International Journal of Community Medicine and Public Health
Harshitha J et al. Int J Community Med Public Health. 2026 Sep;13(9):5218-5226
https://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20263208

Original Research Article

Geographic distribution and temporal trends of malnutrition and anaemia among women and children in malaria-endemic districts of India: a comparative analysis of NFHS-4 and NFHS-5

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Received: 02 July 2026
Accepted: 19 August 2026

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ABSTRACT

Introduction: In India malaria and malnutrition are major public health concerns. However, this interplay between anaemia and malnutrition remain poorly understood at the administrative unit (district) level. This study aims to analyse changes in the geographical distribution and temporal trends of malnutrition, and anaemia among children and women in the malaria endemic districts with Annual Parasite Index > 1.
Methods: This study used district-level data from National Family Health Survey –4 (NFHS-4) (2015–16) and National Family Health Survey-5 (NFHS-5) (2019–21) to assess geographical distribution and temporal patterns of malnutrition and anaemia in 29 malaria-endemic districts of India with API≥1 (2024). District-level trends across survey were compared and mapped using R software.
Results: Between NFHS-4 and NFHS-5, several malaria-endemic districts (API≥1) demonstrated meaningful improvements in child nutrition and anaemia indicators. Stunting declined notably in Uttar Bastar Kanker (36.3% to 24.8%) and Godda (54.0% to 39.4%). Wasting showed reduction in Bastar (33.9% to 20.4%), while underweight decreased in Kabeerdham (38.4% to 27.3%). Encouraging improvements in anaemia were observed among children in South Garo Hills (74.9% to 33.6%) and among pregnant women in Uttar Bastar Kanker (56.7% to 33.4%).
Conclusion: The observed reductions in malnutrition and anaemia across multiple malaria-endemic districts highlight the potential impact of focused nutrition and maternal health interventions. Strengthening and scaling successful district-level strategies can support integrated approaches toward improving nutritional outcomes and advancing malaria elimination goals by 2030.

Keywords: Anaemia, Children under 5, Malaria, Malaria elimination, Malnutrition, NFHS, non-pregnant women, Pregnant women

INTRODUCTION

Malaria and malnutrition remain two persistent and interlinked public health challenge globally; this mainly affects women of reproductive Age and children under five years.[1] Globally, an estimated 148 million children were reported stunted, 45 million wasted, and nearly 40% of pregnant women were anaemic in 2022, low and middle-income countries contributing highest burden, specially, Countries where infectious diseases such as malaria is endemic.[2] Malaria being a global burden itself with an estimate of 263 million cases in 2025 and 597000 malaria deaths worldwide in 2023.[3] and strong evidence indicates bidirectional interactions between malaria infection, undernutrition and anemia particularly among the children and women.[1] India contributes significantly

to this dual burden; despite notable advancements, it still accounts a significant share of malaria cases in the WHO South-East Asia region and simultaneously has large burden of child and undernutrition and anaemia.[4,5] Malaria endemic states such as Chhattisgarh, Jharkhand, Odisha, Madhya Pradesh and north-eastern region where stunting, wasting, underweight, and anemia has also been persistently high, this underscores an overlap of Malnutrition and malaria risk.[6,7]

The interaction between infection and malnutrition is bidirectional, recurrent infectious disease such as malaria can exacerbate nutritional deficits through inflammation, haemolysis and reduced appetite, while malnutrition may impair immune functions and increase the vulnerability to infections.[8,9]

Studies have shown district-level geographical analysis of malnutrition and anaemia pattern in India. A persistent burden of malnutrition and anaemia was observed across India.[10] Hence, bridging this gap is important to determine whether malaria-endemic districts demonstrate distinct patterns of improvement or worsening in child and maternal nutritional indicators, and to generate evidence that supports integrated geographical targeted public health approaches addressing both infectious disease transmission and underlying nutritional vulnerabilities.

The research seeks to address the following question that, what are the geographical and temporal trajectories and determinants of nutritional indicators, including stunting, wasting, underweight, and anaemia among children under five and women of reproductive age in malaria endemic districts of India. Accordingly, the objective of this study is to analyse changes in the geographical distribution and temporal trends of malnutrition and anaemia among children and women residing in districts with an API >1, using district-level data from NFHS-4 and NFHS-5 to generate comprehensive evidence to inform targeted public health interventions. To suggest and monitor these endemic states with this selected nutritional health indicator as a proxy malaria indicator, inform context specific health system interventions for malaria elimination by 2030.

