Changing Scenario of Anemia Among Women in India: Understanding the Maternal Health Concern and Its Associated Predictors Through National Family Health Survey

Nivedita Roy

Society for Applied Studies <https://orcid.org/0000-0003-4121-9124>

Vijay Kumar Mishra

Public Health Foundation of India

Piyush Kumar Mishra (✉ piyushm641@gmail.com)

Department of Community Medicine, Government Medical College Khandwa

Ashish Bandhu

IIHMR University

Rajeev Dhakad

Khushi Baby

Research

Keywords: anaemia, multivariate decomposition, contributing predictors, projection, National Family Health Survey

Posted Date: October 18th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-948470/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Objectives: To study the changes in Anemia among women and to study the association between anemia and socio-demographic and economic predictors, also estimating the percentage contribution of selected predictors to Anemia among women belonging to poor and non-poor households.

Methods: The State-wise percentages were taken from the extracted factsheets of National Family Health Survey 2015-2016 and 2019-2020. Absolute and relative percent changes to understand the changes in prevalence have been calculated. Multiple logistic regression was done to understand the associated varying predictors of Anemia among women. Percentage contribution of selected varying predictors through multivariate decomposition analysis have also been estimated.

Results: Anemia prevalence was found the highest among the women in Goa and least in Lakshwadeep. The relative change in prevalence of Anemia was highest in Assam and lowest in Lakshwadeep. Socio-economic factors like marriage at a young age, lack of education, exposure to media, malnutrition, and poor economic status contribute significantly to the prevalence of Anemia among women of age 15-49 years.

Conclusion: It is seen that the socio-demographic and economic burden on Anemia still continues to be higher than other medical predictors. The focus should be made more on education, malnutrition, and economic status to reduce the prevalence of Anemia.

Introduction

The disease of anaemia affects approximately 2.5 billion individuals globally, and its effect is mostly on women and children whose epidemiology varies according to socio-economic, cultural, and geographical context. [1] Although there is a noticeable progress in socio-economic status and health welfare in most low-income countries in South East Asia, countries, especially India, still have a high malnutrition burden. [2]. The prevalence of under nutrition among less than 5 years aged children is high among Empowered Action Group (EAG) states of India, and the most important predictors were socioeconomic factors, exposure to media, and biomedical factors. [3] One of the leading causes of maternal deaths in India is Anemia and is a major factor of poor health, economic loss, and social burden. [4] According to the National Family Health Survey 4 (NFHS-4), 58.4 % of children aged 6–59 months and 53 % of all women aged 15–49 years, were anaemic in India. [5]

The World Health Organization (WHO) defines Anemia as "a condition in which the number of red blood cells or the haemoglobin (Hb) concentration within them is lower than normal". [6, 7] The disease is associated with increased morbidity and mortality in women, especially pregnant and lactating women. Child growth faltering, impairment of cognitive function, increased chances of various kinds of infection, loss of productivity from impaired work capacity eventually also results in substantial economic burden to the family and entire population. [8–10] The prevalence of Anemia has declined from an estimated 55.4 % in 1990 to an estimated 51.4 % in 2016 with a decrease of roughly four percentage points over

this time. [7, 10] Additionally, it is to be noted that from 2014, the prevalence had increased from 51.19 % to 51.43 % in 2016, which is an increase of 0.24 percent points which is a serious concern [11].

To strategies reduction of Anemia, the program named Anemia Mukht Bharat (AMB) was launched by the Government of India under the Prime Minister's scheme for Holistic Nourishment (POSHAN) Abhiyaan. [12, 13] One of the goals of the program is to reduce the prevalence of the disease by 3 % per year to support the end of goal of attaining a malnutrition free India by 2022. [12–15] However, the progress made is far less than the expected with socioeconomic burden still being a major concern. [16–19] The Sustainable Development Goals (SDGs) also targeted under SDG-2 to reduce the malnutrition burden among under-5 children, pregnant women, lactating mothers, adolescents girls, and older people [20–23].

