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Household Food Insecurity Is Associated with RBC Folate Deficiency and Iron-Deficiency Anaemia Among Non-Pregnant Nepalese Women Aged 15-49 Years

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Abstract: Although food insecurity (a measure of a household's availability, accessibility, utilisation, and stability of food) and micronutrient deficiencies have remained a serious public health concern in Nepal, research assessing the association between them is least known. Using data from the 2016 Nepal Multiple Indicators Cluster Survey (NMICS), this cross-sectional study that included a sample of 2143 non-pregnant women aged 15-49 years assessed whether there is an association between household (HH) food insecurity with red blood cell (RBC) folate deficiency and iron-deficiency anaemia. Multivariate analysis was conducted to examine the association between HH food insecurity and Iron-deficiency anaemia (IDA) and RBC folate deficiency. Overall, 56% of participants were from food-secure households, whilst 7% were from severely food-insecure households. In adjusted models, living in a severely food insecure household was significantly associated with both IDA [adjusted odds ratio (AOR): 1.63; 95% confidence interval (CI): (1.02, 2.60)] and RBC folate deficiency [AOR: 3.83; 95% CI: (1.03, 14.18)]. Findings from this study revealed that severe household food insecurity was associated with both IDA and RBC folate. Public health policies to ameliorate IDA and RBC folate should provision for spending on food assistance programmes to address household food insecurity in Nepal. Social protection schemes should be expanded for those belonging to severely food insecure HHs who are unable to feed themselves and produce food for subsistence to strengthen their livelihood and ensure access to adequate, nutritious, and diverse food. Further, Food System needs to be strengthened to increase access to and consumption of nutritious, safe, affordable and sustainable diets. Pro-poor and women-focused food security policies need to be developed.

Keywords: Food Insecurity, RBC Folate, Iron-Deficiency, Non-Pregnant Women, Nepal, Social Protection

1. Introduction

The Food and Agriculture Organisation (FAO) defines food security as "A situation when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" [1]. On contrary, Household Food Insecurity (HFI) is defined as "a limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to acquire food in socially acceptable ways" [2]. HFI has remained one of the important public health problems in the world, and has an adverse impact on the individual, mostly in resource-poor settings [3] and Nepal is no exception. The 2016 Nepal National Micronutrient Status Survey (NNMSS) reports that a three-fifth (59 percent) of the households (HHs) are food secure, with 16 percent of households mildly food insecure,

18 percent of households moderately food insecure, and 7 percent of household severely food insecure [4].

The overall food security situation in Nepal has gradually improved as indicated by the Global Hunger Index (GHI)- a multidimensional approach for measuring hunger that looks at the adequacy of the national food supply. GHI has reached 20.8 (moderate level) in 2019 from 36.8 (serious level) in 2000. The Nepal District Food Security Networks (DFSN) has also reported gradual improvement in the overall food security situation in the districts of the western, central and eastern regions affected by the April-May 2015 earthquake. The major factors contributing to an improvement in the food security situation compared were summer crops (paddy and maize) harvests and the resumption of livelihood activities.

Despite the gradual improvement in the food security situation challenges persist. Over 40 percent of the HHs in Nepal are food insecure [4]. Moreover, the year-round availability of sufficient food, particularly in Hills and Mountain regions remains a challenge as these areas have less arable land. In addition, poor road network connections in Hills and Mountains make transporting sufficient food tasking. In recent years, the conversion of farmland into residential areas, and abandonment of farmland following the male migration from rural areas has further threatened the food security in the country.

Seasonal fluctuations and shocks in the form of earthquake, and flood has further influenced food availability and price which in turn drive food insecurity. The DFSNs in Humla, Mugu, Kalikot, and Bajura classified some rural/municipalities as highly food insecure and attributed the situation to the winter lean period, a poor summer crop harvest, poor incomes from agriculture and livestock, and limited development activities during the winter. Many of these districts have also observed earlier crop losses in 2015 and 2016 due to insufficient rainfall and drought [7]. Moreover, though poverty has reduced substantially from 2011 (MPI 0.185) to 2019 (MPI 0.075) (Global Multidimensional Poverty Index, 2019), still, 17.5 percent of the population in Nepal (5,137 thousand people in 2020) is multidimensionally poor which constrains their economic access to food.

