ORIGINAL RESEARCH

Institutional Deliveries and Public Health Infrastructure in Assam: A District-level Correlation based on NFHS-5 Data

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Abstract

Institutional delivery is a critical marker of maternal health outcomes. While the availability of healthcare facilities is a precondition for increasing institutional deliveries, it does not necessarily ensure their utilization. The present study attempted to examine the relationship between the institutional delivery rates and the availability of public health institutions across the districts of Assam. Using secondary data available on the Fifth National Family Health Survey (2019–2021) and the Statistical Handbook Assam (2020), a two-tailed Pearson correlation analysis was carried out. It was found that the two variables have a very weak and statistically insignificant linear relationship ($r = 0.009$, $p = 0.960$). This means that just increasing the number of health institutions does not guarantee that more women will give birth in those facilities. Thus, the findings revealed the need to look beyond infrastructure quantity to other factors like quality of care, physical and financial accessibility, education and awareness, sociocultural norms, and women's decision-making autonomy to improve maternal health outcomes. Amartya Sen's capability approach helps in interpreting these findings: While the presence of health institutions may represent "available resources," but what truly matters is the freedom and ability of women to convert that resource into actual functioning, i.e., a safe and supported institutional delivery. Therefore, future government health planning regarding maternal care should adopt a broader, gender-sensitive, and context-specific approach.

Keywords: Healthcare utilization, Institutional delivery, Maternal health, Public health infrastructure, Reproductive health.

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Introduction

Institutional delivery denotes the process of a mother delivering her child in a recognized healthcare institute, like a hospital, health center, or maternity clinic, under the supervision of trained healthcare staff. Home births, often performed by dais (traditional birth attendants) or family members without having the necessary skills and equipment, are associated with higher chances of maternal and neonatal mortality as well as morbidity. In contrast, as institutional deliveries take place in proper medical settings by professional healthcare facilitators, it helps in averting these risks and other related complications for both mother and child.[1–3] These positive outcomes are in line with the Sustainable Development Goal 3 (Ensure Healthy Lives and Promote Well-being for All at All Ages), where Target 3.1 aims to reduce the global maternal mortality ratio (MMR) and Target 3.2 seeks to end preventable deaths of newborns and children under 5 years of age.[4]

India has made remarkable progress in improving institutional delivery rates. According to the National Family Health Survey-1 (NFHS-1, 1992–1993), India's institutional delivery rate stood at 26.1%, which has become 88.6% in the latest NFHS-5 (2019–2021).[5] To address the country's maternal health challenges, a series of policy measures have been undertaken by the Indian government in recent decades. The National Rural Health Mission (NRHM, 2005), which was later merged with the National Health Mission (NHM, 2013), aims to provide equitable, affordable, and quality healthcare services to all, with a focus on infrastructural development to hasten improvements in the health sector.[6] Under NHM, flagship schemes like Janani Suraksha Yojana (JSY) and Janani Shishu Suraksha Karyakram (JSSK) were created to incentivize institutional births. Janani Suraksha Yojana provides financial assistance to pregnant women, with special provision for below the poverty line (BPL) and Scheduled Caste/Scheduled Tribe women, for institutional delivery.[7] Janani Shishu Suraksha Karyakram complements this by focusing on eliminating "out-of-pocket" costs borne by pregnant women and sick newborns when seeking care at public health institutions. It provides free services, including delivery (even C-sections), medicines, medical tests, blood, and transportation between the home and the healthcare facilities.[8] Apart from this, Pradhan Mantri Matru Vandana Yojana (PMMVY), a centrally sponsored maternal support scheme, grants monetary incentives for the first child (regardless of gender) and the second child if it is a girl. But with the condition that the delivery takes place in a healthcare institution.[9] Thus, these schemes encourage institutional delivery by linking financial benefits to health-seeking behaviors. The implementation of these health interventions has led to a marked rise in institutional delivery service utilization across India.[10–13] The Accredited Social Health Activists (ASHAs), who are trained frontline health providers, contribute significantly to facilitating uptake of maternal health care within their communities. The rise in institutional deliveries in India in recent times is widely credited to the introduction of ASHAs.[14–16]

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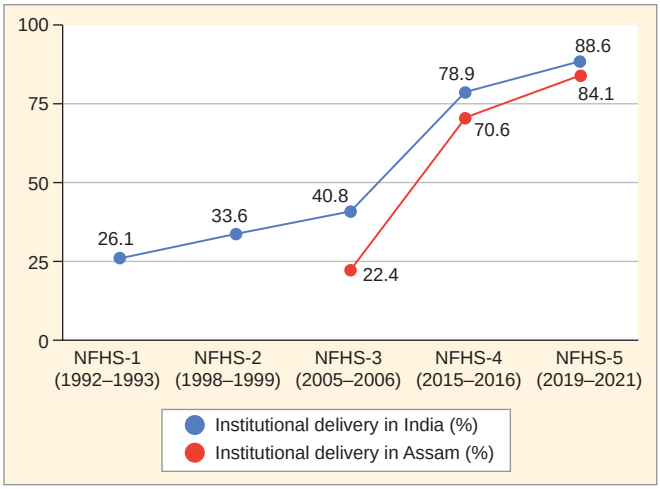

Fig. 1: Trend in institutional deliveries in India and Assam
Source: National Family Health Survey (NFHS-1 to NFHS-5)

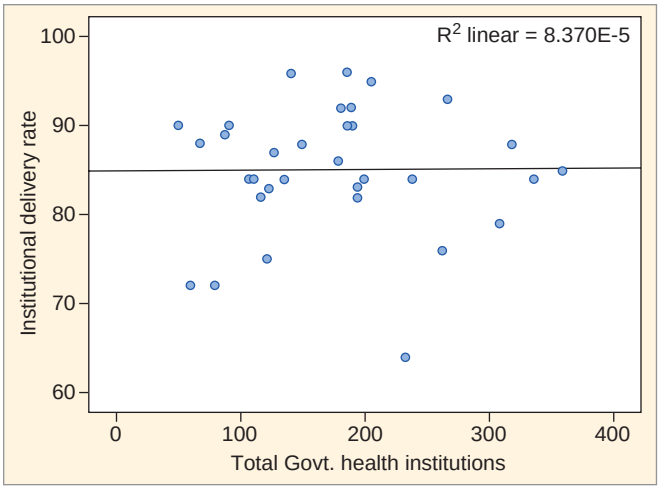

Fig. 2: Scatter plot of institutional delivery rate vs total number of health institutions

A noticeable growth in maternal health, including institutional delivery rates, is also evident in the state of Assam. However, compared with other Indian states, Assam's performance in reproductive health remains poor. According to the Special Bulletin on Maternal Mortality in India 2020–2022, Assam recorded an MMR of 125 per 1,00,000 live births, higher than the national average of 88 per 1,00,000 live births.[17] Despite some improvement, Assam's performance in institutional deliveries is still unsatisfactory. NFHS-5 data reveal that all the northeastern states, except Sikkim, have scored below 90% in terms of institutional delivery rate. Meghalaya (58.1%) and Nagaland (45.7%) have the lowest rates for the same in the entire nation.[5] Nevertheless, over the years, Assam's institutional delivery rate has risen significantly, from 22.4% in the NFHS-3 (2005–2006) to 84.1% in the NFHS-5 (2019–2021), almost there to match the national rate (Fig. 1).[5]

Within the state of Assam, disparities exist between the districts in terms of institutional delivery rates. A number of factors influence this. It is generally assumed that a higher number of healthcare facilities or infrastructure will lead to more utilization. The present study attempted to test that assumption by correlating institutional delivery rates with the number of government health facilities across districts in Assam.

Methodology

This study has adopted a quantitative, cross-sectional design to examine the relationship between public health infrastructure and institutional delivery rates across districts of Assam. For the study, data were collected from secondary sources. The National Family Health Survey-5 (NFHS-5), conducted in Assam during Phase I (2019–2020), was used for obtaining the institutional delivery rates of different districts of Assam. Data on the number of government health institutions across districts were collected from the Statistical Handbook Assam, 2020, ensuring temporal alignment with the NFHS-5 Phase I data. The types of government health institutions included in the study are District Civil Hospitals, Subdivisional Civil Hospitals (SDCHs), First Referral Units (FRUs), Subcenters, Primary Health Centers (PHCs), and Community Health Centers (CHCs). Furthermore, to make the list more comprehensive, tertiary government medical colleges that were operating by 2020 were also included. For this purpose, Gauhati Medical College (Kamrup Metro), Assam Medical College (Dibrugarh), Silchar Medical College (Cachar), Jorhat Medical College (Jorhat), Tezpur Medical College (Sonitpur), and Fakhruddin Ali Ahmed Medical College (Barpeta) were added. It is substantial to note that the study has only taken into consideration the government health facilities, as reliable district-wise data on private health institutions were not available.

For data analysis, IBM SPSS Statistics was used. A two-tailed Pearson correlation test was performed to examine the linear relationship between the number of government healthcare institutions and institutional delivery rates at the district level.

Table 1: Correlation between institutional delivery rate and number of government health institutions

Variables	*Institutional delivery*	*Total govt. health institutions*
Institutional delivery		
Pearson correlation	1	0.009
Sig. (two-tailed)		0.960
N	33	33
Total govt. health institutions		
Pearson correlation	0.009	1
Sig. (two-tailed)	0.960	
N	33	33

Findings

The Pearson correlation coefficient examining the association of institutional delivery rates with the count of government health institutions across districts of Assam is found to be $r = 0.009$, with a p-value of 0.960 (two-tailed). This indicates a very weak, statistically insignificant linear association between the two variables. In other words, districts with a higher number of public health institutions did not necessarily have higher institutional delivery rates (Fig. 2; Tables 1 and 2).

As evident from Table 2, Dhubri district had one of the highest counts of public health institutions (232) but the lowest instuitional delivery rate (64.2%) in the entire state. On the other hand, Jorhat

Table 2: District-wise institutional delivery rates and number of government health institutions in Assam

District	*Institutional delivery rate*	*Civil hospital*	*SDHCs*	*FRUs*	*Subcenters*	*PHCs*	*CHCs*	*Tertiary medical college*	*Total no. of Govt. health institutions*
Baksa	89.9	1	0	0	157	23	8		189
Barpeta	87.6	1	1	0	264	40	11	1	318
Biswanath	84.3	0	0	0	85	19	3		107
Bongaigaon	84.5	1	0	0	108	22	4		135
Cachar	79.2	1	0	0	270	29	7	1	308
Charaideo	88.2	0	0	0	47	18	2		67
Chirang	83.7	1	0	0	87	18	4		110
Darrang	84.4	1	0	0	159	32	7		199
Dhemaji	87.3	1	0	0	98	24	4		127
Dhubri	64.2	1	1	0	189	35	6		232
Dibrugarh	93.1	0	0	0	234	21	10	1	266
Dima Hasao	89.5	1	0	0	76	10	3		90
Goalpara	92.3	1	0	0	155	27	6		189
Golaghat	90.4	1	1	0	144	35	5		186
Hailakandi	83	1	0	0	107	12	3		123
Hojai	82.1	0	0	0	92	19	5		116
Jorhat	96.5	0	2	1	105	25	6	1	140
Kamrup	85	1	1	2	279	63	13		359
Kamrup Metropolitan	89.1	1	0	0	51	31	3	1	87
Karbi Anglong	74.9	0	1	0	88	26	6		121
Karimganj	76.4	1	0	0	230	24	7		262
Kokrajhar	81.9	1	1	0	162	27	2		193
Lakhimpur	96.2	1	1	0	156	20	8		186
Majuli	90.3	0	0	0	40	8	2		50
Morigaon	88.3	1	0	1	122	19	6		149
Nagaon	83.7	1	0	6	260	56	13		336
Nalbari	91.8	1	0	2	122	44	11		180
Sivasagar	95.3	1	2	0	173	27	2		205
Sonitpur	83.5	1	2	0	199	29	6	1	238
South Salmara Mankachar	71.7	0	1	0	49	8	2		60
Tinsukia	82.6	1	0	0	166	19	8		194
Udalguri	86.2	1	0	0	150	20	7		178
West Karbi Anglong	72.5	0	0	0	66	11	2		79

Source: Statistical Handbook Assam, 2020[18]
Note: Data on tertiary government medical colleges were added by the researcher based on institutions operational by 2020

district, with fewer government health institutions (140), had the highest institutional delivery rate (96.5%) in Assam.

Discussion

It can be discerned from the findings that just increasing the number of health institutions does not automatically lead to more women giving birth in those facilities. Even though the availability of health institutions is important for accessing maternal healthcare, including institutional delivery, multiple factors may explain this gap between availability and utilization.

Debnath et al. have found in their study that for better health outcomes, making health facilities accessible is more vital than the availability of the same.[19] Poor road conditions, long distances, and dearth of transportation contribute to home deliveries.[20,21] Kumar et al. found that each additional kilometer between a woman's home and the nearest health center lowers the likelihood of delivery in a medical setting by 4.4%.[20] However, mere proximity

to healthcare centers does not guarantee institutional delivery. Kesterton et al. reported that the delivery rate in institutions in India remains low even among households residing within five kilometers of hospitals. They noted that household wealth had a stronger influence on delivery decisions than geographic access. While schemes like JSY provide financial incentives, fear of out-of-pocket expenses influences women's decisions to avoid delivering in health facilities.[22] Sarkar et al. reported that families worry about travel and food costs, particularly because they receive the scheme money after delivery only, and it is insufficient.[23]

The mere presence of healthcare institutions is not enough if the quality of care is low. Studies have found that, in India, especially the government health facilities lack essential services.[23] Also, there is a major paucity of qualified health workers in the country, particularly in remote regions. Such shortages adversely affect care standards and overburden the available staff.[24–26] Moreover, many women avoid government hospitals because of poor hygiene, lack of privacy, delays in treatment, and rude behavior by staff.[27] Research conducted in Northeast India by Chattopadhyay et al. shows many women face obstetric violence during delivery in hospitals, which discourages them from using the institutional facilities.[28]

Education and awareness are two closely related factors that have a significant impact on institutional delivery. Studies analyzing NFHS data in India have found that women with higher educational qualifications have a greater tendency to opt for institutional delivery.[2,3,21,29] Since awareness and education are interrelated, women who are more educated are usually more informed about reproductive health care. On the other hand, women with low literacy levels often lack knowledge about reproductive health and available government schemes. As a result, they are less likely to utilize these services, perceiving them to be expensive and unnecessary.[23] Moreover, women who have exposure to mass media exhibit increased awareness of reproductive health, making their inclination towards delivering in institutional setups greater than women lacking such exposure.[21,30,31]

Even with the presence of medical facilities, free-of-cost services, and proper transportation facilities (including free ambulance services provided by the government), women may still prefer home birth due to sociocultural beliefs and family pressure related to that. Research shows that women from certain religious or caste backgrounds, such as Muslims or SC/STs, are less likely to use maternal healthcare services.[15,32] Furthermore, a study by Ou et al. revealed that almost one in every eight women (12%) in India who had home delivery reported that they were restricted by family members from institutional delivery.[33] A similar result was found by Gorain et al., where 14.5% of respondents stated that even though they wanted to deliver in a healthcare setup, they were restricted by family members, such as husbands or in-laws.[34] This reflects the influence of patriarchal norms and lack of autonomy among women in maternal healthcare choices, where the preferences of women are often pushed to the back burner.

Conclusion

The present study, based on district-level analysis in Assam, reveals that the correlation between the availability of public health facilities and institutional delivery rates is very weak and statistically insignificant. This shows that simply increasing infrastructure may not directly lead to higher maternal health services utilization. However, we cannot deny the crucial significance that the availability of health facilities holds in enhancing maternal and child health outcomes. The study findings show the vitality of looking beyond the quantity of infrastructure to other factors like quality of care, physical and financial accessibility, education and awareness, sociocultural norms, and, most importantly, women's autonomy in making decisions, especially regarding their own bodies.

Amartya Sen's capability approach helps in contextualizing these findings: While the presence of health institutions may represent "available resources," but what truly matters is the freedom and ability of women to convert that resource into actual functioning, i.e., a safe and supported institutional delivery. Therefore, prospective health planning by the government in terms of maternal health care should take a multipronged approach, considering gender-sensitive and context-specific factors as well.

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ORIGINAL RESEARCH

Prevalence and Associated Risk Factors of Hypertension among Adult Men and Women in India

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Abstract

Hypertension is one of the most common yet life-threatening health issues, and a recent estimate by the World Health Organization (WHO) shows that 1.28 billion people worldwide have hypertension, of whom two-thirds belong to low- and middle-income countries (LMICs). In India, the overall prevalence of hypertension is reported to be around 25–30% among adults aged 18 years and above. The present study aimed to investigate the prevalence and various risk factors of hypertension among men and women in India. The study used secondary data from the National Family Health Survey (NFHS)-5, 2019–2021, and conducted statistical analysis based on information gathered from 7,24,115 women aged 15–49 and 1,01,839 men aged 15–54 in India. Bivariate and multivariate logistic regression analyses were employed for data analysis, utilizing Stata software version 18, R version 4.3.2 and QGIS. Overall, hypertension was more common in men (21.1%) compared to women (16.5%). Among men, hypertension was more common in urban areas (23.4%) than in rural areas (20.4%). Among women, hypertension prevalence was 17.5% in urban and 15.5% in rural areas. Results indicate that hypertension prevalence increases with age. Women with higher educational attainment showed a significantly lower risk of hypertension [adjusted odds ratio (AOR) = 0.72; 95% CI: 0.70–0.74; $p < 0.001$], but among men, higher education was associated with a 10% increased risk of hypertension (AOR = 1.10; 95% CI: 1.02–1.17; $p < 0.001$). Hypertension continues to be a major public health issue in India and requires significant efforts to reduce its prevalence. An effective, multifaceted implementation strategy is crucial to address the growing burden of hypertension.

Keywords: Adjusted odds ratio, Health issue, Hypertension, Multivariate logistic regression, National Family Health Survey-5.

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Introduction

Hypertension, also known as high blood pressure, denotes a medical condition characterized by persistently elevated blood pressure levels, specifically readings of 140/90 mm Hg or higher. Hypertension is a common yet life-threatening health condition, affecting approximately 1.28 billion people worldwide. Of these, about two-thirds reside in low- and middle-income countries (LMICs).[1] High blood pressure results in severe health consequences, including strokes, cardiovascular attacks, kidney damage, and numerous other health issues.[2] Globally, there has been a two-fold increase in the number of people having hypertension between 1990 and 2019, and almost half of the people are unaware of the condition, and hence, it is often referred to as "Silent killer."[3] In 2016, non-communicable diseases contributed to 40.5 million fatalities, representing 71% of all global deaths. Approximately 44% of deaths associated with non-communicable diseases were attributable to cardiovascular conditions, with hypertension identified as the most significant risk factor.[4] Moreover, it is projected that by 2025, the worldwide burden of hypertension will probably surpass 1.6 billion cases, which is why emphasis has been placed on its prevention, early detection, and proper management.[5]

It has been widely documented that hypertension has significantly risen in the East, South, and Southeast Asian countries, and that the prevalence is now higher in LMICs. Globally, hypertension accounted for 8.5 million deaths in 2015, of which 88% were in LMICs.[6,7] Despite the high prevalence and burden of hypertension-related health issues in this region, researchers reported the dearth of studies on effective coverage of hypertension control and management services. The review study also highlights the barriers to management and treatment of hypertension in LMICs, such as long time waits, scarcity of drugs, and poor adherence to treatment from patient's side, whereas health providers highlighted problems such as lack of equipment, unavailability of medicines, and not having enough time to provide counseling services on lifestyle advice.[8] Furthermore, factors such as low consumption of fresh fruits, high salt intake, and the high prevalence of maternal and childhood malnutrition are also associated with hypertension in LMICs.[6] In a review study conducted among member countries of the South Asian Association for Regional Cooperation (SAARC), varying prevalence rate is reported within countries; the latest being 31% for India and the Maldives, followed by Pakistan (25%), Bhutan (24%), Sri Lanka (21%), and Bangladesh (18%). Results of this study also show that the majority of the associated risk factors are modifiable, such as obesity, use of tobacco/alcohol, and lack of physical activity, emphasizing the fact that hypertension can be prevented to some extend by adopting healthy lifestyle choices.[9]

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In India, a recent WHO report estimated that 63% of total deaths were caused by non-communicable diseases, out of which cardiovascular diseases account for 27%, thereby affecting 45% of people aged 40–69.[1] The prevalence varies across regions from 46 to 66%, with the highest reported in South and North regions of the country. Further, newly detected cases also increased from 41.6 in 2016 to 52.1% in 2021.[10] In addition to the high prevalence and burden of hypertension, India has the least capacity of physicians to treat patients with hypertension when compared to the rest of the countries.[11] This underscores the need to adopt innovative approaches to hypertension care and control. Among the people diagnosed with hypertension in India, less than half (44.7%) takes prescribed medications and among the ones who are treated, around 52% had their blood pressure under control. Further, considerable disparities were reported in diagnosis, treatment, and control across states and within states in the country.[12,13] This is particularly important for a country like India with a very diverse geographical as well as sociocultural practices and sheds light on the need to adopt decentralized and tailored intervention approaches.

Rationale

A recent study indicated that the prevalence of hypertension in India is approximately 28.2%, and there has been an increasing trend in the prevalence rate in the country, as reported by various studies.[12,14–16] Although reports show that hypertension is more prevalent among men in the country, women reported an 8% increase in hypertension prevalence over 8 years.[14] Though efforts have been made to control and manage hypertension-related health complications through health care-related policies and programs, there are risk factors which are beyond the reach of the health system. For instance, studies have documented about such risk factors, also called the social determinants of health, such as early life exposure, social support, mental health-related factors such as psychosocial stress, employment and social status, and other environmental factors that can impact health outcomes.[6] As such, there is a lack of studies on these factors, which can directly or indirectly lead to hypertension.

In India, a country with the second-highest population in the world, prevalence studies using nationally representative data become important for guiding policy makers toward effective control, management, and treatment strategies for both men and women. This study aimed to evaluate the prevalence and associated risk factors of hypertension among male and female populations in India, using data from the latest National Family Health Survey (NFHS).

Data

Data were drawn from the NFHS-5, conducted from 2019 to 2021. The NFHS is a set of nationally representative cross-sectional surveys that collect data on a variety of demographic, socio-economic, health, and nutrition status, such as reproductive health, fertility, maternal and child mortality, high-risk sexual behavior, nutritional status of women and children, family planning methods, immunization, non-communicable diseases, women's autonomy, and domestic violence. National Family Health Survey-5 was conducted by India's Ministry of Health, with the International Institute of Population Sciences (IIPS) as the nodal agency. The NFHS-5 used two-stage stratified sampling to survey 7,24,115 women aged 15–49 and 1,01,839 men aged 15–54 in 6,36,699 households, with a response rate of 97%.[17]

Outcome Measures

- An individual is considered to have hypertension if their systolic blood pressure is 140 mm Hg or higher, or their diastolic blood pressure is 90 mm Hg or higher. Blood pressure was measured three times at 5-minute intervals, and the average was used for assessment.
- An individual is currently undergoing antihypertensive treatment to reduce their blood pressure following a diagnosis of hypertension.
- Self-reported currently has hypertension.

For analytical purposes, a dichotomous variable for hypertension was constructed, with hypertensive samples coded as 1 and non-hypertensive samples coded as 0.