METHODS

Study design and data

This repeated cross-sectional secondary analysis study was done using the national family health survey (NFHS-4, 2015–16 and NFHS-5, 2019–21) survey conducted in India by the international institute for population science under the ministry of health and family welfare, The survey follows stratified two-stage sampling design and provides district-level estimates on nutritional status, anemia, maternal and child health indicators, fertility, mortality and health service utilization 12. This study collected information on nutritional status and anemia, these indicators for the 29 malaria-endemic districts with an API >1 according to National Centre for Vector Borne Disease Control Centre (NCVBDC) Annual Report 2024 12. The selected districts were Andaman & Nicobar (Nicobar), Assam (Chirang, Kokrajhar), Chhattisgarh (Bastar, Bijapur, Kabeerdham, Narayanpur, Uttar Bastar Kanker,) Jharkhand (Godda, Khunti, Pakur, Pashchimi Singhbhum, Purbi Singhbhum), Maharashtra (Gadchiroli), Meghalaya (South Garo Hills), Mizoram (Lawngtlai, Lunglei, Mamit, Saiha), Odisha (Baudh, Gajapati, Kalahandi, Kandhamal, Koraput, Malkangiri, Rayagada), Tripura (Dhalai, South Tripura), West Bengal (Kolkata). The districts of Alluri Sitharama Raju, Parvathipuram Manyam, Sukma, Kodagaon, Khowai and Gomati, each reporting an Annual Parasite Incidence (API)>1, were excluded due to non-availability of data (Figure 1).

Variables of interest

Stunting, wasting, underweight, anemia among children of 6-59 months, anemia in pregnant and non-pregnant women taken from NFHS-4 and NFHS-5 data focusing on nutritional status and anemia status of the specified region. NCVBDC collects data for continuous active and passive surveillance of malaria in the country and represents the actual burden of malaria. The total number of cases per 1000 population constitutes API, which is used as indicator for malaria burden. NCVBDC classifies the state and districts of India into various phases of malaria based on API, states with <1 API in all districts are considered to be in elimination phase, due to the large variation in malaria incidence, some districts reporting API > 1 are placed in the pre-elimination phase and states that have > 1 API are kept in the intensified control phase, based on this we included all districts of India with API ≥ 1 from NCVBDC 2024 Annual Report 11.

Data analysis

Analysis was done among NCVBDC Districts with API >1. District and state level prevalence for stunting, wasting, underweight (Children under 5 years), and anemia among children (6-59 months), pregnant women, and non-pregnant women was extracted from NFHS-4 (2015-16) and NFHS-5 (2019-2021). Analysis was performed using R software (Version 2025.09.0+387). Prevalence percentages and absolute point changes from NFHS4 to NFHS 5 was calculated to assess temporal trends 12. Districts were classified based on trajectory of change between surveys to identify significant improvement, stability, or deterioration. Findings were interpreted based on the public health significance cut-off values.

Public health significance prevalence for

Children under 5 who are stunted[13]

<2.5% (very low), 2.5 –<10% (low), 10 – <20% (medium), 20 – <30% (high), ≥30% (very high).

Children under 5 who are wasted[13]

<2.5% (very low), 2.5 – <5% (low), 5 – <10% (medium), 10 – <15% (high), ≥ 15% (very high).

Children under 5 who are underweight[14]

<25% low, 25–35% medium, 35% high.

Anaemia status of children aged 6-59 months, non-pregnant women aged 15-49 years, and pregnant women aged 15-49 years.[15]

Mild: 5-20, moderate: 20-40, severe: ≥40.

RESULTS

Nutritional status among children under 5 years

Stunting

Stunting level marked reduction in Uttar Bastar Kanker, Chhattisgarh (36.3% to 24.8%) and Godda Jharkhand (54% to 39.4%), showing substantial improvement. Bijapur, Chhattisgarh (48.2% to 53.8%) and Dhalai, Tripura (32.5% to 45.7%) has shown considerable increase, which indicates the worsening nutritional conditions. At the state level, Bihar, Jharkhand, Chhattisgarh, and Uttar Pradesh recorded measurable declines in stunting prevalence, whereas Goa, Nagaland, Telangana and Tripura demonstrated deterioration. This analysis (Figure 2) shows distinct geographical distribution patterns, with improvement in Jharkhand and Chhattisgarh districts, stagnation in Odisha and deterioration in areas of Tripura and Chhattisgarh, which highlights regional disparities and need for the targeted nutritional interventions in high burden areas.

