International Journal of Community Medicine and Public Health
Jha RK et al. Int J Community Med Public Health. 2022 Dec;9(12):4463-4471
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20223200

Original Research Article

Socio-demographic factors associated with anaemia among non-pregnant and non-lactating women from low-income families in two selected districts of Madhya Pradesh state of India: a random forest analysis

Ranjan Kumar Jha[1], Sucharita Dutta[1], Ritu Ghosh[2], Archana Mishra[3], J. C. Reddy[2], Suresh Lakshminarayanan[1], Aarati Pillai[2], Suvabrata Dey[2], Manoj Kumar Raut[2]*

[1]India Country Office, Nutrition International, New Delhi, India
[2]Asia Regional Office, Nutrition International, New Delhi India
[3]Deputy Director, Maternal Health, National Health Mission, Government of Madhya Pradesh, India

Received: 17 July 2022
Revised: 26 October 2022
Accepted: 27 October 2022

***Correspondence:**
Dr. Manoj Kumar Raut,
E-mail: rautmanojkumar@gmail.com

ABSTRACT

Background: Anaemia is one of the most common public health challenges. The objective of this paper was to estimate the prevalence of anaemia among non-pregnant and non-lactating women (NPNLW) (15-49 years) from low-income families and to assess the associations between socio-demographic and economic factors, and the prevalence of anaemia.
Methods: Primary data of non-pregnant and non-lactating women of reproductive age (15 to 49 years) from low-income families collected from two selected districts of Madhya Pradesh state, India were used. Inferential statistical tools like; multiple binary logistic regressions and random forest analysis were adopted to assess the socio-demographic and economic factors associated with anaemia.
Results: The results revealed that prevalence of anaemia in both the districts are quite high at 60.8% (95% CI: 58.6%, 62.9%) in Vidisha to 63.7% (95% CI: 61.6%, 65.7%) in Raisen with mean haemoglobin levels of 11.27±1.92 g/dl in Vidisha to 11.24±1.70 g/dl in Raisen, which is close to <12 g/dl cut-off based on WHO categorization. It was also found that those who are from the scheduled caste and other castes were less likely to be anaemic compared to those who were from scheduled tribes in Vidisha district. Majority of women not consuming iron supplements were found to be anaemic.
Conclusions: Education was observed to be the most predominant factor inversely associated with anaemia. Age and the type of household were also found to be associated factors. Along with supplementation and nutrition education, fortification of foods is also recommended in addressing the anaemia burden.

Keywords: Anaemia, IFA supplementation, NPNLW, Mass media, Food fortification, low-income families, National iron plus initiative program

INTRODUCTION

Anaemia is one of the most common and widespread disorders affecting around 800 million children and women in the world. Iron deficiency makes a large contribution to anaemia, global efforts to reduce the anaemia burden have mostly been directed towards increasing intake of iron through supplementation, food

fortification, and diversification of the diet. It affects 1.62 billion people globally and South Asian countries, including India, have the highest prevalence of anaemia in the world. India contributes to this burden, with approximately 53% of women in reproductive age (WRA) who are anaemic.[1] According to the National family health survey-4, 52.5% of WRA in the state of Madhya Pradesh (MP) are anaemic; which is further observed to be 60% among rural women and 74% among tribal women with serious negative consequences and harmful effects on the physical and mental health of a person. Iron deficiency anaemia is the most common cause of anaemia globally, though other factors also contribute.[2] Anaemia can have adverse consequences and can be particularly detrimental to WRA who become pregnant, continuing the cycle of malnutrition to the next generation. There is also an increased perinatal risk of impaired foetal growth, risk of Low Birth Weight (LBW), and increased risk of infant mortality and maternal mortality among women with anaemia.[3]

Table 1: Socio-demographic, health and nutrition indicators in selected districts of Madhya Pradesh state, average and India (%)

