Prevalence of Anemia and Vitamin B12 deficiency in children of brick kiln workers, aged 6 to 59 months: A cross sectional study

Neeta Hanumante (neeta.hanumante@gmail.com)
Bharati Vidyapeeth Deemed University
Arvinder Pal Singh Narula
Bharati Vidyapeeth Deemed University
Aruna Deshpande
Bharati Vidyapeeth Deemed University

Research Article

Keywords: Anemia, Vitamin B12 deficiency, Under-five children, Brick kiln workers

Posted Date: September 29th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3313055/v1

Additional Declarations: No competing interests reported.

Abstract

Background

The brick kiln workers, migrate with family to work in brick kilns along with their children & circular migration affects health service utilization and thus the health status of children who are most vulnerable. The present study was carried out to assess prevalence of anemia & vitamin B12 deficiency in children of brick kiln workers, aged 6 to 59 months.

Methods

It was observational, cross-sectional study. 90 children aged 6–59 months from randomly selected brick kilns were enrolled. After obtaining consent, detailed history was taken & thorough physical examination was performed. Blood sample was collected for estimation of Hemogram, serum ferritin & vitamin B12 levels.

Results

55children (61.1%) were found to have anemia and 25.6% children had vitamin B12 deficiency. The majority of children 52/55(94.5%) were considered to have iron deficiency anemia, 80.4% children had mild anemia followed by moderate and severe anemia. All children with anemia were malnourished. There was no significant association between sex of the child & maternal education with anemia, whereas age below 24 months, birth order ≥ 2 & exclusive breastfeeding less than 6 months were significantly associated with anemia. Vitamin B12 deficiency was seen in 23 (25.6%) children & there was no significant association between Vitamin B12 deficiency & the demographic characteristics under study.

Conclusion

The prevalence of anemia in under-five children of brick kiln workers was higher than that reported in Pune district as per NFHS 5. Vitamin B12 deficiency was seen in 25.6% children. Implementation of various government programmes to combat anemia need to be strengthened.

BACKGROUND

The brick kiln industry in India is next to China in terms of global production having more than 150,000 kilns, employing around 10 million workers.[1] The seasonal migration usually occurs post monsoon i.e., from October to June cycle, in which the brick kilns operate all over India.[2] These migrants go with family to work in brick kilns along with their children. Circular migration affects health service utilization and

thus the health status of children who are most vulnerable. Unhygienic living space and lack of nutritious food affect the health of children residing at these brick kiln sites.

In India, despite improvements in its economy, healthcare provision is poor, and many families, especially in rural areas, have major difficulties in accessing healthcare. Local authorities do not include the migrant workers' children in basic access to health, nutrition, education and other services available from *Anganwadis*, schools and hospitals.[3] The last two rounds of the National Family Health Survey documented an alarming rising trend of anemia prevalence, most sharply in children aged 6–59 months old. The proportion of anemic children rose by almost 9%, from 58.6% in 2015-16 to 67.1% in 2020 – 21[4].

Anemia in children aged 6–59 months is a major health problem in nearly all developing world. The World Health Organization (WHO) has estimated that globally, over 293 million children under five are anemic, with a prevalence of around 47.4%.[5] According to the WHO, iron deficiency is the single most important nutritional risk factor in India, accounting for more than 3% of all disability-adjusted life years (DALYs) lost [6]. Iron deficiency in early childhood is especially detrimental due to increased mortality and its permanent impact on cognitive development, which leads to an irreversible loss of productivity in adult life.[6]

Iron deficiency, linked to low nutritional iron consumption is one of the critical causes of childhood anemia in India, other critical factors, associated with childhood anemia, include vitamin deficiencies, especially folate & vitamin B12. The results have revealed failure of anemia control programme in successfully controlling the occurrence of childhood anemia in Indian populations.[7]

Vitamin B12 is also an essential micronutrient which is critical especially during infancy and early childhood as these are periods of rapid growth, development, and increased demand.

The prevalence of anemia is higher in socioeconomically lagging communities, poorer areas and children of uneducated women. Despite iron supplementation programs in place, anemia has continued to prevail, especially amongst the vulnerable as reported by Rohil Bhatnagar et al.[8]

The study by Christine Bohne et al [9] have stated that seasonal brick kiln migrants face unique challenges. The gaps in implementation of national schemes which largely exclude seasonal migrants from the benefits, thereby interrupting continuity of care and denying them the services to which they are entitled. The core government maternal and child health programs do not reach the brick kiln workers.

The most comprehensive health survey of India, the National Family Health Survey/Demographic Health Survey (NFHS/DHS) fails to capture migrants as a category. As there is paucity of data on anemia & Vitamin B12 deficiency in children of brick kiln workers, aged 6 to 59 months old, the present study was carried out.

Materials and Methods

Study Design

It was observational, cross-sectional study

Setting

It was carried out in the field practice area of 'Rural Health Training Center' (RHTC), of a Deemed university medical college, Pune, Maharashtra state in India.

Participants and Sampling

Out of the 13 villages covered by the RHTC, 6 villages were randomly selected. Out of the selected villages, 21 brick kiln sites were randomly chosen. The eligible children from these sites whose parents consented for the study were enrolled consecutively till the sample size of 90 was reached.

