomised the aggregate variables into 'high' or 'low' based on the distribution of the proportion values calculated for each community,[42] but it was not applicable for the provinces and place of residence. Based on distribution of the aggregate variable (normal or non-normal), mean and median was used as a cut-off point for the categorisation of community-level variables, respectively. The community wealth was categorised as 'high' if the proportion of women from richest (rich, richest) households in the community was above 21% and 'low' if the proportion was 0%–21%. Community female education was defined as the mean percentage of women in the community with at least primary education and above.[43] Water supply and sanitation guidelines based on the WHO and UNICEF Joint Monitoring Progamme were used to define improved toilet facility and improved water source.[44]

Data analysis

Statistical analysis

Data were analysed using Stata/MP V.14.1 (StataCorp). The 'svy' command was used to account for sampling weights, clustering, and stratification in complex survey data. Weighted frequencies, weighted percentage, mean and SD were used for the descriptive analysis. Pearson χ^2 test for categorical variables and independent t-test for continuous variables were used. The multilevel mixed-effect logistic regression analysis was performed to estimate the adjusted OR (aOR) and to estimate the extent of random variations between communities.

Four models were created and were fitted. Model 1 (empty model) was fitted without predictor variable to test random variability in the intercept and to estimate the intraclass correlation (ICC).[45] Model 2 examined the effects of individual-level characteristics, model 3 examined the effects of community-level variables, and model 4 examined the effects of both individual and community-level characteristics simultaneously. In the multilevel mixed-effect logistic regression models, the fixed effects estimated the association between the likelihood of anaemia among WRA and the individual-level and community-level factors, and the findings are reported in terms of aOR, and 95% CIs. To prevent statistical bias in the multilevel logistic regression model, we examined and reported multicollinearity among the predictor variables using variation inflation factors (VIF). In this study, we used '10' as a cut-off value for the maximum level of VIF.[46] The random effects are expressed as ICC,[45] and proportional change in variance (PCV).[47] The ICC was calculated to evaluate the cluster variability; and PCV can measure the total variation due to factors at the individual and community levels.[45] Models fit were assessed using Akaike information criterion and the Bayesian information criterion. Considering the nested structure of the survey data, a multilevel model is considered to be appropriate than ordinary single-level regression model because it provides correct parameter estimates by handling the cluster data.[48 49]

Spatial analysis

Spatial analysis was performed using ArcGIS software V.10.8, and base files of the administrative provinces and districts of Nepal were obtained from Government of Nepal, Ministry of Land Management,[50] and Natural Earth.[51] The global positioning system (GPS) data set for NDHS was obtained from the DHS website after receiving the approval letter. The prevalence of anaemia and standardised prevalence ratio (SPR) were computed for both the districts and provinces in Stata/MP V.14.1

software and were later transferred to Excel spreadsheet. These data were imported into the ArcGIS software to link the reported anaemia prevalence for each cluster to the corresponding geographical location (survey cluster data). The spatial variations of the prevalence of anaemia among WRA by both districts and provinces were visualised. To estimate the SPR (ratio of observed prevalence to expected prevalence)[52] of anaemia among WRA, we first determined the prevalence of anaemia for both districts and provinces. District and province wise prevalence rate of anaemia among WRA was multiplied by the national prevalence rate of 41% (normalised to the national prevalence of 41%).

The Local Moran's I, Gettis-Ord G-statistics tool in ArcGIS software was used to compute to measure how spatial autocorrelation of anaemia among WRA varies across different locations in Nepal. The Getis-Ord G-statistics identifies statistically significant spatial clusters of hotspot clusters (high-high) and cold spot clusters (low-low).[53 54] Hotspot analysis computes Z-score and p value to determine the statistical significance of the clustering of anaemia over the study area at different significance levels simultaneously.[54 55] The statistical significance of autocorrelation was determined by z-scores and $p \leq 0.05$ with a 95% CIs.[39 55] An anaemia hotspot was defined as the occurrence of high prevalence rates of anaemia clustered together on the map. Anaemia cold spot was referred to the occurrence of low prevalence rates of anaemia clustered together on the map.[39 55] The spatial pattern and distribution of anaemia prevalence rates among WRA in Nepal are visualised on the map (figure 2).

Ethical consideration

The details on ethical procedures used in this survey have been published elsewhere.[12] We registered and requested for access to both main data and GPS data from the DHS website[56] and received an approval to access and download the DHS data file. DHS programme collected data following a written informed consent from each individual. All individual identifiers were precluded from the final dataset in this study.