Explanatory Variables

We analyzed sociodemographic characteristics as covariates to determine key risk factors linked to hypertension in both men and women. Age was stratified into three groups: 15–24, 25–39, and 40–49 years for women, and 15–24, 25–39, and 40–54 years for men. Additional information encompasses place of residence (rural or urban), educational attainment (illiterate, primary, secondary, or higher education), marital status (never married, married, and widowed/divorced/separated), religion (Hindus, Muslims, Christians, and others), caste [Scheduled Castes (SCs), Scheduled Tribes, Other Backward Classes (OBCs), or others], wealth quintile (poorest, poorer, middle, richer, or richest), alcohol consumption (yes or no), non-vegetarian food consumption (yes or no), and categories of occupation (not employed, professionals, clerical, sales, service, agriculture, or production workers). We additionally utilized information regarding the presence of diabetes (yes or no) to examine the relationship between co-morbidity and the risk of hypertension, differentiated by sex.

Statistical Analyses

Statistical analyses were carried out using Stata software (version 18). Chi-square tests and logistic regression models examined variable relationships. The proportions of women and men with hypertension were analyzed in relation to selected background characteristics. We employed multivariate binary logistic regression models to identify key sociodemographic factors of hypertension at the individual level. Multifactorial diseases, such as hypertension, are most appropriately conceptualized and assessed at the individual level. To identify potential sex-based differences in hypertension determinants, regression analyses were performed separately for females and males. Statistical significance was evaluated using a two-tailed *p*-value of 0.05, with appropriate sampling weights in the analyses. Additionally, we used a geographic information system (GIS) to map hypertension prevalence separately for females and males by state.

Results

In India, hypertension was more common in men (21.1%) compared to women (16.5%) (shown in Table 1 and Fig. 1A). Among men, hypertension was more common in urban areas (23.4%) than in rural areas (20.4%) (shown in Fig. 1B). Among women, hypertension prevalence was 17.5% in urban and 15.5% in rural areas (shown in Fig. 1C). Sikkim has the highest rates of hypertension, affecting 40.1% of men and 31.4% of women (shown in Fig. 2B). The lowest hypertension prevalence among men was observed in Ladakh at

Table 1: Prevalence of hypertension among men and women aged 15 and above in India, 2019–2021

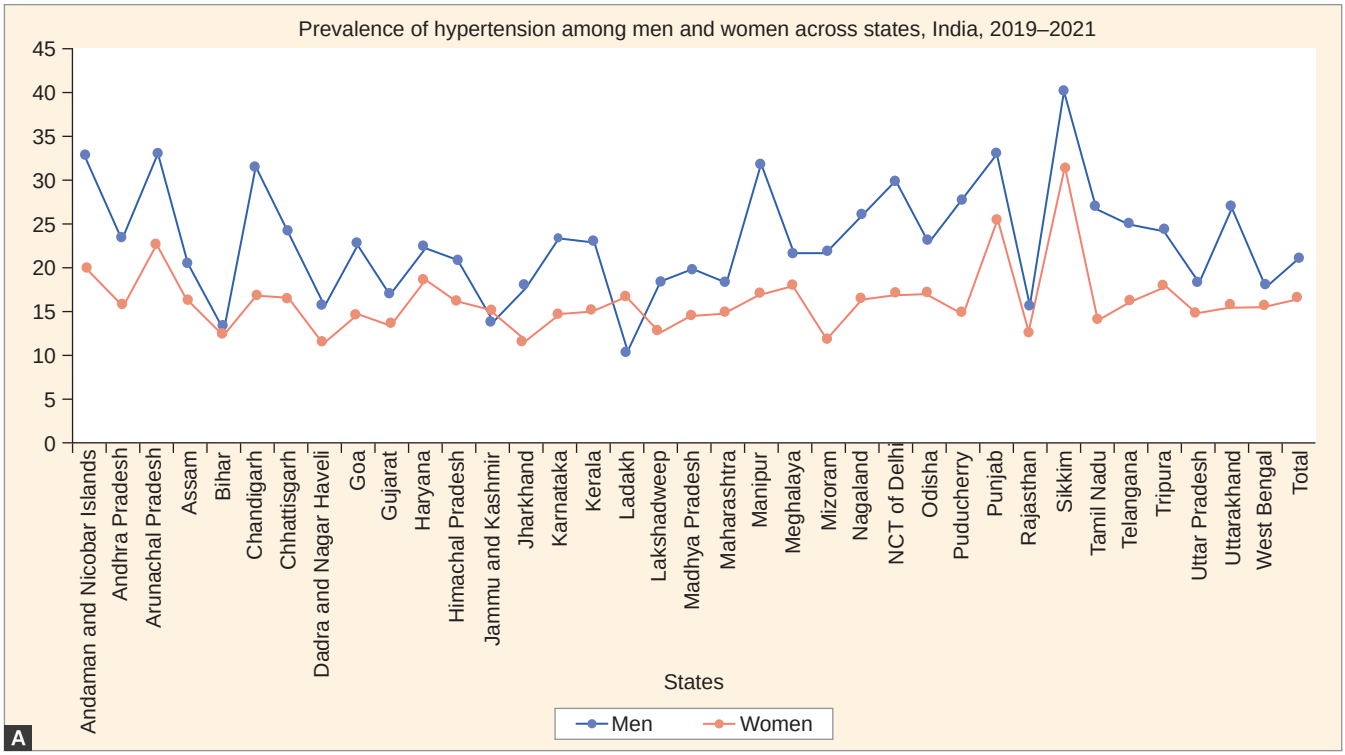
	Men			*Women*		
State	*n (%)*	*Urban (%)*	*Rural (%)*	*n (%)*	*Urban (%)*	*Rural (%)*
Jammu and Kashmir	3,087 (13.8)	15.8	13.4	23,037 (15)	16.3	14.7
Himachal Pradesh	1,477 (20.7)	27.8	20	10,368 (16.2)	17	16.2
Punjab	3,296 (33)	32.1	33.5	21,771 (25.4)	23	26.5
Chandigarh	104 (31.7)	31.7	Nil	746 (16.9)	16.5	26.9
Uttarakhand	1,586 (26.9)	28.5	26.5	13,280 (15.6)	17.9	15
Haryana	3,224 (22.3)	23.9	21.6	21,909 (18.5)	18.1	18.6
NCT of Delhi	1,700 (29.8)	29.5	39	11,159 (17)	17.1	15.7
Rajasthan	6,353 (15.7)	17	15.2	42,990 (12.4)	14.1	11.9
Uttar Pradesh	12,043 (18.2)	20.9	17.5	93,124 (14.9)	16.5	14.5
Bihar	4,897 (13.3)	12.1	13.5	42,483 (12.3)	13.2	12.1
Sikkim	469 (40.1)	50	38.3	3,271 (31.4)	27.5	32.1
Arunachal Pradesh	2,881 (32.8)	34.6	32.3	19,765 (22.5)	24.7	21.9
Nagaland	1,456 (26.1)	25.7	26.2	9,694 (16.4)	15.6	16.7
Manipur	1,162 (31.8)	35.5	30.3	8,042 (17.1)	19.2	16.3
Mizoram	1,105 (21.8)	24.8	19.5	7,279 (11.6)	13.8	9.9
Tripura	990 (24)	29.1	22.9	7,314 (17.8)	21.2	17.1
Meghalaya	1,824 (21.6)	27.6	20.9	13,089 (17.9)	21.3	17.4
Assam	4,973 (20.3)	27	19.3	34,979 (16)	16.6	15.9
West Bengal	3,021 (17.9)	19.6	17.1	21,408 (15.6)	16.7	15.2
Jharkhand	3,414 (17.9)	21.6	16.8	26,495 (11.5)	13	11.2
Odisha	3,865 (23)	26.5	22.3	27,971 (17)	18.3	16.8
Chhattisgarh	4,174 (24)	25.7	23.6	28,468 (16.4)	17.6	16.2
Madhya Pradesh	7,025 (20)	21.9	19.5	48,410 (14.6)	16.6	14.1
Gujarat	5,351 (16.8)	16.2	17	33,343 (13.5)	13.9	13.3
Dadra & Nagar Haveli and Daman & Diu	427 (15.5)	15	16.2	2,713 (11.4)	14.2	8.1
Maharashtra	5,497 (18.2)	18.4	18.2	33,755 (14.9)	15.4	14.7
Andhra Pradesh	1,558 (23.3)	24	23	10,975 (15.7)	17.7	14.9
Karnataka	4,516 (23.3)	23	23.4	30,455 (14.5)	15.4	14
Goa	313 (22.7)	21.5	24.8	2,030 (14.6)	15.1	13.8
Lakshadweep	135 (18.5)	14.4	28.9	1,234 (12.8)	13.3	11.1
Kerala	1,473 (22.8)	23.4	22.4	10,969 (15)	13.9	15.8
Tamil Nadu	3,372 (26.7)	27.2	26.2	25,650 (14)	15.1	13.2
Puducherry	534 (27.7)	28	26.3	3,669 (14.9)	15.6	12.2
Andaman and Nicobar Islands	367 (32.2)	29.4	33	2,397 (19.6)	15.6	20.9
Telangana	3,863 (24.9)	29	23.4	27,518 (16.1)	17.7	15.5
Ladakh	307 (10.4)	6.9	11.5	2,355 (16.6)	17.1	16.4
Total	1,01,839 (21.1)	23.4	20.4	7,24,115 (16.5)	16.5	15.2

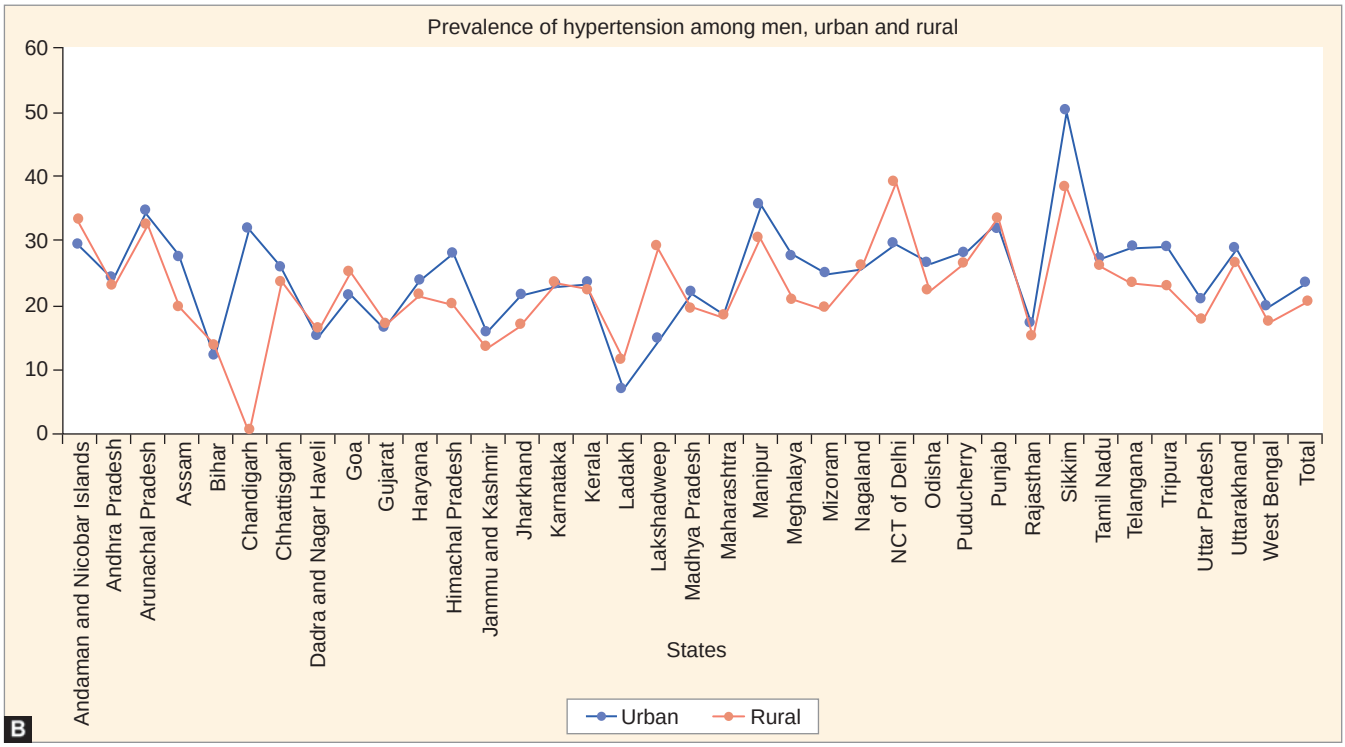
10.4%, while in Dadra & Nagar Haveli and Daman & Diu, it was 11.4% (shown in Fig. 2A).

Results indicate that hypertension prevalence increases with age (shown in Table 2). The findings show the highest prevalence among older adults (40–54 years): 36% for women and 30.8% for men, nearly twice that of the 25–39 years group. Hypertension was significantly more common among urban residents, with rates of 16.5% in women and 23.4% in men, compared to those in rural areas. Hypertension was observed to be more prevalent among illiterate women at 21.3%, whereas it was less prevalent among women with higher education at 10.8%. Regardless of education level, men had a high prevalence of hypertension (ranging from 19.9 to 24.7%). In comparison with Hindus, Muslims, or Christians, the incidence of hypertension was more prevalent among other religious groups, with rates of 22.2% in women and 29.6% in men.

Likewise, hypertension prevalence was elevated among women belonging to other caste groups (16.8%), while among men, the highest prevalence was observed in scheduled tribe groups (22.8%). Moreover, the incidence of hypertension has steadily risen across all wealth quintiles, from the lowest to the highest, with rates of 17.2% among women and 25% among men. In terms of marital status, people who were widowed, divorced, or separated were more likely to have hypertension (26.4% for women and 30.1% for men) than those who were never married or currently married. The prevalence of hypertension, as indicated by lifestyle characteristics, reveals that 25.1% of women and 29.2% of men consume alcohol,

15.5% of women and 21.4% of men consume a non-vegetarian diet, and 15.5% of women and 50.3% of men who have diabetes exhibit higher rates of hypertension. Among substance users, including cigarette smokers, khaini, and paan with tobacco users, the prevalence of hypertension was consistently high for women at 15.5%. For men, the prevalence was higher in the substance use category, ranging from 20 to 25%, compared to non-substance users. However, hypertension prevalence based on occupation type was





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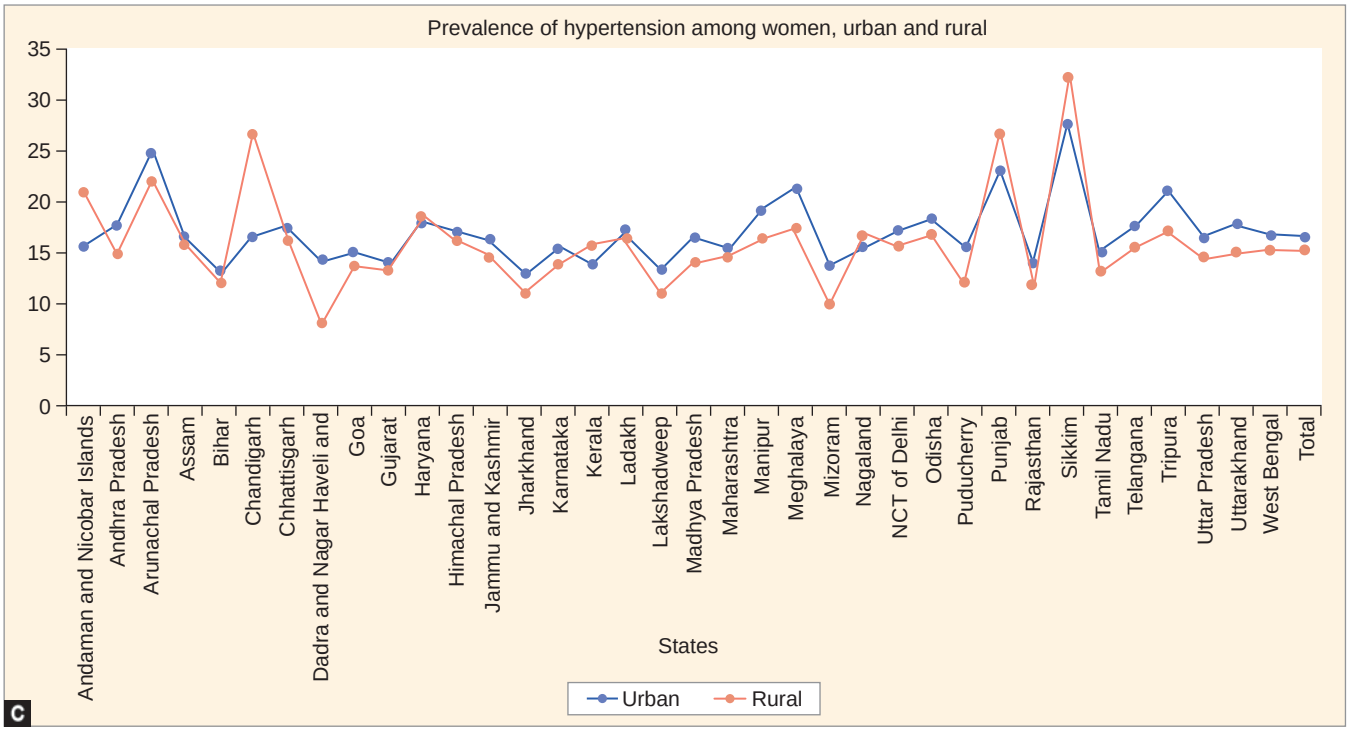


Figs 1A to C: (A) Prevalence of hypertension among men and women across states, India, 2019–2021; (B) Prevalence of hypertension among men, urban, and rural; (C) Prevalence of hypertension among women, urban, and rural

higher among females in the service sector at 20.4% and professional males at 27.7%, compared to their counterparts.

Discussion

The significant odds ratios from the multivariate logistic regression model provide meaningful insights into the socioeconomic determinants of hypertension among Indian men and women. Table 3 displays the adjusted odds ratios (AORs) generated from the regression models for men and women.

The findings showed that in the older age categories, women had a higher probability of hypertension than men. For women, the AOR was 5.05, whereas for men, it was 4.58. The likelihood of hypertension decreased among women with higher educational attainment (AOR = 0.72). Conversely, higher-educated men showed a 10% greater likelihood of hypertension (AOR = 1.10). Hypertension was more common among married women than among never-married women, with their odds exceeding those of married men (men: AOR = 1.3; women: AOR = 1.43). Likewise, women who were widowed, divorced, or separated exhibited a greater likelihood of hypertension than their male counterparts in these groups. This finding may be indicative of the role played by stress related to an unhealthy family environment in the prevalence of hypertension; more extensive studies need to be conducted in this area. The analysis also revealed that living in rural areas was associated with a significantly lower likelihood of hypertension relative to urban residence (men: AOR = 0.96; women: AOR = 0.97). Similar findings were reported from studies conducted in abroad where a sedentary urban lifestyle was strongly associated with hypertension.[18,19] Furthermore, the incidence of hypertension was notably high among adults with diabetes. It was twice as high for women (AOR = 3.96). Similarly, diabetic men exhibited a higher likelihood of being hypertensive; the odds ratio (AOR = 2.49) was lower compared to women. This shows that hypertension is highly comorbid with diabetes, and it is alarming as India is the second leading country with diabetes in the world.[20]

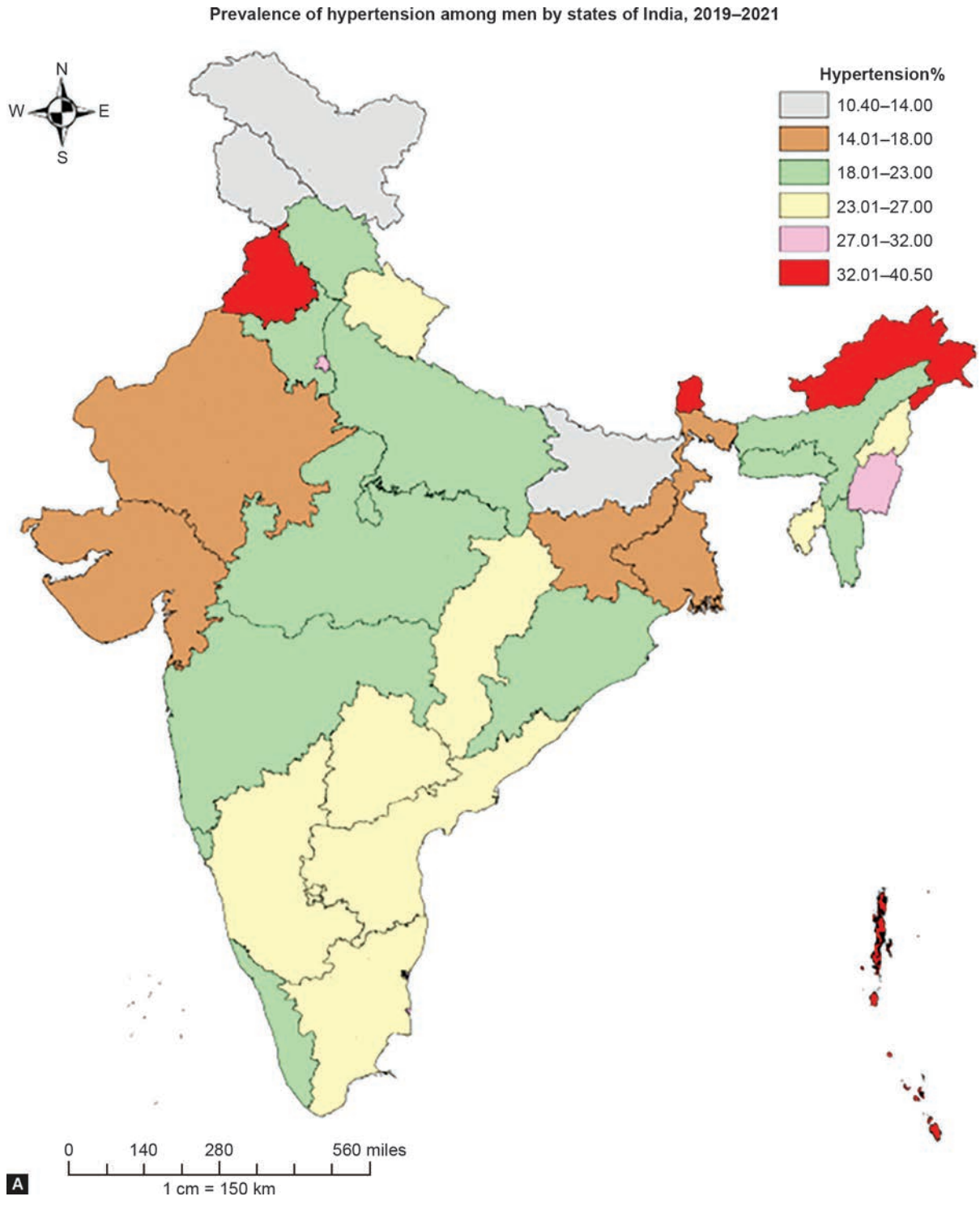
Further, family income or wealth quintiles are important factors influencing hypertension. The highest wealth quintile faces a significant risk of hypertension, with men showing an AOR of 1.46 and women an AOR of 1.28. Alcohol and non-vegetarian food consumption were significantly linked to hypertension prevalence. Alcohol consumption was associated with increased odds of hypertension among both sexes (men: AOR = 1.46; women: AOR = 1.39). A non-vegetarian diet in men was associated with a higher prevalence of hypertension (AOR = 1.05). The above results show that the majority of the risk factors across the two groups were strongly related to lifestyle choices and hence are modifiable; addressing the above behavioral risk factors in health education and intervention will play a pivotal role in hypertension care and control in the country.