Inclusion and exclusion criteria

Children of brick kiln workers, aged 6 to 59 months, whose parents gave written informed consent to enroll their child in the study & comply with the study procedures were included. Child suffering from acute illness was the only exclusion criteria.

Data Collection and Procedures

The brick kiln workers stay in the temporary housing at the brick kilns, door to door visits were carried out by the study team members to identify potential study participants. After taking the signed informed consent, the detailed history of the child aged 6–59 months was obtained from the parents, preferably from mother. In case of illiterate parents, the thumb impression of the parent & sign and date by impartial witness was obtained prior to any study procedure. Thorough physical examination of the child was carried out, details of which were entered in the proforma. The study proforma was prepared & validated prior to study enrollment. The study team members were trained by the investigator on the study proforma completion i.e. 'Google form' which was filled on site.

Blood Processing and Management

Trained experienced phlebotomist collected approximately 3 mL of venous blood from the child, into vacutainers i.e., 1 ml in EDTA tube & 2 ml in plain bulb, taking all universal precautions. The blood sample was sent to the NABL accredited laboratory for estimation of Hemogram, serum ferritin & vitamin B12 level. Hemogram was done using Beckman Coulter DxH8007, serum Ferritin & B12 estimation was done by Chemiluminescence microparticle immunoassay (CMIA -Abbott Alinity).

Blood investigational reports were informed to the subject's parents & necessary treatment was provided. Dietary advice was also given as appropriate.

Definitions & normal ranges:

Anemia: Hemoglobin (Hb) value less than 11.0 g/dL was considered anemia and classified as mild (10–10.9 g/dL), moderate (7–9.9 g/dL), and severe (< 7 g/dL).

B12 level normal range: 187–883 pg/ml

Normal Ferritin levels ≥ 12 ng/ml

MCV (Mean Corpuscular volume): 70-85fl in children up to 2 years of age & for children 2–5 years lower limit is 70 + age in years

MCH (Mean Corpuscular hemoglobin): 27-31pg

RDW (Red Cell Distribution Width): 11.5–14.5%

Sample size calculation

The percentage of cases with anemia was 58.7% was considered as basis for sample size calculation in the following formula.

Sample Size 'n' = Z^2 p * q/d^2 Where,

Z = value associated with 95% confidence p = percentage of anemia

q = 100 – p & d = 17.5% of p = 10.3%

Putting all these values in the above formula, the minimum sample size was 88.

Thus, we recruited 90 children from that brick kiln sites.

Statistical Analysis

The data collected was entered in excel and then analyzed in SPSS Version 25. Qualitative and discrete data was presented as number and percentages. Comparison of

percentages of anemia and B12 deficiency, between socio-demographic parameters was done by

chi-square test and p-value less than 0.05 was considered to be significant.

Ethical clearance:

Approval was obtained from Institutional Ethics Committee of Bharati Vidyapeeth (Deemed to be university) Medical college, prior to study commencement.

RESULTS

Total 90 children of brick kiln workers aged 6 to 59 months were enrolled in the study.

Table 1
Demographic characteristics of the children enrolled

Parameter	Value	Number	Percentage
Sex	Female	44	48.9
	Male	46	51.1
Age	< 24 months	20	22.2
	≥ 24 months	70	77.8
Mother's Education	Illiterate	49	54.4
	Attended School/college	41	45.6
Birth Order	1	29	32.2
	≥ 2	61	67.8

The above table shows that 44 girls & 46 boys were enrolled, majority (77.8%) were ≥ 24 months, 67.8% children were of birth order ≥ 2 and majority of the mothers of enrolled children were illiterate (54.4%).

- Out of 90 children enrolled in our study 55 (61.1%) had Anemia; out of which 3 (5.5%) children had severe anemia, 8 (14.5%) had moderate grade whereas 44 (80%) children had mild anemia.

Figure 2

It shows that Vitamin B12 deficiency was prevalent in 23/90 (25.6%) children out of which 13 children had anemia.

- Majority of Anemia cases 52 /55 (94.5%) had low Mean Corpuscular Volume (MCV) which was significantly associated with Anemia (p value < 0.001)
- Ferritin levels were low only in 26 (47.3%) anemic children (p = 0.010)

Table 2
Association of demographic characteristics with Anemia & Vitamin B12 deficiency

		No. of children	Anemia	p-value	B12 Deficiency	p-value
Gender	M	46	29 (63%)	0.829	14 (30.4%)	0.278
	F	44	26 (59.1%)		9 (20.5%)	
Age	< 2 years	20	17 (85%)	**0.013**	5 (25%)	0.949
	≥ 2 years	70	38 (54.3%)		18 (25.7%)	
Birth Order	1	29	12 (41.4%)	**0.008**	8 (27.6%)	0.761
	≥ 2	61	43 (70.5%)		15 (24.6%)	
Breast Feeding[$]	< 6 M	21	19 (90.5%)	**0.0011**	6 (28.6%)	0.364
	>=6 M	53	26 (49.1%)		10 (19.9%)	
Maternal Education	Illiterate	49	29 (59.2%)	0.683	9 (18.4%)	0.089
	Attended school/college	41	26 (63.4%)		14 (34.2%)	

$: data of breastfeeding duration is not available for 16 children

There was no significant association between sex of the child & maternal education with anemia. Whereas age below 24 months, birth order ≥ 2 & exclusive breastfeeding less than 6 months were significantly associated with Anemia.