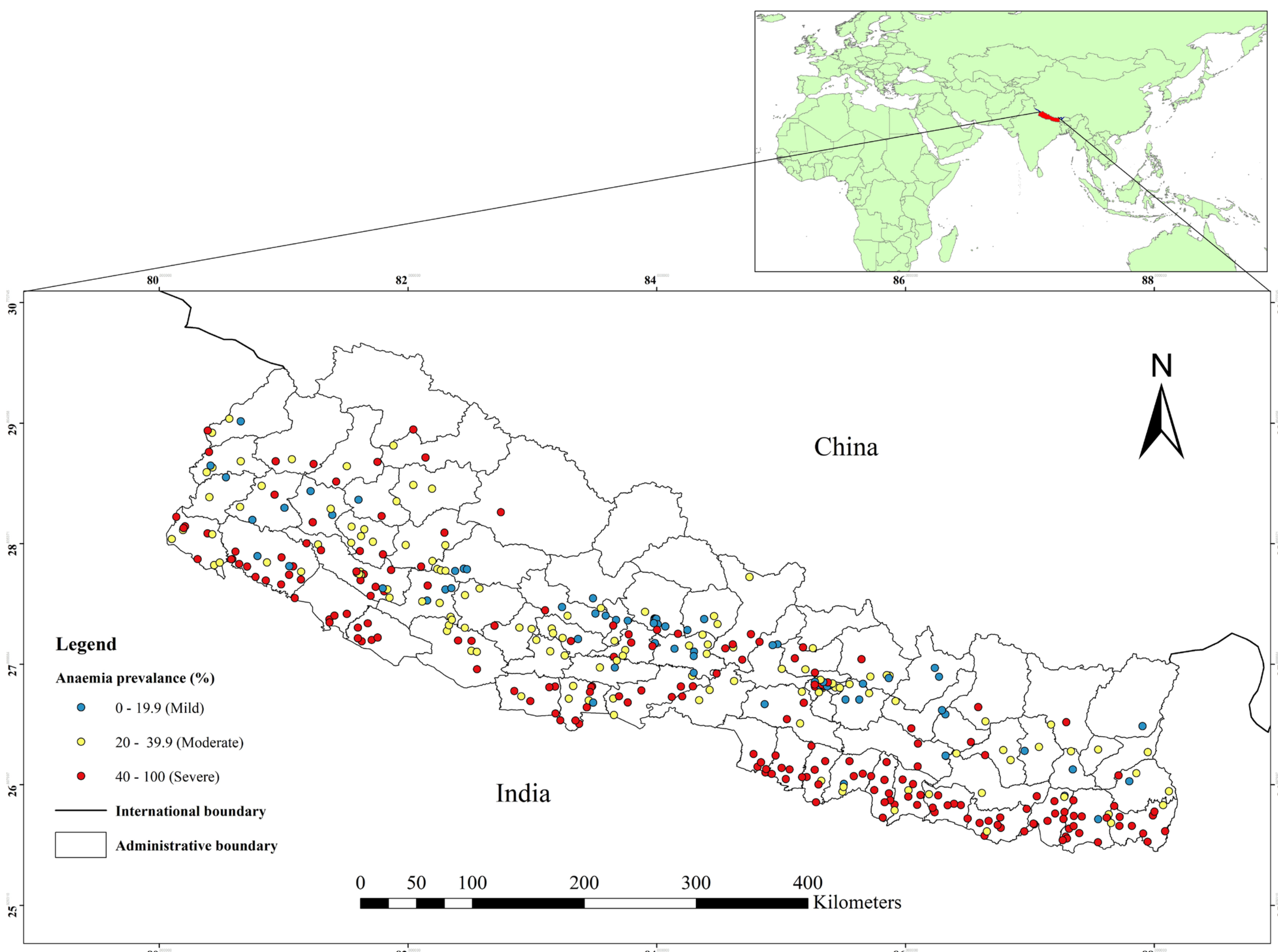

Figure 2 Study area map and observed anaemia prevalence among women of reproductive age for the NDHS survey clusters. NDHS, Nepal Demographic and Health Survey.

RESULTS

Sociodemographic characteristics of study participants

In this study, a total of 6414 WRA were included in the analysis (table 1). The mean (±SD) age of the study participants was 29 (±9.7) years. More than one-third (38.1%) of the participants were from age group 15–24 years, and 35.5% of women had attended secondary level education. Nearly one-quarter (22.4%) of study participants were from richer wealth quintiles and more than half (59.7%) of the women were not using any contraceptive methods, and a half (50.6%) of the participants consumed more than five food types. More than three-quarters (77.1%) of participants had mosquitoe bed nets for sleeping. High proportion of women (68.8%) belonged to urban areas, and were from Bagmati province (21.9%). More than half (54.2%) of the women had the highest percentage of community female education, while, nearly two-thirds (64%) of the women belonged to a low percentage of community female wealth index. Majority of the participants had improved sources of drinking water (91%) and type of toilet facility (84.1%) (table 1).

Prevalence of anaemia among WRA

In the current study, the overall prevalence of any anaemia across Nepal was 41% (95% CI: 38.5% to 42.9%). At the individual level, the prevalence of anaemia was higher among younger age group (43.6%), and women who attended at least secondary level education (42.7%). The higher prevalence of anaemia were found in middle socio-economic class families (48.9%). The prevalence of anaemia was more among women who had undergone female sterilisation (53.7%), and those who consumed less than five food groups (51%). At the community level, the prevalence of anaemia was higher in women who came from province 2 (57.7%). The high prevalence of anaemia was found in community with low female education (47.9%), female wealth index (44.3%) and who did not have improved toilet facility (51.5%) (table 1).

Factors affecting anaemia among WRA

The fixed effects (a measure of association) and the random-effects for the risk of developing anaemia among WRA are presented in table 2. The results of the empty model (model 1) showed that there was statistically significant variability in the odds of anaemia between communities (τ=0.627, p<0.001). The ICC in the empty model implied that 16% of the total variance for the risk of developing anaemia was attributed to differences between the communities. In individual-level factors (model 2), women who did not have formal education (aOR=2.22, 95% CI: 1.35 to 3.82) compared with those with higher education, and who belonged to middle-class families (aOR=1.38, 95% CI: 0.86 to 2.20) compared with the family from poorest families were found to have higher odds of anaemia. Older women had 52% lower (aOR=0.48, 95% CI: 0.24 to 0.83) odds of developing anaemia compared with younger women. Women who used hormonal contraceptive methods had 35% lower (aOR=0.65, 95% CI: 0.46 to 0.92) odds of anaemia compared to who did not use contraceptive methods. The ICC in model 2 indicated that 11.8% of the variation in WRA anaemia was attributable to differences across communities. The PCV indicated that 29.3% of the variance in WRA anaemia across communities was explained by the individual-level characteristics.