In terms of religion, women from other religious groups exhibited higher odds of hypertension compared with men from the same groups (women: AOR = 1.53 and men: AOR = 1.47). After adjusting for caste, no significant associations were observed, except among women from the OBCs and other caste categories. Women from other caste groups had higher odds of hypertension (AOR = 1.05) compared to those from the SCs, while no significant association was found among men. Men employed in professional, clerical, sales, and service occupations exhibited a significantly higher likelihood of hypertension compared to those who were not working (AOR = 1.26). Women working in agricultural fields had lower hypertension rates than non-working women (AOR = 0.91). Likewise, employed women in clerical, sales, and service occupations exhibited a significantly greater likelihood of

hypertension than their non-working counterparts (AOR = 1.16). The working environment and the nature of the work may serve as significant determinants, and evidence has demonstrated a positive relationship between work-related stress and hypertension.[21]

Conclusion

Our study sheds light on the alarming prevalence and the various risk factors of hypertension among men and women in India. Findings show that the major determinants of hypertension were strongly linked to lifestyle choices, hence incorporating lifestyle-related behavioral intervention or counseling services will be an effective preventive approach. Further, some of the risk factors have varying odds of hypertension in men and women, underscoring the need to explore the gender-specific factors associated with hypertension. This will ultimately help in designing tailored intervention approaches. Since our study is based on secondary



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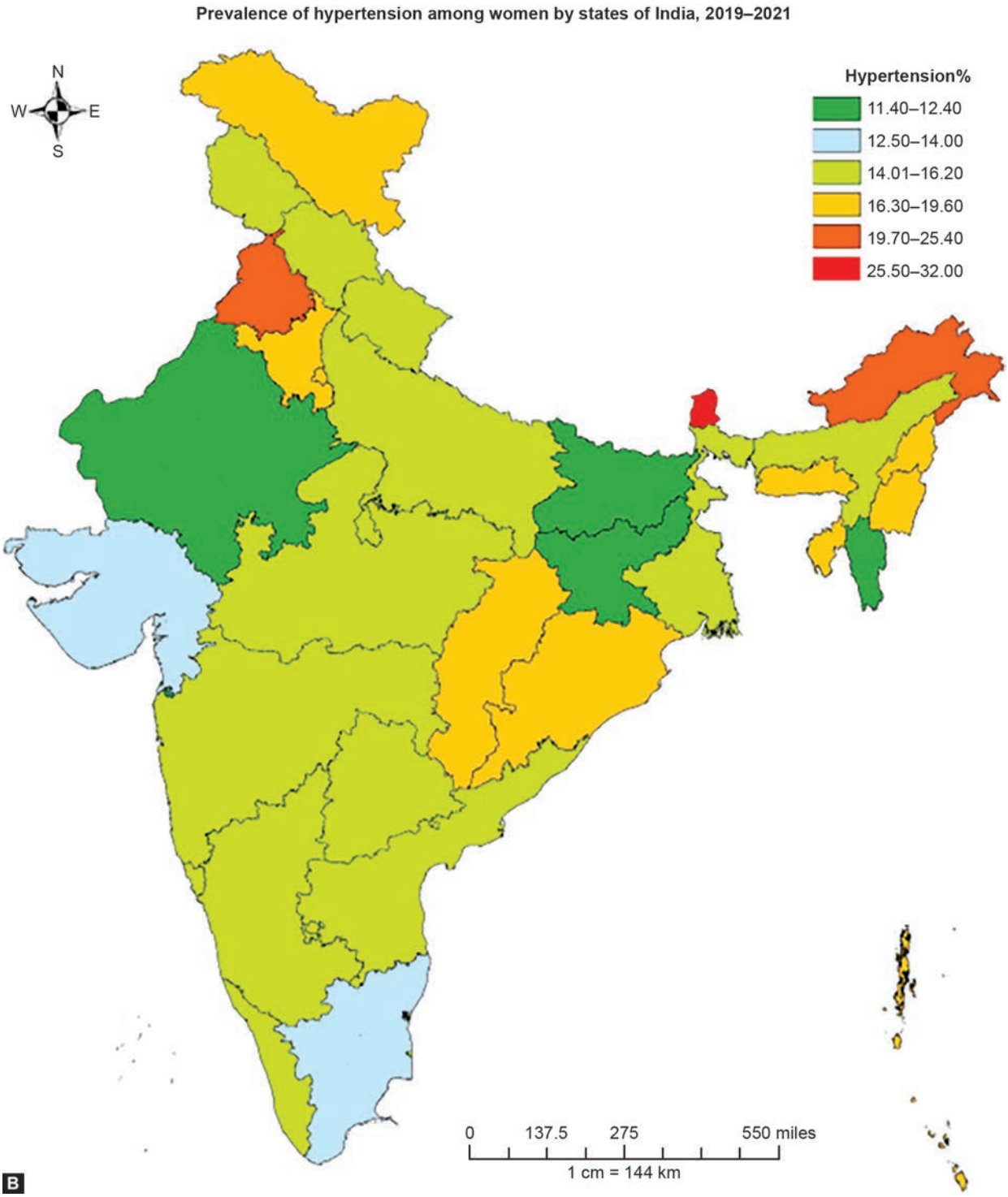

Figs 2A and B: (A) Prevalence of hypertension among men by states of India, 2019–2021; (B) Prevalence of hypertension among women by states of India, 2019–2021

data, exploration of psychosocial determinants such as experience of stress and anxiety and social support system was not possible, and incorporating the same in future research will play a pivotal role in developing holistic policies and programs. Focus should also be given to population-level interventions, such as the regulation of salt used in packaged food items; this is particularly important for a country like India, where the consumption of packaged snacks is quite high. Hypertension has become a major public issue in India, and consistent efforts are required to reduce its prevalence. A multifaceted implementation approach will be highly effective

Table 2: Prevalence of hypertension among adult men and women (15–54 years) in India by socioeconomic background

	Women		*Men*	
Socioeconomic background	*n (%)*	*Chi-square p-value*	*n (%)*	*Chi-square p-value*
Age-group				
15–24	2,41,180 (5.7)	0.00	31,070 (7.8)	0.00
25–39	3,17,496 (14.9)		40,526 (20.3)	
40–49/40–54*[a]	1,65,439 (30.8)		30,243 (36)	
Place of residence				
Urban	1,79,535 (16.5)	0.00	26,420 (23.4)	0.001
Rural	5,44,580 (15.2)		75,419 (20.4)	
Marital status				
Never married	1,81,285 (5.8)	0.00	36,892 (10.2)	0.00
Widowed*[b]	30,422 (26.4)		1,570 (30.1)	
Married	5,12,408 (18.3)		63,377 (27.3)	
Educational				
No education	1,67,304 (21.3)	0.001	12,269 (24.4)	0.001
Primary	84,983 (19.8)		11,710 (24.7)	
Secondary	3,70,012 (13.2)		60,018 (19.9)	
Higher	1,01,816 (10.8)		17,842 (20.9)	
Occupation				
Not working	73,809 (14.5)	0.00	19,241 (9.8)	0.00
Professional*[c]	2,985 (15.1)		5,266 (27.7)	
Clerical/Sales	2,525 (20.1)		9,921 (25.5)	
Service	3,433 (20.4)		6,341 (26.8)	
Agricultural	18,031 (16.9)		32,864 (22.7)	
Production work*[d]	6,23,332 (15.5)		28,206 (23.1)	
Eat non-vegetarian				
No	2,10,132 (15.8)	0.00	21,230 (20.1)	0.00
Yes	5,13,983 (15.4)		80,609 (21.4)	
Religion				
Hindu	5,46,007 (14.9)	0.001	77,211 (20.9)	0.00
Muslim	90,729 (15.5)		12,112 (16.7)	
Christian	52,146 (16.7)		7,267 (24.9)	
Others	35,233 (22.2)		5,249 (29.6)	
Caste/Tribe				
Schedule caste	1,39,957 (15.2)	0.001	19,240 (21)	0.001
Schedule tribe	1,35,239 (15.8)		19,354 (22.8)	
OBC	276881 (14.7)		39,326 (20.1)	
Others	1,72,038 (16.8)		23,919 (21.7)	
Wealth index				
Poorest	1,49,844 (13.8)	0.00	19,796 (18.1)	0.00
Poorer	1,60,340 (14.8)		22,599 (19.7)	
Middle	1,51,505 (15.7)		21,715 (21)	
Richer	1,39,607 (16.4)		20,209 (22.6)	
Richest	1,22,819 (17.2)		17,520 (25)	
Drink alcohol				
No	7,10,587 (15.3)	0.00	75,391 (18.3)	0.00
Yes	13,528 (25.1)		26,448 (29.2)	
Smokes cigarettes				
No	7,22,694 (15.5)	0.00	87,283 (20.6)	0.00
Yes	1,421 (15.5)		14,556 (24.7)	
Use Khaini				
No	7,13,918 (15.5)	0.00	89,020 (20.6)	0.00
Yes	10,197 (15.5)		12,819 (24.9)	

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Table 2: *(Contd...)*

	Women		*Men*	
Socioeconomic background	*n (%)*	*Chi-square p-value*	*n (%)*	*Chi-square p-value*
Paan with tobacco				
No	7,07,603 (15.5)	0.00	95,526 (20.8)	0.00
Yes	16,512 (15.5)		6,313 (25.6)	
Currently diabetes				
No	7,12,009 (15.5)	0.00	99,651 (20.5)	0.00
Yes	12,106 (15.5)		2,188 (50.3)	

*[a], The last age-group category for men is 50–54; *[b], Includes divorced and separated; *[c], Includes technical, administrative, and managerial occupations; *[d], Includes skilled and unskilled manual occupations; OBC, other backward caste

Table 3: Multivariate binary logistic regression to show the OR of hypertension diseases among adult men and women (15–54 years) in India

	Women		*Men*	
Socioeconomic background	*Adjusted p-value*	*Adjusted OR (95% CI)*	*Adjusted p-value*	*Adjusted OR (95% CI)*
Age-group				
15–24		1		1
25–39	0.00	2.22 (2.17–2.28)	0.00	2.19 (2.06–2.33)
40–54	0.00	5.09 (4.96–5.23)	0.00	4.58 (4.27–4.90)
Type of place of residence				
Urban		1		1
Rural	0.00	0.97 (0.96–0.99)	0.08	0.96 (0.92–1.00)
Marital status				
Never married		1		1
Widowed	0.00	1.66 (1.59–1.72)	0.00	1.37 (1.21–1.55)
Married	0.00	1.43 (1.40–1.48)	0.00	1.31 (1.24–1.38)
Level of education				
No education		1		1
Primary	0.00	1.05 (1.03–1.07)	0.02	1.08 (1.01–1.14)
Secondary	0.00	0.90 (0.89–0.92)	0.00	1.08 (1.03–1.14)
Higher	0.00	0.72 (0.70–0.74)	0.01	1.10 (1.02–1.17)
Occupation				
Not working		1		1
Professional	0.85	0.99 (0.89–1.10)	0.00	1.19 (1.09–1.30)
Clerical/sales	0.00	1.16 (1.05–1.29)	0.00	1.21 (1.13–1.31)
Service	0.01	1.12 (1.03–1.23)	0.00	1.26 (1.16–1.36)
Agriculture	0.00	0.91 (0.87–0.95)	0.15	1.05 (0.98–1.12)
Production worker	0.58	0.99 (0.97–1.02)	0.00	1.16 (1.08–1.24)
Eat non-vegetarian				
No		1		1
Yes	0.00	0.94 (0.92–0.95)	0.03	1.05 (1.00–1.09)
Religion				
Hindu		1		1
Muslim	0.00	1.11 (1.08–1.13)	0.00	0.83 (0.79–0.88)
Christian	0.00	1.16 (1.13–1.19)	0.00	1.20 (1.12–1.28)
Others	0.00	1.53 (1.48–1.57)	0.00	1.47 (1.37–1.57)
Caste/Tribe				
Schedule caste (SC)		1		1
Schedule tribe (ST)	0.09	1.02 (1.00–1.05)	0.00	1.09 (1.03–1.15)
OBC	0.00	0.95 (0.93–0.97)	0.11	0.96 (0.92–1.01)
Others	0.00	1.05 (1.02–1.07)	0.56	1.02 (0.96–1.07)

(Contd...)

Table 3: *(Contd...)*

	Women		*Men*	
Socioeconomic background	*Adjusted p-value*	*Adjusted OR (95% CI)*	*Adjusted p-value*	*Adjusted OR (95% CI)*
Wealth index				
Poorest		1		1
Poorer	0.00	1.11 (1.08–1.13)	0.00	1.15 (1.09–1.21)
Middle	0.00	1.19 (1.16–1.21)	0.00	1.23 (1.16–1.29)
Richer	0.00	1.24 (1.21–1.27)	0.00	1.32 (1.25–1.40)
Richest	0.00	1.28 (1.25–1.32)	0.00	1.46 (1.36–1.56)
Drink alcohol				
No		1		1
Yes	0.00	1.39 (1.33–1.45)	0.00	1.41 (1.36–1.47)
Smokes cigarettes				
No		1		1
Yes	0.51	1.05 (0.92–1.20)	0.13	0.97 (0.92–1.01)
Uses khaini				
No		1		1
Yes	0.89	1.00 (0.95–1.06)	0.54	0.99 (0.94–1.03)
Uses a pan with tobacco				
No		1		1
Yes	0.00	1.15 (1.10–1.19)	0.29	1.03 (0.97–1.10)
Currently has diabetes				
No		1		1
Yes	0.00	3.96 (3.81–4.11)	0.00	2.49 (2.27–2.72)

OBC, other backward caste; OR, odds ratio

in combating the emerging burden of hypertension. Such efforts will help strengthen the government's already existing programs and policies.

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ORIGINAL RESEARCH

Awareness and Use of Garden Cress Seed (*Lepidium sativum* L.) among Rural Pregnant and Lactating Women in Bengaluru

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Abstract

Garden cress seed (*Lepidium sativum* L.) belongs to the Brassicaceae family. In India, it is used as a culinary seed. The seeds, leaves, and roots of garden cress have economic value, but it is mostly cultivated for its seeds. Garden cress seeds have long been used as functional food in some geographical areas. It is a rich source of iron and a good source of calcium. Garden cress seed is known to have antidiabetic, antiasthmatic, diuretic, anti-inflammatory, galactagogue, and emmenagogue properties. Studies have shown that it is used as a traditional supplementary food given to pregnant and lactating mothers, and to people suffering from back pain in selected areas of north Karnataka. The objective of this research was to study the awareness and usage of the garden cress seed among pregnant and lactating mothers in rural Bengaluru, South Karnataka. A questionnaire was developed for this purpose. The subjects were pregnant women and lactating mothers ($n = 100$). Data were collected using an interviewer-administered questionnaire. The results of the study showed that none of the subjects were aware of garden cress seeds. It can be concluded that awareness should be created among rural women in Bengaluru regarding the use of garden cress seeds to reduce micronutrient deficiency.

Keywords: Culinary seed, Emmenagogue, Galactagogue, Iron deficiency anemia.

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Introduction

Garden cress seed (*Lepidium sativum* L.) is a fast-growing annual herb that originated in Egypt and Western Asia and is now grown all over the world. Common names of garden cress seeds are Common Cress (English), Halim (Bengali), Aseliyo (Gujrati), Chansur (Hindi), Alvibija (Kannada), Alian (Kashmiri), Asali (Malayalam), Ahaliva and Haliv (Marathi), Allivirai (Tamil), and Adityalu, Aadalu (Telugu). The seeds are the most commonly used part of the plant. They are small, brownish-red in color, oval in shape, with a triangular, pointed end, and smooth in texture. Some farmers believe that while this underutilized crop was formerly grown on a modest scale by their ancestors, it is now rarely cultivated due to lack of customer demand. Customers are largely unaware of the nutritional and health benefits of garden cress seeds which is responsible for the lack of demand.

Nutritional Composition of Garden Cress Seeds

The macronutrient composition of garden cress seed indicates that it provides 445.18 kcal/100 gm of energy, 24.11 gm/100 gm of protein, 32.76 gm/100 gm of carbohydrate, and 9.01 gm/100 gm of fiber. Among 19 amino acids present in garden cress seeds, it is an important source of aspartic acid (providing 10.71 gm/100 gm) and glutamic acid (providing 21.65 gm/100 gm). Garden cress seed provides vitamins such as biotin (8.66 mg/100 gm) and folate (30.92 µg/100 gm). The mineral composition of garden cress seed indicates that it provides 320.45 mg/100 gm of calcium 1141.67 mg/100 gm of potassium, 619.82 mg/100 gm of phosphorus, and 353.8 mg/100 gm of magnesium.[1]

Traditionally, garden cress seeds are used in different forms such as dessert, side dishes, and snacks. Many products, such as laddu, burfi, chikki, sandwich, soups, bhujia, raitha, biscuits, muffins, and mathri have been developed by food scientists in laboratory and have been evaluated for their acceptability by sensory panel. These products are yet to be produced on a commercial scale.

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Conflict of interest: None

Materials and Methods

Development of Research Tool

An interviewer-administered questionnaire was developed to address the research objectives. The questionnaire contained five sections, such as, general information, anthropometry, health status, nutrient intake and knowledge of garden cress seeds.

Selection of the Subjects

Subjects were 100 adult women in the reproductive-age-group (20 to 45 years). The pregnant and lactating women beneficiaries of the ICDS project at selected anganwadis were included in the study.

Table 1: Classification of body mass index (BMI)

BMI category	*Cut-offs*
Underweight	<18.5
Normal weight	18.5–22.9
At risk of overweight	23–24.9
Overweight	25–29.9
Obese	≥30

Source: WHO (2006)

Locale of the Study

The study was conducted in state government preschool (anganwadi centers) in South Urban Bengaluru. The subjects were from Raghuvananhalli, Jarganahalli, and Doddakallasandra.

Ethical Consent

Permission was obtained from the Deputy Director of Women and Child Welfare Department, and subjects' individual informed consent was obtained after briefing them about the research objective.

Assessment of Nutritional Status

Nutritional status was assessed using anthropometric, biochemical, nutrition-focused physical examination, and dietary methods.

Anthropometric Method

The anthropometric method to determine nutritional status was done using the BMI. The BMI classification given in Table 1 was used for interpretation.

Biochemical Method

Hemoglobin levels of the subjects were obtained from the records of Department of Women and Child Welfare (July–September 2021) maintained by anganwadi teachers. Hemoglobin levels were assessed by the manual method.

Nutrition Focused Physical Examination

The assessment was done by the researcher by personally examining the subjects for general clinical signs and symptoms such as fatigue, brittle, spoon-shaped nails, irritability or apathy, paleness, headache, dizziness, unusual tiredness, weight loss or weight gain, bone fractures, dental issues, and edema.

Dietary Method

The 24-hour dietary recall and diet diversity score were assessed. The nutritive value of food was calculated using the Indian food composition table (NIN 2017).[2] The FAO[3] minimum dietary diversity for women (MDD-W) is an indicator based on the number of food groups consumed and quantifies the percentage of women consuming at least five out of ten specified food groups in the preceding 24 hours. The dietary diversity questionnaire has 15 categories/food groups, and based on the consumption it is scored (Yes = 1, No = 0). Research has shown that MDD-W reflects micronutrient intake.

Assessment of Health Status

The health status was assessed by a questionnaire developed and administered by the researcher. The questions pertained to gestational diabetes, high blood pressure, low blood pressure, thyroid disorders, or any other condition.

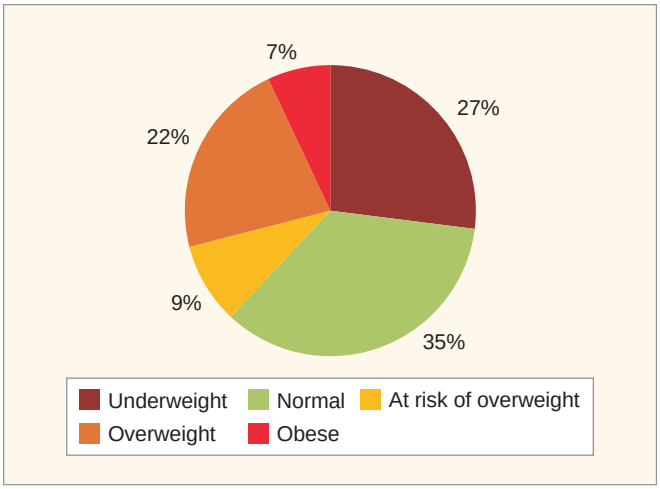

Fig. 1: Body mass index of subjects (%)

Development of Educational Visual Aid

A pamphlet was developed in local language to create awareness on nutritive value, health benefits, and usage of garden cress seeds.

Statistical Analysis of Data

Results of continuous measurements have been expressed as mean and percent.

Results and Discussion

General Information of Subjects

The age of the subjects ranged from 20 to 45 years. Of the subjects, 98% were housewives and 2% were factory workers. The highest educational qualification of the subjects was SSLC (62%) and the average annual family income of the subjects ranged from ₹10,000 to a maximum of ₹30,000.

Nutritional Status of the Subjects

Anthropometric Assessment

The nutritional status of subjects based on body mass index is depicted in Figure 1. It can be observed that 65% of subjects were malnourished, whereas 35% were normal. Half of the malnourished subjects were underweight, and the remaining were overweight.

The results of the study show that the level of malnutrition among the subjects is above the national level statistics. In India, 18.7% of women are undernourished and 19.7% of women are overnourished (NFHS survey 2019–2021).[4] Globally, 10% are found to be underweight, 35% are overweight and 13% are obese among women in reproductive age-group (UNICEF data, 2025).[5]

The clinical signs and symptoms of the subjects are presented in Table 2. It shows that 19% of the subjects had unusual tiredness. Overall, 50% of the subjects were not experiencing any of the clinical signs or symptoms.