To achieve these targets, it is essential that enough evidence is produced on the predictors of Anemia to eventually lead to optimum contribution to timely interventions in anemia reduction and prevention. Additionally, exploring the commonalities and differences across the states in the country can inform and upgrade the state policies. Several previous studies have attempted to estimate the prevalence of Anemia, [24, 25] but few studies have attempted to utilized nationally representative data to investigate the prevalence and determinants of Anemia among the states of India. Furthermore, the updated evidence using NFHS 5 data on prevalence and factors associated with Anemia among at-risk populations is lacking for the country.

In this context, we aimed to study the Anemia among women with the following objectives, a) To study the changes in Anemia among women across selected Indian states, b) To study the association between anemia and socio-demographic and economic predictors, and estimating percentage contribution of selected predictors to Anemia among women belonging to poor and non-poor households.

Methods

Our study utilized data from the National Family Health Survey of India, round 4 (NFHS-4) and round 5 (NFHS-5) fact sheets. NFHS is the Indian version of the global demographic and health survey (DHS). NFHS is a large scale periodic national survey conducted by the Government of India to obtain nationwide data on health and family welfare. Twenty-nine Indian states and 7 union territories were covered for data collection in NFHS-4. Separate questionnaires were used for men, women and households. Biomarker details for different disease conditions were also recorded. The data collected for the variables was self-reported. The NFHS-4 sample used a stratified two stage sampling with a cross-sectional study design. The details of the study, methods, sampling frame and questionnaire have been mentioned in the published report of NFHS-4. 699,686 women between the age of 15-49 years and 112,122 men between the ages of 15-54 years and 259,627 children were included in the survey and the overall response rate was 98 per cent. Our study included data of women in the age group 15-49 years from NFHS-4 (n=684,911). Blood samples from eligible and consenting women in the 15-49 years age group were collected by trained health investigators during NFHS surveys. The Hb analysis was done on-site with a battery-operated, portable HemoCue Hb 201+ analyzer. Participants with severe Anemia (Hb

level less than 9 g/dL for women) were sent to a health facility for further evaluation and treatment. The details of the survey methods, sampling frame and questionnaire are detailed elsewhere.

Outcome and predictor variables

The outcome variable used in the study is 'anemia level'. The variables age, education, media, wealth index, source of drinking water and body mass index were used as predictors. The variable 'respondent current age' was categorized into '15-29', '30-39' and '40-49'. The variable 'wealth index' which was categorized as 'poorest', 'poorer', 'middle', 'richer' and 'richest' in the existing data (NFHS-4), was recategorized as 'poor', 'middle' and 'rich'. We have further re-categorised into dichotomous categories as 'poor' and 'non-poor' to understand the differentials of Anemia among poor and non-poor women. The variable 'education in single years' was categorised into 'less than 10 years of schooling' and '10 or more years of schooling'. The variable media was generated on clubbing and then dichotomising the responses of three pre-existing variables in NFHS-4 data, i.e., 'frequency of reading newspaper', 'frequency of listening radio' and 'frequency of watching television'. We have categorized the maternal body mass index into 'underweight (<18.5)', 'normal (18.5-24.9)' and 'overweight/obese (>25.0)' as per the guidelines of the world health organization (WHO). We have also dichotomised the pre-existing variable 'anemia level' in the existing NFHS-4 data, into 'anemic=1' and 'not anemic =0' for logistic regression and decomposition analyses. The dummy variables having dichotomous categories for all selected predictor variables were used in multiple logistic regression as well as in multivariate decomposition analysis.

Data Analyses

The analyses were done after removing list wise missing, flagged and no information cases. The State-wise percentages were taken from the extracted factsheets of NFHS 4 and NFHS-5. We have calculated absolute and relative percent changes to understand the changes in prevalence of anaemia among women. The multiple logistic regression was done to understand the association predictors and Anemia among women on NFHS-4 data. We have also estimated the percentage contribution of selected predictors (education, media, BMI, source of drinking water and smoking) through multivariate decomposition analysis. The package 'mvdcmp' was used to estimate the contributing factors of anaemia among women in the age group 15-49.