There was no significant association of Vitamin B12 deficiency & the demographic characteristics under study.

The graph above shows that all children (100%) with anemia were malnourished whereas prevalence of malnutrition in children without anemia was 88.6%.

DISCUSSION

This study was carried out to determine the magnitude and type of anemia among under-five children of brick kiln workers, in rural area. These workers were from low socio-economic strata & were migrant laborourers. The anemia among under-five children has serious consequences & needs timely identification, treatment and prevention as they are more vulnerable and cognitive impairment resulting from Iron Deficiency Anemia, may be irreversible in them.[10]

In this study 90 children were enrolled (44 girls & 46 boys), majority (77.8%) were ≥ 24 months and 67.8% children were of birth order ≥ 2. 54.4% of the mothers of enrolled children were illiterate, as mentioned in Table 1. Out of the 90 children, 55children (61.1%) were found to have anemia, which is more than the anemia prevalence in Pune district (58.7%) reported in National Family Health Survey 5.[11] As shown in Fig. 1, the majority of the anemic children had mild anemia 44/55(80.4%), whereas anemia of moderate & severe grade was seen in 8/55(14.3%) & 3/55 (5.4%) children respectively, this was similar to study by Janardhan R. Bandi et. al. [12] in which majority of children had mild anemia followed by moderate and severe anemia.

As shown in the flow diagram, Fig. 2a, out of 55 children with anemia, 26/55(47.3%) children had definitive iron deficiency anemia with low Hb, low MCV, low MCH, low ferritin, increased RDW levels and the peripheral blood smear revealed hypochromia, microcytosis, aniso poikilocytosis, occasional pencil cells and/or tear drop cells. Whereas 26/55(47.3%) children with anemia had low Hb, low MCV, low MCH, increased RDW levels, hypochromia, microcytosis but serum ferritin was normal i.e., > 12 ng/ml, though mean ferritin levels were below 30 ng/ml. So most likely these children would have iron deficiency anemia. We presumed that the serum ferritin values may have been normal due to previous, subclinical infection, inflammation etc. The Serum ferritin < 12 ng/mL is sensitive, with high false negative rates being common as it is an acute phase reactant[13]. Thus, in our study, majority of children 52/55(94.5%) were considered to have iron deficiency anemia. In the remaining 3/55(5.5%) children with anemia, Hb & MCH were low, but RDW& MCV was within normal range, Ferritin levels were normal and the peripheral blood smear was normochromic, normocytic, so less likely to be iron deficiency anemia & further studies would be needed to determine cause of anemia.

As seen in Fig. 3, there was significant association of anemia with low Mean Corpuscular Volume (p value < 0.001) in our study, similar to study by Vibha Awad et al. [14]

Iron deficiency (ID) without anemia was observed in 7/90(7.8%) study children who had normal Hb, but low ferritin, low MCV & low MCH, which is similar to the study by Branly Kilola Mbunga et al [15] who have reported that among children aged < 5 years, anemia was highly prevalent (68.1%) while ID without anemia was remarkably low(12.9%).

Iron deficiency is the most common cause of anemia among children in low-income and middle-income countries like India.[16] Specifically in India, over half of the anemia burden can be attributed to dietary iron deficiency. According to the Indian Council of Medical Research (ICMR), dietary iron deficiency contributed to 11% of all disability in India in 2016. [8] It's reported that globally, fifty percent of anemia

cases are caused by iron deficiency.[8,17,18,19] Children are particularly vulnerable to iron-deficiency anemia because of their increased iron requirements during periods of rapid growth, especially in the first five years of life.

The association of demographic characteristics with Anemia & Vitamin B12 deficiency is delineated in Table 2. In our study the prevalence of anemia was significantly higher in children below 24 months i.e., 17/20 (85.7%). (p-value = 0.009). Various authors have also reported higher incidence of anemia in infants & toddlers, as compared to older children. [5,17,20,21] Solomon Gedfie et al[22] have reported that children under the age of 2 years were 1.26 times more likely to acquire anemia, which may be attributed to lack of iron intake during the period of rapid growth and development. Literature has reported a similar trend that the risk of having anemia prevalence decreases with age.[23]We didn't observe any significant difference between prevalence of anemia & gender of the child similar to few other studies.[23,24] Birth order ≥ 2 was significantly associated with anemia similar to prior studies. [5,16,23]It has been reported by many previous authors that the children of less educated mothers have higher prevalence of anemia, though we didn't find such association, probably because majority of mothers were involved in brick making & children were looked after by other family members. Mili Dutta et al[23] have reported that the prevalence of anemia is higher where community education is low and vice versa.