A study was conducted to investigate the to rate of prevalence of pregnancy related physical discomfort and its management among pregnant women aged 18–40 years. Symptoms such as nausea and vomiting (87.8%), fatigue (77.9%), breast pain or tenderness (76.2%), increased urination (79.9–88.4%) and heartburn (71.3–88.4%) were observed during the first and second trimesters. Based on their previous experience and knowledge, the pregnant women were able to manage these physical discomforts on their own without seeking professional medical help.[6]

Table 2: Clinical signs and symptoms of subjects

Signs and symptoms	*Frequency of prevalence*
Fatigue	8
Brittle and spoon shape nails	Nil
Apathy or irritability	Nil
Lack of appetite	Nil
Unusual tiredness	19
Paleness	Nil
Headache	17
Dizziness	4
Weight loss	Nil
Recurrent illness (cold, fever, cough)	Nil
Bone factures	Nil
Dental problems	2
Edema	Nil

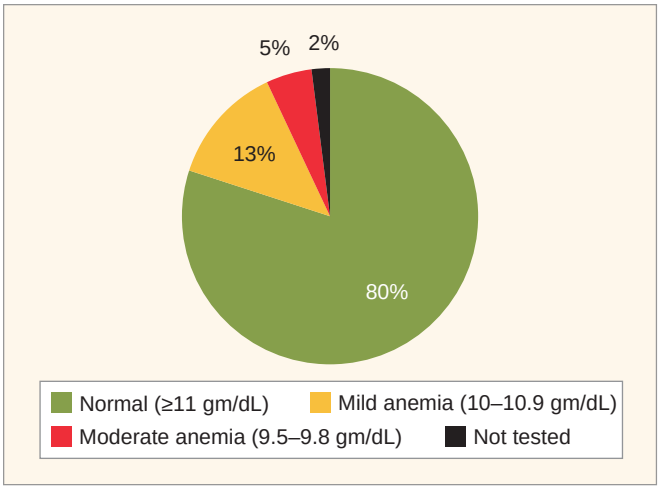

Fig. 3: Hemoglobin level of subjects

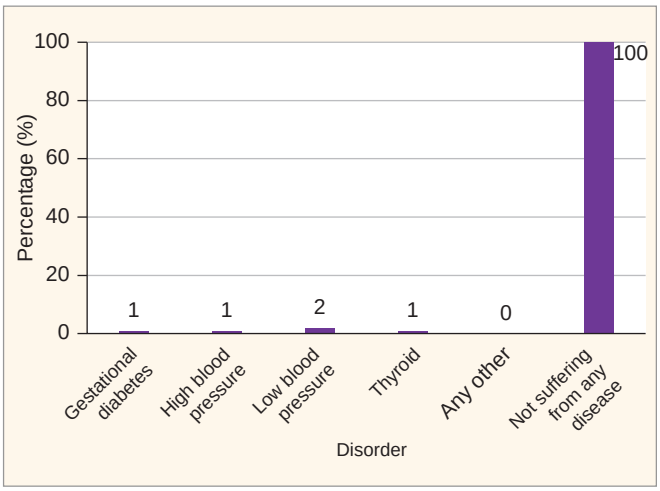

Fig. 2: Health status of the subjects (%)

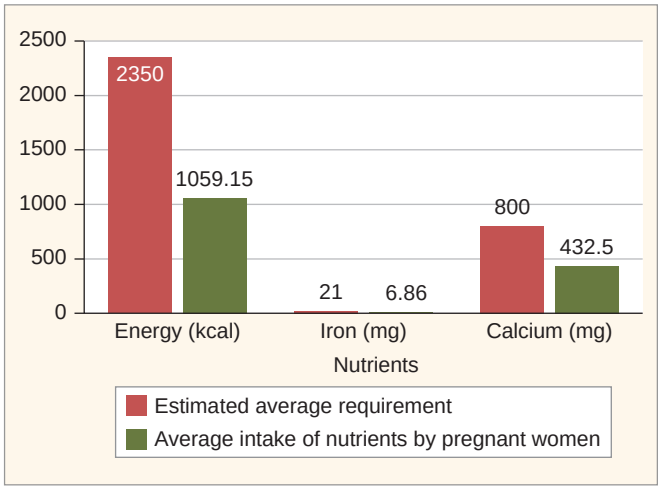

Fig. 4: Average nutrient intake of pregnant women compared with estimated average requirement

The health problems of the subjects are shown in Figure 2. It was found that 1% of the subjects suffered from gestational diabetes and 2% had low blood pressure, whereas 96% of the pregnant and lactating women were not experiencing any health problems. One subject was suffering from both gestational diabetes and high blood pressure. The hemoglobin status of the subjects is given in Figure 3. The results show that 80% of the subjects had hemoglobin levels above 11 gm/dL which is considered normal. No cases of severe anemia were found among these subjects.

A study was conducted on anemia in pregnant and lactating mothers in Devbhumi Dwarka, Gujarat, in the age-group of 18–25 years.[7] It was observed that 38.96% of the subjects had mild anemia (10.0–10.9 gm/dL); 33.9% moderate anemia (7.0–9.9 gm/dL) and 0.83% had severe anemia (<7.0 gm/dL). Among lactating mothers, 26% had mild anemia (10.0–11.9 gm/dL), 63.93% had moderate anemia (8.0–10.9 gm/dL) and 1.29% had severe anemia (<8.0 gm/dL).

A study on 578 pregnant women in the age-group of 20–30 years, who were hospitalized during the course of pregnancy, showed that nearly half of them were hypertensive (42.3%), and other health problems reported include hematological disorder (38.7%), liver disorder (5%), endocrine disorders (4.8%), epilepsy (3.8%), and HIV (2.6%).[8]

Iron and Folic Acid Supplementation

In the present study, it was observed that all pregnant and lactating mothers (100%) were provided with iron and folic acid supplementation. Research has shown both positive and negative effects of blanket iron and folic acid supplementation in pregnant women. A randomized study,[9] on 791 pregnant women analyzed the hemoglobin levels during the initial days of pregnancy with different doses of iron supplements. Those who had hemoglobin levels of 11–12.9 gm/dL were given 80 mg/day and were protected against iron deficiency, whereas those who had serum ferritin levels ≥ 15 µg/L were given 20 mg/day, which reduced the risk of hemoconcentration (excess of iron) during 36th week of pregnancy. The authors concluded that iron supplementation should be administered in early pregnancy based on hemoglobin levels and iron stores.

Nutrient Intake of Subjects

The nutrient intake and the estimated average nutrient requirements of the pregnant women in the present study are shown in Figure 4.

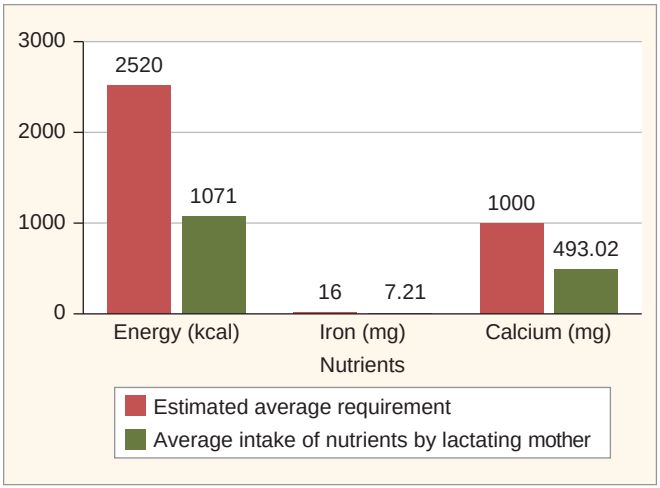

Fig. 5: Average nutrient intake of lactating mothers compared with estimated average requirement

Table 3: Diet diversity score of the subjects

		Score (%)	
S. No.	*Food groups*	*Yes*	*No*
1.	Cereals and millets	100	0
2.	Pulses and legumes	70	30
3.	Milk	62	38
4.	Milk products	15	85
5.	Roots and tubers	61	39
6.	Green leafy vegetables	26	74
7.	Other vegetables	46	54
8.	Fruits	21	79
9.	Organ meat	0	100
10.	Flesh meats	4	96
11.	Egg	1	99
12.	Fish and seafood	6	94
13.	Nuts and oilseeds	0	100
14.	Fats and oils	100	0
15.	Spices, condiments and beverage	100	0

Analysis of dietary nutrient intake of the pregnant women shows that there was a deficiency of 32.6% in iron intake compared to their estimated average requirements.[10] The nutrient intake of lactating mothers, as depicted in Figure 5, shows that they were consuming only 50% of the required iron and calcium. These results are comparable to those of previous studies. A cross-sectional study, conducted among urban slum dwellers in Siddipet among pregnant and lactating mothers to assess the adequacy of nutrient intake, revealed that 90% of pregnant women and 50% of lactating mothers consumed inadequate amounts of calorie and protein.[11]

Table 3 shows the diet diversity of the subjects. All the subjects consumed more than six food groups and therefore fell under the high diet diversity category.

Table 4: Awareness on usage of garden cress seed

	Response of subjects in %	
Awareness aspects	*Yes*	*No*
Identification of garden cress seeds	0	100
Knowledge about garden cress seeds	0	100
Cost of garden cress seeds	0	100
Consumption of garden cress seeds	0	100
If yes, form of consumption	0	100
Garden cress seeds consuming during	Not applicable	
How often do you consume?	Not applicable	
Reason for using garden cress seeds	Not applicable	
Special food consumed during pregnancy and lactation period	Banana stem, all types of greens (methi, spinach, shepu, and amaranth leaves), lentils	

Fig. 6: Garden cress seed

Utilization and Awareness of Garden Cress Seeds

Awareness regarding the use of garden cress seed is presented in Table 4. A list of the questions was asked to each subject about the identification, cost and in which form they consumed garden cress seeds, reason, allergies, and health benefits of garden cress seeds. Based on the study, it was found that none of the subjects were able to identify garden cress seeds and had never used garden cress seeds. Greens were consumed as a special food during their pregnancy and lactating period as they are considered as galactagogues and rich in iron.

A number of studies have reported the usage of garden cress seeds across various parts of India as well as worldwide (Fig. 6). According to one research study, garden cress seeds help to prevent several diseases and improve hemoglobin levels.[12] They have many medicinal properties, including anti-inflammatory, anti-diabetic, hepatoprotective, anti-microbial and chemoprotective qualities. Garden cress seeds are used as an emmenagogue to induce menstruation because of their estrogenic properties, and

they are used to prevent hormonal imbalances or conditions such as oligomenorrhea. In the postnatal stage, garden cress seeds are used as galactagogue, to improve milk production in lactating mothers. By stimulating dopamine receptors, they provide pharmacological effects that raise prolactin level and thereby increase milk production.

A study was conducted on the effect of supplementation with garden cress seeds on hemoglobin levels in Bilwara city.[13] Out of 50 girls selected for the study, 10 girls were identified as anemic. Every morning, soaked and dried 5 g of garden cress seed powder was mixed with different recipes and provided for 1 month. The results showed that the hemoglobin level improved from 9.19 to 10.93 gm/dL.

Several studies have reported the culinary use of garden cress seeds. Foods such as dahiwala bread, rice-wheat bread, iron-rich biscuits, and healthy drinks have been supplemented with garden cress seeds.[14] The garden cress plant and its seeds are traditionally used in Saudi Arabia and other Arab countries as a medication to treat bone fractures. Because of their high iron and protein content, they are used in preparing sweets and given to postnatal mothers.[15] In India, according to NFHS survey (2019–21), 57% of women suffer from anemia, and anemia has been recognized as a public-health problem, and popularizing the usage of garden cress seed can be a right step toward achieving Anemia Mukth Bharath.

Conclusion

In the present study, 65% of pregnant and lactating women were suffering from malnutrition. The average intake of micronutrients such as iron and calcium was almost half of the recommended requirements. Although garden cress seed are a rich source of macronutrients and micronutrients—providing energy, protein, fat, calcium, and iron—the subjects had neither heard of garden cress seeds nor could identify them. Therefore, there is a need to popularize the usage of garden cress seeds, particularly among pregnant and lactating women.

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RESEARCH ARTICLE

Association between Digital Literacy and Utilization of Healthcare Services among Women in India

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Abstract

This study attempts to understand the association between digital literacy and the utilization of maternal healthcare services among women in India, utilizing data from the National Family Health Survey (NFHS-5, 2019–2021). Digital literacy, defined as the ability to effectively use digital tools and platforms, plays a crucial role in accessing healthcare information and services, particularly in a rapidly digitalizing world. The study assesses three key maternal healthcare components: Antenatal care (ANC), institutional delivery, and postnatal care (PNC). It explores the influence of digital literacy indicators, including mobile phone ownership, internet use, and text message reading, on service utilization. Findings reveal significant disparities in digital literacy based on age, residence, education, wealth, religion, and occupation. Women with digital literacy demonstrated higher utilization rates across all maternal healthcare services. For instance, digitally literate women had higher institutional delivery rates (96.9%) compared to those without digital literacy (86.5%). Urban residents, educated individuals, and wealthier groups exhibited greater digital proficiency, translating into improved healthcare access. The study underscores the transformative potential of digital literacy in enhancing maternal healthcare utilization and highlights the need for targeted interventions to bridge digital divides among marginalized groups, ensuring equitable healthcare access and improving maternal health outcomes in India.

Keywords: Antenatal care, Digital literacy, Healthcare utilization, India, Postnatal care, Women.

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Introduction

Digital literacy is defined as an individual's ability to search, find, evaluate, and compose clear information through typing, writing, tapping, and using other mediums (e.g., multimedia videos, video calling, and messaging) on various digital platforms, which requires a basic level of computer competency.[1–3] Digital literacy is no less equivocal a concept than that of information services. It is one of numerous new literacies introduced and discussed in various disciplinary contexts during the last couple of decades. Several researchers have attempted to bring analytical order into the discourse by writing comprehensive reviews of the concept of digital literacy and its relation to partly overlapping concepts such as information literacy, library literacy, media literacy, and computer literacy.[1,4] As Bawden remarks, there is a certain observable continuum from the early references to computer literacy and the subsequent emergence of new forms of literacy, from information literacy to the internet, web literacy, and digital literacy. The importance of digital literacy has been recently recognized by UN Women; the theme for International Women's Day 2023 was "DigitALL: Innovation and Technology for Gender Equality." The transformational and all-encompassing role of digital technology is growing even faster in the post-pandemic world.

Digital literacy plays a significant role in healthcare utilization, especially in today's technologically advanced world.[5] Digital literacy can impact healthcare utilization in access to information, telemedicine and telehealth, electronic health records (EHRs), health tracking and wearable devices, online appointment booking, health education and remote support, health apps, and self-management. Digital literacy enables individuals to access a wealth of health-related information available online.[6,7] People can research symptoms, diseases, treatment options, and preventive measures, allowing them to make informed decisions about their health and healthcare utilization.[8] Digital literacy is crucial for utilizing telemedicine and telehealth services. These services involve remote consultations, virtual appointments, and remote monitoring of patients.[9] Individuals with digital literacy can effectively use video conferencing platforms, mobile apps, and remote monitoring devices, expanding their access to healthcare professionals without physical barriers. Digital literacy enables individuals to schedule appointments with healthcare providers using online platforms. This convenience saves time and encourages regular check-ups and preventive care, enhancing healthcare utilization rates. It enables individuals to access online health education resources and support communities. They can participate in webinars, online forums, and social media groups to learn about specific health conditions, share experiences, and seek support from peers and healthcare professionals. This knowledge and support can positively influence healthcare utilization by encouraging individuals to seek appropriate care when needed. With digital literacy, individuals can utilize health apps that help

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with self-management of chronic conditions, medication reminders, mental health support, and healthy lifestyle choices. These tools empower individuals to take an active role in their healthcare, leading to better healthcare utilization outcomes. The current study examines the impact of digital literacy on healthcare service utilization among women in India.

Materials and Methods

Data Source

The study used information collected from women aged 15–49 years who had at least one live birth in the past 5 years preceding the survey. These data were taken from the fifth round of the National Family Health Survey (NFHS-5) 2019–2021. The NFHS is a nationally representative survey of households and is designed to complement existing Indian surveys by bringing together a wide range of socioeconomic, demographic, and health issues. The sample households are selected through a stratified probability proportion to size sampling design.

Outcome Variables

Utilization of maternal health care services has three major components: Antenatal care (ANC), delivery care, and postnatal care (PNC). Adequate ANC was assessed based on at least four ANC visits. We have considered "institutional delivery" as an indicator of safe delivery care. Institutional deliveries were defined as those deliveries that occurred in a medical institution such as a government hospital, dispensary, primary health center, community health center or subcenter, non-governmental hospital, or private clinic. In addition, a PNC check-up within 42 days of delivery is considered the PNC indicator as per the recommendation of the World Health Organization (WHO).

Predictor Variables

Information on digital literacy was collected in the NFHS, including the use of a mobile phone, use of the internet, and reading text messages. This information was collected to calculate digital literacy among eligible women.

Calculation of Digital Literacy

Those who said "yes" to at least one variable is considered as having digital literacy:

- Do you have any mobile phone that you use yourself?
- Do you use your mobile phone for any financial transactions?
- Have you ever used the internet?
- Are you able to read text (SMS) messages?

Further, information on the socioeconomic and demographic characteristics of women that could potentially affect healthcare utilization was collected, including education, age at marriage, birth order, place of residence, social group, religion, wealth index, and state.

Statistical Analysis

Inferential statistics, including bivariate and multivariate analysis and percentage change, were used to examine the level and pattern of digital literacy among women and its effect on healthcare utilization. Chi-square tests at a 95% level of significance were used to check the statistical significance of any specific association studied in the above-mentioned analysis.

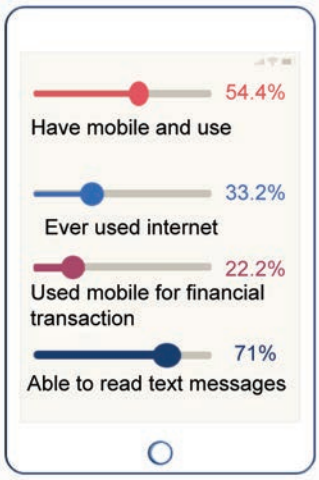

Fig. 1: Status of mobile phone uses among women in India, 2021

Result and Discussion

The current study found that 54% of women have a mobile phone that they themselves use. Seventy-one percent of women who have a mobile phone can read text messages (Fig. 1). One-third of women aged 15–49 have ever used the internet in India and only 22% of them are using a mobile for financial transactions. Recently, the Odisha government introduced the "Subhadra" scheme aimed at empowering women across the state. This initiative focuses on promoting the use of mobile phones and online transactions, integrating women into the vision of a Digital India. The scheme encourages women to actively engage in digital transactions, fostering financial independence and digital literacy.[10]

Table 1 presents the socioeconomic and demographic characteristics of women aged 15–49 in India between 2019 and 2021, based on their digital literacy levels. The data show that women in the 20–29 age-group had the highest digital literacy rate (14.3%), followed by those aged 30 or above (8.0%). The youngest group (<20) had the lowest digital literacy rate at 7.0%. Previous studies conducted also support a similar pattern where digital literacy varies by age-group.[9] When considering the place of residence, urban women exhibited significantly higher digital literacy rates (19.5%) compared to their rural counterparts (6.7%). Educational level also had a significant impact on digital literacy. Women with higher education levels had the highest digital literacy rate (36.9%), followed by those with secondary education (8.3%), primary education (1.9%), and no education (0.8%). The wealth index also played a role; women in the richest category had the highest digital literacy rate (27.1%), followed by the richer (13.2%), middle (7.4%), poorer (3.9%), and poorest (1.8%) categories. In terms of religion, Christian women had the highest digital literacy rate of 14.2%, followed by those from other religions (16.2%), Hindu women (9.5%), and Muslim women (7.4%). Occupation type also had a significant association with digital literacy. Professional women had the highest digital literacy rate (49.3%), followed by those engaged in agriculture (16.6%), unskilled manual labor (12.3%), sales and services (8.1%), and domestic service (3.2%). Lastly, exposure to mass media showed a significant correlation with digital literacy. Women who were exposed to mass media had a higher digital literacy rate (12.1%) compared to those who were not exposed (2.8%). Overall, the findings indicate that younger

Table 1: Socioeconomic and demographic characteristics of women aged 15–49 years who had digital literacy in India, 2019–2021

Characteristics	*Digital literacy*	*p-value*
Age		0.000
<20	7.0	
20–29	14.3	
30 or above	8.0	
Place of residence		0.000
Urban	19.5	
Rural	6.7	
Educational level		
No education	0.8	
Primary	1.9	
Secondary	8.3	
Higher	36.9	
Wealth index		0.017
Poorest	1.8	
Poorer	3.9	
Middle	7.4	
Richer	13.2	
Richest	27.1	
Religion		0.000
Hindu	9.5	
Muslim	7.4	
Christian	14.2	
Others	16.2	
Occupation type		0.000
Professional	49.3	
Sales and services	8.1	
Unskilled manual	12.3	
Domestic service	3.2	
Agriculture	16.6	
Mass media		0.000
Not exposed	2.8	
Exposed	12.1	

age-groups, urban residents, women with higher education levels, wealthier individuals, Christians and women from other religions, professionals, and those exposed to mass media are more likely to have higher levels of digital literacy in India.[7]

Table 2 presents the percentage distributions of ever-married women aged 15–49 in India who had at least one live birth in the last 5 years preceding the survey, based on their utilization of maternal health care services. The categories include ANC, institutional delivery, and PNC checkups. When analyzing the data by age-group, result show that women across all age-groups had relatively similar rates of ANC utilization, ranging from 56.05 to 58.27%. However, the

Table 2: Percentage distributions of utilization of maternal health care services by background characteristics in India, 2019–2021

Characteristics	*Atleast four ANC*	*Institutional delivery*	*PNC check-up*
Digital literacy			
No	57.38	86.51	35.75
Yes	69.34	96.89	37.6
Age			
<20	56.05	88.14	36.27
20–29	58.27	89.1	37.39
30 or above	58.03	84.98	38.59
Place of residence			
Urban	68.74	94.29	39.13
Rural	55.24	86	32.41
Educational level			
No education	43.17	75.29	33.07
Primary	52.01	81.59	35.71
Secondary	61.75	91.29	41.02
Higher	70.91	97.54	45.32
Wealth index			
Poorest	43.3	74.33	32.29
Poorer	53.76	86.42	34.53
Middle	62.49	92.43	36.1
Richer	68.34	95.54	39.12
Richest	72.7	97.7	43.84
Religion			
Hindu	59.17	90.22	37.3
Muslim	58.07	86.16	38.19
Christian	49.71	68.23	41.13
Others	55.58	87.5	41.09
Occupation type			
Professional	72.11	95.35	36.67
Sales and services	61.25	84.9	35.81
Unskilled manual	54.15	82.46	44.95
Domestic service	54.24	79.77	43.91
Agriculture	60.16	88.98	43.97
Mass media			
Not exposed	43.09	77.5	35.35
Exposed	63.9	91.72	45.02
Have mobile phone and use			
No	53.7	83.06	35.49
Yes	61.73	90.47	40.33
Financial transaction through mobile			
No	60.67	89.21	34.56
Yes	65.91	95.39	38.76
Internet use			
No	54.28	83.95	33.94
Yes	66.98	94.59	39.31
Read text messages			
No	50.44	79.85	34.05
Yes	64.47	92.96	42.79

percentage of institutional delivery and PNC checkup varied slightly, with the highest rates found among women aged 20–29. Looking at the place of residence, urban women had higher utilization rates across all three categories compared to rural women. Urban women had the highest rates of institutional delivery (94.29%) and PNC checkup (39.13%), while rural women had lower rates, particularly regarding PNC checkups (32.41%).

Educational level exhibited a positive association with maternal health care service utilization. As educational levels increased, the percentage of women utilizing ANC, institutional delivery, and PNC checkups also increased. Women with higher education levels had the highest utilization rates in all three categories. The wealth index showed a similar trend, with the richest women having the highest utilization rates across all categories while the poorest women had the lowest rates. In terms of religion, Christian women had the lowest utilization rates for ANC and institutional delivery, while Muslim women had the lowest utilization rate for PNC checkup. Hindu women had the highest rates for ANC and institutional delivery. Occupation type showed variation in utilization rates. Professional women had the highest rates across all three categories, followed by women in agriculture and sales/services occupations. Exposure to mass media had a positive impact on utilization rates, with women who were exposed to mass media having higher rates in all categories compared to those who were not exposed. When considering digital literacy factors, women with digital literacy had higher utilization rates in all three categories compared to those without digital literacy. Overall, the findings suggest that there are disparities in maternal health care service utilization based on age, place of residence, educational level, wealth index, religion, occupation type, exposure to mass media, and digital literacy.[11] Efforts should be made to improve access and awareness of maternal health care services among marginalized groups and ensure equitable utilization across all demographics in India.

The Figure 2 represents the status of digital literacy among women in different states and union territories of India. The findings reveal significant variations in digital literacy levels across different regions. Among the states and union territories mentioned, Goa had the highest digital literacy rate at 43.2%, indicating a relatively higher level of technological proficiency among women. Puducherry followed closely with a digital literacy rate of 29.5%. These regions seem to have made significant progress in equipping women with digital skills. Other states and union territories with relatively higher digital literacy rates include Chandigarh (23.3%), Arunachal Pradesh (27.6%), NCT of Delhi (26.2%), and Ladakh (18.3%). These regions have made commendable efforts to empower women with digital literacy, enabling them to navigate the digital world more effectively. On the other hand, several regions reported lower digital literacy rates. Bihar had the lowest digital literacy rate at 3.0%, indicating a significant gap in digital skills among women in the state. Other states with relatively low rates include Tripura (3.2%), Uttar Pradesh (5.9%), West Bengal (5.2%), Jharkhand (7.2%), and Manipur (5.8%). The data suggests that there is still a considerable disparity in digital literacy levels across different regions in India.[12] Efforts should be directed toward bridging this gap and providing equal opportunities for women to acquire digital skills. Initiatives focused on digital education and training can play a vital role in empowering women, enabling them to access information, opportunities, and resources available in the digital sphere.