The 'mvdcmp' package was primarily made for use in non-linear decomposition and was based on recent contributions, which include convenient method to handle path dependency, calculating asymptotic standard errors, and overcoming the identification of problem associated with the choice of a reference category when dummy variables are included among the predictors [26].

The relative change percentages were calculated to understand the variation in prevalence of Anemia among women across 22 states of India. The growth rate was calculated from 2015 to 2020 for projecting the prevalence numbers and rates till 2030. We used the mathematical growth modeling (geometric growth model) approach for estimating projected values of prevalence rate as well as numbers. In particular, mathematical projections are nothing but fitting of the curve to the observed data.

Assuming the one-third reduction till 2030 from the base year (2015), we have estimated the potential gap from the projected figures in the year 2030.

Mathematical formulae used to calculate relative change and projection are given by-

$$\text{Relative change (per cent)} = (\text{est}_{NFHS-5} - \text{est}_{NFHS-4}) / \text{est}_{NFHS-4} * 100$$

$$\text{Geometric Growth Model (GGM) for projection} - R_{2030} = R_{NFHS-5} * (1+d)^t$$

Where R_{2030} = projected prevalence of Anemia among women in 2030

R_{NFHS-5} = current prevalence of anemia among women

t = no. of years

d = growth rate

Mathematical formulation of the overall decomposition has given below

$$Z = G(Y\sigma)$$

Where Z = $n \times 1$ dependent variable vector anaemia (dependent variable), Y = $n \times k$ matrix of independent variables and σ is $k \times 1$ vector of coefficients. $G(.)$ is any once-differential function mapping a linear combination of $Y(Y\sigma)$ to Z .

The average difference in Z between two groups H (poor) and I (non-poor) can be decomposed as –

$$Z_H - Z_I = G(Y_H\sigma_H) - G(Y_I\sigma_I)$$

$$Z_H - Z_I = \{G(Y_H\sigma_H) - G(Y_I\sigma_H)\} + \{G(Y_I\sigma_H) - G(Y_I\sigma_I)\}$$

E

C

Here component 'E' refers to the part of the differential attributable to difference in endowments or characteristics while, 'C' refers to the part of the differential attributable to differences in coefficients. Here, H has been selected as the comparison group and I as the reference group. All the statistical analyses have been performed using STATA (version 13.0).

Results

Status of Anemia among women in age-group 15-49 years across Indian States

It is clear that the prevalence of Anemia among women has increased over a period of 5 years in most of the Indian states except Lakshadweep, Dadra & Nagar Haveli, Andaman & Nicobar, Nagaland, Himachal Pradesh, and Meghalaya. Anemia prevalence was found the highest among the women living in Goa

(92.8 %) and Sikkim (71.4 %); in the fifth round of NFHS. The prevalence of Anemia was the lowest among the women living in Lakshadweep (25.8 %).

The positive value of relative change (per cent) indicates the increment in the prevalence from NFHS-4 to NHFS-5, while the negative sign indicates the decrease. The relative change in prevalence of Anemia was higher in Assam (43.3 %) followed by Ladakh (34.8 %), J&K (40.3 %), and Tripura (24.6 %) respectively while lower percentage was reported in states namely Lakshadweep (-43.9 %) followed by Dadra & Nagar Haveli (-14.3 %), Andaman & Nicobar (-12.5 %), Dadra Nagar Havel & Daman Div (-14.3 %), Nagaland (-4.3 %) respectively.

The project value of anaemia prevalence across the states for the year 2030 for this study identified the top 5 states with the higher gaps in prevalence of Anemia, i.e., Assam (91.3 %), Ladakh (75.8 %), Goa (68.2 %), Gujarat (57.4 %), while the lower gaps are Lakshadweep (-9.1 %), Dadra & Nagar Haveli (4.3 %), Andaman & Nicobar (5.7 %) (Table 1).