Socio-economic status of the family has a significant effect on degree and prevalence of anemia.[12] A study by Ketan Bharadva et al[13] have reported that being migrant worker parents is an additional risk factors for anemia along with low socioeconomic status. Association of low socioeconomic status with anemia has been reported by many previous authors.[7,8,14,22,23,25,26] This study was carried out in rural area where brick kilns operate, the anemia prevalence is shown to be higher in rural as compared to urban, by many authors. [6,7,27,28]

Prevalence of anemia in children who were exclusively breastfed for less than 6 months was significantly high i.e., 90.9% (p value = 0.00073) similar to report by Wubet Takele et al[27]. Exclusive breastfeeding not only gives adequate nutrition but also has immunological and anti-inflammatory properties which protects baby against lot of illnesses and diseases. Wubshet Fentaw et al[25] have reported that children who were exclusively breastfed up to six months were 73% less likely to be anemic compared to children who were not exclusively breastfed.

As shown in Fig. 2b, the Vitamin B12 levels were low in 23 (25.6%) children out of which 13 children had anemia,. Macrocytosis i.e., high MCV, was not seen in any of these children. Swati Umasanker et al[29] have stated that there is varying prevalence of B12 deficiency in developing countries & is reported as 21–45%. Jagdish Chandra et al.[10] have stated that Iron deficiency was common in under-five children, while vitamin B12 deficiency was higher among school going and adolescent age groups.

Malnutrition is more prevalent among children from the marginalized population[30]. In our study all children with anemia (100%) were malnourished as depicted by bar diagram in Fig. 4. This is due to the

fact that undernourishment leads to both macronutrient and micronutrient deficiencies, such as protein, iron, and vitamin A, which are responsible for iron deficiency.

Thus, multiple factors do contribute for anemia in young children e.g., increased demand, dietary insufficiency, cow's milk consumption, acute or chronic blood loss, intestinal malabsorption of iron, worm infestation, high phytates in vegetarian diet, less intake of non vegetarian food, malnutrition, poor sanitation, low wages, poor housing, low education, living in rural areas, etc.

Limitations of the study were that the sample size was small & due to funding constraints, additional tests for anemia diagnosis could not be performed.

CONCLUSION

In this study, 61.1%children were found to have anemia and 25.6% children had vitamin B12 deficiency. The majority of children 52/55(94.5%) were considered to have iron deficiency anemia, mild anemia was more common as seen in 80.4% children followed by moderate and severe anemia. All children with anemia were malnourished. The elimination of iron deficiency anemia in children is a public-health priority, given the association of anemia with impaired cognitive and psychomotor development.

Brick kiln workers' children, being migrant, are most vulnerable in terms of accessing their rights on health and nutrition so relevant community interventions should be strengthened.

Declarations

Acknowledgement:

I wish to acknowledge the help extended by Dr. Vibha Bafna, Hemato-oncologist at our hospital in the analysis & Dr Prakash Doke, Head of Central research & Publication Unit at our hospital for his invaluable support throughout the study.

a. Ethics approval and consent to participate: The study was approved by Institutional Ethics Committee Bharati Vidyapeeth (Deemed to be University) Medical College (DCGI Reg. no. ECR 518/Inst/MH/2014/RR-17) vide letter dated 27 Jan 2021.

b. Consent for publication: Not applicable

c. Availability of data and materials: The datasets used and/or analysed during the current study shall be available from the corresponding author on reasonable request.

d. Conflict of Interests: None

e. Funding: Received in- house funding from Bharati Vidyapeeth (Deemed to Be University). The funding body has had no role in the design of the study, collection, analysis, and interpretation of data and in

writing the manuscript.

f. Authors' contributions:

1. Conceptualization, methodology, carrying out study activities and original draft preparation : Dr Neeta Hanumante (NH) & Dr. Arvinder Pal Singh Narula (AN)

2. Data analysis - Mrs. Aruna Deshpande (AD)

g. Authors' information (optional)

Dr Neeta Hanumante: First & *Corresponding author

Associate Professor in Pediatrics, Bharati Vidyapeeth (Deemed to Be University) Medical college, Pune-Satara road, Katraj Dhankawadi, Pune-411043

2. Dr. Arvinder Pal Singh Narula : second author

Assistant Professor, Department of Community Medicine

Bharati Vidyapeeth (Deemed to Be University) Medical College, Pune

& Medical Officer, In charge of Rural Health Training Center

Lavale. Mulshi, Dist. Pune.

3. Mrs. Aruna Deshpande : Third author

Biostatistician, Department of community Medicine, Bharati Vidyapeeth (Deemed to Be University) Medical College, Pune- Satara road, Katraj Dhankawadi, Pune-411043

References

1. Shabir Ahmad Najar et al. Living conditions of informal workers: A sociological study of brick kiln workers in district Budgam of Kashmir valley January 2021Temida 24(2):217-237
2. Sourav Halder & Uttam kumar Patra. Status of brick kiln workers in south -east Asia; journal of natural remedies vol. 21, no. 10(1), (2021)
3. Sahoo, Manoj K., and D. Sriram; Nutrition and Health Status of Construction Workers’ Children in Gujarat: An Empirical Study of Gandhinagar." Child Health and Nutrition in India 2021 pp 225-246
4. National Family Health Survey (NFHS-5) 2019-21.
5. Chowdhury MRK, Khan MMH, Khan HTA, Rahman MS, Islam MR, Islam MM, et al. (2020) Prevalence and risk factors of childhood anemia in Nepal: A multilevel analysis. PLoS ONE 15(10): e0239409