Indicators	India	Madhya Pradesh state	Vidisha district	Raisen district
Socio-demographic characteristics				
Population census 2011 (million)	1,210.9	72.6	1.5	1.3
Population density (persons per sq. km.) (Census, 2011)	238	230	198	157
Overall sex ratio females/male *1000) (Census, 2011)	943	931	896	901
Women who are literate	65.4	60.0	64.2	60.8
Households with electricity	88.2	89.9	84.7	92.8
Households with an improved drinking-water source	89.9	84.7	94.1	95.1
Households using improved sanitation facility	48.4	33.7	24.0	39.0
Household using clean fuel for cooking	43.8	29.6	17.9	26.7
Household with any usual member covered by a health scheme or health insurance	28.7	17.7	10.6	22.7
Women and child nutrition and anaemia status				
Stunting (height-for-age) (moderate and severe)	38.4	42.0	41.1	45.8
Wasting (weight-for-height) (moderate and severe)	21.0	25.8	21.4	24.9
Underweight (weight-for-age) (moderate and severe)	35.7	42.8	40.4	44.4
Women whose body mass index (BMI) is below normal (BMI<18.5 kg/m$^{2)}$	22.9	28.3	28.0	29.5
Children aged 6-59 months who are anaemic (<11.0 g/dl)	58.4	68.9	69.8	68.0
Non-pregnant women aged 15-49 years who are anaemic (<12.0 g/dl)	53.1	52.4	43.5	50.6
Pregnant women aged 15-49 years who are anaemic (<11.0 g/dl)	50.3	54.6	55.5	54.3
All women aged 15-49 years who are anaemic	53.0	52.5	44.2	50.7
Micronutrient Supplementation				
Households using iodized salt	93.1	93.2	93.7	92.2
Children aged 9-59 months who received a vitamin A dose in the last 6 months	60.2	60.4	41.5	74.1
Children with diarrhoea in the last 2 weeks who received oral rehydration salts (ORS)	50.6	55.2	32.7	39.9
Children with diarrhoea in the last 2 weeks who received zinc	20.3	26.6	18.5	23.4
Mothers who consumed iron folic acid for 100 days or more when they were pregnant	30.3	23.6	15.2	23.2

Census 2011 UNFPA & NFHS-4, Government of India.[8,9]

One of the significant steps to decrease the prevalence and incidence of anaemia initiated by the Government of India is the "National Nutritional Anaemia Control Program" and the more inclusive "National iron plus initiative program." Under the former scheme, a life cycle approach was adopted to address anaemia.[4] Other strategies are nutrition education and screening and treatment of severe anaemia.[5] However, various studies have shown that compliance and program implementation, especially in remote rural areas, continue to remain a challenge.[6] Since, inadequate dietary intake and lack of dietary diversification in food pattern are also a key contributor towards iron deficiency anaemia, especially among the lower socio-economic class. Thus, it is conceptualized that to mitigate the prevalence of iron deficiency anaemia (IDA), one of the most commonly

accepted remedy is to improve the dietary intake of a population by ensuring that their daily food consumption consists of the adequate amount of iron. Fortification of the daily diet with iron and folic acid is one method which can address this public health issue with a broader reach, and provide a visible spatial impact on the prevalence of this medical condition. Fortification is the addition of micronutrients to a staple food to make it nutrient-dense. Some of the commonly fortified staples are rice, wheat, millet, and maize. These staples are consumed by the most vulnerable population groups who require these micronutrients the most.[7]

Nutrition International (formerly the micronutrient initiative) in collaboration with the Government of Madhya Pradesh is working towards decreasing the prevalence of anaemia. One of the approaches is to fortify staples such as wheat flour, but evidence is lacking on whether this is likely to have an impact on anaemia in the Indian context. Therefore, keeping this in mind, Nutrition International sought to assess haemoglobin levels, knowledge on anaemia, iron supplement consumption, general food habits, acceptability of fortified wheat flour and related environmental and socio-demographic factors among non-pregnant non lactating (NPNL) women of reproductive age from the lower socio-economic group living in the Vidisha and Raisen districts in Madhya Pradesh. According to the census of India, 2011, Vidisha and Raisen have a population density of 198 and 157 persons residing per sq. km respectively, with a population of 1.50 and 1.3 million respectively.[8]

According to the NFHS-4, 2015-16, in Vidisha, 44% NPNL women and 56% pregnant women were anaemic; while in Raisen, 51% of NPNL women and 54% of pregnant women were anaemic. Only 15% of mothers in Vidisha compared with 23% of mothers in Raisen reported to have consumed iron and folic acid tablets for 100 days or more. Between the districts, Raisen (61%) had a lower percentage of literate women compared with Vidisha (64%). In both the districts, 84-95% of households had electricity and an improved drinking water source. The household sanitation facilities were generally poor, in both districts, only 24% in Vidisha and 39% in Raisen had improved sanitation facility.