The community level (model 3) showed that women from province 2 had 2.5 times higher (aOR=2.51, 95% CI: 1.79 to 3.53) odds of anaemia compared to women from Bagmati province. Women who belonged to communities with a low percentage of the wealthy households had 1.48 times higher (aOR=1.48, 95% CI: 1.21 to 1.80) odds of anaemia compared to those coming from high percentage of the wealthy household; and women residing in communities with a low percentage of community female education had 1.39 times higher (aOR=1.39, 95% CI: 1.15 to 1.68) odds of anaemia compared to those coming from the communities with a high percentage of education. The ICC in model 3 showed that differences between communities accounted for about 11.1% of the variation in anaemia among WRA. In addition, the PCV indicated that 33.9% of the variation in WRA anaemia between communities was explained by community-level characteristics.

In model 4, women who had undergone female sterilisation were at higher (aOR: 3.61, 95% CI: 1.10 to 11.84) odds of anaemia compared to those who did not use contraceptive methods. Women with no formal education were found to have two times higher (aOR=1.99, 95% CI: 1.17 to 3.39) odds of anaemia compared to women who had higher education. Women from middle socioeconomic family had higher (aOR=1.65, 95% CI: 1.02 to 2.68) odds of anaemia compared to poorest counterparts. Women who came from province 2 (aOR=2.97, 95% CI: 1.52 to 5.82) had higher odds of anaemia compared to Bagmati province. The older women had 49% lower (aOR=0.51, 95% CI: 0.26 to 0.97) odds of anaemia compared to younger women, and women who used hormonal contraceptive methods had 37% lower (aOR=0.63, 95% CI: 0.43 to 0.90) odds of anaemia compared to who did not use contraceptive methods. After the inclusion of both the individual and community-level variables in model 4, the ICC indicated that 9.5% of the variability in anaemia among WRA was attributable to the difference between communities. Furthermore, the PCV indicated that 44.6% of the variation in anaemia among WRA between communities was explained by both individual and community-level characteristics (table 2).

Table 1 Sociodemographic characteristics and prevalence of anaemia among women of reproductive age by determining factors (n=6414)

Variables	Total sample Frequency (%)	Anaemia status % (95% CI) Not anaemic	Anaemic	P value*
Overall prevalence	6414	59.3 (57.0 to 61.4)	40.7 (38.5 to 42.9)	
Severe anaemia	17 (0.3)			
Moderate anaemia	450 (7)			
Mild anaemia	2147 (33.4)			
Haemoglobin level (g/L), mean (±SD)	123±15	132±9	108±11	<0.001†
Individual-level factors				
Age in years, mean (±SD)	29.1±9.7	29.5±9.7	28.4±9.5	<0.001†
Age				<0.001†
15–24	2443 (38.1)	56.4 (53.4 to 59.3)	43.6 (40.6 to 46.5)	
25–34	1971 (30.7)	58.7 (55.7 to 61.5)	41.3 (38.4 to 44.2)	
≥35	2000 (31.1)	63.2 (60.3 to 66.0)	36.8 (34 to 39.6)	
Education				0.086
No education	2144 (33.4)	58.4 (55 to 61.7)	41.6 (38.2 to 44.9)	
Primary	1069 (16.6)	61.5 (57.1 to 65.7)	38.5 (34.2 to 42.8)	
Secondary	2277 (35.5)	57.3 (54.2 to 60.3)	42.7 (39.6 to 45.7)	
Higher	924 (14.4)	63.3 (58.7 to 67.6)	36.7 (32.3 to 41.3)	
Occupation				0.084
Not working	2096 (32.6)	57.1 (53.7 to 60.3)	42.9 (39.6 to 46.2)	
Working	4318 (67.3)	60.3 (57.7 to 62.7)	39.7 (37.2 to 42.2)	
Wealth index				<0.001†
Poorest	1093 (17.0)	67.7 (63.8 to 71.2)	32.3 (28.7 to 36.1)	
Poorer	1225 (19.1)	58.5 (54.8 to 62.1)	41.5 (37.9 to 45.2)	
Middle	1317 (20.5)	51.1 (47.2 to 54.8)	48.9 (45.1 to 52.8)	
Richer	1441 (22.4)	56.6 (51.8 to 61.1)	43.4 (38.8 to 48.1)	
Richest	1338 (20.8)	64.1 (59.9 to 67.9)	35.9 (32.1 to 40.1)	
BMI, mean (±SD)	22±3.8	22.4±3.9	21.4±3.6	<0.001†
BMI (n=6411)				<0.001†
Normal	3925 (61.2)	57.4 (54.4 to 60.2)	42.6 (39.7 to 45.5)	
Underweight	1077 (16.8)	51.9 (48.3 to 55.4)	48.1 (44.6 to 51.6)	
Overweight/obesity	1408 (21.9)	69.9 (66.5 to 73.2)	30.1 (26.7 to 33.4)	
Currently pregnant				0.081
No	6124 (95.4)	59.5 (57.3 to 61.6)	40.5 (38.3 to 42.7)	
Yes	290 (4.5)	53.9 (47.2 to 60.5)	46.1 (39.4 to 52.7)	
Currently breast feeding				<0.001†
No	4988 (77.7)	60.7 (58.4 to 62.9)	39.3 (37.1 to 41.6)	
Yes	1426 (22.2)	54.2 (50.6 to 57.7)	45.8 (42.2 to 49.3)	
Total children ever born				0.612
No child	1842 (28.7)	58.2 (54.5 to 61.7)	41.8 (38.2 to 45.4)	
1–3 child	3386 (52.8)	59.9 (57.4 to 62.2)	40.1 (37.7 to 42.5)	
4+child	1186 (18.4)	58.9 (55.1 to 62.7)	41.1 (37.2 to 44.8)	
Current contraceptive use				<0.001†
Not using	3832 (59.7)	57.6 (54.9 to 60.1)	42.4 (39.8 to 45.1)	
Hormonal	905 (14.1)	70.5 (66.5 to 74.2)	29.5 (25.7 to 33.4)	
Female sterilisation	730 (11.4)	46.3 (41.8 to 50.8)	53.7 (49.1 to 58.2)	
Male contraception	268 (4.2)	71.7 (61.9 to 79.8)	28.3 (20.1 to 38.1)	