Table 1. Prevalence of Actual, Targeted, Projected and potential gaps of Anemia among women (15-49 years) across Indian States

States	NFHS-4(per cent)	NFHS-5(per cent)	Relative Change (per cent)	One-third reduction by NFHS-5 till 2030(per cent)	Potential gap for 2030 target (per cent)
Lakshadweep	46.0	25.8	-43.9	17.2	-9.1
Dadra Nagar Havel & Daman Div	72.9	62.5	-14.3	41.7	4.3
Andaman and Nicobar	65.7	57.5	-12.5	38.3	5.7
Andhra Pradesh	27.9	28.9	3.6	19.3	11.7
Nagaland	56.2	53.8	-4.3	35.9	13.4
Telangana	34.3	36.3	5.8	24.2	16.5
Himachal Pradesh	53.5	53.0	-0.9	35.3	16.7
Bihar	26.4	29.4	11.4	19.6	16.9
Meghalaya	60.0	58.8	-2.0	39.2	17.3
Kerala	56.6	57.6	1.8	38.4	21.3
Karnataka	44.8	47.8	6.7	31.9	22.5
Manipur	60.3	63.5	5.3	42.3	28.1
Maharashtra	48.0	54.2	12.9	36.1	33.0
Mizoram	34.9	42.1	20.6	28.1	33.2
Tripura	31.3	39.0	24.6	26.0	34.5
Jammu and Kashmir	24.8	34.8	40.3	23.2	45.3
Sikkim	62.5	71.4	14.2	47.6	45.6
West Bengal	54.9	65.0	18.4	43.3	47.8
Gujarat	54.5	67.2	23.3	44.8	57.4
Goa	78.4	92.8	18.4	61.9	68.2
Ladakh	48.9	65.9	34.8	43.9	75.8
Assam	46.0	65.9	43.3	43.9	91.3

Potential Gap (per cent)	no gap	<20	20-40	40-60	60+
Colour code					

Legend

Factors associated with Anemia among women in India

The results of multiple logistic regression revealed that socio-economic factors were significantly associated with Anemia. The women belonging to age group 40-49 were less likely [OR(CI),0.96 (0.95-0.98)] to developing Anemia as compared to women of age group 15–29, followed by age group 30-39 [OR(CI),0.95 (0.94-0.97)] respectively. The chances of Anemia is lesser [OR(CI), 0.76 (0.74-0.77)] among highly educated women than uneducated. The odds ratio was significantly lower in women who had

exposed to media [OR(CI), 0.97 (0.96, 0.98)]. The overweight women [OR (CI), 0.71(0.64-0.79)] were less likely to developing Anemia as compared to underweight women followed by women having normal weight. The women consuming water from well water and spring [OR (CI), 1.22(1.20-1.24)], [OR (CI), 1.10(1.08-1.13)] were more likely to developing Anemia as compared to those having tap water respectively. The women belonging to richer sections of the society are less likely to become anemic than poor section of the society (Table.2).

Table 2
Results of the multiple logistic regression showing predictors associated with risk of
developing Anemia among women in the age group 15-49 years

Anemia	Odds Ratio	Std. Err.	[95 per cent Conf. Interval]	
age group			LL	UL
15-29®	1.00			
30-39	0.95***	0.006	0.94	0.97
40-49	0.96***	0.007	0.95	0.98
education				
no education®	1.00			
Primary	0.91***	0.008	0.89	0.92
Secondary	0.84***	0.006	0.83	0.85
Higher	0.76***	0.008	0.74	0.77
media exposure				
no®	1.00			
Yes	0.97***	0.007	0.96	0.98
wealth index				
poor®	1.00			
Medium	0.92***	0.007	0.91	0.94
Rich	0.94***	0.007	0.92	0.95
source of drinking water				
tap water®	1.00			
well	1.22***	0.010	1.20	1.24
Spring	1.10***	0.012	1.08	1.13
body mass index				
under weight®	1.00			
Normal	0.88**	0.046	0.79	0.97
overweight/obese	0.71***	0.038	0.64	0.79
®-Reference Category, p**<0.001, p*** <0.0001, LL – Lower limit, UL – Upper limit,				

Main contributing factors affecting Anemia among poor and non-poor women

The multivariate decomposition results revealed that both endowment and coefficient are significant among high outcome group (poor). Differences in effects account for about 44.8 % of the observed poor-non-poor differential in the prevalence of Anemia among women, with differences in intercepts (baseline logits). As per the convention, positive E(characteristic) coefficient indicates the expected reduction in poor to non-poor anemia gap in pregnant women if poor were equal to non-poor on the distribution of independent variables.