6. Plessow R, Arora NK, Brunner B, Tzogiou C, Eichler K, Brügger U, Wieser S. Social Costs of Iron Deficiency Anemia in 6-59-Month-Old Children in India. PLoS One. 2015 Aug 27;10(8):e0136581
7. Onyeneho NG, Ozumba BC, Subramanian SV. Determinants of Childhood Anemia in India. Sci Rep. 2019 Nov 12;9(1):16540.
8. Bhatnagar RS, Padilla-Zakour OI. Plant-Based Dietary Practices and Socioeconomic Factors That Influence Anemia in India. Nutrients. 2021 Oct 9;13(10):3538
9. Christine bohne. Seasonal work, interrupted care: maternal and child health gaps of brick kiln migrants in bihar, India. A delta doctoral thesis submitted to the faculty of (the Harvard t.h. chan school of public health
10. Jagdish Chandra Treating Iron Deficiency Anemia. The Indian Journal of Pediatrics volume 86, pages1085–1086 (2019)
11. National Family Health Survey 5, 1919-20, District Fact Sheet Pune Maharashtra
12. Bandi JR Sanket A. Bari. International Journal of Community Medicine and Public Health Int J Community Med Public Health. 2018 Nov;5(11):
13. Bharadva, K., Mishra, S., Tiwari, S. *et al.* Prevention of Micronutrient Deficiencies in Young Children: Consensus Statement from Infant and Young Child Feeding Chapter of Indian Academy of Pediatrics. *Indian Pediatr* 56, 577–586 (2019)
14. Dr. Vibha Awad1, Dr. Satish Ashtekar A Cross Sectional Study of Nutritional Status of Patients with Iron Deficiency Anemia from 1-5 Years of Age International Journal of Medical and Pharmaceutical Research Volume: 4 Issue:3 (May-June 2023); Page No: 50-61
15. Mbunga BK, Mapatano MA, Strand TA, Gjengedal ELF, Akilimali PZ, Engebretsen IMS. Prevalence of Anemia, Iron-Deficiency Anemia, and Associated Factors among Children Aged 1-5 Years in the Rural, Malaria-Endemic Setting of Popokabaka, Democratic Republic of Congo: A Cross-Sectional Study. Nutrients. 2021 Mar 21;13(3):1010.
16. Tamal Basu Roy, Partha Das & Tanu Das. Unique Contribution of Maternal Factors and Its Association with Anemia Among Under 5 Children in Indian Context. Global Social Welfare Published: 23 May 2023
17. Molla A, Egata G, Mesfin F, Arega M, Getacher L. Prevalence of Anemia and Associated Factors among Infants and Young Children Aged 6-23 Months in Debre Berhan Town, North Shewa, Ethiopia. J Nutr Metab. 2020 Dec 17;2020:2956129.
18. Alamneh YM, Akalu TY, Shiferaw AA, Atnaf A. Magnitude of anemia and associated factors among children aged 6-59 months at Debre Markos referral hospital, Northwest Ethiopia: a hospital-based cross-sectional study. Ital J Pediatr. 2021 Aug 13;47(1):172
19. Ali Sungkar et al.A Life Course Approach to the Prevention of Iron Deficiency Anemia in Indonesia Nutrients. 2022 Jan; 14(2): 277.
20. Omer A, Hailu D, Nigusse G, Mulugeta A. Magnitude and morphological types of anemia differ by age among under five children: A facility-based study. Heliyon. 2022 Sep 1;8(9):e10494

21. Nkurunziza JC, Nabukeera-Barungi N, Kalyango JN, Niyongabo A, Mwanja MM, Mupere E, Nankabirwa JI. Prevalence and factors associated with anemia in children aged 6-24 months living a high malaria transmission setting in Burundi. PLoS One. 2022 Sep 2;17(9):e0273651
22. Gedfie S, Getawa S, Melku M. Prevalence and Associated Factors of Iron Deficiency and Iron Deficiency Anemia Among Under-5 Children: A Systematic Review and Meta-Analysis. Glob Pediatr Health. 2022 Jul 6;9:2333794X221110860
23. Mili Duttaa , Mahadev Bhisea , Lokender Prashadb , Himanshu Chaurasiac,∗ , Paramita Debnatha Prevalence and risk factors of anemia among children 6–59 months in India: A multilevel analysis Clinical Epidemiology and Global Health 8 (2020) 868–878
24. Gebrie A, Alebel A. A systematic review and meta-analysis of the prevalence and predictors of anemia among children in Ethiopia. Afr Health Sci. 2020 Dec;20(4):2007-2021. doi: 10.4314/ahs.v20i4.59. PMID: 34394267; PMCID: PMC8351872.
25. Fentaw W, Belachew T, Andargie A. Anemia and associated factors among 6 to 59 months age children attending health facilities in Kombolcha town, Northeast Ethiopia: a facility-based cross-sectional study. BMC Pediatr. 2023 May 3;23(1):209. doi: 10.1186/s12887-023-04031-z. PMID: 37138229; PMCID: PMC10154745.
26. Sharma S, Acharya BK, Wu Q. Spatial Variations and Determinants of Anemia among Under-five Children in Nepal, DHS (2006-2016). Int J Environ Res Public Health. 2022 Jul 16;19(14):8664. doi: 10.3390/ijerph19148664. PMID: 35886516; PMCID: PMC9323660.
27. Takele WW, Baraki AG, Wolde HF, Desyibelew HD, Derseh BT, Dadi AF, Mekonnen EG, Akalu TY. Anemia and Contributing Factors in Severely Malnourished Infants and Children Aged between 0 and 59 Months Admitted to the Treatment Centers of the Amhara Region, Ethiopia: A Multicenter Chart Review Study. Anemia. 2021 Mar 27;2021:6636043. doi: 10.1155/2021/6636043. PMID: 33854799; PMCID: PMC8019621.
28. Kumar SB, Arnipalli SR, Mehta P, Carrau S, Ziouzenkova O. Iron Deficiency Anemia: Efficacy and Limitations of Nutritional and Comprehensive Mitigation Strategies. Nutrients. 2022 Jul 20;14(14):2976
29. Umasanker S, Bhakat R, Mehta S, Rathaur VK, Verma PK, Bhat NK, Naithani M, Chacham S. Vitamin B12 deficiency in children from Northern India: Time to reconsider nutritional handicaps. J Family Med Prim Care. 2020 Sep 30;9(9):4985-4991. doi: 10.4103/jfmpc.jfmpc_712_20. PMID: 33209833; PMCID: PMC7652153.
30. Sharma S, Akhtar F, Singh RK, Mehra S. Dietary Intakes, Patterns, and Determinants of Children Under 5 Years from Marginalized Communities in Odisha: A Cross-sectional Study. J Epidemiol Glob Health. 2020 Dec;10(4):315-325.