Continued

Table 1 Continued

Variables	Total sample Frequency (%)	Anaemia status % (95% CI) Not anaemic	Anaemic	P value*
Traditional	679 (10.6)	62.4 (58.1 to 61.4)	37.6 (33.3 to 41.9)	
Cigarette/smoking				<0.001†
Smoking	573 (8.9)	71.1 (66.5 to 75.2)	28.9 (24.7 to 33.4)	
Not smoking	5841 (91.1)	58.1 (55.8 to 60.3)	41.9 (39.7 to 44.1)	
MDD-W (n=1131)				0.025†
Not diverse	558 (49.3)	49 (43.8 to 54.1)	51 (45.8 to 56.1)	
Diverse	573 (50.6)	56.8 (51.7 to 61.7)	43.2 (38.2 to 48.2)	
Mosquitoes bed net for sleeping				0.024†
No	1412 (22.1)	68.9 (65.6 to 72.1)	31.1 (27.9 to 34.3)	
Yes	5002 (77.1)	56.5 (53.9 to 59)	43.5 (41 to 46.1)	
Place of residence				0.202
Urban	4029 (68.8)	60.4 (57.5 to 63.1)	39.6 (36.8 to 42.4)	
Rural	2385 (37.1)	57.3 (53.6 to 60.9)	42.7 (39.1 to 46.3)	
Province				<0.001†
Province 1	1073 (16.7)	56.7 (51.2 to 62.1)	43.3 (37.9 to 48.7)	
Province 2	1285 (20)	42.2 (37.3 to 47.2)	57.7 (52.7 to 62.6)	
Bagmati	1408 (21.9)	70.9 (66.4 to 75.1)	29.1 (24.8 to 33.5)	
Gandaki	627 (9.7)	71.9 (66.3 to 76.9)	28.1 (23.1 to 33.6)	
Province 5	1086 (16.9)	56.5 (52.5 to 60.5)	43.5 (39.4 to 47.5)	
Karnali	369 (5.7)	65.1 (59.7 to 70.1)	34.9 (29.9 to 40.2)	
Sudurpaschim	566 (8.8)	60.7 (54.7 to 66.3)	39.3 (33.6 to 45.2)	
Community female education§				<0.001†
Low	2936 (45.7)	52.1 (49.1 to 55.2)	47.9 (44.8 to 50.9)	
High	3478 (54.2)	65.3 (62.3 to 68.1)	34.7 (31.9 to 37.6)	
Community female wealth index‡				<0.001†
Low	4107 (64)	55.7 (52.6 to 58.7)	44.3 (41.2 to 47.3)	
High	2307 (35.9)	65.5 (62.1 to 68.8)	34.5 (31.1 to 37.8)	
Source of drinking water (n=6084)				0.004†
Improved	5537 (91)	58.7 (56.3 to 61.1)	41.3 (38.9 to 43.6)	
Not improved	547 (8.9)	66.3 (61.4 to 70.8)	33.7 (29.2 to 38.5)	
Type of toilet facility (n=6084)				<0.001†
Improved	5117 (84.1)	61.5 (59.3 to 63.6)	38.5 (36.3 to 40.7)	
Not improved	967 (16)	48.5 (43.1 to 53.9)	51.5 (46.1 to 56.8)	

Frequency and percentage (%) are weighted.
*Denotes Pearson X^2test for categorical variables and independent t-test for continuous variables.
†Denotes statistically significant at p<0.05.
‡Mean per cent of households wealth quintiles categorised richer and richest and above
§Mean per cent of women with primary education level and above.
BMI, body mass index; MDD-W, minimum dietary diversity for women.

Spatial data analysis

Figure 3A shows the prevalence of anaemia among WRA across provinces in Nepal. A severe anaemia prevalence (≥40%) among WRA was seen in province 2, followed by province 1 and 5. The prevalence of moderate anaemia (20.0%–39.9%) was observed in Bagmati, Gandaki, Karnali and Sudurpaschim province. Mild anaemia (prevalence <19.9%) was not found in any provinces. Figure 3B shows the prevalence of anaemia among WRA across 75 districts in Nepal. The prevalence rate of severe anaemia was observed in 29 out of 75 districts, and mild anaemia was found in only eight districts (figure 3).