Objectives

The objectives of the study were to examine the association between different socio-demographic characteristics and the prevalence of anaemia among non-pregnant non-lactating women of reproductive age from low-income families in two selected districts of Madhya Pradesh state in India.

METHODS

We conducted a cross-sectional survey in two districts of Madhya Pradesh in India between January and March 2017. Data were collected from 4,170 non-pregnant and non-lactating women 15-45 years of age (NPNLW) from low-income homes (BPL) (2,082 in the Vidisha district and 2,088 in Raisen district); and from 217 decentralized millers, fair price shop owners and warehouse managers.

Sampling

NPNLW were selected using a two-stage sampling design. Villages were selected from the two districts using probability proportionate to size (PPS) method. In each selected village, segments of approximately 200 households were identified based on natural boundaries. One segment was selected at random using a computer-generated random number table. In the selected segment, all households were listed to prepare the sampling frame for eligible low-income households having at least one NPNLW. The required number of NPNLW were selected from these lists by systematic random sampling.In order to understand, the distribution mechanism of wheat and micronutrient pre-blend, mixing of pre-blend in wheat flour and knowledge and awareness on anaemia and benefits of providing Iron Folic Acid-fortified food, chakki operators, fair price shop owners, warehouse in-charges and district-level officials were interviewed. One each chakki operator/owner and the fair price shop owner was interviewed in every second village. At the district level, one staff each from the food and supply department was interviewed.

Data analysis

Individual-level datasets were analyzed using PASW Statistics 18, Release 18.0 software to analyze NPNLW characteristics and status indicators; and to conduct multiple binary logistic regressions to explore factors associated with adherence to iron folic acid supplements or presence of anaemia. The dependent variable was considered as the prevalence of any anaemia, which was coded as 0 if the women had any anaemia and 1 if she did not. The independent covariates included in the multiple binary logistic regression analyses were; socio-demographic characteristics like; place of residence, age, type of family, social status, literacy, type of house, sanitation facilities, source of drinking water, electricity and knowledge about anaemia. Apart from canvassing background information and knowledge levels on anaemia, haemoglobin concentration was estimated using capillary Hemocue. In addition, random forests (RF) analysis was conducted, using data from NPNLW, to identify independent variables importance and model accuracy using Python 3.6 software. Random forest is a recently developed machine learning technique that deals with classification and clustering of data non-parametrically. It is an ensemble method that combines several trees by taking the same number of bootstrap samples from the original data and growing a tree on each bootstrap sample. Tree implementations are very simple and user-friendly and require fewer techniques from the investigator. The individual trees in a random forest are not pruned and used for decision in classification or

clustering. Random forest uses a randomly selected subset of predictors for splitting the root nodes into new daughter nodes for each split. From all trees grown in this process based on the bootstrap samples, we generate a forest. From the complete forest, the response variable for instance, is predicted as an average or majority vote of the predictions of all trees. RF can highly increase the prediction accuracy compared to an individual tree, as the ensemble reduces the variance. RF is one of the most effective machine learning models for predictive analytics. The model feature importance from sklearn random forest was used to calculate feature importance. Random forest uses gini importance or mean decrease in impurity (MDI) to calculate the importance of each feature. Gini importance is also known as the total decrease in node impurity. This is how much the model fit or accuracy decreases when you drop a variable. The larger the decrease, the more significant the variable is. Here, the mean decrease is a significant parameter for variable selection.

RESULTS

Haemoglobin concentration and knowledge of anaemia

The results revealed that both the districts have a high prevalence of anaemia ranging from 60.8% (95% CI: 58.6%, 62.9%) in Vidisha to 63.7% (95% CI: 61.6%, 65.7%) in Raisen district amongst NPNLW. The mean±standard deviation haemoglobin concentrations were 11.28±1.93 g/dl in Vidisha and 11.24±1.71 g/dl in Raisen (Figure 3).

In both the districts, majority of the respondents were moderately anaemic (31% in Vidisha and 34% in Raisen) while 24% and 26% were detected with 'mild' anaemia in Vidisha and Raisen respectively. Severe anaemia was observed only in <5% respondents. Less than 5% of respondents with anaemia reported consuming iron supplements, as a majority (95.7%) of the respondents tested to be anaemic in the study area were not taking any iron supplements. Majority of the population lived in rural areas (81% in Vidisha and 77% in Raisen), with the mean age being similar in both districts (31.14±9.88 in Vidisha and 30.82±9.97 in Raisen).