Inadequate nutrient intake due to chronic food insecurity leads to various deficiency disorders. Folate and Iron deficiency anaemia is the most prevailing form of micronutrient deficiency disorder in Nepal. Anaemia, defined as a condition associated with a lower than normal concentration of hemoglobin, is a global public health problem. Globally, over 60% of all anaemia is due to a deficiency of iron – one of the major constituents of haemoglobin. [6]. According to the NNMSS 2016, the percentage of non-pregnant women aged 15-49 years, who contracted iron deficiency anaemia (IDA) (haemoglobin <12.0 g/dL, and ferritin <15.0μg/L) was almost 8%.

Folate belongs to the group of water-soluble B vitamins which occur naturally in food, and is required in cellular megaloblastic anaemia. Low folate status has been found to increase the risk of a woman of childbearing age having offspring with neural tube defects. Further, a low folate status is found to increase plasma homocysteine levels, a potential risk factor for cardiovascular disease, in the general population [5]. The 2016 NNMSS reports that about 12% of non-pregnant women aged 15-49 years were at risk of red blood cell (RBC) folate deficiency.

To comprehensively improve food security and nutrition status in Nepal, GoN has been implementing Multi-sector Nutrition Plan (MSNP) I (2013-2017) and II (2018-2022), Agriculture Development Strategy (ADS) (2015-2035), and Zero Hunger Challenge National Action Plan (2016 - 2025). Additionally, food security and nutrition have been mainstreamed into Fifteenth Plan (2019/20-2023/24) with a high priority. Moreover, the Right to Food and Food Sovereignty Act 2018- a landmark piece of legislation has declared food as a basic right and holds the GoN accountable for ensuring its people's food security.

The Government of Nepal (GoN), Ministry of Health and Population (MoHP) has considered anaemia as the most serious problem and recognised reducing its prevalence as a challenge. Consequently, several efforts have been made for addressing the issue of the increasing prevalence of IDA and to minimise the burden of RBC folate. As envisaged in Multi-sector Nutrition Plan (MSNP-II 2018-2022) -a broader national policy framework for nutrition- GoN initiated the implementation of the Intensification of Maternal and Neonatal Micronutrient Program (IMNMP) in 2003 to improve the access and utilization of IFA for prevention and control of anemia. As per the protocol, a daily dose of 60 mg of elemental iron and 400 micrograms of folic acid for 180 days is recommended for pregnant women starting from their second trimester of pregnancy and additional 45 days of IFA supplementation for post-partum mothers. Additionally, National Anaemia Control Strategy 2007 was developed and endorsed to identify and enforce effective measures to minimise the occurrence of anaemia in children, adolescent girls, and women of reproductive age- one of the key objectives of the strategy [8]. Policies of this objective included conducting necessary research on anaemia and encouraging research on same; reviewing the possibility of extending the distribution of iron/folate tablets to at-risk groups, including women of reproductive age and carrying out research to identify effective programmes to prevent iron deficiency in children aged 6-59 months, adolescents and women of reproductive age [8]. Besides GoN, the development partner in particular USAID through a five-year integrated nutrition project named SUAAHARA spanning from August 2011 to August 2016 implemented interventions to address iron deficiency anemia among women and adopted a household-based approach to improving access to, and consumption of, nutritious foods in areas with very poor nutrition indicators.

With the implementation of Community-Based distribution of IFA through IMNMP, the coverage of IFA supplementation increased considerably. Data from the Nepal Demographic Health Survey (NDHS) 2016 show that the proportion of women taking any IFA supplements during

pregnancy increased from 23% to 91% between 2001 and 2016, whereas the proportion of women consuming supplements for at least 90 days increased from 6% to 71%. Despite these notable improvements, challenges remain, as still 43% of the women aged 15-49 years are anemic- one of the highest in South Asia. According to the 2016 Nepal National Micronutrient Status Survey (NNMS), 18.7% of non-pregnant women had iron deficiency whilst 4.5% had megaloblastic anaemia (a hematological indicator of folate deficiency). Many vulnerable pregnant mothers are not taking IFA supplements as per the protocol leading to issues with the compliance of IFA. Besides, there is notable variation in the intake of IFA supplements by socio-demographic characteristics. The higher prevalence of anemia in women of reproductive age is spurred by low intake of quality and diverse food, and helminthic infections among others. Moreover, there is no specific programme to supplement non-pregnant women with iron supplements in Nepal, except school-going adolescents.

In pursuance of the Nepal government's efforts at improving food security in the country, and also reducing the burden of IDA and RBC folate deficiency, this paper aimed to assess how household food security is associated with IDA and RBC folate deficiency in Nepal to provide an evidence base for GoN/MoHP and other relevant stakeholders working in Nepal to design and institute appropriate interventions for reducing the burden of anaemia and micronutrient deficiencies, particularly RBC folate deficiency.