The SPR by provinces (standardised to the national mean prevalence of 41%) are shown in figure 4A, and ranged from 0.68 to 1.4. The higher prevalence ratio of anaemia was found in province 2, whereas a lower prevalence ratio was observed in Bagmati, Gandaki and Karnali

Table 2 Multilevel mixed-effects logistic regression analysis for individual and community-level factors affecting anaemia among women of reproductive age (n=6414)

Variables	Model 1 empty model	Model 2 Individual-level factors aOR (95% CI)	Model 3 community-level factors aOR (95% CI)	Model 4 individual and community-level factors aOR (95% CI)
Fixed-effects model				
Individual-level factors				
Age				
15–24		0.80 (0.57 to 1.08)		0.75 (0.54 to 1.04)
25–34		Ref		Ref
≥35		0.48 (0.24 to 0.83)*		0.51 (0.26 to 0.97)*
Education				
No education		2.22 (1.35 to 3.82)**		1.99 (1.17 to 3.39)*
Primary		1.52 (0.99 to 2.63)		1.33 (0.79 to 2.23)
Secondary		1.61 (1.08 to 2.54)*		1.46 (0.93 to 2.29)
Higher		Ref		Ref
Occupation				
Not working		Ref		
Working		0.98 (0.73 to 1.32)		
Wealth index				
Poorest		Ref		Ref
Poorer		1.20 (0.79 to 1.86)		1.46 (0.95 to 2.25)
Middle		1.38 (0.86 to 2.20)**		1.65 (1.02 to 2.68)*
Richer		1.13 (0.68 to 1.82)		1.39 (0.84 to 2.32)
Richest		1.28 (0.69 to 2.30)		1.33 (0.70 to 2.52)
BMI (n=6411)				
Normal		Ref		Ref
Underweight		1.10 (0.80 to 1.60)		1.05 (0.72 to 1.51)
Overweight/obesity		0.89 (0.59 to 1.35)		1.03 (0.65 to 1.58)
Currently pregnant				
No		0.81 (0.42 to 1.58)		1.08 (0.53 to 2.19)
Yes		Ref		Ref
Currently breast feeding				
No		Ref		Ref
Yes		1.34 (0.63 to 2.82)		1.60 (0.71 to 3.59)
Total children ever born				
No child		Ref		Ref
1–3 child		–		–
4+ child		1.15 (0.75 to 1.87)		1.02 (0.63 to 1.63)
Current contraceptive use				
Not using		Ref		Ref
Hormonal		0.65 (0.46 to 0.92)*		0.63 (0.43 to 0.90)*
Female sterilisation		3.55 (1.21 to 10.44)*		3.61 (1.10 to 11.84)*
Male contraception		0.92 (0.17 to 4.79)		0.74 (0.14 to 3.77)
Traditional		1.10 (0.74 to 1.63)		1.12 (0.74 to 1.69)
Cigarette/smoking				
Smoking		0.89 (0.48 to 1.66)		1.21 (0.63 to 2.33)
Not smoking		Ref		Ref
MDD-W (n=1131)				
Not diverse		1.20 (0.91 to 1.59)		1.03 (0.76 to 1.40)

Continued

Table 2 Continued

Variables	Model 1 empty model	Model 2 Individual-level factors aOR (95% CI)	Model 3 community-level factors aOR (95% CI)	Model 4 individual and community-level factors aOR (95% CI)
Diverse		Ref		Ref
Mosquitoes bed net for sleeping				
No		0.57 (0.38 to 0.86)		
Yes		Ref		
Community-level factors				
Place of residence				
Urban			Ref	Ref
Rural			1.01 (0.83 to 1.21)	0.89 (0.64 to 1.24)
Province				
Province 1			1.70 (1.23 to 2.34)**	2.07 (1.57 to 5.64)**
Province 2			2.51 (1.79 to 3.53)***	2.97 (1.52 to 5.82)**
Bagmati			Ref	Ref
Gandaki			0.90 (0.64 to 1.26)	0.76 (0.39 to 1.49)
Province 5			1.60 (1.16 to 2.21)**	2.42 (1.31 to 4.50)**
Karnali			1.19 (0.85 to 1.66)	1.66 (0.88 to 3.14)
Sudurpaschim			1.54 (1.11 to 2.15)*	1.62 (0.84 to 3.10)
Community female education†§				
Low			1.39 (1.15 to 1.68)***	–
High			Ref	–
Community wealth index‡§				
Low			1.48 (1.21 to 1.80)***	–
High			Ref	–
Source of drinking water (n=6084)				
Improved			Ref	Ref
Not improved			1.05 (0.84 to 1.30)	1.13 (0.68 to 1.86)
Type of toilet facility (n=6084)				
Improved			Ref	Ref
Not improved			1.03 (0.84 to 1.24)	0.96 (0.63 to 1.45)
Random-effects model				
Community-level variance (τ) (SE)	0.627 (0.073)***	0.443 (0.192)***	0.414 (0.056)***	0.347 (0.194)**
ICC (%)	16	11.8	11.1	9.5
PCV (%)	Ref	29.3	33.9	44.6
Model fit statistics				
AIC	8322.6	1554.7	7838.4	1400.6
BIC	8336.1	1675.8	7925.8	1559.1

Model 1 (empty model): without adjusted predictors variables; model 2: adjusted for individual-level factors; model 3: adjusted for community-level factors; model 4: adjusted for both individual-level and community-level factors.
*p<0.05, **p<0.01, ***p<0.001.
†Mean per cent of women with primary education level and above.
‡Mean per cent of households wealth quintiles categorised richer and richest and above.
§Community female education and community wealth index is omitted in Model four due to collinearity.
AIC, Akaike information criterion; aOR, adjusted OR; BIC, Bayesian information criterion; BMI, body mass index; ICC, intraclass correlation; MDD-W, minimum dietary diversity for women; PCV, percentage change in variation; Ref, reference category.

province. Figure 4B shows the SPR across the 75 districts, and ranged from 0.76 to 1.59. The higher SPR of anaemia was observed in 17 out of 75 districts across the country (figure 4).