Equalizing the level of education would be expected to reduce the poor to non-poor anemia gap by around 11 %. Percentage contribution of exposure to media was around 12 %. This suggests us that by increasing awareness through mass media like newspaper/radio/television may be effective for reducing risk of developing Anemia among women. The chances of Anemia may be reduced by around 16 % among women if we equalised the distribution of safe drinking water among households in all regions of India. Similarly, probability of Anemia may be reduced by around 15 % if the women have normal BMI (Table 3).

Table 3

Results of multivariate decomposition showing percent contribution of selected predictors of Anemia, NFHF-4

<i>Decomposition Results</i>		<i>Number of obs = 684911</i>				
High outcome group: poor==1		Low outcome group: poor==0				
Anemia	Coef.	Std. Err.	P-value	[95 per cent Conf.	Interval]	Pct.
E	0.035	0.001	0.000	0.032	0.037	55.14
C	0.028	0.002	0.000	0.025	0.032	44.86
R	0.064	0.001	0.000	0.06	0.066	100
Due to Difference in Characteristics (E)						
Anemia	Coef.	Std. Err.	P-value	[95 per cent Conf.	Interval]	Pct.
Education	0.007	0.001	0.000	0.005	0.008	11.19
Media	0.008	0.001	0.000	0.006	0.009	12.08
Source of drinking water (Safe drinking water)	0.010	0.001	0.000	0.008	0.011	16.44
BMI (Normal)	0.010	0.000	0.000	0.009	0.010	15.44
Total (Pct.)						55.14
Due to Difference in Coefficients (C)						
Anemia	Coef.	Std. Err.	P-value	[95 per cent Conf.	Interval]	Pct.
Education	-0.002	0.001	0.140	-0.005	0.001	-3.95
Media	-0.003	0.003	0.407	-0.010	0.004	-4.98
Source of drinking water (Safe drinking water)	-0.149	0.001	0.000	-0.017	-0.012	-23.51
BMI (Normal)	2.6099e-06	0.000	0.996	-0.001	0.001	0.00
_cons	0.049	0.005	0.000	0.039	0.058	77.30
Total (Pct.)						44.86

Discussion

In the present study, it is seen that 92.8 % of women are anemic in Goa which is the highest among all the states, whereas the lowest prevalence is in Lakshadweep with 25.8 % of women being anemic.

Additionally, the prevalence of Anemia have increased with time in Assam (43.3 %), followed by Ladakh (34.8 %), J&K (40.3 %), and Tripura (24.6 %). On the other hand, the occurrence of Anemia has decreased from NFHS 4 to NFHS 5 in Lakshadweep (-43.9 %) followed by Dadra & Nagar Haveli (-14.3 %), Andaman & Nicobar (-12.5 %), Dadra Nagar Havel & Daman Div (-14.3 %) and Nagaland (-4.3 %) and thus the relative change is in negative value. The project value of anaemia prevalence across the states for the year 2030 helped us to understand the potential gaps in prevalence of Anemia across the states and identify the states with higher gaps that required immediate mitigation measures to eradicate the prevalence of Anemia. The states with higher gaps were Assam (91.3 %), Ladakh (75.8 %), Goa (68.2 %), Gujarat (57.4 %), while the states with lower gaps were Lakshadweep (-9.1 %), Dadra & Nagar Haveli (4.3 %), Andaman & Nicobar (5.7 %). The negative value for Lakshadweep suggests downfall in the prevalence of Anemia by 2030. Additionally, it is found out from the multiple logistic regressions that socio-economic factors like age, education, and exposure to media, malnutrition and wealth contribute significantly to the prevalence of Anemia among women of age 15-49 years. In terms of the main contributing factors affecting the prevalence of Anemia among women among poor and non-poor women, it is found out that both endowment and coefficient are significant among high outcome group (poor). [27] Differences in effects account for about 44.8 % of the observed poor-non-poor differential in the prevalence of Anemia among women, with differences in intercepts (baseline logits). Additionally, equalizing the level of education would be expected to reduce the poor to non-poor anemia gap by around 11 %. In terms of safe drinking water consumption, the incidence of Anemia may be reduced by around 16 % among women if the distribution of safe drinking water is equalized among households in all regions of India. Similarly, probability of Anemia may be reduced by around 15 % if the women have normal BMI.