1.1. Ethical Consideration

Permission was sought from the Nepal Ministry of Health and Population, which approved the NNMSS for the use of the available dataset.

1.2. Key Messages

1. Living in a severely food insecure household was significantly associated with both IDA and RBC folate deficiency.
2. The majority of the participants lived in households with full food security.
3. Less than one out of ten households suffered severe food insecurity.
4. Participants from the Mountain ecological zone had an increased likelihood of contracting IDA.
5. Participants who had a fever in the two weeks preceding the survey were significantly more likely to suffer from RBC folate deficiency compared with those who had no fever.

2. Methods

2.1. Study Design and Participants

This study included a sample of 2143 non-pregnant Nepalese women aged 15-49 years. Data for the participants were extracted from the 2016 Nepal National Micronutrient Status Survey (NNMSS). A description of details of sampling design, data collection, specimen collection, and processing can be obtained from the 2016 NNMSS final report [4].

2.2. Study Outcomes

The outcome variables for our study were the prevalence of IDA and RBC folate deficiency. The cut-off point for altitude IDA levels was set at <12.0 g/L, while the cut-off point for RBC folate deficiency was set at <906 nmol/L. The presence of Iron deficiency anaemia was categorised as 1; otherwise 0. The occurrence of RBC folate deficiency was coded as 1, and its non-occurrence was coded as 0.

2.3. Exposure Variables

In the NNMSS 2016, the households were grouped into four food insecurity categories, according to participants' responses to a set of questions regarding their access to adequate food and food of their preference in the last 12 months. The four categories of households were [4]:

1. Food secure - The households who did not experience any food insecurity conditions and rarely worried about such conditions.
2. Mildly food insecure - Those who worried about not having enough food sometimes or often, and/or were unable to eat preferred foods, and/or eat a more monotonous diet than desired and/or some foods considered undesirable but did so only rarely. These HHs did not however cut back on quantity or experience any of the three most severe conditions, namely running out of food, going to bed hungry, or going a whole day and night without eating.
3. Moderately food insecure - Those who sacrificed quality more frequently, by eating a monotonous diet or undesirable foods sometimes or often, and/or have rarely or sometimes started to cut back on quantity by reducing the size of meals or the number of meals, but never experienced any of the three most severe conditions.
4. Severely food insecure - Those who had to cut back on meal size or number of meals often and/or had experienced any of the three most severe conditions, even if only rarely.

2.4. Potential Confounding Variables

The possible confounding variables for this current study were based on the extant literature on factors associated with micronutrient deficiencies [9-12] and their accessibility in the NNMSS dataset. The potential confounding variables were categorised into community-level factors, household level factors, individual-level factors, health status related factors (a day before the survey), and dietary factors including WASH related factors.

In our study, community-level factors constituted geographical region, type of residence (urban/rural), province and ecological zone. The household-level factors consisted of ethnicity (caste) and household wealth index. We used a principal components analysis (PCA) [13] to construct the

household wealth index, and assigned scores to the household facilities and assets of respondents after computation of the index, ranking each member of the sample by their score. The household wealth index was grouped into three classes: Poor, Middle, and Rich. The bottom 40% of the households were referred to as the 'Poor', the upper next bottom 40% was referred to as the 'Middle' and the top 20% as 'Rich'. Individual-level factors comprised the age of the participant and the level of education completed. Contraction of fever, cough and diarrhoea, as well as dietary diversity, constituted the health status factors. WASH related factors included quality of drinking water, type of toilet facility used by participants, and water treatment practice at the HH level.

2.5. Statistical Analyses

In our study, STATA/MP version 14 (Stata Corp, College Station, TX, USA) was used for statistical analyses. We employed the 'Svy' command to adjust for the cluster-sampling design and weight. Firstly, the frequency of exposure and all confounding factors were tabulated. Secondly, we calculated the prevalence, median, 25th and 75th percentiles; and performed univariate analyses which independently examined the IDA and RBC folate deficiency by household food insecurity status. We then used multivariate analyses to examine the association between household food insecurity and IDA and RBC folate deficiency. A staged modelling technique was carried out as part of the multivariate analyses. The multivariate modelling process is described in the preceding paragraph.

First, all community and household level factors were entered into the baseline multivariable model with the elimination process to eliminate statistically non-significant variables (Model 1). Next, individual level factors were examined with model 1 (Model 2), then health related factors were assessed with model 2 (Model 3). In the fourth modelling stage, WASH related factors were examined with model 3 (Model 4), and in the next model (model 5), the exposure variables (household food insecurity status) were examined with those variables significant in models 1-4.