Wasting

Wasting was observed (Figure 3) to have marked reduction in Bastar, Chhattisgarh (33.9% to 20.4%), Malkangiri, Odisha (32.5% to 19.3%) and Gadchiroli, Maharashtra (45.8% to 30%), reflecting substantial improvement. Whereas, Chirag, (13% to 19.5%) and, Kokrajhar (15.7% to 20.5%) in Assam and Kolkata (17.4% to 29.3%) observed notable increases. At state level, Karnataka, Jharkhand, Chhattisgarh and Rajasthan showed reduction, whereas Bihar, Nagaland, assam and Telangana worsened. The trajectory classification (Figure 3) showed strong improvement in Odisha, Chhattisgarh and Jharkhand districts, but no significant change was observed in Mizoram and Tripura. Deterioration in areas of West Bengal and Assam, underscoring persistent regional disparities in acute malnutrition among API>1 regions.

Underweight

Underweight prevalence across selected Indian states and districts with API>1 exhibited marked geographical distribution and temporal trends between NFHs-4 and NFHS-5 (Figure 4). Although few regions showed progress, most areas remained in medium (25 to <35%) or High ((≥35%) category. A considerable reduction in Kabeerdham (38.4% to 27.3%), Uttar Bastar Kanker (49.9% to 36.1%) and Malkangiri (51.8% to 41.6%) in Chhattisgarh and Odisha, indicating substantial improvement. However, Chirag (24.7% to 39.7%) and Kokrajhar (27.1% to 35.2%) in Assam and Kolkata in West Bengal (19.6% to 32.9%) an increase was observed. At the state level, a notable improvement was observed in Bihar, Jharkhand, Chhattisgarh and Uttar Pradesh. Whereas, an increased prevalence was seen in Assam, Nagaland and Telangana. The trajectory (Figure 4) revealed significant improvement in several districts of Odisha, Chhattisgarh and Jharkhand, stability across Mizoram and Tripura and a deterioration in parts of Assam and West Bengal was observed.

Anaemia status among children and women (Pregnant and non-pregnant)

Anaemia in children (6-59 months)

A significant increase in anemia was observed in Chirag (35.6% to 70.4%) and Kokrajhar (40.4% to 74.7%) in Assam, Bastaer (59.4% to 80.7%) and Narayanpur (48.2% to 86.8%) in Chhattisgarh, and Dhalai (50.4% to 81.2%) in Tripura. But, whereas, South Garo hills in Meghalaya recorded reduction (74.9% to 33.6%), indicating localized improvement. At state level, anemia prevalence increased in assam, Chhattisgarh and Maharashtra, while Andaman & Nicobar Island showed a decline. The trajectory classification (Fig.5) revealed large deterioration across central and eastern India, with limited improvements only in Meghalaya and Andaman & Nicobar Islands, underscoring the intensifying anemia burden among high API regions.

Anemia in pregnant women

Uttar Bastar Kanker (56.7% to 33.4%) and Kabeerdham (43% to 35.6%) in Chhattisgarh, Baudh (50.2% to 40.7%) in Odisha, and Jharkhand (62.6% to 56.8%) showed a significant reduction, which reflects the positive outcomes from targeted nutrition and maternal health interventions. Improvements in Maharashtra (49.3% to 45.7%) and Andaman & Nicobar Island (61.4% to 53.7%) was observed. However, high prevalence of anemia was also observed in several districts such as Bastar (57.3% to 79%) and Naraynpur (50.3% to 57.2%) in Chhattisgarh, Chirag (34.7% to 54.1%) and Kokrajhar (42.2% to 59.5%) in Assam, and Dhalai (55.8% to 75.4%) in Tripura. The Trajectory analysis (Figure 6) showed improvement in parts of Chhattisgarh and Odisha but deterioration still continued across eastern and northeastern India, underscoring uneven progress towards reducing maternal anemia.

Anaemia in non-pregnant women

Moderate improvement was observed in Godda (72.1% to 66.3%) in Jharkhand, Koraput (63.4% to 58.2%) and Kandhamal (52.9% to 48.8%) in Odisha and Lunglei (37% to 35.1&) in Mizoram. At the state level, Andaman & Nicobar Islands (65.8% to 57.6%) and Meghalaya (56.4% to 54.4%) recorded notable reduction, reflecting the achievements of localized progress in Women's nutrition. Whereas, anemia prevalence marked increase in bastar (68.2% to 77.1%) and Narayanpur (59.5% to 72.8%) in Chhattisgarh, Chirang (50.9% to 65.7%) in Assam, Pakur (71.6% to 80.4%) in Jharkhand, and Dhalai (56.5% to 69.7%) in Tripura.