The main limitation of the projective mathematical model: The projection modeling helps us to understand the futuristic trend so that we can get the idea on the seriousness of the diseases in coming days, months, or years. In geometric growth model, there is no problem like arithmetic growth for the selection of the base year population. The mathematical growth modeling curve may fit the observed data with greater accuracy and, yet fail to produce the prevalence number/rate for future with same accuracy if the population trends undergo drastic change.

Other limitations: The study's one of the other main limitation was that it was not feasible to compare entire national estimates due to unavailability of NFHS-5 data. Also, we cannot establish any causal relationship because of a cross-sectional study.

Conclusion And Recommendation

It is clearly seen that the socio-demographic and economic burden on Anemia still continues to be higher than other medical predictors. To accelerate the reduction of the prevalence of Anemia, it is important to equalize the level of education among women and spread awareness on the development of risk of Anemia and its effect on children. This can be done by increasing awareness through mass media like newspaper/radio/television, may be effective for reducing the risk of developing anaemia among women.

One of the leading indirect socio-economic factors causing Anemia is the increasing wealth inequality in our society, which essentially needs to reduce and strong policies should be built towards the same.

Main Messages:

1. The prevalence of Anaemia have increased with time in Assam (43.3 %), followed by Ladakh (34.8 %), J&K (40.3 %), and Tripura (24.6 %).
2. States with higher gaps which requires immediate mitigation measures to eradicate the prevalence of anemia are Assam (91.3 %), Ladakh (75.8 %), Goa (68.2 %), Gujarat (57.4 %).
3. Socio-economic factors like age, education, and low exposure to media, malnutrition and wealth contribute significantly to the prevalence of anemia among women of age 15-49 years who are poor.
4. Equalizing the level of education would be expected to reduce poor to non-poor anemia gap by around 11 %.
5. The incidence of anemia may be reduced by around 16 % among women if the distribution of safe drinking water is equalized among household in all regions of India.
6. Probability of anemia may be reduced by around 15 % if the women have normal BMI.

Abbreviations

EAG – Empowered Action Group; NFHS – National Family Health Survey; WHO – World Health Organization; Hb – Haemoglobin; AMB – Anemia Mukht Bharat; POSHAN - Prime Minister's scheme for Holistic Nourishment; SDG - Sustainable Development Goals; DHS - Demographic and Health Survey; dL – DeciLiter; BMI – Body Mass Index; GGM – Geometric Growth Model; OR – Odds Ratio; CI – Confidence Interval; J&K – Jammu and Kashmir

Declarations

Acknowledgements -

The authors would like to thank Demographic and Health Survey's Data Archivist for providing us access to NFHS data.

Funding -

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Availability of data and materials -

Data availability statement

The secondary data used for this study is freely available on the website of the Demographic and Health Surveys (DHS). Author received access of data through DHS. The data can be accessed through the website of DHS (DHS, 2021). [28]

Ethics approval and consent to participate -

This study used open-source secondary data. Not ethical approval was required.

Competing interests -

The authors declare that they have no competing interests.

Consent for publication -

All authors have consented for publication of this original research article.