Raisen had a higher percentage of literacy (65%) as compared to Vidisha (54%). Majority of the respondents were observed to be living in a nuclear family and belonged to the other castes (non-ST/SC) category in both districts. We also observed, the 81% and 90% respondents in Vidisha and Raisen respectively had heard about anaemia. Other factors potentially affecting anaemia, like sanitation and drinking water, fared differently. Sanitation was better in Raisen (61%) than in Vidisha (49%), though in both the districts <5% of the respondents had "piped water into dwelling." Majority of the respondents had "other sources of drinking water" (96% in Vidisha and 97% in Raisen).

Table 2: Socio-economic, demographic, anaemia and knowledge variables in selected districts of Madhya Pradesh state of India, 2017 (%).

Predictors used in the model	Vidisha district	Raisen district
Total number	2,082	2,088
Residence		
Rural	80.9	77.1
Urban	19.1	22.9
Age (years)		
Mean±SD	31.14±9.88	30.82±9.97
15-19	19.0	19.9
20-29	20.8	21.4
30-39	35.1	34.7
40-49	25.1	24.0
Religion		
Hindu	90.5	92.6
Non-Hindu	9.5	7.4
Type of family		
Joint or extended	21.0	17.2
Nuclear	79.0	82.8
Social category		
Schedule tribe (ST)	6.7	13.5
Schedule caste (SC)	31.3	21.2
Other castes	62.0	65.4
Literacy		
Illiterate	46.0	34.9
Literate	54.0	65.1
Type of house		
Semi-Pucca or Pucca	39.0	39.6
Kachha	61.0	60.4
Sanitation facility		
Has no toilet	51.0	39.1
Has toilet	49.0	60.9
Source of drinking water		
Other sources of drinking water	96.2	97.0
Piped water into dwelling	3.8	3.0
Electricity		
Does not have electricity	17.6	7.7
Has electricity	82.4	92.3
Heard of anaemia		
Did not hear about anaemia	19.4	10.1
Heard about anaemia	80.6	89.9
Consumption of iron supplements		
Not consuming iron	94.9	95.9
Consuming iron	5.1	4.1
Prevalence of anaemia (<12.0 g/dl)		
Anaemic	60.8	63.7
Non-anaemic	39.2	36.3
Levels of anaemia		
Mild	24.1	25.8
Moderate	30.8	34.1
Severe	5.8	3.8

Association between socio-demographic factors and anaemia

The findings of the multiple binary logistic regression indicated that those who were from the scheduled caste (SC) [AOR 2.162 (95% CI: 1.535-3.045, p=0.000) in Raisen] and other (non SC/ST) castes [AOR 1.951 (95% CI: 1.429-2.664, p=0.000) in Raisen] were less likely to be anaemic compared to those who were from scheduled tribe (ST), which was observed in Raisen district. In Vidisha district, those respondents consuming iron supplements were less likely to be anaemic [AOR 1.502 (95% CI: 2.007-2.239, p=0.046)]. The random forest analysis (Figure 2) revealed that the age and caste of the woman were important variables in the model.

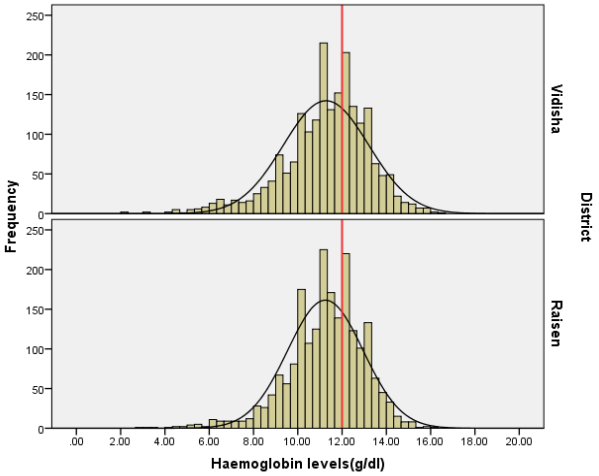

Figure 1: Distribution of NPNL women by haemoglobin levels in selected districts of Madhya Pradesh State of India.