State-level increases were most evident in Assam (46.1% to 66.4%), Chhattisgarh (47.3% to 61.2%), and West Bengal (62.8% to 71.7%). The trajectory analysis (Figure 7) indicates significant deterioration across eastern and central India, no significant changes in Jharkhand districts and localized improvements was observed in parts of Odisha and Mizoram, highlighting regional disparities in anemia burden among non-pregnant women.

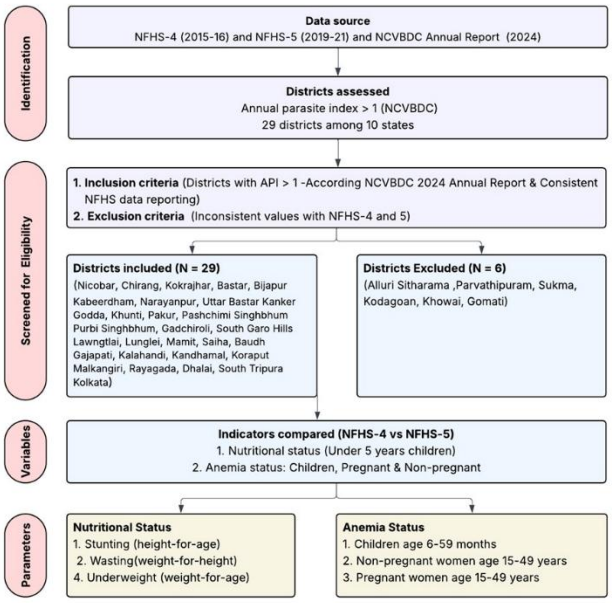

Figure 1: Detailed flowchart of methodology.

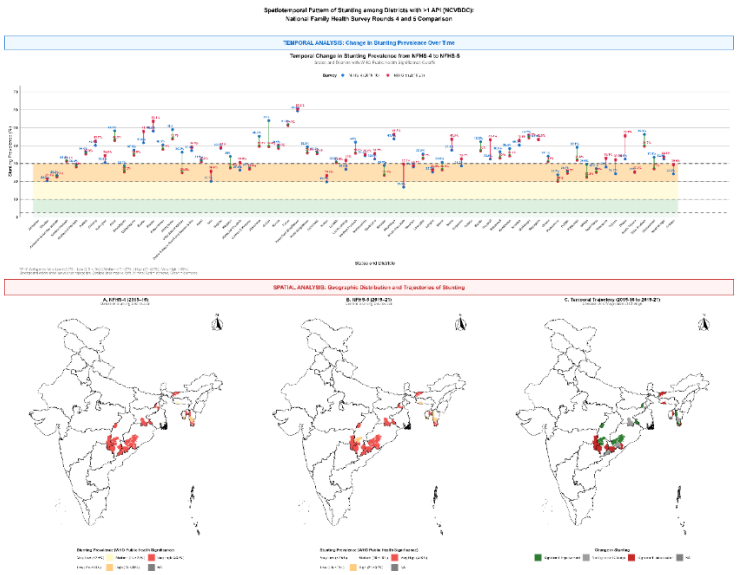

Figure 2: Geographical distribution of childhood stunting in selected Indian states and districts with API>1, comparing NFHS-4 (2015-16) and NFHS-5 (2019-21). Panel A shows temporal changes by WHO severity categories, and panel B shows geographical trajectories highlighting improvement in Jharkhand and Chhattisgarh, stagnation in Odisha, and deterioration in Tripura and Chhattisgarh.