The spatial pattern and distribution of anaemia among WRA at the cluster level are displayed in figure 5. The spatial analysis at the cluster level showed that statistically significant high hotspots of anaemia were observed in the

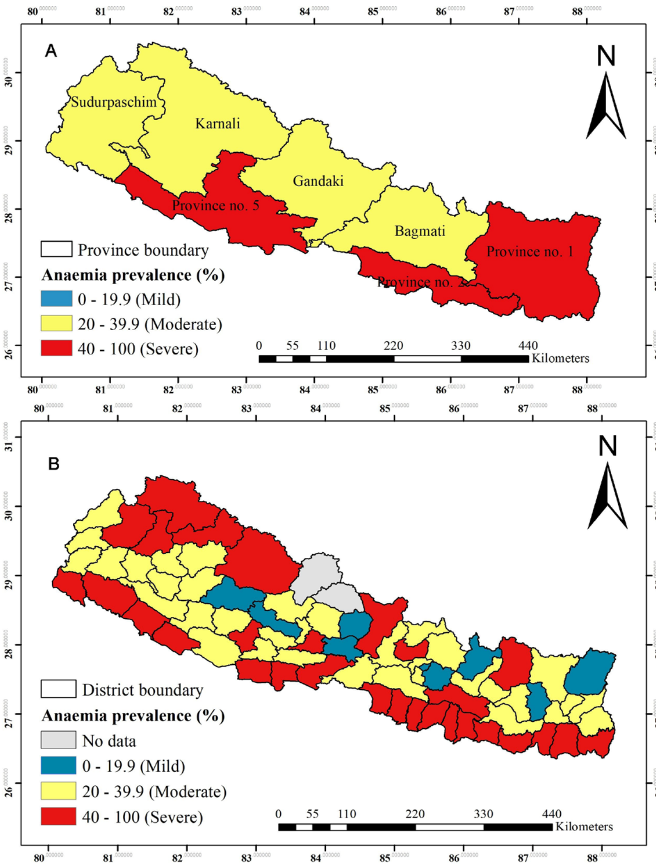

Figure 3 (A) Prevalence of anaemia among women of reproductive age across provinces. (B) Prevalence of anaemia among women of reproductive age across districts.

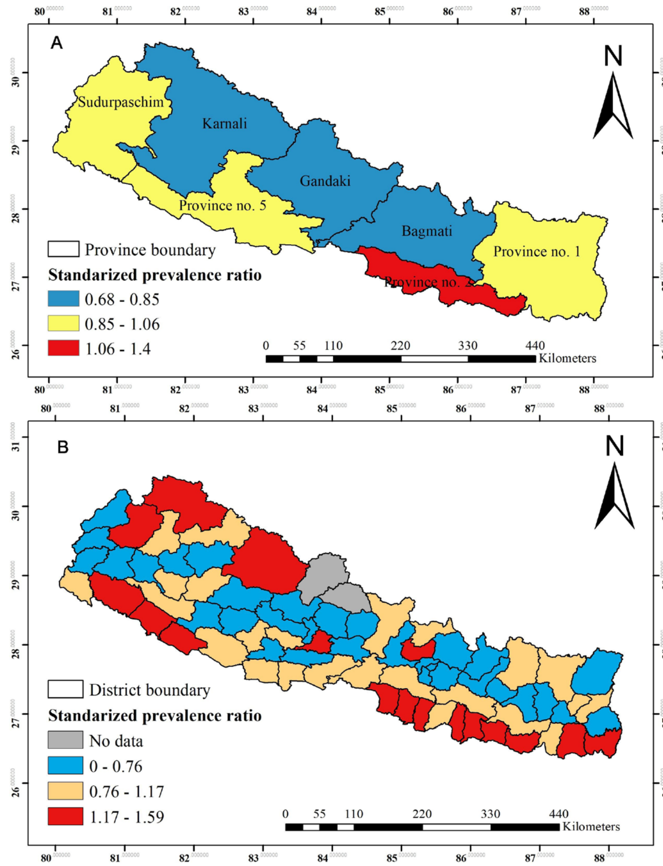

Figure 4 (A) Standardised prevalence ratio of anaemia among women of reproductive age across provinces. (B) Standardised prevalence ratio of anaemia among women of reproductive age across districts (standardised to the national mean prevalence of 41%).

southern Terai of the country bordering India: province 2 (eight districts), province 1 (four districts), southern plain of the Bagmati province (one district) southwestern region of province 5 (two districts) and southern plain of Sudurpaschim province (one district). While, cold spots of anaemia were observed in most of the Hilly regions of the country (figure 5).