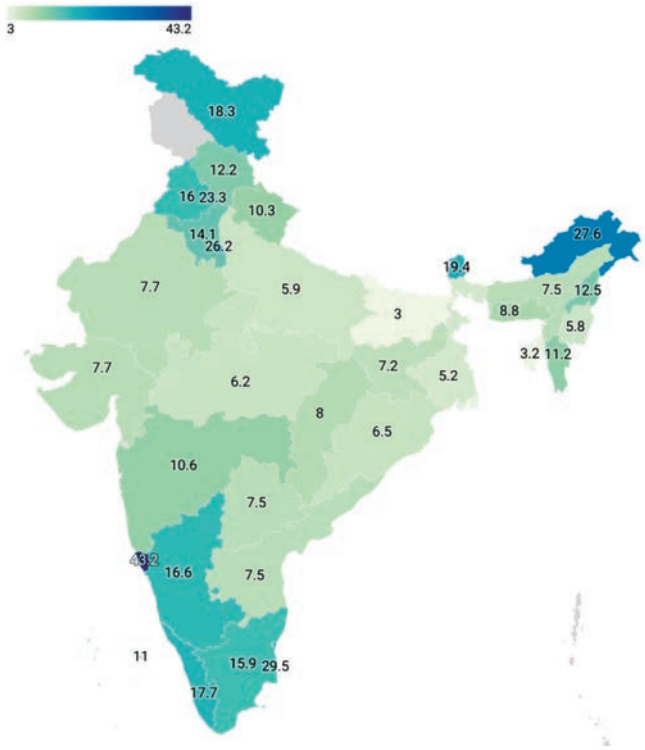

Fig. 2: Status of digital literacy among women in India, 2021

Conclusion

This study shows the profound impact of digital literacy on maternal healthcare utilization in India. Women with even basic digital skills are better equipped to access essential healthcare services such as ANC, institutional deliveries, and PNC checkups, which are critical for reducing maternal and neonatal morbidity and mortality. The findings reveal that digital literacy not only empowers women to make informed decisions but also enhances their interaction with healthcare providers and access to vital health information. Women from rural areas, lower-income households, and marginalized communities are disproportionately affected, emphasizing the urgent need for targeted interventions. Bridging this digital divide through inclusive policies, community-based digital training programs, and investments in digital infrastructure can significantly enhance healthcare equity. Policymakers, healthcare providers, and stakeholders must collaborate to harness the potential of digital literacy as a catalyst for improved maternal health outcomes. Ultimately, fostering digital empowerment among women will not only address maternal health challenges but also contribute to broader goals of gender equity and sustainable development.

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RESEARCH ARTICLE

Menstrual Hygiene Practice and Nutritional Status among Adolescent Girls of Gadaba Tribe of Koraput District, Odisha

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Abstract

Adolescence is an important phase of life that bridges childhood and adulthood. This represents a transitional period with biophysical, psychosocial, and physiological development. It is one of the most vulnerable times for female reproductive health. This phase requires an adequate diet and nutrition for proper development and growth. Along with good nutrition, proper menstrual hygiene is essential to ensure the overall health of adolescent females. The study aims to provide insight into menstrual hygiene practices, along with the age at menarche, patterns of menstruation, and sources of knowledge regarding menstruation, and the nutritional status among adolescent girls of the Gadaba tribe in the Koraput district of Odisha. A total of 142 girls aged 10–19 years were selected using purposive sampling from different school hostels and households. Inclusion criteria were an age between 10 and 19 years, female sex, belonging to the Gadaba tribe, and a willingness to participate. Data were collected using a pre-tested, semi-structured questionnaire. The study found that out of 133 participants, 93.7% had already attained menarche, while the mean age at menarche was 12 years. Furthermore, 35% reported an irregular menstrual cycle, and 51% experienced menstrual discomfort. About 49% used only sanitary pads, 3% used only cloth and 48% used both. Most of the participants received knowledge of menstruation from mother (46.5%), followed by friends (24.6%), sisters (16.9%), and teachers (12%). As per body mass index (BMI) classification, 91.5% were normal and 7.74% were underweight. This study revealed that most of the girls used both cloth and sanitary napkins; however, they preferred to use cloth during the initial days of their menstrual cycle when there was a heavy flow. The menstrual absorbent cloths were often reused without adequate washing or sun-drying, thereby increasing the risk of reproductive tract infections. This practice is reinforced by sociocultural taboos that discourage the exposure of menstrual materials to male members or other family members within the household.

Keywords: Adolescent health, Cross-sectional study, India, Menarche, Reproductive health, Tribal health, Women.

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Introduction

Adolescence is a separate phase of life that bridges childhood and adulthood. This represents a transitional period with biophysical, psychosocial, and physiological development from puberty to adulthood. Adolescents, often called as teens, are young boys and girls between the age of 10 and 19 years.[1] Around 22% of the population in India are adolescents (243 million).[2] This is one of the most vulnerable time periods for girls' reproductive health and nutrition, which require prime attention and protection. Malnutrition is a multifactorial condition that is always embedded within various sociocultural and economic reasons. Among adolescents, the girls are more vulnerable to malnutrition in developing countries including India. Adolescent girls are future mothers; therefore, their health is of critical importance, as neglecting it adversely affects the health and nutritional status of future generations.

Odisha, a state of India, occupies a unique position in tribal ethnography comprising 64 Scheduled Tribes, including 13 particularly vulnerable tribal groups (PVTGs).[3] As per the 2011 census, the Scheduled Tribe population accounts for 22.21% of the state population.[4] Tribal communities are found in almost all districts of Odisha with significant numbers in Mayurbhanj, Sundargarh, Koraput, Malkangiri, Rayagada, Nabarangpur, Kalahandi, and Nuapada. Koraput district, located at the southernmost point of the state, is a home to 22 major tribal communities, and the Gadaba is one of them. Gadaba is a prominent and colorful tribe with total population of 84,689, having a major concentration in the Semiliguda, Pottangi, Nandapur, Boipariguda, and Lamtaput blocks of the Koraput district. They are broadly classified as Gutob Gadaba or Bada Gadaba and Ollar Gadaba or Sana Gadaba speaking Austroasiatic and Dravidian languages, respectively. Their sex ratio is 1,008, and the total literacy rate is 39.30% (Male = 51.12, Female = 28.42).[5]

Despite recently launched Reproductive and Child Health (RCH) program in National Family Health Survey-4 (NFHS-4), adolescent health and nutrition is still a public health issue in India. In fact, many studies show that tribal populations are the major victims of undernutrition in the country due to their unique sociocultural practices and traditional norms. However, there is a paucity of information regarding adolescent health and nutrition in Odisha, especially among tribes. The Gadaba tribe is the only one community in the state with two linguistic off-shoots, one speaking Gutob (Austroasiatic stock) and the other speaking Ollar

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(Dravidian stock). They are entitled PVTGs status in Andhra Pradesh and ST status in Odisha.[5] This is the unique characteristic for which the Gadaba tribe was selected for this study. Keeping this in view, the present study aims to assess the health and nutritional status of adolescent girls of the Gadaba community. In addition, it also attempts to know their menstrual health and hygienic practices.

Methods

A community-based cross-sectional study was conducted in the Lamtaput block of Koraput district, Odisha, to assess the menstrual health and nutritional status of adolescent girls belonging to the Gadaba tribal community. Prior consent was obtained from the study participants and their guardians before collecting the data. A total of 142 girls aged 10–19 years were selected using purposive sampling from high school hostels, ashram schools, and individual households. Inclusion criteria were an age between 10 and 19 years, female sex, belonging to the Gadaba tribe, and a willingness to participate. Data were collected using a pre-tested, semi-structured questionnaire covering sociodemographic details, age at menarche, menstrual patterns, hygiene practices, and sources of menstrual knowledge. Anthropometric measurements, including height and weight, were recorded to calculate body mass index (BMI), which was then converted into BMI-for-age Z-scores (BAZ) using WHO reference standards for ages 5–19. Nutritional status was classified based on BAZ as severely thin (BAZ < –3 SD), thin (–3 SD ≤ BAZ < –2 SD), normal (–2 SD ≤ BAZ ≤ +1 SD), overweight (+1 SD < BAZ ≤ +2 SD), and obese (BAZ > +2 SD). Data were analyzed using IBM SPSS Statistics Version 20, and descriptive statistics such as frequency, percentage, and mean were used for the analysis.

Results

A total of 142 adolescent girls aged between 10 and 19 years and belonging to the Gadaba tribal community participated in the study. Among them, 17.6% were in early adolescence (10–12 years), 48.6% were in the middle adolescence group (13–15 years), and 33.8% were in late adolescence (16–19 years). With regard to education, 9.15% had completed primary education, 25.4% had lower secondary education, 62% had attained the upper secondary level, 2.11% had reached higher secondary, and 1.4% were at the graduation level. The majority (93.7%) were currently attending an educational institution. Most participants (77.5%) resided in high school hostels, 14.08% in their own homes, and 8.5% in ashram school hostels. All respondents reported Hinduism as their religion (Table 1).

Out of the total participants, 93.7% (n = 133) had already attained menarche, while 6.3% (n = 9) had not yet experienced it. Among those who had attained menarche 71.5% experienced it between the ages of 11 and 13, 15.03% between 14 and 16 years, and 13.6% at or before the age of 10. The mean age at menarche was 12 years (Fig. 1). Regular menstrual cycles were reported by 65% of participants, while 35% indicated irregular patterns (Fig. 2). The duration of menstrual flow was 4–5 days in 45.12% of participants, 6 days or more in another 45.12%, and 3 days or less in 9.77%. Out of the 133 girls who responded to the question regarding menstrual discomfort, 51.1% reported experiencing discomfort during menstruation, while 48.9% did not report any discomfort (Table 2).

Regarding menstrual hygiene practices, 49% used only sanitary pads, 48% used both sanitary pads and cloth, and 3% used cloth alone (Fig. 3). For disposal, 53.3% used methods like burning or burying after a single use, 43.7% reused and combined disposal, and 3% reused cloth without disposal (Fig. 4). Most of the participants received knowledge of menstruation from their mothers (46.5%), followed by friends (24.6%), sisters (16.9%), and teachers (12%) (Fig. 5).

As per the BMI-for-age classification, 130 out of 142 participants were in the normal category. A small fraction, 10 out of 142, fell under the thinness category, while one participant in each was classified as severely thin and overweight. No participants were found to be obese (Table 3).

Table 1: Characteristics table of participants

Characteristics	*N (%)*
Age	
Early	25 (17.6)
Middle	69 (48.6)
Late	48 (33.8)
Educational status	
Primary	13 (9.15)
Lower secondary	36 (25.40)
Upper secondary	88 (62.00)
Higher secondary	3 (2.11)
Graduation	2 (1.40)
Currently attending educational institute	
Yes	133 (93.7)
No	9 (6.3)
Type of residence	
Own home	20 (14.08)
High school hostel	110 (77.5)
Ashram school hostel	12 (8.5)
Religion	
Hindu	142 (100)
Others	Nil

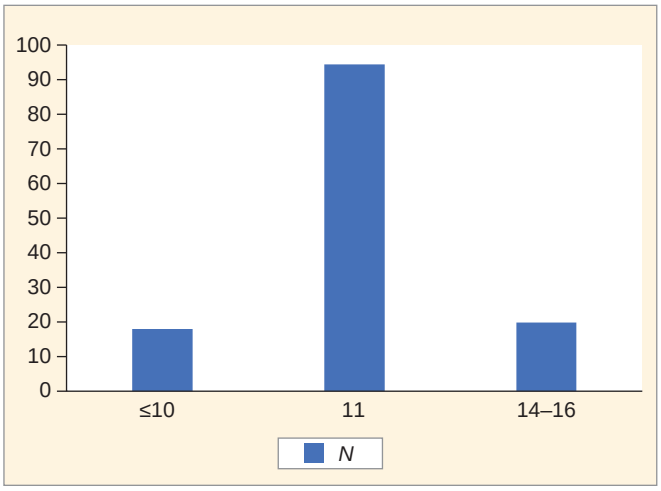

Fig. 1: Age at menarche

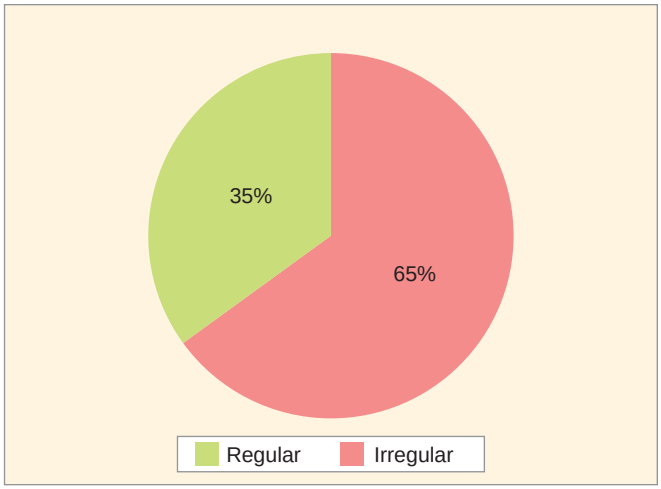

Fig. 2: Menstrual cycle

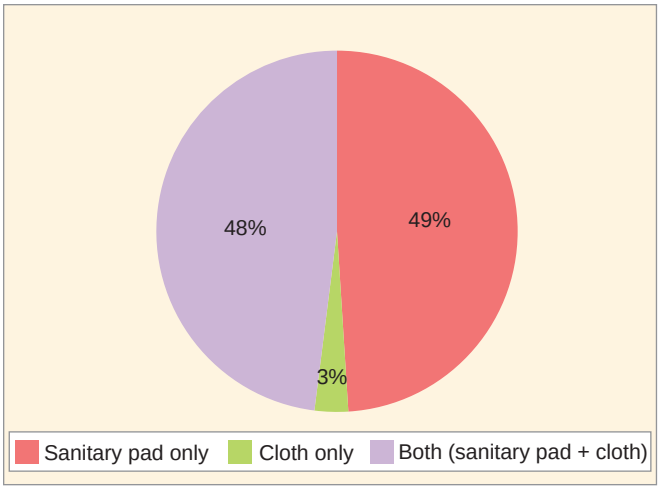

Fig. 3: Types of absorbent

Table 2: Menstrual variables

Menstrual variables	*N (%)*
Attended menarche	
Yes	133 (93.7)
No	9 (6.3)
Age at menarche	
≤10	18 (13.60)
11–13	95 (71.50)
14–16	20 (15.03)
Menstrual cycle	
Regular	87 (65)
Irregular	46 (35)
Duration of menstrual flow (days)	
≤3	13 (9.77)
4–5	60 (45.12)
≥6	60 (45.12)
Felling discomfort during menstruation	
Yes	68 (51.1)
No	65 (48.9)

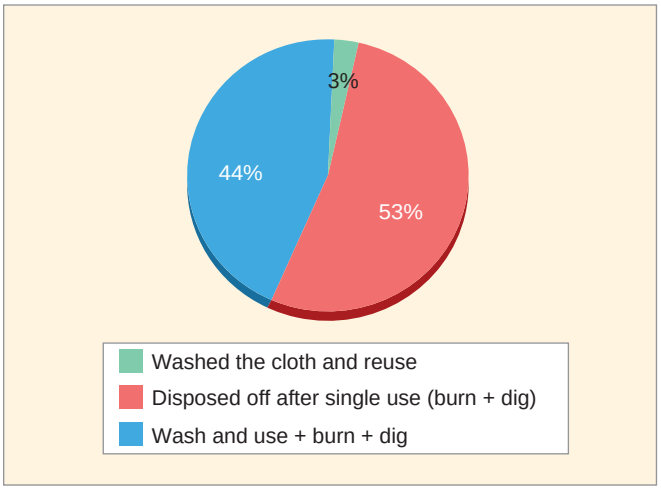

Fig. 4: Disposal method

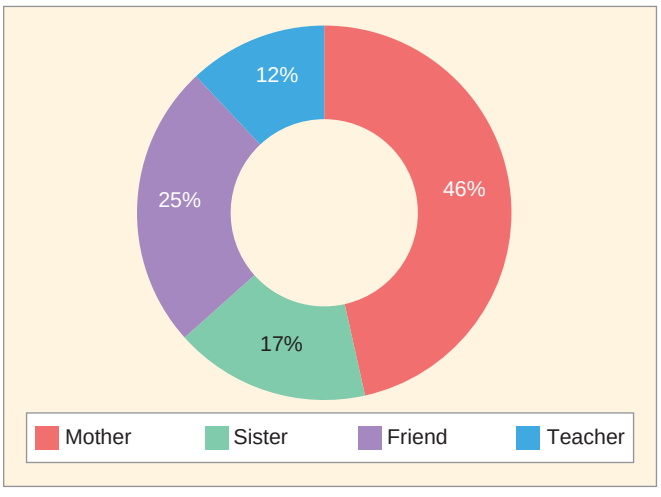

Fig. 5: Source of knowledge regarding menstruation

Discussion

Adolescent girls are more vulnerable to malnutrition and poor health. Menstrual hygiene practices determine the knowledge, attitudes, and practices towards their health. In this regard, the present study found that 17.6, 48.6, and 33.8% of girls belonged to early adolescence (10–12 years), mid-adolescence (13–15 years), and late adolescence (16–19 years), respectively. All the participants were literate, with the highest 62% upper secondary education followed by 25.4% with lower secondary education, 9.15% with primary education, 2.11% with higher secondary, and 1.4% who were graduates. Almost all of them were students and currently attending educational institutions (93.7%), residing in high school hostels (77.5%), followed by ashram hostels (14.8%) and their own houses (8.5%). All participants followed Hinduism.

In this study, around 93.7% (n = 133) of the girls had already attained menarche, while 6.3% (n = 9) were yet to experience it. Of the girls who had reached menarche, 71.55% experienced it between 11 and 13 years of age and 15.03% between 14 and 16

Table 3: Nutritional status as per BMI for age

BMI for age category	*N (%)*
Severe thinness	1 (0.70)
Thinness	10 (7.04)
Normal	130 (91.5)
Overweight	1 (0.70)
Obesity	Nil

years, and only 13.6% experienced their first menstruation at or before the age of 10 years. Similarly, the previous cross-sectional studies conducted by Panda et al.[6] and Baliga et al.[7] showed 13.5 ± 0.22 and 13.00 ± 2.15 years, respectively, as the mean age of menarche. A study conducted among the Dongria Kondh girls by Nanda and Dhar[8] reported that 4.3% of girls attained menarche between 10 and 12 years, 74.19% between 12 and 14 years, and 21.51% between 14 and 16 years, which is similar to the current study. It was also noticed that most of the Gadaba girls under study had menses on a regular basis (65%), while 35% reported irregular cases. About 45.12% of girls experienced menstrual flow for more than 6 days, which was similar to the study by Panda et al.,[6] which reported 54.8% irregular cases and 63.5% experiencing menstrual flow for more than 6 days. Regarding the source of information about menstruation, Chattopadhyay et al.[9] reported the primary source of information about menstruation as mothers followed by other family members, friends, sisters, and teachers. Similarly, the present study found mothers (46.5%) followed by friends (24.6%), sisters (16.9%), and teachers (12%) but no other family members except mother as primary source of information. Nonetheless, menstrual discomfort is a part of the cycle, and some face painful symptoms while others do not. Unlike the study reported by Chattopadhyay et al.,[9] where 37.4% underwent menstrual pain, the current study revealed that more than 50% of the participants experienced discomfort (51.1%). It is a matter of concern that unhygienic menstrual practices is a public health issue in India. And menstrual hygiene is a crucial practice leading to better adolescent health and reproduction. It involves awareness, knowledge, attitudes, and practices towards menstruation. When it comes to tribals, the menstrual hygienic practices are poor and always deals with sociocultural rituals. As the participants in the present study were school-going girls, it was found that 49% used only pads, 48% used both pads and cloths, and 3% used only cloth. These findings showed similarities to other studies, such as Chattopadhyay et al.,[9] who reported 61% using only pads, 31.6% only cloth, and 7.2% both pads and cloths; the study conducted by Das et al.[10] reported 53% use of napkins/pads by elder girls, 22.2% both pad and cloth, 13.3% clean cloth, and 11% only ordinary cloth and the study in Jaipur city by Shekhawat et al.[11] showed 96.8% use of sanitary napkins and 3.2% used cloth as menstrual absorbent. But current study differed from the study among Dongria Kondh girls by Nanda and Dhar which revealed poor menstrual hygiene as they used only old cloth and do not bathe during menstruation.[8] After the use of menstrual absorbents, their disposal is a crucial practice. The current study found that 53.3% of girls adopted methods like burning or burying after a single use, 43.7% reused materials or and combined disposal methods, and 3% reused cloth without disposal. The reuse of used cloths without proper disposal shows unhygienic health practices which may cause infections and irritations. The reasons for this may be a lack of awareness about its ill effects and unlikeness towards modern menstrual absorbents by the Gadaba girls.

As adolescence is a critical transitional stage from childhood to adulthood, any imbalance in growth and development will consequently affect the future generations. The nutritional status of adolescent girls determines the health of the future mothers. Consequently, the present study found a prevalence of 0.70% severe thinness, 7.04% thinness, 0.70% overweight, and no participants who were obese. The current findings were less compared to an international community study by Teji et al.[12] which showed the prevalence of 6.6% severe thin, 15.0% thin, 4.8% overweight, and 1.1% obese in Eastern Ethiopia. Similarly, the present study found thinness (7.04%) to be very less than 14.7% in North 24 Parganas district of West Bengal a study conducted by Das and Biswas[13] and 17% in the study by Chattopadhyay et al.[9] in the poverty pockets of eastern India.

The cross-sectional studies which showed a higher prevalence of thinness than the present study include the study by Prashant and Shaw,[14] which showed a 20.6% prevalence among the adolescent girls in an urban slum area of South India, by Kuiti et al.[15] among the Juangs of the Keonjhar district in Odisha, and the study by Nair et al.[16] in a rural area of Maharashtra, which reported an 18.87% prevalence of thinness. Furthermore, the findings of the current study were extremely less than the study conducted by Mulugeta et al.,[17] which found a 58% prevalence of thinness among the northern Ethiopian girls. The present study reported 0.70% overweight and no obese individuals. This finding was much lower than the findings of other studies conducted by Chandrashekarappa et al.,[18] which showed a prevalence of 12.3% overweight, Wolde et al.,[19] which showed a prevalence of 5.21% overweight among the adolescent girls in southwest Ethiopia, and Shekhawat et al.[11] in Jaipur city, which revealed 38% overweight and 2.2% obese rates among adolescent girls.

The variations in the nutritional status of these studies may be due to the use of different reference cut-off points, age group classifications, socioeconomic status, age-sex selection, and obviously diverse regions. A major limitation of the study is that it included only height and weight, BMI for age as anthropometric parameters, for the nutritional status assessment whereas other studies had combination of the 24-hour food recall method, mid-upper arm circumference (MUAC). Additionally, many studies[6–11] lacked the data on the disposal of sanitary napkins.