Authors' contributions -

Conceptualization: VKM, NR. Data curation: VKM. Formal analysis: PKM. Funding acquisition: Methodology: VKM, PKM, NR. Project administration: Visualization: NR. Writing - original draft: NR, VKM, PKM. Writing – review: AB, RD & editing: AB, NR.

References

1. Stevens GA, Finucane MM, De-Regil LM, Paciorek CJ, Flaxman SR, Branca F, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: A systematic analysis of population representative data. *Lancet Glob Health* 2013;1(1):16–25. [https://doi.org/10.1016/S2214-109X\(13\)70001-9](https://doi.org/10.1016/S2214-109X(13)70001-9)
2. da Silva Lopes K, Takemoto Y, Garcia-Casal MN, Ota E. Nutrition-specific interventions for preventing and controlling anaemia throughout the life cycle: an overview of systematic reviews. *Cochrane Database Syst Rev*. 2018 Aug 10;2018(8):CD013092. doi: <https://doi.org/10.1002/14651858.CD013092> PMID: PMC6513621.
3. Mishra PK, Mishra VK. Scenario of under nutrition among under five years children in India and its states: findings from National Family Health Survey. *International Journal of Community Medicine and Public Health* 2020;7(8):3087-3094. <http://dx.doi.org/10.18203/2394-6040.ijcmph20203382>
4. Manyeh AK, Nathan R, Nelson G. Maternal mortality in Ifakara Health and Demographic Surveillance System: Spatial patterns, trends and risk factors, 2006 - 2010. *PLoS One* 2018;13(10):e0205370. doi: <https://doi.org/10.1371/journal.pone.0205370>
5. Government of India. National Family Health Survey 4- key indicators: 2015-2016. National Family Health Survey 4 2016;p:1–8.

6. WHO. Anemia. WHO Website. [cited 2021 March 12]. Available from: <http://www.who.int/topics/anaemia/en/>
7. Baumeister P, Canis M, Reiter M. Preoperative anemia and perioperative blood transfusion in head and neck squamous cell carcinoma. PLoS One 2018 Oct 22; 13(10):e0205712. doi: <https://doi.org/10.1371/journal.pone.0205712> PMID: 30347001; PMCID: PMC6197687.
8. Sunuwar DR, Singh DR, Chaudhary NK, Pradhan PMS, Rai P, Tiwari K. Prevalence and factors associated with anemia among women of reproductive age in seven South and Southeast Asian countries: Evidence from nationally representative surveys. PLoS One 2020 Aug 13;15(8):e0236449. doi: <https://doi.org/10.1371/journal.pone.0236449> PMID: 32790764; PMCID: PMC7425935.
9. Stevens GA, Finucane MM, De-Regil LM, Paciorek CJ, Flaxman SR, Branca F, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: A systematic analysis of population-representative data. Lancet Glob Health 2013; 1:e16. Doi: [https://doi.org/10.1016/S2214-109X\(13\)70001-9](https://doi.org/10.1016/S2214-109X(13)70001-9) PMID:25103581
10. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, De Onis M, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. The Lancet. Lancet Publishing Group 2013. pp.427–451. [https://doi.org/10.1016/S0140-6736\(13\)60937-X](https://doi.org/10.1016/S0140-6736(13)60937-X)
11. WHO. Prevalence of anaemia in women of reproductive age (per cent). WHO Website 2016. [cited on 2021 March 12] Available from: [https://www.who.int/data/gho/data/indicators/indicator-details/GHO/prevalence-of-anaemia-in-women-of-reproductive-age\(-\)](https://www.who.int/data/gho/data/indicators/indicator-details/GHO/prevalence-of-anaemia-in-women-of-reproductive-age(-))
12. GOI. Accelerating Progress on Nutrition in India: What will it take? Third Progress Report. Poshan Abhiyaan. Niti Aayog. WCD Division. [cited on 2021 Feb 9] Available from: <AbhiyaanMonitoringReport.pdf> (niti.gov.in)
13. Department of Health and Family Welfare. MoHFW. GOI. Annual Report. 2019-2020, p.13-14.
14. Evidence Action. Working Towards An Anemia-Mukt Bharat. Poshan Outlook 2.0; 2020 April 1 [cited on 2021 March 19]. Available from: <https://poshan.outlookindia.com/story/working-towards-an-anemia-mukt-bharat/349875>
15. GOI. MoHFW. Programmes to Control Anaemia Among Women. Press Release; Dec 13 2019 [cited on 2021 Feb 27] Available from: <https://pib.gov.in/PressReleasePage.aspx?PRID=1596308>
16. Nguyen PH, Scott S, Avula R, Tran LM, Menon P. Trends and drivers of change in the prevalence of anaemia among 1 million women and children in India, 2006 to 2016. BMJ Glob Health 2018;3(5):e001010. doi: <https://doi.org/10.1136/bmjgh-2018-001010>
17. MOSPI. National Indicator Framework: SDG Progress Report. Version 2.0; 2020 [cited 2021 March 6] Available from: <SDGProgressReport2020.pdf> (mospi.nic.in)
18. WHO/UNICEF. The extension of the 2025 Maternal, Infant and Young Child nutrition targets to 2030.Discussion Paper; 2016 [cited 2021 Jan 21]. Available from: <discussion-paper-extension-targets-2030.pdf> (who.int)