DISCUSSION

In this study, more than 40% of WRA were anaemic which implies that anaemia is still an important public health problem in Nepal.[40] Geographical patterns showed that anaemia is an important public health problem in three of the seven provinces and 29 out of the 75 districts in Nepal. The higher prevalence of anaemia was observed in the southern Terai bordering India particularly in province 2, and the upper Himalayan region of the country. The spatial analysis at the cluster level showed that high hotspots of anaemia were observed in Terai region especially in provinces 1, 2, 5 and Sudurpaschim. These findings are consistent with a previous study,[57] which was based on the analysis of Nepal National Micronutrient Status Survey 2016 and found WRA living in the Terai ecological zone had higher odds of anaemia relative to women living in the Mountain and Hill regions. A possible reason could be that in the Terai region, there is a shortage of safe and adequate drinking water supply and the risks of malaria and hookworm infestations are high.[30]

In the southern Terai of Nepal, despite ecological richness, people have long suffered from a deficiency of micronutrients such as Vitamin A, iron and zinc,[26] and a high burden of hookworm infestations and malaria which can contribute to development of anaemia.[30] Diet of women in the Terai lack diversity and, nutrient adequacy which pose an increased risk of anaemia.[27] Terai region of Nepal is endemic to malaria in contrast to Hill and Mountain region of Nepal,[31 32 58] and thus poses higher risk of anaemia.[30] The majority (90%) of the population from Terai region rely on groundwater especially shallow tube well for domestic purposes including drinking whereas most of the people from Mountain and Hill region rely on municipal taps, spring water source, and stone spouts as drinking water sources. Terai region is the most densely populated region compared to Hill and Mountain regions of Nepal. The population of Terai increased dramatically after the 1970s because people from the Mountains and Hills migrated to for permanent settlement.[33] Most of the water wells were installed to meet the growing population demand. However, well water in the Terai consists of high arsenic concentrations (>10 µg/L)

Sunuwar DR, *et al*. *BMJ Open* 2021;**11**:e041982. doi:10.1136/bmjopen-2020-041982

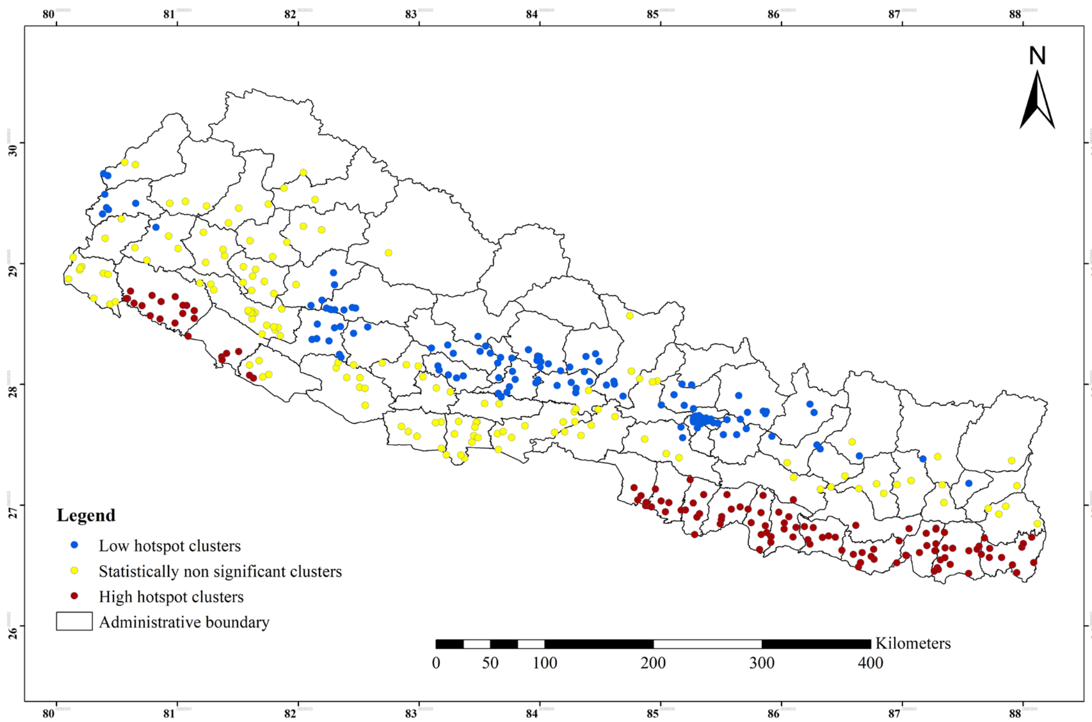

Figure 5 Spatial pattern and distribution of hot and cold spots of anaemia among women of reproductive age at cluster level in Nepal.

beyond the WHO recommendation.[33] A previous study also explained the high burden of anaemia might be due to chronic exposure to arsenic in drinking water.[57] Higher arsenic concentration can inhibit haem iron metabolism and increase erythrocyte hemolysis.[59] Consequently, drinking arsenic-containing water poses an increased risk of anaemia among women.[60] Arsenic exposure was more likely to cause anaemia among women in Bangladesh.[61] The spatial analysis at the cluster level found that high hotspots of anaemia were also observed in southwestern region (province 5 and southern plain of Sudurpaschim province), particularly Banke, Bardiya and Kailali district. A previous study highlighted that glucose 6 phosphate dehydrogenase (G6PD) deficiency, sickle cell trait (SCT) and sickle cell anaemia as the most common disorders in Tharu communities living in southwestern province 5, and sudurpaschim province.[62 63] Study based on the Nepal National Micronutrient Status Survey 2016 also found the G6PD and haemoglobinopathies had strong association with anaemia among WRA.[57]

The geographical variance of high cases of anaemia across the high Mountainous region could be attributed to food insecurity, low dietary diversity,[12 27 34] less calorie diet,[27] poor health service coverage,[25] high illiteracy, gender based-inequality and poor health-seeking behaviour.[23 24]

Sociodemographic characteristic among women and anaemia

Women who had no formal education, and those who came from middle socio-economic households, and from younger age group were at increased risk of anaemia. These findings are in line with previous studies from low-income and middle-income countries including Ethiopia,[39] India,[64] Tanzania,[65] Rwanda,[66] Timor-Leste[67] and Bangladesh.[68] Studies from Ethiopia and Tanzania suggest that higher-level education might enable women to gain knowledge and improve attitude which in turn can promote them to adopt healthier lifestyle including good nutrition habits, better health-seeking behaviour and good hygiene practices.[39 65]