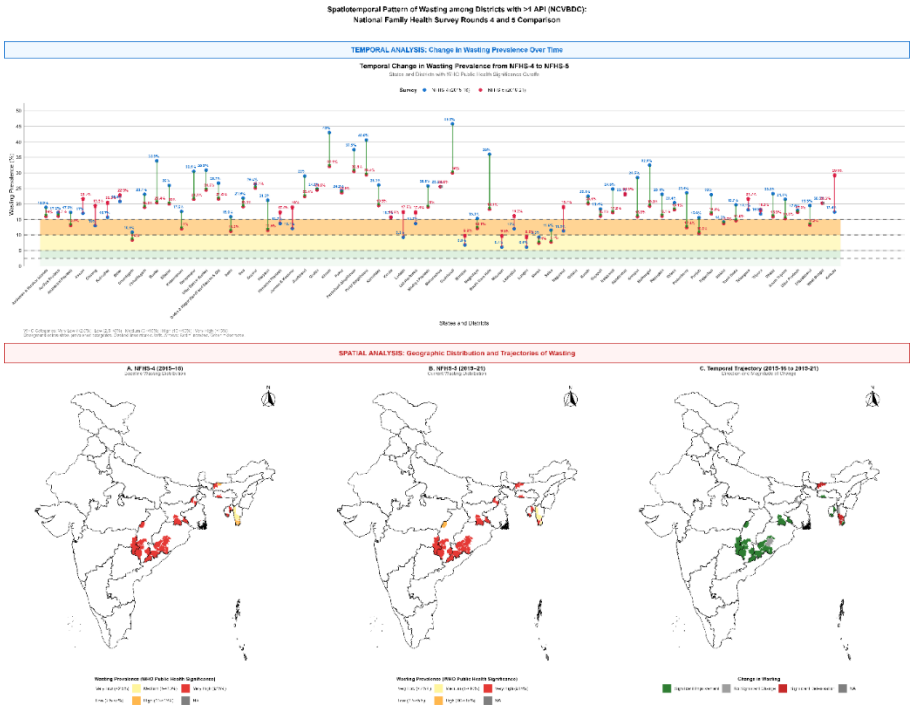

Figure 3: Geographical distribution of childhood wasting in selected Indian states and districts with API>1, comparing NFHS-4 (2015-16) and NFHS-5 (2019-21). Panel A shows temporal changes by WHO severity categories, and panel B shows geographical trajectories highlighting improvement in Jharkhand, Odisha and Chhattisgarh, stagnation in parts of Mizoram, and deterioration in Assam and West Bengal.

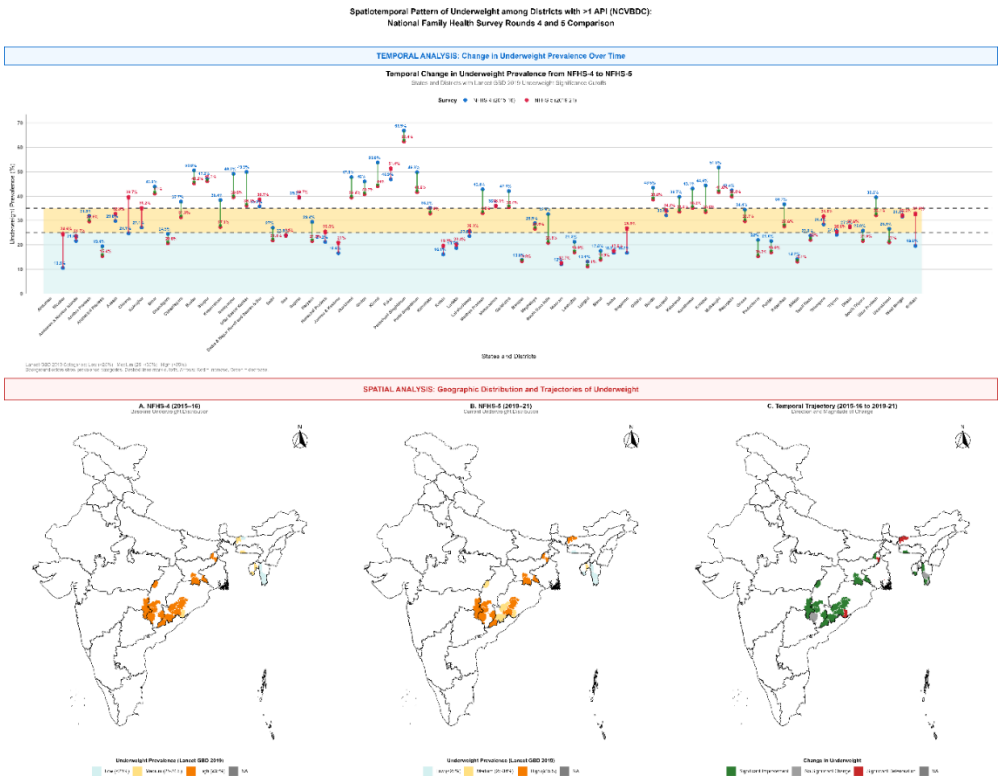

Figure 4: Geographical distribution of childhood underweight in selected Indian states and districts with API>1, comparing NFHS-4 (2015-16) and NFHS-5 (2019-21). Panel A shows temporal changes by WHO severity categories, and panel B shows geographical trajectories highlighting improvement in Jharkhand, Odisha and Chhattisgarh, stability in Mizoram, and deterioration in Assam and West Bengal.