19. Mehrotra M, Yadav S, Deshpande A, Mehrotra H. A study of the prevalence of anemia and associated sociodemographic factors in pregnant women in Port Blair, Andaman and Nicobar Islands. *J Family Med Prim Care* 2018;7(6):1288-1293. doi: https://doi.org/10.4103/jfmpc.jfmpc_139_18
20. Suryanarayana R, Chandrappa M, Santhuram AN, Prathima S, Sheela SR. Prospective study on prevalence of anemia of pregnant women and its outcome: A community based study. *J Family Med Prim Care* 2017;6(4):739-743. doi: https://doi.org/10.4103/jfmpc.jfmpc_33_17
21. Gautam S, Min H, Kim H, Jeong H-S. Determining factors for the prevalence of anemia in women of reproductive age in Nepal: Evidence from recent national survey data. *PLoS ONE* 2019;14(6):e0218288. <https://doi.org/10.1371/journal.pone.0218288>
22. Le CHH. The Prevalence of Anemia and Moderate-Severe Anemia in the US Population (NHANES 2003-2012). *PLoS ONE* 2016; 11(11):e0166635. <https://doi.org/10.1371/journal.pone.0166635>
23. United Nations. Transforming Our World: The 2030 Agenda for Sustainable Development-A/RES/70/1. UN Website; 2016 [cited 2020 Dec 20]. Available from: <https://sustainabledevelopment.un.org/content/documents/21252030>
24. Kishore S, Singh M, Jain B, Verma N, Gawande K, Kishore S, Aggarwal P, Verma SK. A study to assess prevalence of anaemia among beneficiaries of Anaemia Mukht Bharat Campaign in Uttarakhand. *J Family Med Prim Care* 2020;9:1691-4 doi: https://doi.org/10.4103/jfmpc.jfmpc_941_19
25. PTI. Need to intensify efforts to address all causes of anemia: Healthcare expert. *The Economic Times*; 2020 Nov 29 [cited 2021 Jan 18]. Available from: https://economictimes.indiatimes.com/industry/healthcare/biotech/healthcare/need-to-intensify-efforts-to-address-all-causes-of-anemia-healthcare-experts/articleshow/79472930.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst (Indian)
26. Powers DA, Yoshioka H, Yun M-S. Mvdcmp: Multivariate Decomposition for Nonlinear Response Models. *The Stata Journal* 2011;11(4):556-576. doi: <https://doi.org/10.1177/1536867X1201100404>
27. Vir SC, Suri S. The 5th National Family Health Survey of India: A Sub-National Analysis of Child Nutrition. Observer Research Foundation 2021 May; 315.
28. DHS. (2021). *The DHS Program - Data*. <https://dhsprogram.com/data/>