Conclusion

As adolescence is a critical transitional stage from childhood to adulthood, any imbalance in the growth and development will consequently affect the future generations. Adolescent girls are future mothers, and their health is of great significance; if it is not prioritized, it will adversely affect the health and nutritional status of future generations. Almost all study participants were under the normal category with least thinness and none were obese. As most of the participants were residing in nearby hostels in Lamtaput, a planned and balanced food menu may be an advantage. Regarding menstrual hygiene, most of them are using the sanitary napkins, some are using both cloth and pads, while a few are using cloth only. Most of the girls preferred to use cloth during the initial days of their menstrual cycle if there was a heavy flow. The menstrual absorbent cloths were often reused without adequate washing or sun-drying, thereby increasing the risk of reproductive tract infections. This is

reinforced by sociocultural taboos that discourage the exposure of menstrual materials to male members or other family members within the household. Their belief about the evil effect of exposure of menstrual materials led them to dispose the menstrual absorbent by cleaning and then burning or burying under earth. The fact that most of the respondents are currently attending educational institutions is a good sign of growth and development.

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RESEARCH ARTICLE

Determinants of Life Expectancy in Developing Countries: A Comparative Analysis 2012–2022

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Abstract

Introduction: Life expectancy is a key indicator of population health and development. Understanding its determinants is crucial for effective health policy, especially in developing countries where resources are limited.

Objective: This study aimed to identify and compare the socio-economic and demographic determinants of life expectancy in 2012 and 2022 across 110 developing countries, assessing how their influence and the explanatory power of a standard model changed over the decade.

Methodology: A comparative cross-sectional analysis was conducted using national data from the World Bank's World Development Indicators (WDI). Multiple linear regression models were used to analyze the relationship between life expectancy and four independent variables: Gross domestic product (GDP) per capita, access to basic sanitation, total fertility rate, and urban population percentage.

Results and conclusion: Access to basic sanitation and a lower fertility rate were strong, significant predictors of higher life expectancy in both periods, with the influence of fertility strengthening over time. Gross domestic product per capita and urbanization were not significant direct predictors. A critical finding was a marked decline in the model's explanatory power, with R^2 falling from 0.737 in 2012 to 0.629 in 2022. This indicates that while investments in sanitation and fertility reduction remain fundamental, factors beyond traditional socio-economic models, such as health system resilience and governance, have become increasingly important. Policymakers must therefore bolster foundational health investments while building systems capable of addressing complex modern challenges like pandemics and non-communicable diseases (NCDs).

Keywords: Fertility rate, Gross domestic product per capita, Health policy, Life expectancy, Sanitation, Urbanization.

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Introduction

Life expectancy at birth (LEB) stands as a paramount indicator, synthesizing the overall health, economic, and social well-being of a nation's population.[1] It provides a crucial metric for assessing human development and the effectiveness of public policy.[2] Despite a steady rise in global averages, profound disparities in life expectancy persist, particularly between high-income and developing countries.[3] Understanding the specific factors that drive these disparities is essential for formulating targeted and effective strategies to improve population health outcomes.[4]

Economic and public health literature has established a robust association between life expectancy and a suite of socio-economic and demographic variables.[5,6] A nation's economic capacity, measured by gross domestic product (GDP) per capita (constant 2015 US$), is often considered a foundational determinant, as it provides the financial means for investments in healthcare, education, and infrastructure.[7,8] Furthermore, direct mechanisms of health are critical. Access to at least basic sanitation services (% of population) is a cornerstone of public health, directly reducing the prevalence of fatal infectious diseases.[9,10] Demographically, the fertility rate (total births per woman) is a powerful driver; lower fertility is associated with improved maternal and child health outcomes and greater investment per child.[11,12] The role of the urban population (% of total population) is more complex, as urbanization can offer better access to services but also introduce new health risks.[13,14] Thus, this study is guided by a conceptual framework focusing on four key determinants: (1) economic capacity (GDP per capita, constant 2015 US$), (2) environmental health (access to basic sanitation), (3) demographic structure (fertility rate), and (4) settlement patterns (urbanization).

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Most existing research takes a static view of these relationships.[15–17] A significant gap exists in our understanding of how the influence of these specific determinants, such as economic capacity, sanitation access, fertility, and urbanization, evolves over time. This knowledge is vital, as the pathways to health improvement are not static and may shift during periods of significant global change.

The decade between 2012 and 2022 offers a critical lens through which to examine this evolution. This period saw uneven socio-economic development, abruptly disrupted by the COVID-19 pandemic.[18,19] The pandemic's heterogeneous impact on global mortality exposed vulnerabilities that may not be fully captured by traditional socio-economic models, suggesting that the influence of established determinants may be changing.[20]

This study aims to fill this gap by conducting a comparative cross-country analysis. It seeks to determine the evolving influence of GDP per capita, access to basic sanitation services, the total fertility rate, and the percentage of the urban population on life expectancy at birth. Specifically, this research compares the

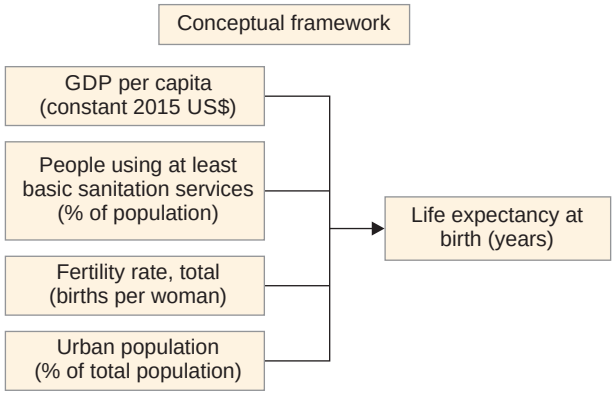

Fig. 1: Conceptual framework to investigate the determinants of life expectancy at birth

strength and significance of these relationships in 2012 and 2022 across 110 developing countries. We hypothesize that sanitation and fertility will remain significant predictors, while GDP per capita and urbanization will have weaker effects over time. The findings aim to provide timely insights for policymakers on how to prioritize investments effectively to improve health outcomes in a rapidly changing world.

Methodology

Research Design

This study employs a comparative cross-sectional design to analyze the determinants of life expectancy at two distinct points in time: 2012 and 2022. This design is optimal for assessing how the relationship between the independent variables and the dependent variable has evolved over a decade marked by significant global change. By constructing separate regression models for each year, we can directly compare the strength, significance, and explanatory power of the determinants across the two periods.

Data Source and Sample Selection

Secondary data for this analysis were extracted from the World Bank's World Development Indicators (WDI) database, a comprehensive and widely recognized repository of global development data. The initial population consisted of all countries classified by the World Bank as low-income, lower-middle-income, and upper-middle-income economies. From an initial 129 developing countries, 19 were excluded due to missing data, leaving a balanced sample of 110 with complete information for 2012 and 2022.

Variable Description and Measurement

The selection of variables is guided by the study's conceptual framework, which posits a relationship between key socio-economic and demographic factors and life expectancy. All variables were sourced directly from the WDI database.

Life Expectancy at Birth (LEB): Measured in years. This variable represents the average number of years a newborn is expected to live if prevailing patterns of mortality at the time of birth remain constant throughout its life (Fig. 1).

Gross domestic product per Capita (GDPPC): Measured in constant 2015 US dollars. This variable serves as the indicator for a nation's economic capacity. Using constant dollars adjusts for inflation and allows for an accurate comparison over time.

Access to Basic Sanitation Services (Sanitation): Measured as the percentage of the population using at least basic sanitation facilities. This variable operationalizes the environmental health component of the framework, representing access to infrastructure that hygienically separates human waste from human contact.

Fertility Rate, Total (fertility): Measured as the number of births per woman. This variable captures the demographic structure of a country, reflecting factors such as female education, empowerment, and family planning access.

Urban Population (urban): Measured as the percentage of the total population living in urban areas according to national definitions. This variable represents the settlement pattern within a country.

Empirical Model

While panel data methods are valuable for controlling for time-invariant country effects, separate cross-sectional models were chosen to allow for a direct comparison of coefficient sizes and model explanatory power (R^2) at each distinct point in time, which is the primary objective of this comparative analysis. To analyze the relationship between the independent variables and life expectancy, the following multiple linear regression model was estimated separately for the years 2012–2022:

$$\text{Life Expectancy\_}t = \beta_0 + \beta_1\,(\text{GDPpc\_}t) + \beta_2\,(\text{Sanitation\_}t) + \beta_3\,(\text{Fertility\_}t) + \beta_4\,(\text{Urban\_}t) + \varepsilon\_t$$

Where

t denotes the year (2012 or 2022).

β_0 is the constant or intercept.

β_1, β_2, β_3, and β_4 are the coefficients of the independent variables, representing the expected change in life expectancy (in years) associated with a one-unit change in each predictor, holding all other variables constant.

ε is the error term, representing the variation in life expectancy not explained by the model.

Analytical Technique

Data analysis was conducted using IBM SPSS Statistics 27 software. Descriptive statistics were calculated for all variables for both years to summarize the data and describe the progress over the decade. The ordinary least squares (OLS) method was used to estimate the coefficients of the multiple regression models. The overall significance of each regression model was assessed using the *F*-test. The statistical significance of individual coefficients was evaluated using *t*-tests, with a *p*-value of less than 0.05 considered significant. The goodness-of-fit for each model was evaluated using the coefficient of determination (R^2) and the adjusted R^2. Variance inflation factor (VIF) scores were calculated for all independent variables. As shown in Table 1, all VIF values were below 3 for both models, indicating that multicollinearity was not a significant concern.

Results

Descriptive Statistics

Descriptive statistics for all study variables for the years 2012–2022, providing an overview of the trends across the 110 developing countries in the sample, are presented (Table 2). A clear narrative of progress emerges over the decade. The average life expectancy at birth increased by 2.32 years, rising from 66.65 years in 2012 to

Table 1: Regression coefficients, model summary, and collinearity statistics (2012 vs 2022)

Predictor	*Year*	*Unstandardized coefficient (B)*	*Std. error*	*Standardized coefficient (β)*	*t-value*	*p-value*	*VIF*
(Constant)	2012	64.501***	2.581		24.988	<0.001	
	2022	66.518***	3.483		19.097	<0.001	
GDP per capita	2012	0.0002	0.000	0.067	0.905	0.368	2.218
	2022	0.0001	0.000	0.038	0.429	0.669	2.184
Sanitation	2012	0.115***	0.022	0.446	5.198	<0.001	2.940
	2022	0.117***	0.027	0.428	4.293	<0.001	2.816
Fertility rate	2012	−1.874***	0.391	−0.384	−4.795	<0.001	2.564
	2022	−2.200***	0.582	−0.371	−3.779	<0.001	2.733
Urban population	2012	0.021	0.024	0.056	0.881	0.380	1.600
	2022	0.011	0.027	0.029	0.414	0.680	1.386
R^2	2012	0.737					
	2022	0.629					
Adjusted R^2	2012	0.727					
	2022	0.615					
F-statistic (*p*-value)	2012	73.536***					
	2022	44.513***					

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. GDP, gross domestic product

Table 2: Descriptive statistics of life expectancy and determinants in 110 developing countries (2012 vs 2022)

Variable	*Year*	*Mean*	*Std. deviation*	*Change (2022–2012)*	*Change (%)*
Life expectancy (years)	2012	66.65	7.39	+2.32	+3.5%
	2022	68.97	7.62		
GDP per capita (2015 US$)	2012	3,320.14	2,731.34	+472.41	+14.2%
	2022	3,792.55	3,037.10		
Basic sanitation access (%)	2012	61.96	28.70	+7.25	+11.7%
	2022	69.21	27.85		
Fertility rate (births/woman)	2012	3.52	1.52	−0.52	−14.8%
	2022	3.00	1.29		
Urban population (%)	2012	48.05	19.49	+4.14	+8.6%
	2022	52.19	19.95		

GDP, gross domestic product

68.97 years in 2022. Economically, average GDP per capita grew by approximately 14.2%, from $3,320.14 to $3,792.55 (constant 2015 US$).

Substantial improvements were observed in public health infrastructure. The average population with access to at least basic sanitation services increased by 7.25 percentage points, from 61.96 to 69.21%. A pronounced demographic shift is also evident, as the average fertility rate fell by 14.8%, from 3.52 to 3.00 births per woman. Concurrently, the urban population continued to grow, increasing by 4.14 percentage points from 48.05 to 52.19%, indicating ongoing urbanization.

Regression Results

The multiple linear regression model was estimated separately for 2012–2022 to assess the determinants of life expectancy (Table 1).

Both regression models were statistically significant at the 99.9% confidence level (2012: $F = 73.536$, $p < 0.001$; 2022: $F = 44.513$, $p < 0.001$). This indicates that the combination of the four independent variables—GDP per capita, sanitation access, fertility rate, and urban population—is a significant predictor of life expectancy in both periods.

The model exhibited a very strong fit in 2012, explaining 73.7% of the variance in life expectancy across countries ($R^2 = 0.737$, adjusted $R^2 = 0.727$). A key finding of this study is the notable decrease in the model's explanatory power by 2022. The R^2 value declined to 0.629, meaning the model accounted for 62.9% of the variance in life expectancy (adjusted $R^2 = 0.615$).

Regarding analysis of individual determinants, access to basic sanitation services was a positive and statistically significant predictor of life expectancy in both 2012 ($B = 0.115$, $p < 0.001$) and 2022 ($B = 0.117$, $p < 0.001$). Holding other factors constant, a 1% point increase in sanitation access was associated with an increase in life expectancy of approximately 0.115 years in 2012 and 0.117 years in 2022.

Fertility rate was a negative and highly significant predictor in both periods. The magnitude of its association with life expectancy strengthened substantially over the decade, with the unstandardized coefficient (B) increasing in absolute value from −1.874 ($p < 0.001$) in 2012 to −2.200 ($p < 0.001$) in 2022 (a 17.4% increase). This indicates that the life expectancy gain associated with a one-unit decrease in the fertility rate became larger over time. The standardized coefficients (β) further revealed that access

to sanitation was a relatively stronger predictor within the model than fertility rate in both 2012 ($\beta = 0.446$ vs $\beta = -0.384$) and 2022 ($\beta = 0.428$ vs $\beta = -0.371$).

Gross domestic product per capita was not a statistically significant predictor of life expectancy in either 2012 ($B = 0.0002$, $p = 0.368$) or 2022 ($B = 0.0001$, $p = 0.669$). To interpret the coefficient meaningfully, a $1,000 increase in GDP per capita was associated with a mere 0.2-year increase in life expectancy in 2012 and a 0.1-year increase in 2022, effects that were not statistically different from zero. This indicates that, when controlling for factors like sanitation and fertility, the independent, direct effect of economic capacity on life expectancy is negligible.

Similarly, the percentage of the urban population was not a statistically significant predictor in either 2012 ($B = 0.021$, $p = 0.380$) or 2022 ($B = 0.011$, $p = 0.680$). This suggests that a 1% point increase in urbanization was associated with minimal and non-significant gains in life expectancy of 0.021 years (about 8 days) in 2012 and 0.011 years (about 4 days) in 2022. The results imply that the net effect of urbanization—balancing its potential health advantages and disadvantages—was neutral in the average developing country in our sample.

Discussion

This study provides a longitudinal perspective on the determinants of life expectancy in developing countries, comparing the influence of key factors from a defined conceptual framework across a decade of significant global change. The results offer two primary categories of insight: First, a confirmation of the persistent power of direct health and demographic drivers and second, evidence of a shifting health landscape where traditional models have declining explanatory power. Not only were these factors persistent, but access to sanitation consistently emerged as the relatively strongest predictor within the model, underscoring its unparalleled importance.

The core empirical finding is the robust and enduring significance of access to basic sanitation services and the fertility rate as powerful predictors of life expectancy. The stability of the sanitation coefficient across the decade ($B \approx 0.12$) underscores its non-negotiable role as a foundational pillar of public health. This result strongly aligns with the extensive literature on water, sanitation, and hygiene (WASH) initiatives, confirming that even as countries develop, investments in this basic infrastructure continue to yield significant, reliable returns by reducing mortality from infectious diseases.[21–23] It validates its central place in our conceptual framework as a critical proximate cause of improved health outcomes. Its position as the strongest predictor, as indicated by the standardized coefficients, highlights that investments in basic public health infrastructure may yield the most direct and measurable returns on population health.

A particularly insightful finding is the substantial strengthening of the fertility rate coefficient, which increased in magnitude from −1.874 to −2.200. This strengthening association suggests that the health returns on investments facilitating the demographic transition, such as female education, economic empowerment, and access to family planning services, may have become more pronounced over the decade. As fertility declines, the theorized "demographic dividend" accelerates: Resources are reallocated from the quantity of children to the quality of their upbringing, leading to better nutrition, healthcare, and education that directly translate into longer lifespans.[24,25] The increasing coefficient implies that these dynamics become more impactful over time, reinforcing that policies associated with lower fertility are not merely about population control but may be critically important for improving population health outcomes.

Conversely, the consistent insignificance of GDP per capita is a critical result that refines economic theories of health. These results are consistent with the notion that national income may function primarily as an enabling factor rather than showing a strong direct association with better health when other factors are controlled. Gross domestic product growth provides the fiscal space to build sanitation systems and fund the education programs that lower fertility. The regression model controls for these direct pathways; once they are accounted for, the independent, residual effect of GDP itself becomes statistically irrelevant.[26,27] The finding challenges simplistic narratives and highlights that how a nation spends its wealth is ultimately more important for health outcomes than the absolute level of wealth itself.

Similarly, the neutral effect of urbanization aligns perfectly with its theorized dual nature, as captured in the conceptual framework. While cities offer greater access to healthcare facilities, education, and economic opportunities (the "urban advantage"), they also concentrate health risks like pollution, unhealthy lifestyles, and overcrowded living conditions in slums (the "urban penalty").[28,29] The net effect captured in this model is neutral, suggesting that for the average developing country in this sample, these positive and negative forces have effectively canceled each other out over the past decade.

The most significant and intriguing result, however, is the pronounced decline in the model's explanatory power (R^2), which fell from 73.7% in 2012 to 62.9% in 2022. While the core drivers remained significant, other unmeasured factors evidently played a much larger role in determining life expectancy in 2022. The most plausible explanation for this increase in "unexplained variance" is the COVID-19 pandemic. The pandemic was a massive exogenous shock whose mortality impact was highly variable and influenced by factors outside this model's scope. The quality of governance, the preparedness and resilience of healthcare systems (e.g., ICU capacity, healthcare worker density), the effectiveness of public health responses, and pre-existing population health profiles became critical determinants of mortality.[30] This massive and heterogeneous shock to global mortality introduced substantial noise that the core socio-economic variables could not capture.[19,31]

Alternatively, this decline could signal a broader epidemiological transition. As countries develop and the disease burden shifts from communicable to non-communicable diseases (NCDs), factors like the quality of healthcare, which extends beyond mere access to basic sanitation, along with dietary patterns, physical activity, and, crucially, within-country inequality (e.g., the GINI coefficient), may have become more salient determinants of health outcomes. Our model, focused on national averages and basic access, would miss these nuances. The convergence of the pandemic and this ongoing transition suggests that the health landscape has become more complex, requiring a more sophisticated model that includes measures of governance, equity, and health system quality to fully explain contemporary trends in life expectancy.

Limitations

While this study provides valuable insights into the evolving determinants of life expectancy, several limitations must be acknowledged. First, the comparative cross-sectional design is optimal for identifying associations and comparing their strength

at two points in time but cannot establish causality. Second, this analysis is susceptible to the ecological fallacy, whereby associations found at the country level may not accurately reflect relationships at the individual level. Third, and most critically, the significant decline in the model's explanatory power (R^2) strongly suggests the presence of omitted variable bias. Our parsimonious model, while grounded in a standard conceptual framework, excludes other critical determinants such as governance quality, health expenditure, within-country inequality, and the burden of NCDs. Finally, the study relies on nationally aggregated data from the World Bank, where data quality and definitions may vary across countries, potentially introducing measurement error.

Conclusion

This study concludes that while direct health and demographic factors, specifically access to basic sanitation and lower fertility rates, remained powerful and consistent predictors of life expectancy in developing countries from 2012 to 2022, the overall health landscape has fundamentally changed. The insignificance of GDP per capita and urbanization confirms that economic growth and urban development are only beneficial for health when they enable direct interventions. Most critically, a significant decline in the model's explanatory power signals a paradigm shift. It indicates that traditional socio-economic models are no longer sufficient, as factors like healthcare quality, governance, resilience, and equity, which were highlighted by the COVID-19 pandemic and the shift to NCDs, have become increasingly important determinants of population health.

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ORIGINAL ARTICLE

A Mixed-methods Descriptive Cross-sectional Study on Knowledge, Attitudes, and Practices for Cardiovascular Diseases among Adults of Urban Slums in Delhi, India

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Abstract

The present study assessed the knowledge regarding cardiovascular diseases (CVDs), attitudes, and practices among 246 adult urban slum residents of South Delhi. A majority (88.2%) of participants recognized coronary heart disease as a type of CVD, with fewer identifying cerebrovascular disease (29.7%). Commonly known MI symptoms, such as chest pain/discomfort, were widely recognized (92.3%), followed by fainting (69.1%) and difficulty breathing (61%). For stroke symptoms, most participants recognized sudden numbness of the face, arm, and leg (90.2%), with awareness of other symptoms varying: trouble speaking (70.3%), trouble seeing (44.3%), and dizziness (65%). Many were aware of CVD risk factors, including smoking/smokeless tobacco (81.7%), alcohol consumption (81.3%), unhealthy diet (78.5%), physical inactivity (72.4%), obesity (84.1%), stress (89.8%), positive family history (56.5%), hypertension (76.8%), and diabetes mellitus (76%). Yet very few (28.5%) identified high cholesterol levels as a risk factor. The study found that while most participants were aware of coronary heart disease and common CVD risk factors, significant gaps remain in recognizing other types of CVDs, CVD symptoms, and high cholesterol as a CVD risk factor. This highlights the need for targeted community-based awareness programs and regular CVD screening in urban slums.

Keywords: Cardiovascular diseases, Community-based study, Health-seeking behavior, Knowledge, attitude, and practices, Mixed-method study, Non-communicable diseases, Urban slums.

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Introduction

Non-communicable diseases (NCDs) are chronic diseases resulting from a combination of genetic, physiological, behavioral, and environmental factors. The main types of NCD are cardiovascular diseases (CVDs) (such as heart attacks and stroke), cancers, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma), and diabetes mellitus.[1] The major metabolic risk factors for NCDs are obesity, raised blood pressure, raised blood glucose, and raised total cholesterol levels in the blood.[1] The leading cause of death globally is CVDs.[2] At least three-quarters of the world's deaths from CVDs occur in low- and middle-income countries.[2] Detection of CVDs and other NCDs is often late in the course of the disease in low- and middle-income countries. As a result, people die at a younger age from CVDs and other NCDs, often in their most productive years.[3] Non-communicable diseases (NCDs) account for 65% of all deaths in India.[4] The total disability-adjusted life years from NCDs were 30.5% in 1990, which increased in 2016 to 55.4%.[5] Most CVDs can be prevented by addressing behavioral risk factors such as tobacco use, unhealthy diet, obesity, physical inactivity, and harmful use of alcohol.[2] Urbanization, lifestyle changes, and street food consumption increase the risk of cardiovascular disorders in the urban population.[3] Furthermore, increased stress levels contribute to the higher incidence of chronic diseases among both urban and rural populations.[6] Within urban environments, particularly in rapidly expanding cities like Delhi, the rise of CVDs is exacerbated by factors such as unhealthy lifestyles, high levels of stress, and limited access to healthcare services.[7] However, these challenges are particularly acute in urban slum populations, where residents face compounded vulnerabilities, including poverty, overcrowding, and limited access to education and healthcare facilities.[8] Despite the recognized burden of CVDs, there remains a significant gap in understanding the knowledge, attitudes, and health-seeking behaviors related to cardiovascular health within these marginalized populations.[9] Most existing research has focused on more accessible urban populations or rural areas, leaving a critical gap in understanding the unique challenges faced by those living in urban slums. This knowledge gap is particularly concerning, given that slum populations often have lower health literacy, fewer resources, and limited

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access to preventative care, which can lead to delayed diagnosis and treatment of CVDs.[10] Delhi's urban slums, with their dense populations and diverse demographics, provide a crucial setting for examining these issues.[11] Understanding the community's knowledge and perceptions of cardiovascular health, as well as the barriers they face in seeking care, is essential for designing effective public health interventions tailored to the needs of this vulnerable population. Furthermore, a mixed-methods approach allows for a comprehensive understanding by integrating quantitative data on prevalence and behavioral patterns with qualitative insights into residents' lived experiences and challenges.[12] This study aimed to fill this critical gap by systematically exploring the knowledge, attitudes, and health-seeking behaviors related to CVDs among adults in Delhi's urban slums. By addressing the specific needs and barriers of urban slum populations, this study has the potential to contribute significantly to reducing the burden of CVDs in Delhi and similar urban settings across India.