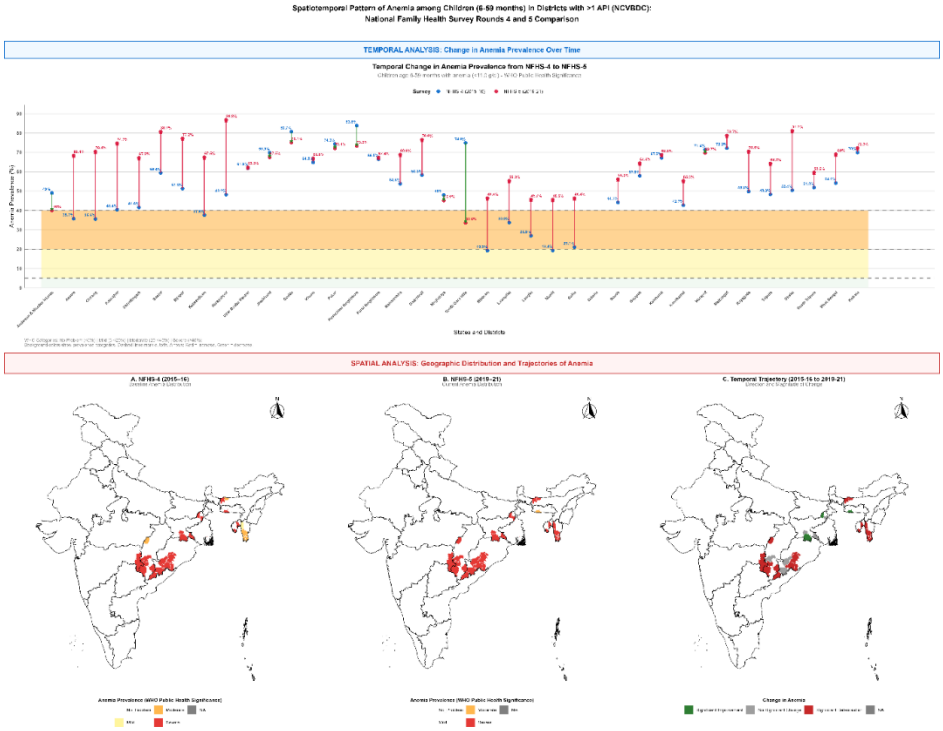

Figure 5: Geographical distribution of childhood anemia (6–59 months) across Indian states and districts with API > 1, comparing NFHS-4 (2015–16) and NFHS-5 (2019–21). Panel A illustrates temporal changes in anemia prevalence, while Panel B presents the geographical distribution along with temporal trajectories, highlighting widespread deterioration across most regions with isolated areas of improvement based on WHO public health categories.