The co-linearity was tested and reported in the final model, and the odds ratios with 95% confidence intervals were calculated to assess the adjusted odds of independent variables.

3. Results

3.1. Characteristics of the Sample

The characteristics of the study population are summarised in Table 1. Of the 2143 women, more than three-quarters (86%) were from rural areas, and one-third of them (35%) were from the central region. Approximately a quarter of the women came from rich households, and the majority of them were Brahmin/Chettri. The majority of the women were aged 25-34 years. Only a small proportion of the participants suffered from fever (14%), cough (15%) and diarrhoea (9%) in the two weeks preceding the survey; and over eighty percent of them (88%) had maintained higher dietary diversity. Only 9% of the participants have households with unimproved sources of drinking. The majority of the participants used untreated water (77%) and flush or pour-flush toilets (~71%) at HH levels.

Table 1. *Characteristics distribution of Non pregnant women aged 15-49 years (n=2143).*

Characteristic	N (%)
Community level factors	
Residence	
Urban	294 (13.7)
Rural	1849 (86.3)
Province	
Koshi Province	373 (17.4)
Madhesh Province	435 (20.3)
Bagmati Province	433 (20.2)
Gandhaki Province	217 (10.1)
Lumbini Province	378 (17.6)
Karnali Province	106 (4.9)
Sudurpaschim Province 7	201 (9.4)
Geographical region	
Eastern	484 (22.6)
Central	756 (35.3)
Western	419 (19.5)
Mid-western	283 (13.2)
Far-western	201 (9.4)
Ecological zone	
Mountain	134 (6.3)
Hill	925 (42.2)
Terai	1083 (50.5)
Household level factors	
Household wealth index	
Poor	729 (34.0)
Middle	872 (40.8)
Rich	540 (25.2)
Ethnicity (Caste)	
Brahmin/Chettri	498 (30.2)
Dalit	299 (18.1)
Janajati	486 (29.5)
Others*	365 (22.2)
Individual level factors	
Participant's age (years)	
15-24	669 (31.2)
25-34	769 (35.9)
35-49	705 (32.9)
Level of education completed	
No education	1022 (47.7)
Primary	557 (26.0)
Secondary of higher	563 (26.3)
Health status	
Had fever	
Yes	296 (13.8)
No	1848 (86.2)
Had cough	
Yes	314 (14.6)
No	1829 (85.4)
Had diarrhoea	
Yes	196 (9.2)
No	1945 (90.8)
Dietary diversity	
Low	1062 (64.6)
Moderate	583 (35.4)

Characteristic	N (%)
High	1445 (88.2)
Water and sanitation	
Source of drinking water	
Improved	1951 (91.0)
Unimproved	192 (9.0)
Type of toilet facility	
Flush or pour flush toilet	1648 (71.4)
Pit latrine	496 (28.6)
Water treatment habit	
Yes	494 (23.0)
No	1650 (77.0)

3.2. Haemoglobin and RBC Folate Concentrations by Household Food Insecurity and Dietary Diversity Status

The highest proportion of non-pregnant women (56%) was from households with food security, whilst the lowest proportion (7%) of them were from households with severe food insecurity (Table 2). The median (25th and 75th quartiles) of haemoglobin and RBC folate concentrations among the participants from the food secure households was 12.9 (CI 12.1- 13.7) and 571.7 (CI 415.6- 743.1) respectively, and the corresponding value for participants from the severely food insecure households was 12.8 (CI 11.7-13.8) and 463.9 (CI 317.5-615.4) respectively.

The majority of participants (54%) had low dietary diversity, whilst a few of the participants (21%) had moderate dietary diversity. The median haemoglobin concentration for participants with both low and moderate dietary diversity was 12.9, and participants with high dietary diversity had the highest median haemoglobin concentration (13.0). Further, participants with low dietary diversity had the lowest median RBC folate concentration (~526), whilst those with high dietary diversity had the highest median RBC folate concentration (~587).