Objectives

- To assess the knowledge regarding risk factors of CVDs among the adult population in urban slums of South Delhi.
- To find out health-seeking behavior, attitudes, and practices regarding CVDs among the adult slum population in South Delhi.

Materials and Methods

In the present study, both qualitative and quantitative techniques were adopted. Quantitative methods were used to assess the knowledge level of CVDs. In the qualitative component, in-depth interviews and focused group discussions were conducted to evaluate the attitudes, beliefs, value systems, practices, and health-seeking behavior in the slum population. This study was a community-based descriptive and cross-sectional study that was conducted in the urban slums of South Delhi. The study was conducted over 1 year and 6 months from June 2022 to December 2023. As per the previous studies, a 20% moderate and high CVD risk prevalence was considered, with a 10% non-responder rate; the sample size was calculated as 271.[13] Data collection for the study was done for ten months, from March 2023 to December 2023. Two randomly selected slums of South Delhi under the Urban PHC, Munirka, New Delhi, run by the Municipal Corporation of Delhi, i.e., Coolie Camp and Moti Lal Nehru Camp. The study population included adults aged from 40 to 74 years living in urban slums of South Delhi and ASHA Workers and ANMs of Urban PHC, Munirka. All adults aged 40–74 years were included in the study. All patients with established coronary heart disease and stroke were excluded from the study, and pregnant women were excluded. Two focused group discussions (FGDs), i.e., one for males and one for females in each of the randomly selected slums, were conducted to collect qualitative information like attitudes, beliefs, misconceptions, practices, and health-seeking behavior regarding CVDs in the community. All ASHA workers working in the randomly selected slums and ANMs at UPHC, Munirka, were interviewed using an interview schedule to discover community knowledge, awareness, attitude, beliefs, and health-seeking behavior regarding CVDs.

Operational Definitions

a. Knowledge: This refers to the participant's ability to respond verbally to questions related to CVD, Hypertension, diabetes mellitus, and various risk factors.
b. Awareness: It refers to the concern about and well-informed interest in CVD.
c. Health-seeking behavior: Health-seeking behavior can be defined as any activity undertaken by individuals who perceive themselves to have a health problem or to be ill for the purpose of finding an appropriate remedy.[14]
d. Attitude: Attitude is an individual's feeling and manner towards CVDs.

A structured interview schedule was used to collect participant data. An interview schedule for ASHA workers and ANMs was developed to find out community beliefs, practices, and health-seeking behavior regarding CVDs. An FGD guide was designed to conduct FGD in the community to assess qualitative components. All the interview schedules were translated into the local language, Hindi. Ethical clearance was obtained from the Institutional Review Board of the National Institute of Health and Family Welfare (NIHFW), New Delhi. The data was collected, and after proper scrutiny, the data was entered into Statistical Package for the Social Sciences (IBM SPSS) Version 20® and analyzed using descriptive and analytical techniques with the help of appropriate statistical tests, viz, mean, proportion, Chi-squared, etc. As per the objectives of the study, univariate, bivariate, and multivariate tables were generated, and the findings were presented as graphs and charts. The content analysis technique was used to analyze the qualitative data collected in the study. Findings were presented in thematic areas. A participant information sheet explaining the purpose of the research and all steps involved in data collection was prepared in the local language and issued to the participants. Informed written consent was obtained from the participants prior to the interview being conducted. The confidentiality and privacy of participants were ensured.

Findings

With a response rate of 87.85%, 246 individuals participated in the study. Among the 246 participants (41.5%) were males, and 144 (58.5%) were females. The mean age of the participants was 53.38 ± 9.34 years, and the socio-demographic characteristics of the study participants are presented in Table 1.

Table 2 presents the study participants' knowledge of various categories related to CVDs, including types of CVD, symptoms of myocardial infarction (MI), symptoms of stroke, and risk factors for CVD. It is revealed that the majority of 88% recognized coronary heart disease as a CVD type, 30% knew of cerebrovascular disease as a type of CVD, and 22% knew about congenital heart disease. Peripheral heart disease (1.6%), rheumatic heart disease (2%), and deep vein thrombosis and pulmonary embolism (2.4%) had lower levels of awareness. Most participants (82%) were aware of the smoking/smokeless tobacco, alcohol consumption (81%), unhealthy diet (78%), physical inactivity (72%), and obesity (90%) risk factors associated with CVDs. Only 28.5% recognized high cholesterol levels as a risk factor, but 76.8% recognized hypertension associated with CVD. Diabetes mellitus as a risk factor was acknowledged by 76.0%.

For further analysis, a score of 1 was given to every correct answer, and no mark was allotted to every incorrect answer (i.e., no and don't know). The mean scores for all the knowledge components were calculated. The scores of all four components, i.e., CVD types, symptoms of MI, symptoms of stroke, and CVD risk factors, were summed to calculate the overall CVD knowledge

Table 1: Socio-demographic profile of the study participants (*N* = 246)

Socio-demographic variables	*Sub-groups*	*Number (n)*	*Percent (%)*
Age-group	<50 years	95	38.6
	50–59 years	75	30.5
	60–69 years	56	22.8
	70 years and above	20	8.1
Gender	Male	102	41.5
	Female	144	58.5
Religion	Hindu	206	83.8
	Muslim	22	8.9
	Sikh	1	0.4
	Christian	17	6.9
Caste	General	73	29.7
	OBC	55	22.4
	SC	31	12.6
	ST	3	1.2
	Refused	84	34.1
Marital status	Never married	2	0.8
	Currently married	194	78.9
	Separated	9	3.7
	Divorced	3	1.2
	Widowed	38	15.4
Occupation	Government employee	4	1.6
	Non-government employee	43	17.5
	Self-employed	42	17.1
	Laborer	22	8.9
	Homemaker	105	42.7
	Retired	10	4.1
	Unemployed	20	8.1
Education	No formal schooling	82	33.3
	Less than primary school	13	5.3
	Primary school completed	37	15.1
	Secondary school completed	49	19.9
	High school completed	47	19.1
	College/university completed	15	6.1
	Postgraduate degree	3	1.2
Socio-economic class[a] [per capita monthly income (in Rs.)]	Upper class (Rs. 8822 and above)	28	11.4
	Upper middle class (between Rs. 4411 to Rs. 8821)	90	36.6
	Middle class (between Rs. 2647 to Rs. 4410)	67	27.2
	Lower middle class (between Rs. 1323 to Rs. 2646)	45	18.3
	Lower class (below Rs. 1323)	16	6.5

[a]Updated BG Prasad classification (April 2023)

Table 2: Knowledge of CVD types, heart attack, and stroke symptoms, and CVD risk factors (*N* = 246)

		Yes		*No*		*Uncertain*	
Knowledge component	*Categories*	*N*	*%*	*N*	*%*	*N*	*%*
Types of CVD	Coronary heart disease	217	88.2	8	3.3	21	8.5
	Cerebrovascular disease	73	29.7	34	13.8	139	56.5
	Peripheral heart disease	4	1.6	29	11.8	213	86.6
	Rheumatic heart disease	5	2.0	27	11.0	214	87.0
	Congenital heart disease	55	22.4	21	8.5	170	69.1
	DVT and PE	6	2.4	28	11.4	212	86.2

(Contd...)

Table 2: *(Contd...)*

		Yes		*No*		*Uncertain*	
Knowledge component	*Categories*	*N*	*%*	*N*	*%*	*N*	*%*
Symptoms of MI	Pain in the neck, jaw	38	15.4	29	11.8	179	72.8
	Faint	170	69.1	13	5.3	63	25.6
	Chest pain or discomfort	227	92.3	3	1.2	16	6.5
	Pain in the arms/shoulder	62	25.2	24	9.8	160	65.0
	Difficulty in breathing	150	61.0	11	4.5	85	34.6
Symptoms of stroke	Sudden numbness of the face, arm, and leg	222	90.3	7	2.9	17	6.9
	Trouble speaking	173	70.3	16	6.5	57	23.2
	Trouble seeing	109	44.3	31	12.6	106	43.1
	Dizziness	160	65.0	17	6.9	69	28.1
	Severe headache	38	15.5	53	21.5	155	63.0
Risk factors for CVD	Smoking/smokeless tobacco	201	81.7	11	4.5	34	13.8
	Alcohol consumption	200	81.3	12	4.9	34	13.8
	Unhealthy diet	193	78.5	9	3.6	44	17.9
	Physical inactivity	178	72.4	12	4.9	56	22.8
	Obesity	207	84.1	7	2.9	32	13.0
	Stress	221	89.8	6	2.5	19	7.7
	Positive family history	139	56.5	22	8.9	85	34.6
	High cholesterol levels	70	28.5	13	5.3	163	66.2
	High blood pressure	189	76.8	10	4.1	47	19.1
	Diabetes mellitus	187	76.0	10	4.1	49	19.9

Table 3: Comparison of knowledge of CVDs by gender

	Mean score		
Knowledge component	*Men (n = 102)*	*Women (n = 144)*	*Overall (n = 246)*
Types of CVD (out of 6)	1.52	1.4	1.45
MI symptoms (out of 5)	2.8	2.53	2.64
Stroke symptoms (out of 5)	3.02	2.78	2.88
CVD risk factors (out of 9)	7.64	6.85	7.18
Overall, knowledge of CVD (out of 25)	14.98	13.56	

score. The mean score for the overall CVD knowledge component was 14.15 out of a maximum score of 25. When overall knowledge mean scores were compared by gender, men exhibited a slightly higher average knowledge score of 14.98, while women had a slightly lower average score of 13.56; this difference was statistically significant ($p = 0.035$). Table 3 provides a comparison of knowledge of CVD by gender.

When the knowledge components were grouped based on the correct/incorrect answers given by the study participants for the knowledge-related questions, the components were classified as poor, good, and fair knowledge according to the scores. Since there are six, five, and five questions under types of CVDs, symptoms of MI, and symptoms of stroke, respectively, a score of less than two was considered poor knowledge, 2–3 was considered fair, and above three was regarded as good knowledge. Similarly, the knowledge of the CVD risk factors component, which had 9 questions, was categorized based on the scores obtained as poor, fair, and good for scores less than 3, 3 to 5, and above 5, respectively. Table 4 presents the analysis. It is shown that 60% of respondents had poor knowledge of CVD types, but about 80% had fair/good knowledge of symptoms of MI and stroke, and 85% had good/fair knowledge of risk factors of CVDs.

Table 4: Knowledge level of CVDs: types, symptoms, and risk factors among study participants ($N = 246$)

Knowledge components	*Status*	*Number (n)*	*Percent (%)*
Types of CVD	Poor	147	59.8
	Fair	94	38.2
	Good	5	2.0
Symptoms of MI	Poor	50	20.3
	Fair	143	58.1
	Good	53	21.6
Symptoms of stroke	Poor	51	20.7
	Fair	86	35.0
	Good	109	44.3
Risk factors of CVD	Poor	37	15.0
	Fair	9	3.7
	Good	200	81.3

A Chi-squared test was applied to understand the association between socio-demographic variables and knowledge level among the study participants. It was observed that knowledge of CVD types was associated with educational background; this association was statistically significant ($p \leq 0.001$), and the same has been depicted in Figure 1.

The knowledge of MI symptoms was better among men than women, and the difference was statistically significant ($p = 0.012$). The educational background was associated with knowledge level about symptoms of MI, which was found statistically highly significant ($p \leq 0.001$). The level of knowledge among participants who were in government jobs, private jobs, and business was found to be higher when compared with laborers, homemakers, and unemployed participants, and these differences were found to be statistically significant ($p = 0.014$), as shown in Table 5.

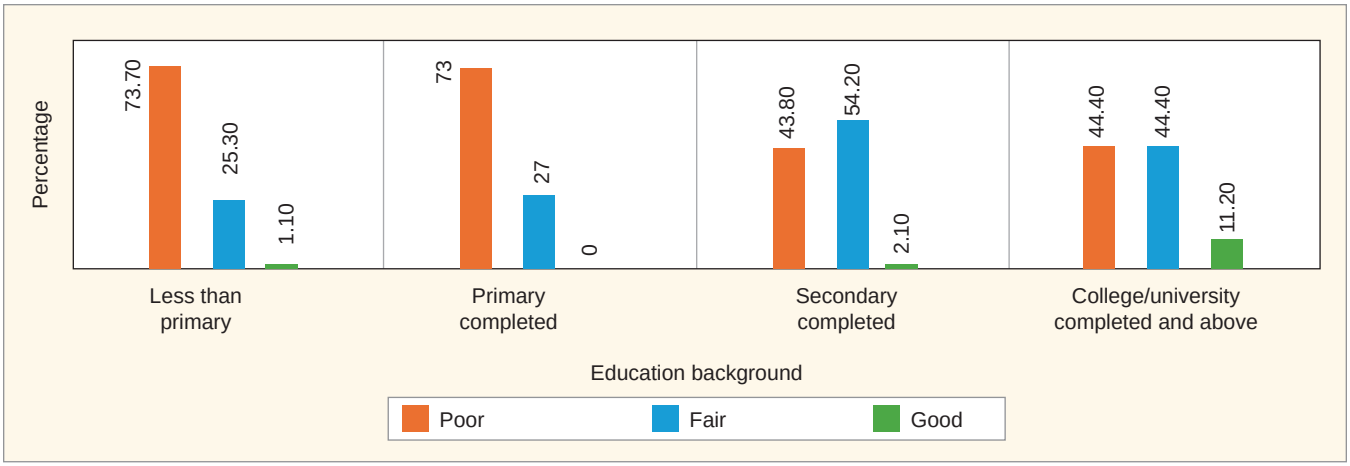

Fig. 1: Association of knowledge of CVD types with education (*N* = 246)

Table 5: Association of knowledge of symptoms of MI with socio-economic background (*N* = 246)

Variable	*Sub-groups*	*Poor n (%)*	*Fair n (%)*	*Good n (%)*	*p-value*
Gender	Male	21(20.6%)	50 (49%)	31 (30.4%)	0.012*
	Female	29 (20.1%)	93 (64.6%)	22 (15.3%)	
Education	No formal schooling	26 (31.7%)	48 (58.5%)	8 (9.8%)	<0.001*
	Less than primary school	3 (23.1%)	9 (69.2%)	1 (7.7%)	
	Primary school completed	8 (21.6%)	24 (64.9%)	5 (13.5%)	
	Secondary school completed	7 (14.3%)	26 (53%)	16 (32.7%)	
	High school completed	3 (6.3%)	31 (66%)	13 (27.7%)	
	College/university completed	3 (20%)	5 (33.3%)	7 (46.7%)	
	Postgraduate degree	0 (0%)	0 (0%)	3 (100%)	
Occupation	Govt employee	1 (25%)	1 (25%)	2 (50%)	0.014*
	Non-govt employee	7 (16.3%)	27 (62.8%)	9 (20.9%)	
	Self-employed	9 (21.4%)	23 (54.8%)	10 (23.8%)	
	Laborer	10 (45.5%)	7 (31.8%)	5 (22.7%)	
	Homemaker	19 (18.1%)	70 (66.7%)	16 (15.2%)	
	Retired	1 (10%)	3 (30%)	6 (60%)	
	Unemployed	3 (15%)	12 (60%)	5 (25%)	

*p-value < 0.05, statistically significant

Participants from lower socioeconomic backgrounds were found to have a lower knowledge of stroke symptoms than those of higher socioeconomic backgrounds, and this difference was found to be statistically significant (Chi-squared value = 22.146, $p = 0.005$), as depicted in Figure 2.

It was found that participants who were aged less than 60 had better knowledge of CVD risk factors than those who were older. This association of age-group and knowledge of CVD risk factors was statistically significant ($p = 0.047$) and is depicted in Figure 3.

Perception about CVDs as a Significant Concern

Table 6 illustrates the participants' perspectives on CVD as a significant concern. Most participants (88.6%) said they consider CVD a considerable problem. Study participants' perception is that CVDs are a significant concern (*N* = 246).

Sources of Information About CVDs

Most participants, 54.5% (*n* = 134), claimed to have received CVD-related information from informal sources like friends, relatives, and colleagues, as depicted in Figure 4.

Attitude, Belief, and Health-seeking Behavior Regarding CVDs

The findings from the focus group discussions and in-depth interviews with ASHA workers and ANMs are presented under the following themes:

Awareness and Knowledge of CVDs

- Approximately 7–8 out of 10 participants in each FGD expressed concern about heart attacks and strokes, citing personal experiences of family members, relatives, friends, or neighbors who had suffered from CVD or had died from it.
- Participants demonstrated limited awareness of CVD types and pathophysiology, with only MI and stroke recognized as CVD conditions.
- However, the majority of the participants (7–8 participants) were knowledgeable about CVD risk factors, including smoking, obesity, hypertension, stress, diabetes, and alcohol, with smoking being the most commonly mentioned risk factor.
- Insights from interviews with healthcare workers further validated the observed patterns of knowledge regarding CVD

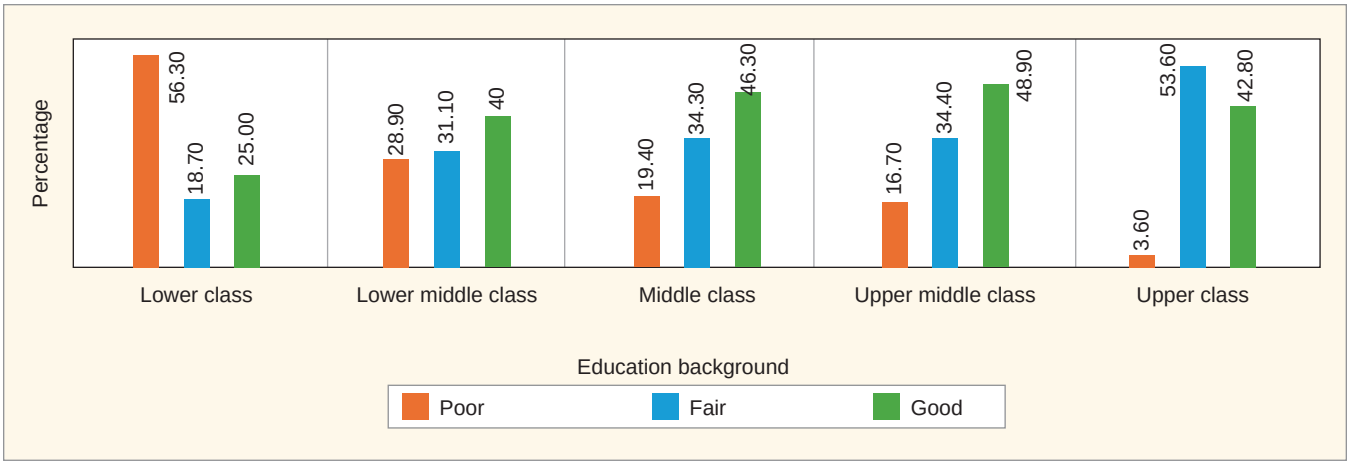

Fig. 2: Comparison of knowledge level of stroke symptoms by socio-economic level (*N* = 246)

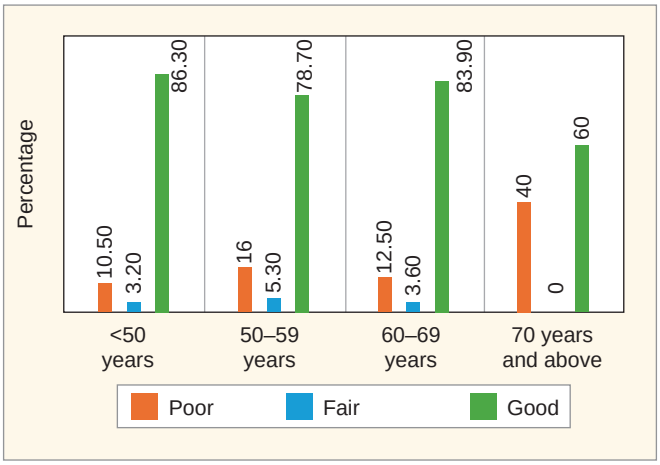

Fig. 3: Comparison of CVD risk factors knowledge by age-group (*N* = 246)

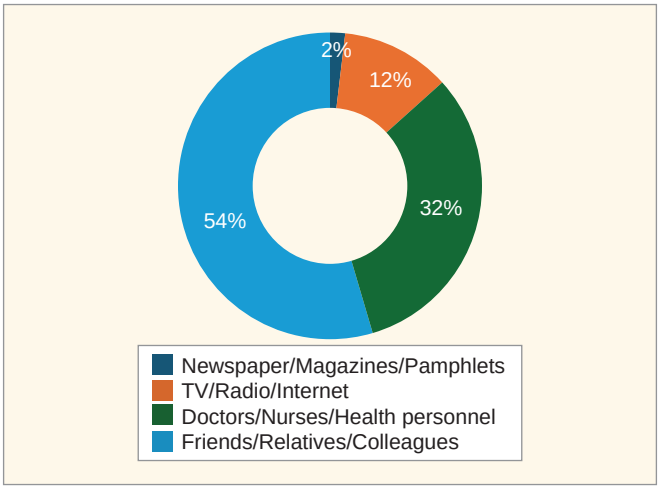

Fig. 4: Sources of information about CVDs (*N* = 246)

Table 6: The perception of study participants is that CVDs are a significant concern

CVD major concern	*Number (n)*	*Percent (%)*
Yes	218	88.6
No	8	3.3
Uncertain	20	8.1

within the community. The interviews confirmed that women tended to exhibit poorer knowledge of CVD compared to men.

Community Perceptions and Beliefs

- A minority of participants, particularly men (2–3 participants), disputed the association between smoking, alcohol consumption, and CVD, while most women acknowledged smoking and alcohol consumption as risk factors.
- Approximately 3–4 participants believed in the protective powers of visiting temples against disease, particularly among women.
- Some participants attributed the occurrence of CVD to their perceived past misdeeds, suggesting a fatalistic view of the disease and its hereditary implications.
- Participants viewed MI and stroke as leading causes of death, with a noticeable increase in cases among younger individuals.
- There was a misconception that diabetes could be controlled solely by avoiding sweets and that once medication is initiated, it becomes a lifelong condition without the possibility of a cure; a few men (4–5) said, "Ek baar dawayi shuru kiya toh zindagi bhar peecha nahi chutegi".
- A few participants, particularly in the women's group (2–3 participants), claimed "tala hua cheez nahi khani chahiye", identifying unhealthy fatty foods as a risk factor for CVD.
- Furthermore, most ASHA workers and ANMs rated the community's awareness of CVD on a scale of 1–10 as relatively low, averaging around 4–5. Some respondents noted that while the community may be aware of the risk factors associated with CVD, there is a lack of proactive action or concern among community members. Additionally, several healthcare workers stated that the community's awareness of CVD risk factors is inadequate. These findings suggest a need for targeted education and outreach efforts to enhance community awareness and encourage proactive health-seeking behaviors to prevent CVD.