Figures

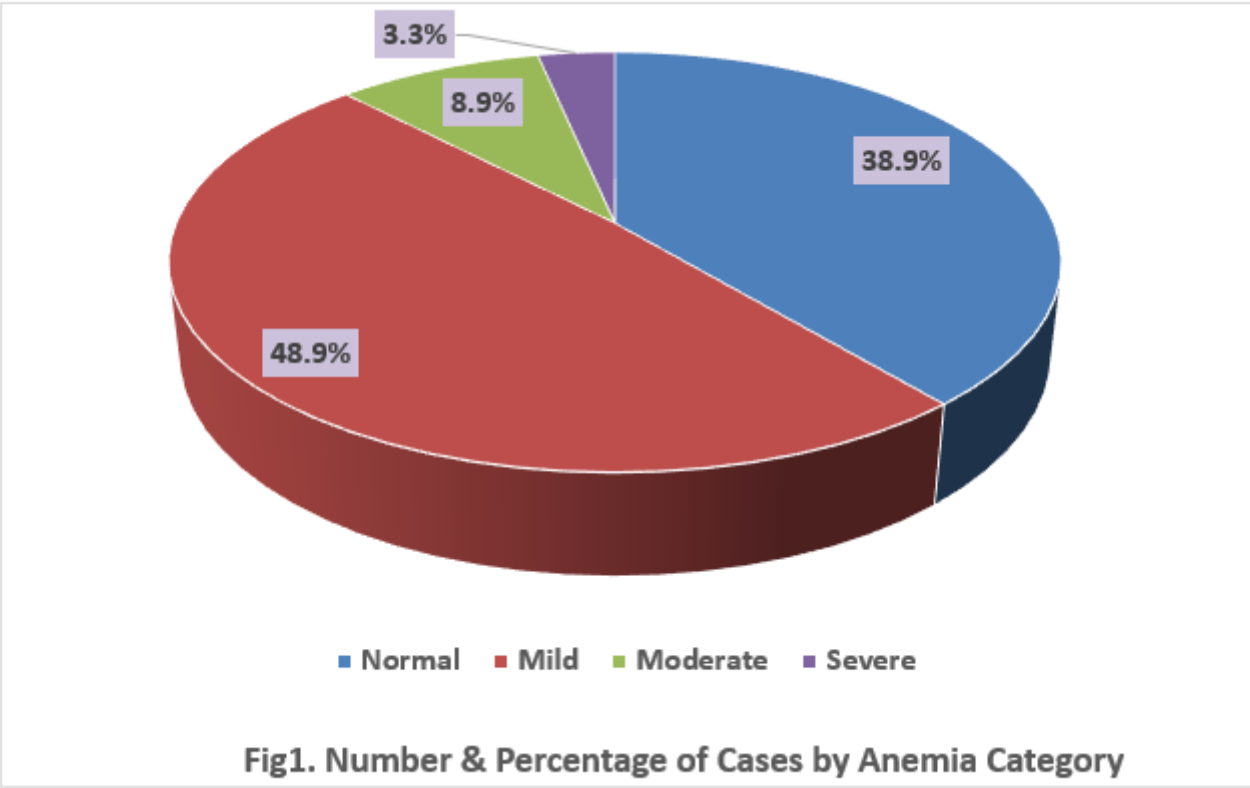

Figure 1

See image above for figure legend

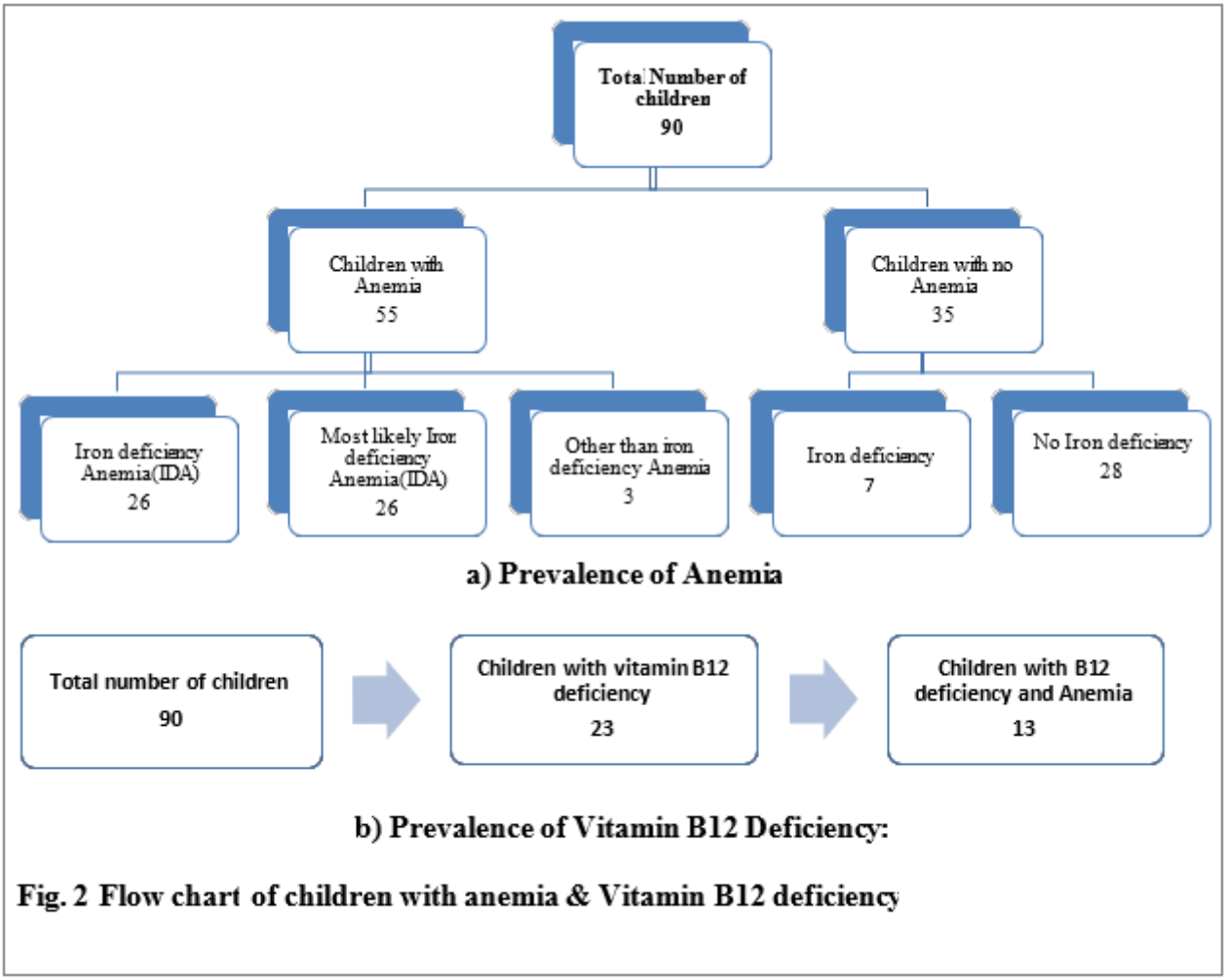