Table 2. *Hemoglobin and RBC Folate concentrations within household food insecurity and dietary diversity intervals.*

Intervals	N*	Adjusted haemoglobin level (g/dL)	RBC folate (nmol/L)
Household food insecurity (HFI)		**median (25th, 75th percentiles)**	**median (25th, 75th percentiles)**
Secure	1205	12.9 (12.1, 13.7)	571.7 (415.6, 743.1)
Mildly insecure	219	12.9 (12.2, 13.7)	531.4 (426.9, 738.0)
Moderately insecure	560	12.9 (12.2, 13.8)	534.9 (392.9, 709.1)
Severely insecure	151	12.8 (11.7, 13.8)	463.9 (317.5, 615.4)
Dietary diversity			
Low	1165	12.9 (12.1, 13.7)	525.9 (374.5, 697.5)
Moderate	454	12.9 (12.1, 13.6)	551.8 (416.2, 725.4)
High	516	13.0 (12.3, 13.8)	586.7 (442.6, 779.4)

N* = weighted number

Table 3. *Risk factors for anaemia and RBC folate among non-pregnant women aged 15-49 in Nepal: Unadjusted and adjusted odds ratios.*

Characteristic	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Anaemia				
Ecological zone				
Mountain	1.00		1.00	
Hill	0.72 (0.49, 1.09)	0.116	0.45 (0.20, 0.98)	0.044
Terai	0.59 (0.43, 0.82)	0.002	0.45 (0.25, 0.80)	0.007
RBC folate				
Province				
Koshi Province	1.00		1.00	
Madhesh Province	2.18 (1.21, 3.90)	0.01	1.99 (1.15, 3.43)	0.015
Bagmati Province	0.96 (0.45, 2.02)	0.909	1.00 (0.49, 2.04)	0.999
Gandaki Province	1.17 (0.47, 2.87)	0.737	1.23 (0.50, 3.05)	0.651
Lumbini Province	2.25 (1.25, 4.05)	0.008	2.25 (1.31, 3.85)	0.004
Karnali Province	1.34 (0.41, 4.40)	0.623	1.18 (0.37, 3.74)	0.776
Sudurpaschim Province	3.95 (2.11, 7.41)	<0.001	3.71 (1.95, 7.05)	<0.001
BMI (kg/m^2)				
≤18.5	1.00		1.00	
19-25	0.48 (0.19, 1.19)	0.112	0.53 (0.21, 1.33)	0.173
25+	0.31 (0.13, 0.77)	0.012	0.39 (0.16, 0.95)	0.039
Had fever in the last two weeks				
No	1.00		1.00	
Yes	1.51 (0.98, 2.32)	0.062	1.73 (1.13, 2.64)	0.012

OR: Odds ratio; CI: confidence interval; RBC: red blood cells; BMI: body mass index

3.3. Association of Household Food Insecurity with IDA and RBC Folate Deficiency

Living in a severely food insecure household was significantly associated with both IDA [adjusted odds ratio (AOR): 1.63; 95% confidence interval (CI): (1.02, 2.60)] and RBC folate deficiency [AOR: 3.83; 95% CI: (1.03, 14.18)] (Figure 1). Living in moderate and mild food-insecure

households was not associated with IDA, although the results were statistically insignificant. However, living in moderate and mild food insecure households was associated with RBC folate deficiency, although these were not statistically significant.

In addition to household food insecurity status, this current study also revealed a few other factors such as ecological region, body mass index, province and disease associated with IDA and RBC folate. Living in the mountain region was positively associated with IDA, and having a low body mass index (≤18.5 kg/m^2) was positively associated with RBC folate deficiency; whilst living in the Sudurpaschim Province and contraction of fever were negatively associated with RBC folate.

Furthermore, in our analysis, we found collinearity between household food insecurity and wealth index. As shown in Figure 2, 8% of rich households were food insecure and 33% were food secure. Among the poor households, 69% were food insecure while 23% were food secure.