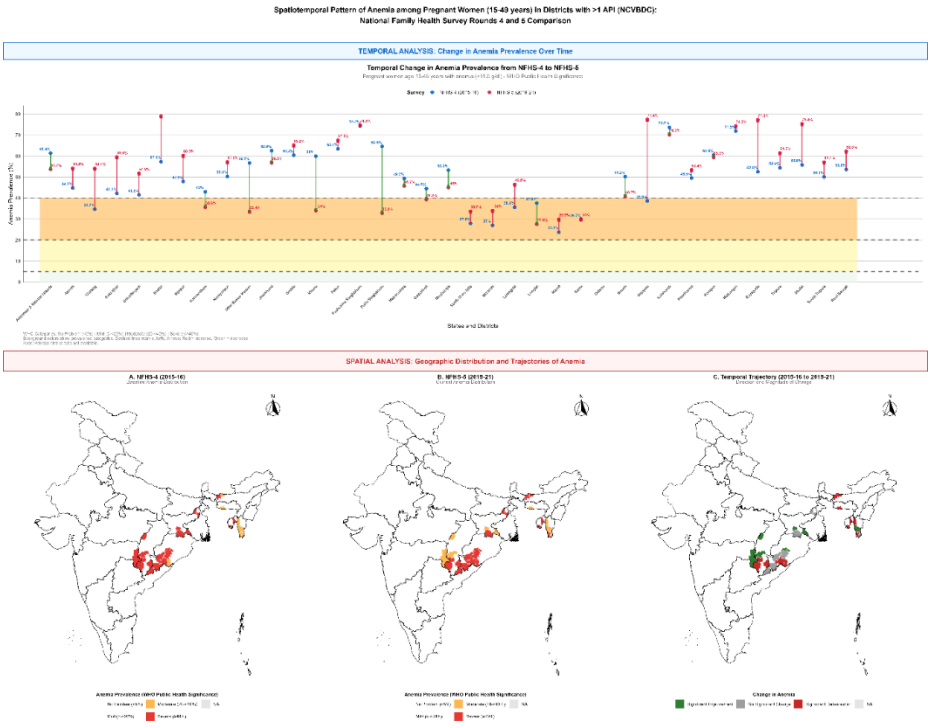

Figure 6: Geographical distribution of anaemia among pregnant women (15–49 years) across selected Indian states and districts with API > 1, comparing NFHS-4 (2015–16) and NFHS-5 (2019–21). Panel A shows temporal variation in prevalence, and Panel B illustrates geographical distribution with trajectory patterns, highlighting regional improvements in Chhattisgarh and Odisha and persistent high anaemia levels in parts of Assam and Tripura.

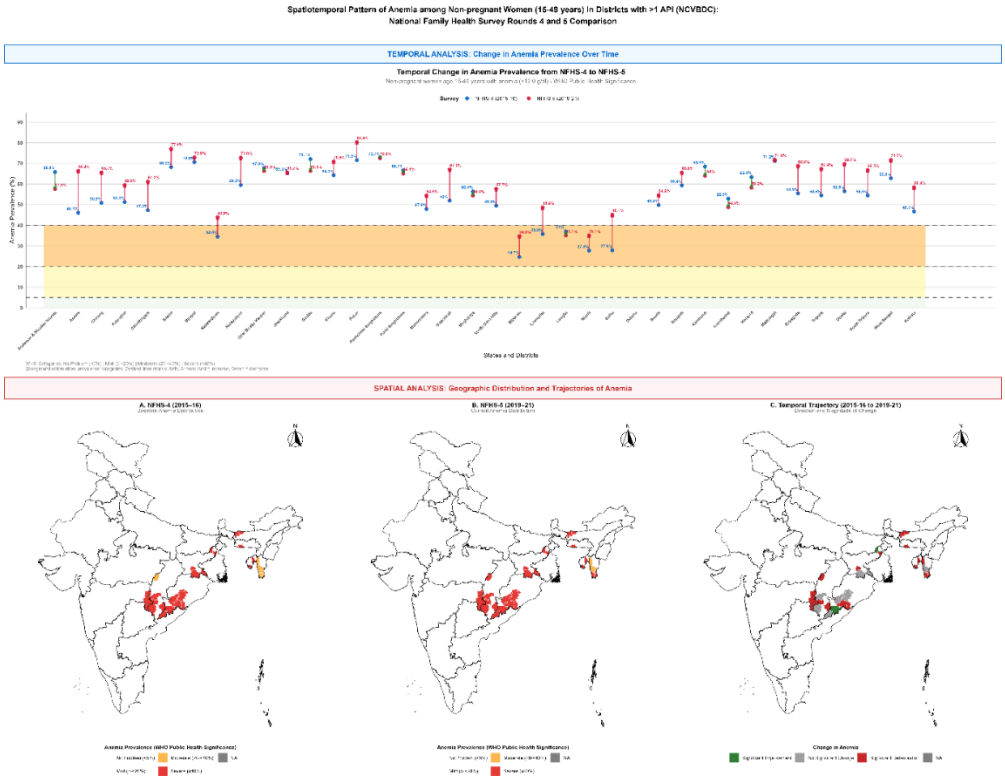

Figure 7: Geographical pattern of anemia among non-pregnant women (15–49 years) in districts and states with API > 1, based on NFHS-4 (2015–16) and NFHS-5 (2019–21). Panel A illustrates temporal changes in prevalence, while Panel B presents geographical distribution and trajectory classification, highlighting widespread deterioration with limited improvement zones in Odisha and Mizoram.