Figure 2

See image above for figure legend

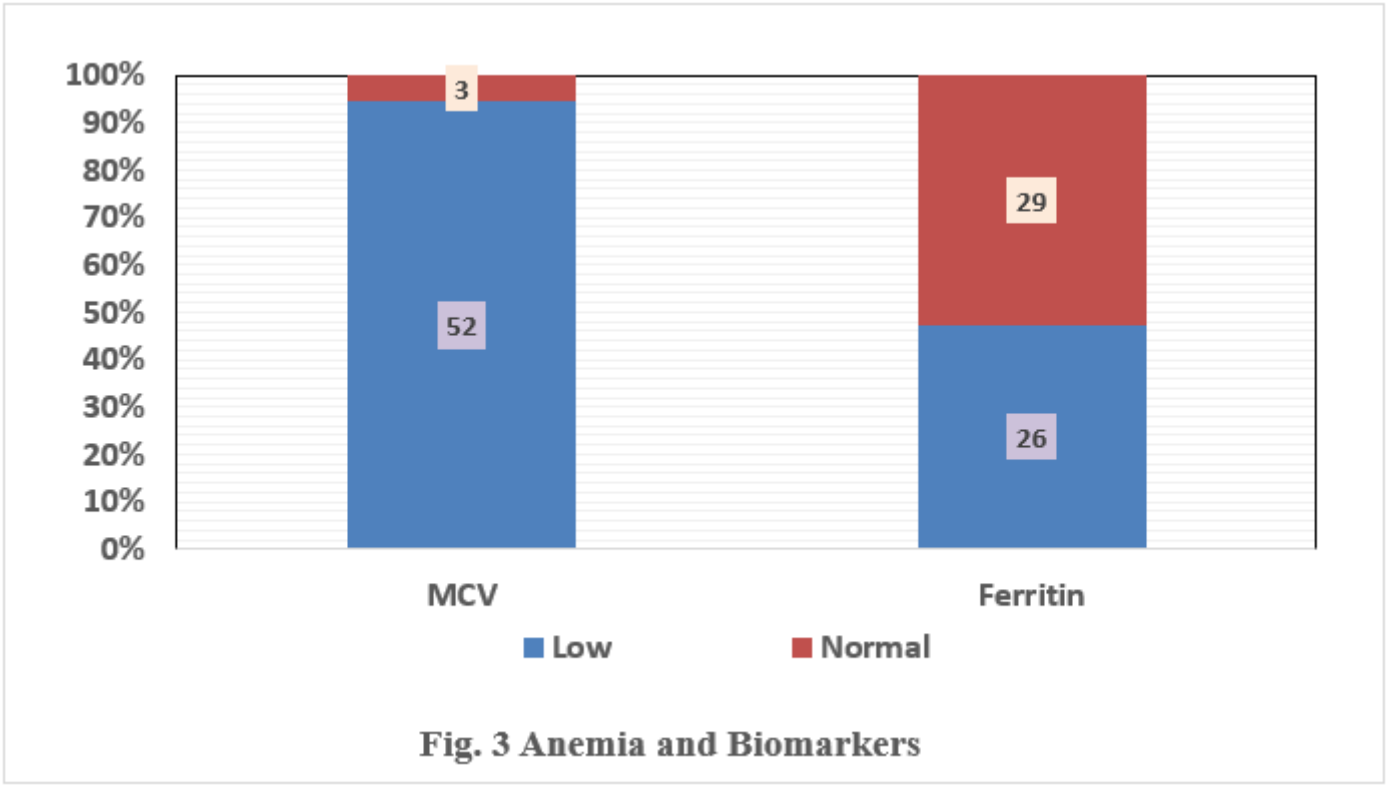

Fig. 3 Anemia and Biomarkers

Figure 3