Anaemia is a multifaceted problem where nutrition and household economic status are considered to have a synergistic association.[66] Women belonging to poorer households are more likely to be anaemic compared to those living in middle or richer households in most of the countries.[17 39 66] Contrastingly, this study revealed that socio-economically poorer women were less likely to be anaemic. Similar findings were reported by a previous study which was based on the analysis of the 2016 NDHS dataset.[36] The possible reason could be first, Nepal is an agrarian-based country and the staple diet may be similar for most of the households.[69] Second, it might be due to the nationwide open defecation free campaign initiated after 2011, which contributed to the reduction in hookworm infestation leading to decrease in anemia.[36] Third, there was various ongoing health and nutrition intervention programme targeted at poorer households. For instance, promoting consumption of iron-rich dark green leafy vegetables available from their kitchen garden,[70] consumption of animal source foods, and dietary iron consumption. Interventions such as Suaahara I (from 2011 to 2016) and Sunaula Hazar Din (from 2014 to 2017), which provided financial and technical support to poor households for poultry farming, and contributed to increased consumption of meat and eggs among WRA.[71 72] Future studies are critical to explore the association of household economic status and anaemia among WRA in Nepal.

In this study, the prevalence of anaemia was found to be decreasing with increasing age. These findings are consistent with studies from Nepal,[36] Ethiopia,[39] Demographic Republic of Congo[73] and Benin.[60] The possible reason could be that the low fertility rates are high among older women.[39] Also, it might be due to young girls being under-represented in the public health programmes that aim to prevent anaemia in Nepalese context.[36] However, government of Nepal has started weekly iron folic acid supplementation to adolescent girls aged 10–19 years only after 2016.[74] In contrast, few studies from Nepal did not show any association of age with anaemia.[35 37] The discrepancies might be due to the nature of statistical model used in the analysis.

Effect of contraceptive use on anaemia

In this study, those using hormonal contraceptive were less likely to be anaemic among WRA which is consistent with previous studies conducted in Nepal,[35 36] Rwanda,[66] Tanzania[65] and Ethiopia.[75] This could be due to multiple reasons. For instance, use of hormonal contraceptive can reduce the blood loss during the menstruation.[76 77] Almost 100–150 mg of iron is lost during menstrual bleeding.[78] Subsequently, this may directly or indirectly furnish iron loss among women at high risk for iron-deficiency anaemia.[77 78] A previous study also suggested that Depo-Provera injections were more likely to increase haemoglobin concentration among WRA in Nepal.[79] Interestingly, in this study, women who had undergone female sterilisation were at increased risk of anaemia. These findings are in line with the similar study conducted in Nepal.[36 80]

Community-level factors and anaemia

In this study, estimated ICC shows that about 9.5% of the community level variability was attributable to the difference between communities among WRA. The PCV indicated that 44.6% of the variation in WRA anaemia between communities was explained by both individual and community-level characteristics. These findings are in line with the study conducted in Ethiopia, where both individual-level and community-level factors accounted for about 43% of the variability of anaemia among WRA.[39] Women who came from province 2 had more than two times higher odds of anaemia. Previous studies reported that women from province number 2 were more likely to be coming from lower socioeconomic status and had less diverse diet (an estimated 29% of MDD).[12 29] Other evidence from Nepal also suggested that women in province 2 have poor nutritional status.[81] In addition, compliance rate of recommended dose of iron tablets among the pregnant mothers in province 2 was also low (28%) compared to other provinces.[12] This study showed that promoting community female education has a potential role in lowering the likelihood of anaemia which echoes with a study from Malawi.[42] This could be explained by the fact that higher community education provides a context where women are enabled to gain nutritional knowledge and material resources[28] that can increase consumption of iron-absorption-enhancers such as vitamin C, phytates (whole grains, legumes) and calcium (dairy products). Increasing community-level education can play an important role in promoting knowledge and attitude which in turn can incite them to adopt healthier lifestyle including good nutrition habits that can ultimately prevent anaemia.[39 65 70]

Strength and limitation

This study is conducted based on the spatial pattern and multilevel epidemiological analysis of anaemia among WRA in Nepal using cluster sampling of nationally representative data. The combined statistical methods including multilevel and spatial analysis used in this study provides important insights on the role of contextual factors and geographical patterns in the occurrences of anaemia among WRA in Nepal. This study has some limitations. The cross-sectional design of the study does not allow us to establish the causality. This study relied on haemoglobin as the measure of anaemia; further studies should consider other indices that include total ferritin and total iron binding capacity to differentiate the types of anaemia. Since this study is based on the secondary data analysis, we are unable to incorporate potential confounding factors of anaemia such as nutrient intake, worm infestations and other non-modifiable risk factors.

CONCLUSION

This study highlighted a high prevalence of anaemia among WRA across Nepal. At an individual level, women who had no formal education, those who came from middle socioeconomic class families were more likely to be anaemic, whereas, older women and those who used hormonal contraceptive were less likely to be anaemic. At the community level, low community female education and women living in province 2 were associated with increased odds of anaemia. In the spatial analysis, our study found statistically significant hotspots in the southern Terai region particularly in province 1 (four districts), province 2 (eight districts), Bagmati province (one district) province 5 (two districts) and Sudurpaschim province (one district). Both nutrition specific and nutrition sensitive interventions such as social and behavioural programmes can tailor their strategies based on the factors identified in this study to reduce the high burden of anaemia.

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