DISCUSSION

Malaria is one of the infectious diseases which is more prevalent in rural and tribal region and most affects the vulnerable and socially marginalized population. Malaria has proven corelation with nutritional indicators such as stunting, wasting, underweight and anaemia.[16] A secondary analysis was conducted using NFHS-4 and NFHS-5 in the Malaria endemic region with API >1 as per NCVBDC (2024) and a spatiotemporal analysis of Nutritional indicators such as stunting, wasting, underweight and also anaemia among children(6-59 m), Pregnant women (aged 15-49 years) and non-pregnant women (15-49 years) was observed. analysis reveals an upward trend in child malnutrition indicators between NFHS-4 and NFHS-5.

In Dalai (Tripura), the stunting rate increased from 32.5% to 45.7%, while at the state level, Goa also recorded a rise from 20.1% to 25.8%. Whereas in a study by Pooja b s et al taking NFHS 4 and 5; It was found that 411 out of 692 districts showed declined trend in childhood stunting, and around 50 districts showed no significant change.[16] A significant reduction in Wasting was observed in South Garo hills of Meghalaya, whereas an increase was observed in Kolkata and Ladakh. Likewise, underweight among children increased in Chirag (Assam), Whereas South Garo hills showed significant decline in underweight with Nagaland showing an overall increase. Whereas in a similar study considering NFHS 4 with Malaria co-occurrence by Yadav et al it was found that Jharkhand had shown High prevalence for both malaria and wasting, whereas Underweight co occurred with malaria specially in districts of Chhattisgarh, Jharkhand, Madhya Pradesh and Odisha.[1] The observed reductions in stunting, wasting and underweight in key malaria-endemic states may reflect the effect of nutrition-focused interventions such as POSHAN abhiyaan and the integrated child development services (ICDS), which are reported to be active in states including Uttar Pradesh, Jharkhand, Meghalaya and Chhattisgarh.

The substantial decline in childhood anaemia was observed in South Garo Hills and in pregnant women in Purbi Singhbhum suggests that targeted nutrition and antenatal programmes in these settings may be achieving notable gains.[17] In contrast, the marked increases in childhood anaemia in Narayanpur, pregnant women in Gajapati and non-pregnant women in Saiha, point to persistently high vulnerability in the eastern and north-eastern states, consistent with findings that anaemia remains clustered in tribal and disadvantaged regions. Which is similar to a study by, Sharif et al where it was found that despite national efforts anaemia persisted above 55 % among socially disadvantaged women in eastern zones.[18]

The linkage of malnutrition with malaria in Central and Eastern India, observed in a study by Yadav et al aligns with the study finding of worsening anemia in districts of Chhattisgarh and Assam1 This observed variation of anemia across malaria endemic districts reflects on both progress and persistent challenges in anemia addressing and related health determinants. Anemia Mukt Bharat and POSHAN Abhiyan and weekly iron and folic acid supplementation (WIFS) programme implementation may have attributed for decline of anemia in states such as Jharkhand, Odisha and Meghalaya.[19] However, increase in regions of Chhattisgarh, Assam and Mizoram highlights the gap in access, coverage and service delivery, mainly in remote and tribal populations.[20]

The limitations of this study is the use of secondary survey data which may be subject to reporting bias and measurement errors inherent to large-scale community-based survey, also it might limit the ability to determine causal relationships between nutritional status, anaemia, and malaria outcomes since it's a cross-sectional data from NFHS. Despite these limitations, the national level NFHS dataset provides robust and valuable insights into the changing burden and regional variations of anaemia and malaria among children in India.

CONCLUSION

This study fills an important gap by giving evidence of how nutrition and malaria are interconnected in India's malaria endemic districts. Also, suggesting bidirectional link between nutritional deficiencies and malaria vulnerability. This underscores the urgent need of recognizing nutritional indicator as a potential proxy indicator for malaria burden, also reflecting shared environmental and socioeconomic determinants that drive both conditions. The study also recommends that districts with >1 API adopt to an integrated surveillance that tracks nutritional indicators alongside malaria cases and trends. This combined monitoring can help identify high-risk group easily, also strengthen district level targeted planning for disease prevention and nutritional support.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Harshitha J, Avinash M, Shrinivasa BM, Tiwary J, Sanjana M, Pavan BL, et al Geographic distribution and temporal trends of malnutrition and anaemia among women and children in malaria-endemic districts of India: a comparative analysis of NFHS-4 and NFHS-5. Int J Community Med Public Health 2026;13:5128-5226.