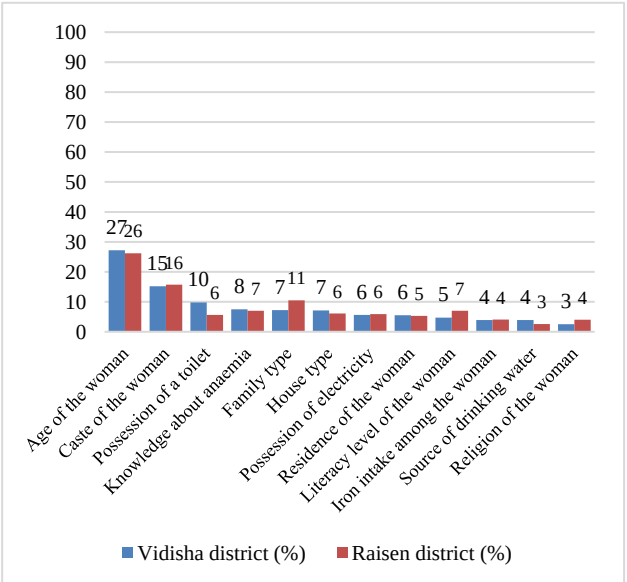

Figure 2: Variable importance based on the random forests (RF) analyses (%) in selected districts of Madhya Pradesh State of India.

Knowledge and awareness among fair price shop (FPS) owners

Out of the FPS owners interviewed in Vidisha and Raisen, almost all of them were aware of anaemia. The knowledge about the fortification of foods was poor (about 45% among decentralized millers and 58.5% among FPS owners in Vidisha), while in Raisen it was even lower at 20.4% among FPS owners and 17.2% among decentralized millers. More than 90% of the FPS owners and 80% of the decentralized millers in both districts stated their willingness to participate in a wheat flour fortification intervention.

DISCUSSION

We conducted a multiple binary logistic regression adjusting for specific variables to understand factors affecting anaemia. The results of our study should be interpreted in the context of socio-demographic factors. Our analysis showed that education and consumption of iron supplements influence predisposition towards anaemia. In addition, we also observed that age, religion, and type of household structure also affect an individuals' likelihood of being anaemic. The prevalence of anaemia in Vidisha and Raisen districts is higher than the prevalence of anaemia in Madhya Pradesh and India.[2] Majority of the respondents were moderately anaemic as per the WHO categorization, similar to other studies.[10-21] The target group for NFHS-4 was both rural and urban population, while our study sampled only the rural population. This observation is in line with other studies, which also report rural population to have a higher chance of being anaemic compared to the urban population. A multitude of factors such as poverty, access to food and health services, lower literacy levels, and poor hygiene and sanitation could be reasons for higher anaemia rates.[6,10,11,13] First, illiteracy as a predictor of anaemia, corroborates with other studies.[11-15] Results from the referenced studies align with our study, confirming that education is an influential factor in the prevention of anaemia. The studies recommend improving maternal knowledge to support sustained positive changes in maternal health and nutrition. Empowering women with knowledge on nutrition will guide them to make healthier choices, which in turn has a bearing on the health and nutrition of the entire family.[15] Second, consumption of iron supplements is inversely related to anemia. Study results revealed that those not consuming iron supplements had a higher likelihood of being anaemic, again, this is in line with other studies.[11,14] Current study results show a high level of non- consumption of iron supplements among the anaemic population, which probably reflects low demand among other factors as this could be either because the respondents were not aware of being anemic or it is not considered as a serious life threatening medical condition. Despite the GoI providing IFA supplementation and it being one of the longest-running programs of the government, India has still not been able to sufficiently tackle the anaemia burden.

Inadequate access to information, lack of counseling on benefits of supplementation and absence of programs to reach NPNLW, especially those who do not fall within the purview of 6 month post-partum, could be reasons for non-consumption of IFA tablets.[10,14]

Table 3: Socio-economic, demographic and health variables of low-income households by the presence of anaemia in selected districts of Madhya Pradesh State of India, 2017 (%).