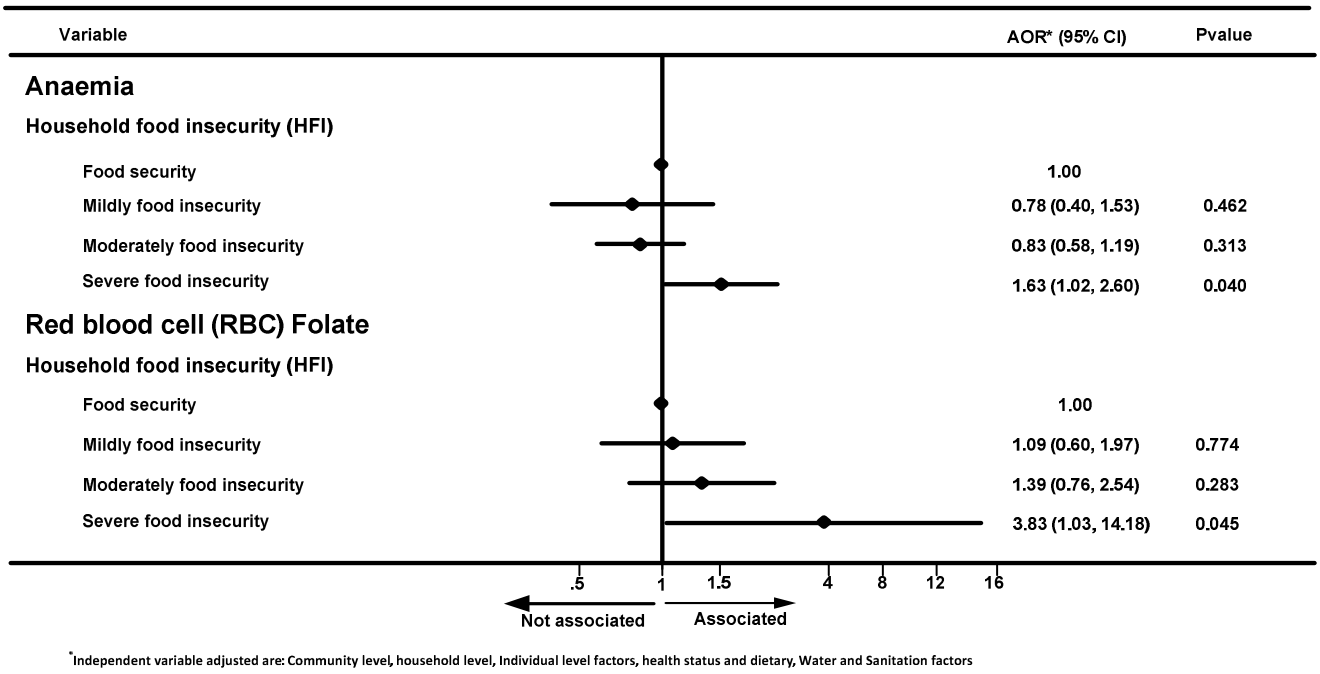

Figure 1. *Association of household food insecurity with IDA and RBC folate.*

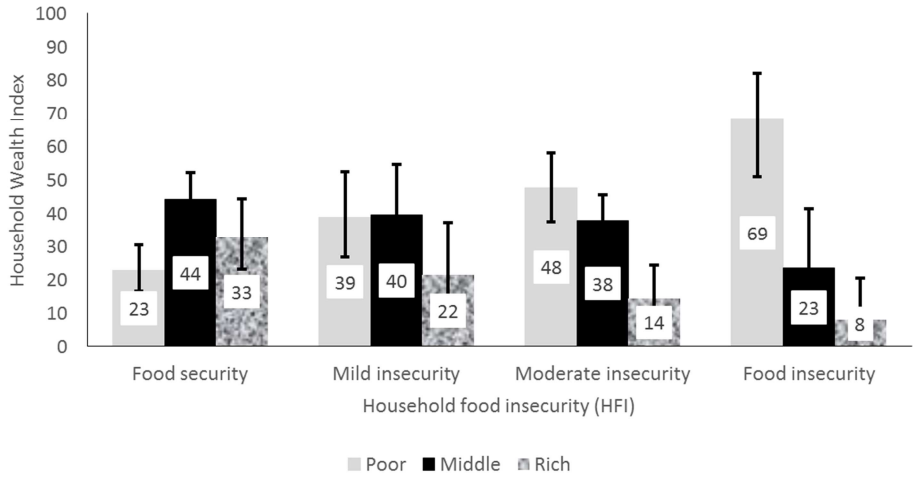

Figure 2. *Household food insecurity status by household wealth index.*

4. Discussion

In this study, we examined how household food insecurity was associated with IDA and RBC folate among non-pregnant women aged 15-49 years in Nepal. We further investigated factors other than HHI associated with IDA and RBC folate among the participants.