See image above for figure legend

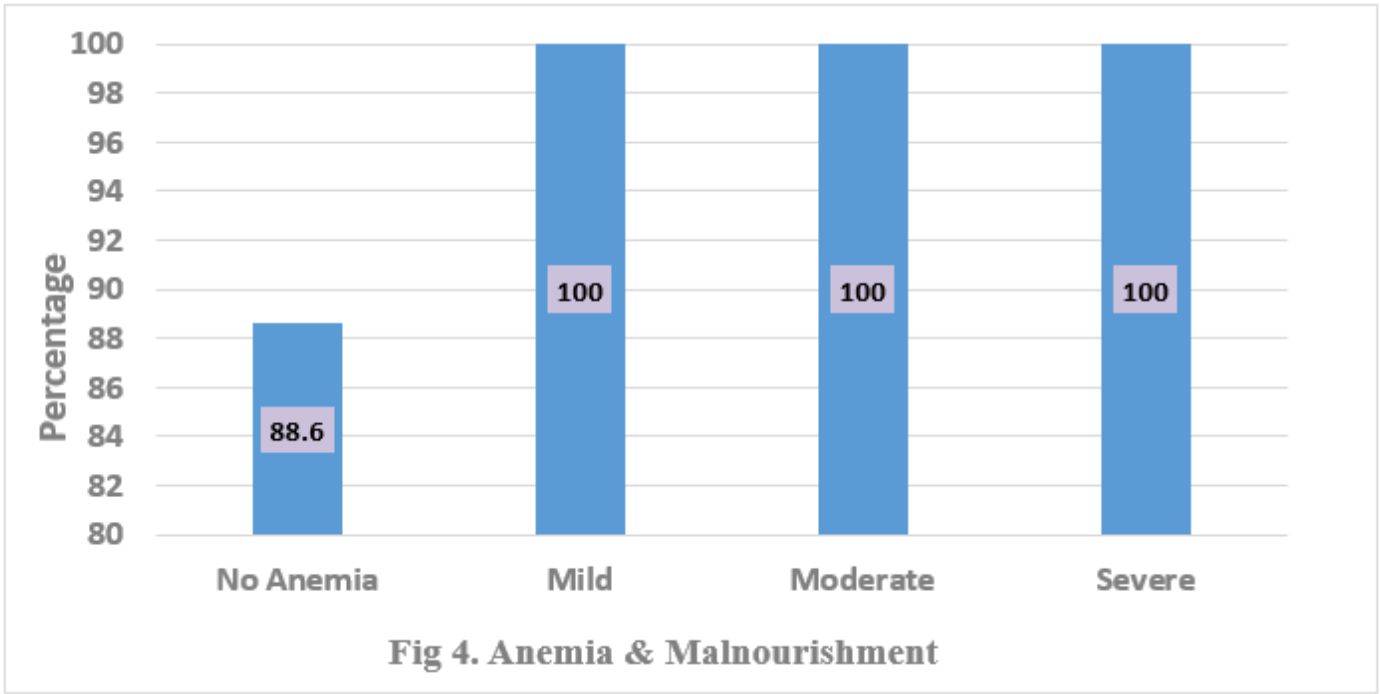

Fig 4. Anemia & Malnourishment

Figure 4

See image above for figure legend