Predictors used in the model	Vidisha			Raisen		
	Anaemic	Non-anaemic	P value	Anaemic	Non-anaemic	P value
Total number	1,272	810		1,335	753	
Residence						
Rural	60.3	39.7	0.358	63.9	36.1	0.011
Urban	62.8	37.2		62.9	37.1	
Age (years)						
15-19	53.9	46.1	0.001	59.2	40.8	0.015
20-29	62.0	38.0		64.9	35.1	
30-39	59.1	40.9		61.9	38.1	
40-49	67.2	32.8		68.8	31.2	
Religion						
Hindu	60.0	40.0	0.032	63.8	36.2	0.672
Non-Hindu	67.9	32.1		62.1	37.9	
Type of family						
Joint or extended	63.4	36.6	0.210	64.0	36.0	0.874
Nuclear	60.1	39.9		63.6	36.4	
Social category						
Schedule tribe (ST)	66.7	33.3	0.334	76.3	23.7	0.000
Schedule caste (SC)	60.6	39.4		60.1	39.9	
Other castes	60.2	39.8		62.2	37.8	
Literacy						
Illiterate	65.1	34.9	0.000	69.1	30.9	0.000
Literate	57.1	43.0		60.8	39.2	
Type of house						
Semi-Pucca or Pucca	63.4	36.6	0.053	63.9	36.1	0.862
Kachha	59.1	40.9		63.5	36.5	
Sanitation facility						
Has no toilet	62.3	37.7	0.143	65.5	34.5	0.172
Has toilet	59.1	40.9		62.5	37.5	
Source of drinking water						
Other sources of drinking water	60.7	39.3	0.638	63.9	36.1	0.142
Piped water into dwelling	63.3	36.7		54.8	45.2	
Electricity						
Does not have electricity	57.4	42.6	0.151	66.7	33.3	0.414
Has electricity	61.5	38.5		63.4	36.6	
Heard of anaemia						
Did not hear about anaemia	61.8	38.3	0.650	70.0	30.0	0.044
Heard about anaemia	60.5	39.5		63.0	37.0	
Consumption of iron supplements						
Not consuming iron	61.3	38.7	0.045	63.5	36.5	0.508
Consuming iron	51.4	48.6		67.1	32.9	

However, the Government of Madhya Pradesh is intensifying its efforts to address anaemia and conducts bi-annual health camps where the haemoglobin levels of NPNLW are assessed and those who are anaemic are provided with iron supplements. In addition, the importance of consuming IFA tablets needs to be reiterated while educating women on health and nutrition in order to achieve sustained progress in tackling anaemia. Third, engaging to improve the sanitation facilities is essential. Poor hygiene and sanitary conditions significantly contribute to anaemia incidence, which could have adverse consequences, especially, on pregnant women and young children.[16] The Government of India has undertaken a 'total sanitation campaign' to

end the practice of open defecation and in turn, improve hygiene and sanitation, which will eventually lead to improved health in the population.[17] However, even though there is sufficient evidence to link sanitation with anaemia, in reality, improving sanitation still remains a major challenge. Sensitizing and educating people and ensuring provision for appropriate sanitation facilities is important while addressing the challenge of anaemia.

Table 4: Adjusted Odds ratio (AOR) with 95% confidence intervals from the multiple binary logistic regression (MLR) of anaemia prevalence in selected districts in Madhya Pradesh state of India.

Predictors used in the model	Vidisha	P value	Raisen	P value
Total number (unweighted)	2,064		2,073	
Residence				
Rural [ref]	-	-	-	-
Urban	0.876 (0.679-1.132)	0.312	0.959 (0.751-1.224)	0.735
Age (years)				
15-19 [ref]	-	-	-	-
20-29	0.748 (0.562-0.995)	0.046	0.795 (0.599-1.055)	0.112
30-39	0.890 (0.678-1.168)	0.401	0.952 (0.729-1.242)	0.716
40-49	0.672 (0.493-0.917)	0.012	0.767 (0.561-1.050)	0.098
Religion				
Hindu [ref]	-	-	-	-
Non-Hindu	0.714 (0.516-0.989)	0.043	1.049 (0.737-1.494)	0.791
Type of family				
Joint or extended [ref]	-	-	-	-
Nuclear	1.158 (0.925-1.449)	0.201	0.983 (0.771-1.253)	0.889
Social status				
Schedule Tribes (ST) [ref]	-	-	-	-
Schedule Castes (SC)	1.244 (0.839-1.846)	0.277	2.162 (1.535-3.045)	0.000
Other castes	1.306 (0.890-1.915)	0.172	1.951 (1.429-2.664)	0.000
Literacy				
Illiterate [ref]	-	-	-	-
Literate	1.303 (1.049-1.617)	0.017	1.318 (1.049-1.656)	0.018
Type of house				
Semi-Pucca or Pucca [ref]	-	-	-	-
Kachha	1.228 (1.000-1.509)	0.050	1.149 (0.930-1.397)	0.181
Sanitation facility				
Has no toilet [ref]	-	-	-	-
Has toilet	1.199 (0.990-1.453)	0.063	1.055 (0.865-1.287)	0.598
Source of drinking water				
Other sources of drinking water [ref]	-	-	-	-
Piped water into dwelling	0.972 (0.600-1.573)	0.907	1.377(0.814-2.328)	0.233
Electricity				
Does not have electricity [ref]	-	-	-	-
Has electricity	0.812 (0.638-1.034)	0.091	1.013 (0.710-1.447)	0.942
Heard of anaemia				
Did not hear about anaemia [ref]	-	-	-	-
Heard about anaemia	1.032 (0.821-1.297)	0.790	1.301 (0.946-1.789)	0.105
Consumption of iron supplements				
Not consuming iron [ref]	-	-	-	-
Consuming iron	1.502 (1.007-2.239)	0.046	0.832 (0.522-1.326)	0.440