This study found that living in households with severe food insecurity was associated positively with both IDA and RBC folate, which is consistent with a finding from a study in Mexico, that examined the association between household food insecurity and anaemia among adult Mexican women of reproductive age and revealed that the adjusted odds of

occurrence of anaemia were significantly higher among those living in households with severe food insecurity, compared with those who lived in food secure households [14]. Our findings are in consonance with findings from a study conducted in Minneapolis, Minnesota, the United States of America [15], which found that participants from households with very low food security (severe food insecurity) were twice as likely to have IDA compared with those from households with high food security, although participants of that study were infants and toddlers, unlike in our study where the participants were non-pregnant women. Further, another study in Indonesia revealed a similar association between anaemia and household food insecurity [16]. The association between household food insecurity and IDA may be explained as follows: Firstly, household food insecurity may result in inadequate consumption of iron rich food and consequently limited concentration of iron in the body including the lack of sufficient micronutrients that facilitate absorption and utilisation of iron (e.g., vitamin C, vitamin A, RBC folate). Additionally, non-consumption of foods rich in phytic acid may further decrease iron absorption [14]. Prior studies have revealed that diets in food insecure households were lower in iron and other micronutrients, and higher in fat and carbohydrate [17-19].

In our study, we found that participants living in the mountain region were more prone to IDA than those from the Terai region, consistent with a finding from a study in Mexico that reported that the southern region of Mexico (with the highest poverty rates) had the highest rates of anaemia. It must be noted that, of the three ecological regions of Nepal, the mountain region has the highest poverty gap [20].

This current study revealed that non-pregnant women who had a BMI of 25 kg/m^2 or higher had a significantly lower predisposition to RBC folate, compared with those who had a BMI of 18.5 kg/m^2 or lower. This finding is in consonance with that of several other previous studies [21, 22]. This finding suggests that non-pregnant women of child-bearing age should be encouraged to consume additional folate in the form of supplements. In addition, our finding suggests that by increasing the consumption of folate in food or as dietary supplements, the lower serum levels in relatively heavier women could be compensated. Relatively heavier women may simply need to have a higher dosage of folate to achieve the same RBC folate level as their lighter counterparts.

This study also found that non-pregnant women who contracted fever were significantly more prone to lower RBC folate concentrations, consistent with results from a past study [23]. This is explained by the fact that malarial infections in human beings by plasmodium species have been found to be associated with a reduction in red blood cells [23].

Living in rich households was found to be positively associated with household food security. This finding is consistent with a result from the previous study [24]; and it is not surprising, as wealthy households have a higher purchasing power than poorer households.

Our study had some limitations. Firstly, our analysis did not assess how diet may have mediated the association between household food insecurity and IDA. Secondly, the 2016 NNMSS is a cross-sectional survey, thus, we could not establish a temporal sequence of events, and there could be the possibility of reverse causality. That is, there is the possibility that anaemia and folate deficiency themselves may lead to household food insecurity, as the non-pregnant women with IDA may have an impaired tissue oxidative capacity that could decrease their well-being and productivity, leading to reduced financial stability and household food insecurity [14]. Finally, it is possible that important unobserved factors not measured in the survey which affect both IDA and household food insecurity, like parasitic infections, could have biased our results [25].

5. Conclusion

To conclude, this study demonstrated that there is positive association of HH food insecurity (severe) with both IDA and RBC folate deficiency among non-pregnant women in Nepal. The findings of our study suggest that the Ministry of Health and Population, Ministry of Agriculture and Livestock including other relevant sectors and stakeholders should institute interventions to effectively address the burden of household food insecurity., Food security at HH level has the potential to improve the health of the non-pregnant women in Nepal, by reducing the risk of IDA and their serious consequences and increasing RBC folate levels. Greater attention should also be paid to heavier non-pregnant women, women from poor HH with severe food insecurity in particular from mountain region and women with higher risk of contracting fever and other infections. A combination of interventions extending from increasing food production and improving market access, to consumption based interventions such as expanding the social protection coverage (including cash transfers) for those who are unable to feed themselves and produce food for subsistence is recommended for ensuring food security, strengthening livelihood and reducing the risk of IDA and folate deficiency. In addition, intensive behaviour change interventions are suggested for improving dietary practices and dietary diversity and ensuring compliance of iron and folate supplements. Moreover, as enshrined in the Constitution of Nepal, to safeguard the basic rights to food for all, food system needs to be strengthened to ensure food for all.

References

[1] FAO, The state of food insecurity in the world. 2000, Food and Agriculture Organization: Rome.

[2] Anderson, S. A., Core indicators of nutritional state for difficult-to-sample populations. The Journal of nutrition (USA), 1990.

[3] FAO, The state of food insecurity in the world: addressing food insecurity in protracted crises. 2010, Food and Agriculture Organisation: Rome.

[4] Ministry of Health Nepal, et al., Nepal National Micronutrient Status Survey – 2016. 2017, Minisry of Health, Nepal: Kathmandu, Nepal.

[5] CDC. Folate Microbiologic Assay 2102 [cited 2018 Oct 31]; Available from: https://www.cdc.gov/nchs/data/nhanes/nhanes_11_12/FOLATE_G_met_RBC.pdf.

[6] DALY, G. and H. Collaborators, Murray CJ, Barber RM, Foreman KJ, Abbasoglu Ozgoren A, Abd-Allah F, et al. Global, regional, and national disability-adjusted life years (DALYs) for 306 diseases and injuries and healthy life expectancy (HALE) for 188 countries, 1990-2013: Quantifying the epidemiological transition. Lancet, 2015. 386: p. 2145-91.

[7] Government of Nepal and World Food Program. Brief on the food security situation in Nepal (mid-November 2016 to mid-March 2017). 2017 [cited 2018 Nov 2]; Available from: https://reliefweb.int/report/nepal/brief-food-security-situation-nepal-mid-november-2016-mid-march-2017.

[8] Government of Nepal and Ministry of Health and Population (MOHP) [Nepal], National Anaemia Control Strategy. 2007, MOHP: Kathmandu.

[9] Balcı, Y. I., et al., Prevalence and risk factors of anemia among adolescents in Denizli, Turkey. Iranian journal of pediatrics, 2012. 22 (1): p. 77.

[10] Alzaheb, R. A. and O. Al-Amer, The Prevalence of Iron Deficiency Anemia and its Associated Risk Factors Among a Sample of Female University Students in Tabuk, Saudi Arabia. Clinical Medicine Insights: Women's Health, 2017. 10: p. 1179562X17745088.

[11] Alaofè, H., et al., Prevalence of anaemia, deficiencies of iron and vitamin A and their determinants in rural women and young children: a cross-sectional study in Kalalé district of northern Benin. Public health nutrition, 2017. 20 (7): p. 1203-1213.

[12] Harding, K.. L., et al., Determinants of anemia among women and children in Nepal and Pakistan: An analysis of recent national survey data. Maternal & child nutrition, 2017.

[13] Filmer, D. and L. H. Pritchett, Estimating Wealth Effects Without Expenditure Data—Or Tears: An Application To Educational Enrollments In States Of India*. Demography, 2001. 38 (1): p. 115-132.

[14] Fischer, N. C., et al., Household Food Insecurity Is Associated with Anemia in Adult Mexican Women of Reproductive Age–3. The Journal of nutrition, 2014. 144 (12): p. 2066-2072.

[15] Park, K., et al., Household food insecurity is a risk factor for iron-deficiency anaemia in a multi-ethnic, low-income sample of infants and toddlers. Public health nutrition, 2009. 12 (11): p. 2120-2128.

[16] Campbell, A., et al., Relationship of household food insecurity to anaemia in children aged 6–59 months among families in rural Indonesia. Annals of tropical paediatrics, 2011. 31 (4): p. 321-330.

[17] Dixon, L. B., M. A. Winkleby, and K. L. Radimer, Dietary intakes and serum nutrients differ between adults from food-insufficient and food-sufficient families: Third National Health and Nutrition Examination Survey, 1988–1994. The Journal of nutrition, 2001. 131 (4): p. 1232-1246.

[18] Tarasuk, V. S., Household food insecurity with hunger is associated with women's food intakes, health and household circumstances. The Journal of nutrition, 2001. 131 (10): p. 2670-2676.

[19] Kaiser, L. L., et al., Food security and nutritional outcomes of preschool-age Mexican-American children. Journal of the American Dietetic Association, 2002. 102 (7): p. 924-929.

[20] The World Bank, Nepal: Country snapshots. 2014, The World Bank: Kathmandu.

[21] Bird, J. K., et al., Obesity Is Associated with Increased Red Blood Cell Folate Despite Lower Dietary Intakes and Serum Concentrations–4. The Journal of nutrition, 2014. 145 (1): p. 79-86.

[22] Mojtabai, R., Body mass index and serum folate in childbearing age women. European journal of epidemiology, 2004. 19 (11): p. 1029-1036.

[23] Menendez, C., A. Fleming, and P. Alonso, Malaria-related anaemia. Parasitology today, 2000. 16 (11): p. 469-476.

[24] Mitiku, A., B. Fufa, and B. Tadese, Emperical analysis of the determinants of rural households food security in Southern Ethiopia: The case of Shashemene District. Basic Res J Agric Sci Rev, 2012. 1 (6): p. 132-8.

[25] Coates, J. C., et al., “He said, she said”: who should speak for households about experiences of food insecurity in Bangladesh? Food Security, 2010. 2 (1): p. 81-95.