Dependent variable: prevalence of any anaemia: coded as 0 if the women had any anaemia and 1 if she did not.

Apart from the above mentioned three factors, which can be addressed through public health interventions, age, religion, and type of household also emerged as predictors of anaemia. Anaemia is observed from a young age in most females, and studies confirm that younger women have a higher chance of being anaemic.[10,18] Our results showed that those in the 20 to 29 years and 40 to 49 years age bracket had the highest risk of being anaemic. As observed in other studies, anaemia from a young age could also be related to gender bias, poverty and lack of nutrition education, thus making it imperative that public health interventions start right from young age.[14,18] Along with the above observations, our study also reported low levels of knowledge on fortification among FPS owners and decentralized millers. The low level of knowledge can be corroborated with studies

conducted in India on the knowledge of fortification of foods.[19,20] Poor knowledge could partially be due to fortification in India not being mandatory.

Table 5: Knowledge and willingness among fair price shop owners and decentralized millers in selected districts of Madhya Pradesh of India.

Indicators	Vidisha (%)	Raisen (%)
Fair price shop owners' awareness on anaemia	95.4	98.1
Decentralized millers awareness on anaemia	95.0	84.4
Fair price shop owners' knowledge about fortification	58.5	20.4
Decentralized millers knowledge about fortification	45.0	17.2
Fair price shop owners' willingness to participate in a wheat flour fortification intervention	98.5	92.6
Decentralized millers' willingness to participate in a wheat flour fortification intervention	83.3	84.4
Fair price shop owners' willingness to undergo training to understand their role	98.5	92.6
Decentralized millers' willingness to undergo training to understand their role	91.7	89.1

Since it still is voluntary, there has been very little to almost no communication on the benefits of fortification.[19]As part of our study, we also observed that almost everyone has access to mobile phones and televisions. It is vital that while planning any behavior change communication campaigns, to try and include as much messaging as possible through these two media sources, as these are most accessible to everyone. Hence, communicating the benefits of any public health intervention, while initiating as well as during the intervention is essential to its success.

CONCLUSION

The results of our study revealed that education and consumption of iron supplements are important determinants of anaemia. Other determinants which emerged were age and type of household. Of all the determinants, two of them (education and iron supplementation) can be addressed through public health interventions. Along with the National Iron Plus Initiative Program, Poshan Abhiyan (Campaign) and the Total Sanitation Campaign, it is imperative that women and the population, in general, be sensitized and educated on anaemia. Explaining to them how all factors work together to affect their health should be the strategy for these education sessions. However, along with this, ensuring proper access to health facilities and supporting programs which provide nutrition education, livelihood skills, and livelihood training are also essential in order to achieve and maintain progress. The World Health Organization (WHO) recommends a comprehensive approach of a mix of nutrition-specific and nutrition-sensitive interventions to address the burden of anaemia, two of which are (i) dietary diversification and food fortification and (ii) food supplementation. Food fortification is stated by The Copenhagen Consensus (2008) as a cost-effective intervention to address malnutrition/iron deficiency anaemia. Along with its cost-effectiveness, fortifying a staple food is also a sustainable way of countering the malnutrition challenges faced by a population. The next steps could be towards creating awareness on the benefits of fortification and ways in which wheat flour can be fortified, followed by generating demand for fortified foods

ACKNOWLEDGEMENTS

Authors are thankful and acknowledge the support received from the officials of the Government of Madhya Pradesh, survey respondents, service providers, and other key stakeholders.

Funding: Global Affairs of Canada
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Benoist B, McLean E, Egli I, Cogswell M. Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia. Available at: https://www.who.int/publications/i/item/9789241596657. Accessed on 20 November 2021.
2. National Family Health Survey 2017 (NFHS-4). Available at: https://www.rchiips.org/nfhs/nfhs4.shtml. Accessed on 20 November 2021.
3. Kalaivani K. Prevalence and consequences of anaemia in pregnancy. Indian J Med Res. 2009;130(5):627-33.
4. Special Bulletin on Maternal Mortality in India 2014-16. Available at: http://www.censusindia.gov.in/vital_statistics/SRS_Bulletins/MMR%20Bulletin-2014-16.pdf. Accessed on 20 November 2021.
5. Kumar A. National nutritional anaemia control programme in India. Indian J of Public Health. 1999;43(1):3-5.
6. Rai RK, Fawzi WW, Barik A, Chowdhury A. The burden of iron-deficiency anaemia among women in India: how have iron and folic acid interventions fared?. WHO South-East Asia J Public Health. 2018;7(1):18-23.
7. Horton S, Mannar V, Wesley A. Second copenhagen consensus: micronutrient fortification best practice.

Available at: https://www.copenhagenconsensus.com/. Accessed on 20 November 2021.
8. India: Census 2011 office of the registrar general & census commissioner, India. Available at: http://censusindia.gov.in/. Accessed on 20 November 2021.
9. District level population projections in eight selected states of India 2006-2016. Available at: https://District_level_population_projections_in_selected_staties_of_India_-_2006_to_2016. Accessed on 20 November 2021.
10. Little M, Zivot C, Humphries S, Dodd W, Patel K, Dewey C. Burden and determinants of anemia in a rural population in south india: a cross-sectional study. Anemia. 2018;2:34-8.
11. Lokare PO, Karanjekar VD, Gattani PL, Kulkarni AP. A study of prevalence of anemia and sociodemographic factors associated with anemia among pregnant women in Aurangabad city, India. Ann Nigerian Med. 2012;6:30-4.
12. Titaley CR, Rahayu E, Damayanti R, Dachlia D, Sartika RAD, Ismail A, et al. Association between knowledge and compliance of taking iron/folic acid supplements during pregnancy. Asian J Pharm Clin Res. 2017;22:159-65.
13. Bentley ME and Griffiths PL. The burden of anemia among women in India. EJCN. 2003;57:52-60.
14. Gautam VP, Bansal Y, Taneja DK, Saha R. Prevalence of anemia amongst pregnant women and its socio-demographic associates in a rural area of Delhi. IJCM. 2002;27(4):157-60.
15. Balarajan Y, Fawzi W, Subramanian SV. Changing patterns of social inequalities in anaemia among women in India: cross-sectional study using nationally representative data. CMJ. 2013;3:23-9.
16. Coffey D, Geruso M, Spears D. Sanitation, disease externalities and anaemia: evidence from Nepal. EJ. 2017;12:1395-432.
17. Patil SR, Arnold BF, Salvatore AL, Criceno B, Ganguly S, Colford JM, et al. The effect of India's total sanitation campaign on defecation behaviors and child health in rural Madhya Pradesh: A cluster randomized controlled trial. PLOS. 2017;11(8):e1001709.
18. Lone FA, Qureshi RN, Emanuel F. Maternal anemia and its impact on perinatal outcome. Trop Med Int Health. 2004;9(4):12-8.
19. Arora H, Dixit V, Srivastava N. Evaluation of knowledge, practices of vitamin D and attitude toward sunlight among Indian students. Asian J Pharm Clin Res. 2016;9(1):23-9.
20. Ahluwalia N. Intervention strategies for improving iron status of young children and adolescents in India. Nutr Res. 2002;60(5):23-9.
21. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Available at: https://www.who.int/vmnis/indicators/haemoglobin.pdf. Accessed on 20 November 2021.

Cite this article as: Jha RK, Dutta S, Ghosh R, Mishra A, Reddy JC, Lakshminarayanan S, et al. Socio-demographic factors associated with anaemia among non-pregnant and non-lactating women from low-income families in two selected districts of Madhya Pradesh state of India: a random forest analysis. Int J Community Med Public Health 2022;9:4463-71.