Health-seeking Behavior

- Participants of FGDs highlighted a tendency for individuals to seek healthcare only after experiencing symptoms, often due to a lack of awareness or financial constraints.
- Most participants (6–8 individuals) believed that CVD and its risk factors are prevalent in their respective slum areas.
- Regarding healthcare-seeking behavior, approximately 4–6 participants stated that most community members visit the dispensary or urban primary health center, Munirka, for medical needs, while a smaller subset (2–3 individuals) prefer alternative treatments such as ayurveda and homoeopathy over allopathy.
- During interviews with ASHA workers and ANMs, it was revealed that they primarily refer patients to the Urban Primary Health Centre, Munirka, with more severely ill patients being directed to Safdarjung Hospital as the referral hospital. According to the interviews with the ASHA workers and ANMs, while most community members prefer seeking healthcare at the dispensary or UPHC, some prefer alternative forms of medicine such as Ayurveda and Homeopathy. Interestingly, a portion of the older population chooses to forego conventional healthcare facilities, relying instead on prayer for healing. Despite this, more than half of community members seek out ASHA workers and ANMs for health advice or check-ups. Moreover, it was noted that people with hypertension and diabetes predominantly visit the dispensary for medications, as mentioned by the ASHA workers and ANMs.

Community Practices and Behaviors

- Additionally, some participants (3–4 individuals), particularly women, indicated a reliance on home remedies for health issues. Conversely, a few participants (2–4) expressed skepticism towards visiting hospitals, considering it a waste of money and time.
- Despite having some knowledge of CVD and its risk factors, the community finds it difficult to adopt lifestyle modifications or measures. They feel it's a financial burden to consume medicines every day.
- A small subset of participants (2–3 individuals) mentioned that they visit temples and engage in various forms of prayer or practice vows, which can lead to healing ailments.

Challenges and Barriers

- ASHA workers and ANMs faced challenges persuading community members to visit healthcare centers for treatments and screening. These difficulties were due to a lack of awareness about the importance of preventive healthcare and competing priorities.
- ASHA workers and ANMs emphasized the importance of refresher training to enhance their knowledge and skills in delivering CVD-related services.
- ASHA workers and ANMs identified challenges in delivering CVD-related services, such as limited resources and inadequate infrastructure, hindering their ability to provide comprehensive care. Additionally, the workload posed difficulties in reaching remote communities. Moreover, cultural barriers and resistance to change among community members sometimes proved challenging when implementing interventions successfully.

To conclude, the findings underscore the importance of targeted interventions to address gaps in CVD awareness, attitudes, and healthcare delivery, considering cultural beliefs, gender disparities, and the need for continuous training of healthcare personnel.

Discussion

Most of the participants were aware of only coronary heart disease among the types of CVD, though they had low knowledge about CVD types and its symptoms; participants had better knowledge of CVD risk factors, consistent with the study by Awad et al.[15] In this current study, knowledge of heart attack symptoms was low, i.e., less than a quarter of the participants provided >60% correct responses to knowledge-related questions. Though the knowledge scores are low, most participants recognized chest pain and fainting as common symptoms of a heart attack, and this finding is consistent with another study conducted by Singh et al.[16] in India. It was noted that less than half of the study participants had good knowledge of stroke symptoms, with many participants identifying numbness or weakness of the face, arm, or leg, or sudden confusion or trouble speaking or walking as symptoms of stroke, which is consistence with a study conducted in India.[16] However, the study showed better knowledge of risk factors, consistent with studies conducted in Nepal, Iran, and Kuwait.[17,18] It was found in the study that the participants identified behavioral factors (e.g., smoking, alcohol consumption) more frequently than other factors (e.g., hypertension, hypercholesterolemia), which is parallel to the study by Vaidya et al.[17] in Nepal.

Higher education was associated with better knowledge of CVD, and the findings are aligned with the results of other studies.[17,19,20] It was also found that the understanding of MI symptoms was associated with socio-economic class and occupation, similar to a study by Ndejjo et al.[19] In the current study, it was discovered that men had better knowledge of CVD than women. In contrast to the findings of the study conducted in Kuwait, probably could be because of the difference in the education level between men and women. Healthcare workers stressed this point, too, at the time of the interview. However, it aligns with the findings of a study by Mukattash et al.[21] The fact that 88% of individuals viewed CVD as a significant societal issue is noteworthy. A comparatively higher level of knowledge of CVD risk factors and the perception of CVD being a concern to society could be because the study is conducted in urban slums, as influential in acquiring CVD knowledge due to better access to health information.[19,22,23] More than half of the participants claimed to have received CVD-related information from informal sources like friends, relatives, and colleagues, one-third from healthcare workers, and the rest from other sources like TV, radio, social media, and print media. It was found that despite having fair knowledge of CVD, more than half of the participants did not want to alter their lifestyle.[17] However, more women than men strongly agreed that their health was ultimately determined by God or a higher power.[17]

Conclusion and Recommendation

In the study, 88.2% of participants recognized coronary heart disease as a type of CVD. Common MI symptoms like chest pain were widely known (92.3%), followed by fainting (69.1%) and difficulty breathing (61%). For stroke, 90.2% identified sudden numbness, with varied awareness of trouble speaking (70.3%), difficulty seeing (44.3%), and dizziness (65%). Many knew CVD risk factors: smoking/tobacco (81.7%), alcohol (81.3%), unhealthy diet

(78.5%), inactivity (72.4%), obesity (84.1%), stress (89.8%), family history (56.5%), hypertension (76.8%), and diabetes (76%), but only 28.5% identified high cholesterol. Men had slightly better CVD knowledge than women, as healthcare professionals confirmed. Additionally, 88.6% viewed CVD as a significant societal concern. Information sources included interpersonal communication (54.5%), healthcare professionals (32.1%), electronic media (11.8%), and print media (1.6%). Participants exhibited varying levels of CVD awareness, with better knowledge of risk factors, particularly smoking. However, urban slum residents had diverse perceptions, highlighting gaps, misconceptions, and fatalistic attitudes toward CVD. They typically sought medical help after symptoms appeared, influenced by awareness gaps and financial constraints. Despite preferring conventional healthcare, some leaned towards alternative treatments and prayer. Community practices leaned towards home remedies, with reluctance towards hospital visits and difficulties in adopting lifestyle changes, such as modifying diets, incorporating physical activity, and quitting smoking and alcohol (particularly among men) for CVD prevention. ASHA workers and ANMs struggled to provide CVD services due to insufficient awareness, limited resources, inadequate infrastructure, and cultural barriers. The study found that while most participants were aware of coronary heart disease and common CVD risk factors, significant gaps remain in recognizing other types of CVDs, CVD symptoms, and high cholesterol as a CVD risk factor. Due to inadequate knowledge of CVD among the urban slum populations, the study recommends a community-based awareness program regarding risk reduction and regular screening of CVDs through outreach activities.

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REVIEW ARTICLE

Nutrition as a National Policy for India: Building the Foundation for a Viksit Bharat

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Abstract

Nutrition is the foundation of human development and a decisive factor in India's economic growth, equity, and global standing. Despite decades of policy attention, India continues to face one of the world's heaviest burdens of malnutrition. One in three children under 5 years is stunted (35.5%), and over half of women of reproductive age are anemic (57.0%). Malnutrition drains an estimated 2–3% of gross domestic product (GDP) annually, undermining India's demographic dividend and its aspiration for a five-trillion-dollar economy. This paper reviews the evolution of India's nutrition policies, including integrated child development services (ICDS), PM Poshan, Poshan Abhiyaan, and Anemia Mukt Bharat (AMB), and assesses progress in reducing stunting, wasting, and anemia. State-level innovations from Tamil Nadu, Odisha, Maharashtra, and Chhattisgarh highlight pathways of success and reveal persistent gaps, especially for adolescents and the urban poor. Structural challenges in behavior change, last-mile delivery, financing, and data-driven monitoring remain barriers. The paper proposes five priorities to align nutrition with the vision of Viksit Bharat 2047: Focusing on the first 1,000 days, including adolescents systematically, innovating in anemia control, designing an urban nutrition agenda, and institutionalizing technology-driven monitoring. Nutrition must be treated not as a welfare issue, but as a national development imperative. Embedding it across health, education, agriculture, and social protection is essential for achieving inclusive growth and global leadership.

Keywords: India, Malnutrition, Nutrition policy, Poshan Abhiyaan, Viksit Bharat 2047.

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Introduction

Nutrition is the foundation of human development. It shapes not only the health of individuals, but also the productivity of societies, the equity of opportunities, and the competitiveness of economies. A nation cannot aspire to prosperity if its population is malnourished. In India, the challenge is stark. Despite rapid economic growth and sustained investments in social programs, malnutrition remains widespread. One in three children under 5 years is stunted (35.5%), and more than half of women aged 15–49 years are anemic (57.0%).[1] These figures reflect not just a humanitarian crisis, but also an economic one (Table 1).

The World Bank estimates that malnutrition reduces India's gross domestic product (GDP) by 2–3% annually.[2] The stakes are high. India aims to become a five-trillion-dollar economy and a global leader. Yet, this ambition cannot be realized without addressing malnutrition. A healthy population is essential to harness the demographic dividend, improve learning outcomes, and build resilience against future health and economic shocks.

Table 1: Trends in child malnutrition and anemia in India [National Family Health Survey (NFHS) 2005–2006 to 2019–2021]

Indicator	*NFHS-3 (2005–2006)*	*NFHS-4 (2015–2016)*	*NFHS-5 (2019–2021)*
Stunting (<5 years)	48.0%	38.0%	35.5%
Wasting (<5 years)	19.8%	21.0%	19.3%
Underweight (<5 years)	42.5%	36.0%	32.1%
Anemia – women (15–49 years)	55.3%	53.1%	57.0%
Anemia – children (6–59 months)	69.5%	58.6%	67.1%

Source: NFHS-3, NFHS-4, NFHS-5[1]

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Globally, India's burden of malnutrition is among the highest. While countries such as Bangladesh and Brazil have made faster progress in reducing child stunting, India's pace has been slower despite having larger programs and investments. This comparison highlights the urgent need for renewed attention and innovation in India's nutrition policies. Nutrition must, therefore, move beyond being seen as a welfare intervention. It must be treated as a national policy priority, embedded across sectors, and central to the vision of a developed India.

Nutrition as a National Priority

The case for nutrition as a national priority is both economic and demographic. Poor nutrition leads to productivity losses, diminished cognitive capacity, and higher healthcare costs. Research shows that every dollar invested in nutrition interventions can yield between 16 and 18 dollars in social and economic returns.[3] Few other investments in development offer such high returns.

The demographic argument strengthens this case. By 2030, India will have the world's largest workforce. This potential dividend can quickly turn into a liability if young people enter the labor market undernourished, cognitively impaired, and physically weak.[4] The first 1,000 days of life, from conception to 2 years of age, are especially critical. Nutrition during this window shapes lifelong health, brain development, and productivity.

Equity concerns make nutrition even more urgent. Malnutrition disproportionately affects the poorest quintiles, tribal communities, and adolescent girls.[5] Regional disparities are striking: States such as Kerala and Tamil Nadu have achieved sharp reductions in stunting, vs states like Bihar, Uttar Pradesh, and Madhya Pradesh, which continue to show high levels.[1] Urban slums add further challenges of food insecurity, overcrowding, and poor sanitation. Addressing these inequities is not only a moral obligation, but also central to inclusive growth.

Nutrition also carries global significance. As the largest country in the Global South, India's success or failure in reducing malnutrition will influence the global nutrition agenda, South–South cooperation, and progress toward the Sustainable Development Goals (SDGs).[6] Nutrition is, therefore, not a sectoral concern, but a national development imperative. Unless addressed with urgency, it threatens India's growth, equity, and global leadership (Box 1).

Policy Landscape and Multi-sectoral Responses

India has long recognized that nutrition is multi-dimensional, cutting across health, education, sanitation, agriculture, and social protection. Over the past five decades, several major programs have sought to address malnutrition with varying degrees of success (Table 2). The Integrated Child Development Services (ICDS), launched in 1975, remains a cornerstone. Through Anganwadi centers, it delivers supplementary nutrition, immunization, health check-ups, and preschool education. The Mid-day Meal Scheme, rebranded as PM Poshan, provides hot cooked meals to schoolchildren, simultaneously addressing hunger and improving enrolment and retention.

More recent initiatives reflect a push for convergence and innovation. The Poshan Abhiyaan (National Nutrition Mission, 2018) integrates actions across ministries, strengthens real-time monitoring through digital platforms, and amplifies behavior change communication. The Anemia Mukt Bharat (AMB) strategy, also launched in 2018, aims to reduce anemia prevalence through supplementation, food fortification, deworming, and education.

Complementary policies reinforce this ecosystem. India has expanded food fortification of staples such as rice, wheat flour, oil, and salt. The Swachh Bharat Mission has improved sanitation, indirectly supporting nutrition outcomes by reducing diarrheal disease. The National Health Mission integrates maternal and child health services. At the same time, agricultural policies now emphasize biofortified crops and millets, especially after India's global leadership during the International Year of Millets 2023.

Collectively, these efforts highlight a consistent recognition that nutrition requires convergence across sectors. However, success depends not only on design, but also on local implementation, financing, and accountability (Box 2).

Gains and Success Stories

India's sustained nutrition programs have delivered measurable, though uneven, improvements. According to NFHS-5 (2019–2021), stunting among children under 5 years declined from 38% in 2015–2016 to 35.5%. Wasting reduced slightly from 21 to 19.3%, and underweight prevalence fell from 36 to 32.1%. However, anemia

Box 1: Global comparisons: Lessons for India

- Brazil: The Zero Hunger Program integrated school feeding, cash transfers, and farmer support. This reduced both poverty and malnutrition within a decade.
- Bangladesh: Community-based nutrition services combined with female health workers and microcredit programs drove rapid reductions in stunting.
- Peru: Conditional cash transfers linked to nutrition services increased coverage of antenatal care and child growth monitoring, sharply reducing chronic malnutrition.

Key message: Countries that combined nutrition with social protection, accountability, and local participation achieved faster reductions than India. These experiences show that India must strengthen cross-sectoral financing and accountability.

Box 2: Convergence in action: Linking agriculture and nutrition

- Biofortified crops (zinc-rich rice and iron-rich pearl millet) are being promoted through agricultural extension.
- Public procurement of fortified rice under public distribution system (PDS) and school meals ensures scale and reach.
- Millets have been positioned as "nutri-cereals," combining farmer income support with nutrition security.
- Such initiatives exemplify how agricultural policy can be harnessed directly for better nutrition outcomes.

Table 2: Major nutrition programs and policies in India

Program/policy	*Year launched*	*Focus area*	*Key features*
ICDS	1975	Early childhood	Anganwadi-based nutrition, health, and preschool education
Mid-day Meal/PM Poshan	1995 (revamped 2021)	School-age children	Hot cooked meals, improved enrolment and retention
Poshan Abhiyaan	2018	Convergence, monitoring	Real-time digital dashboards, community mobilization, and measurable targets
AMB	2018	Women, adolescents, children	Iron-folic acid supplementation, deworming, and fortification
Food Fortification Policy	2016 onwards	Staples	Fortification of rice, wheat, oil, and salt
Swachh Bharat Mission	2014	Sanitation	Toilets, waste management, and reduced open defecation
National Health Mission	2005	Maternal and child health	RMNCH+A services, linkages with nutrition outcomes
Millet Promotion	2023 focus	Agriculture and nutrition	Crop diversification, promotion of biofortified millets

Box 3: State innovations in nutrition

State	*Innovation*	*Why it matters*
Tamil Nadu	Mid-day Meal Program since 1982	Pioneered large-scale school feeding; improved child nutrition and enrolment
Maharashtra	CMAM through NGO–government partnerships	Reduced wasting in urban slums by tailoring interventions
Chhattisgarh	Decentralized food procurement via SHGs	Improved ICDS supply chain and women's economic empowerment
Odisha	SHG-led ration management under Mission Shakti	Increased transparency and accountability in take-home rations

Key message: Gains are possible when states adapt national programs to local contexts. Political will, women's collectives, and accountability mechanisms are consistent drivers of success.

worsened, with over 57% of women aged 15–49 years still affected.[1] State-level experiences demonstrate that success depends on political commitment, community participation, and decentralized implementation (Box 3).

- Tamil Nadu's Mid-day Meal Programme, running since the 1980s, has consistently improved child nutrition and educational outcomes.[4]
- Maharashtra piloted community-based management of acute malnutrition (CMAM), showing reductions in wasting when local non-governmental organizations (NGOs) partnered with municipal bodies.[7]
- Chhattisgarh decentralized food procurement for ICDS and empowered women's self-help groups, which improved supply chains and food quality.[8]
- Odisha's Mission Shakti mobilized self-help groups to manage take-home rations, increasing accountability and community trust.[9]

Community campaigns have also made a difference. The annual Poshan Maah, observed each September, mobilizes districts across India to conduct awareness drives, health check-ups, and community meetings on nutrition. These initiatives show that when programs are localized, decentralized, and inclusive, nutrition outcomes improve.

Persistent Challenges

India's fight against malnutrition faces structural and systemic hurdles that continue to slow progress.

Anemia remains the most pressing concern. Despite the large-scale AMB campaign, NFHS-5 data reveal that 57% of women of reproductive age and 67% of children under five are anemic.[10] Poor compliance with iron supplementation, inadequate dietary diversity, frequent infections, and low bioavailability of iron-rich foods all contribute to the problem.

Adolescents remain a blind spot. Current nutrition programs primarily target pregnant women and young children. Adolescent girls, however, are critical for breaking the intergenerational cycle of malnutrition. Without better school-based nutrition programs, menstrual health interventions, and peer education, this demographic will remain underserved.

Urban poor populations are another neglected group. Most interventions are designed for rural settings and do not adequately address the realities of migrant households, overcrowding, and unaffordable food in urban slums.[11]

Behavioral change is a weak link. Food taboos, cultural myths, and low awareness reduce the impact of even well-designed interventions. Sustained social and behavior change communication is often underfunded and inconsistently implemented.

Service delivery gaps also undermine effectiveness. Many Anganwadi centers lack infrastructure, face absenteeism, or have irregular supply chains. Community monitoring remains weak in several states, reducing accountability at the last mile.

Financing and accountability are fragmented. Nutrition budgets are spread across multiple ministries, with limited mechanisms to track spending or outcomes. This dilutes responsibility and hampers coordinated action.

Finally, data use and monitoring are still limited. Tools like the Poshan Tracker are promising, but the systematic use of real-time data in district planning and decision-making is yet to take root.

Case Examples from India and Beyond

State and community-level innovations demonstrate how local adaptation drives impact. In Maharashtra, NGOs such as the Society for Nutrition, Education and Health Action (SNEHA) partnered with municipal authorities in Mumbai to reduce child wasting through community-based approaches.[7] In Bihar, iron supplementation for adolescent girls was most effective when teachers directly monitored consumption, showing the importance of institutional accountability. Odisha's SHG-led ration management proved that community ownership enhances quality and sustainability.[9]

Global experiences provide valuable lessons. Brazil's Zero Hunger Programme integrated cash transfers, school feeding, and farmer support, reducing both poverty and malnutrition within a decade.[12] Bangladesh combined community-based nutrition services with microcredit and female health workers, achieving faster reductions in stunting than India. Peru linked conditional cash transfers to antenatal care and child growth monitoring, sharply cutting chronic malnutrition.

These experiences highlight that integration, accountability, and social protection are central to success. India's nutrition architecture already contains many of these elements, but stronger convergence and dedicated financing are needed to replicate such results at scale.

Priorities for the Future: Towards Viksit Bharat 2047

The vision of Viksit Bharat 2047 provides a long-term horizon for embedding nutrition as a national development imperative. Five priorities stand out:

1. Focus on the first 1,000 days: Interventions during pregnancy and early childhood must remain central, with emphasis on maternal nutrition, exclusive breastfeeding, and complementary feeding.

2. Include adolescents systematically: Expand school-based nutrition services, integrate menstrual health initiatives, and use digital platforms for awareness.
3. Reimagine anemia control: Move beyond supplementation to dietary diversification, fortification, infection control, and innovations such as community kitchens.
4. Craft an urban nutrition agenda: Address affordability, safety, and food access for the urban poor, while exploring urban agriculture and community canteens.
5. Institutionalize technology and accountability: Integrate nutrition indicators into district planning and budgeting, and mandate annual public reporting to sustain political momentum.

These priorities must be backed by dedicated financing, inter-ministerial coordination, and independent monitoring to ensure results.

Nutrition as a Lever of Development

Nutrition is not just a health concern; it is a central driver of education, gender equality, productivity, and national competitiveness. Malnourished children are more likely to drop out of school, while well-nourished children perform better and contribute more to the knowledge economy.[13] Poor maternal nutrition lowers female labor force participation and perpetuates cycles of disadvantage, constraining growth.

Conversely, a well-nourished population creates a virtuous cycle: Higher productivity, stronger social cohesion, greater gender equity, and sustained economic progress. Nutrition, therefore, is the invisible thread connecting household well-being with India's aspirations of becoming a global leader.

Conclusion

India stands at a defining moment. Ambitions of global leadership and economic transformation cannot be achieved without first addressing malnutrition. Nutrition is not peripheral; it is central to the project of nation-building. The call to action is clear: No child should be hungry, no adolescent girl should be anemic, and no woman should be left behind. Embedding nutrition as a national policy priority, across health, education, agriculture, urban development, and social protection, will lay the strongest foundation for a developed India by 2047. A well-nourished India is the true foundation of a Viksit Bharat.

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REVIEW ARTICLE

Measuring and Sustaining Progress: India's Journey in Multidimensional Poverty Reduction

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Abstract

India's multidimensional poverty transition is one of the most important achievements in global development over the past decade. Based on the National Family Health Survey-4 (NFHS-4) (2015–2016) and NFHS-5 (2019–2021), the multidimensional poverty index (MPI) shows that India reduced its poverty headcount ratio from 24.85 to 14.96%. In just 5 years, more than 135 million people moved out of poverty. This paper presents India's MPI journey, places it in the global fight against poverty, and highlights lessons for other countries working toward Sustainable Development Goal (SDG) 1.2, which aims to reduce poverty in all its forms by half by 2030. India's success comes from bold policy actions that improved living standards through access to sanitation, housing, electricity, safe drinking water, and clean cooking fuel, supported by better maternal health, child nutrition, and education. However, challenges remain. Malnutrition, poor school completion, and regional gaps continue to affect millions. India's example shows how institutionalizing MPI measurement and linking it with governance can drive results. The paper argues that robust data systems, targeted social protection, and systemic resilience are critical for sustaining progress and ensuring that no one is left behind.

Keywords: Education, Global poverty trends, Health, India, Living standards, Multidimensional poverty index, Nutrition, Poverty reduction, Social protection, Sustainable development goals.

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Introduction

Over the past three decades, our understanding of poverty has changed greatly. Earlier, experts defined poverty mainly as a lack of income or consumption below a fixed threshold. Today, we see poverty as a multidimensional problem that combines overlapping deprivations in health, education, and living standards. This conceptual shift has been institutionalized through the development and application of the multidimensional poverty index (MPI), a tool that combines indicators across sectors to measure both the incidence and intensity of poverty.[1,2] India has become one of the most prominent global case studies of this approach, not only because of the scale of its population but also because of the remarkable pace at which it has reduced poverty in recent years. Between 2015–2016 and 2019–2021, India's MPI headcount ratio fell from 24.85% [National Family Health Survey-4 (NFHS-4)] to 14.96% (NFHS-5) (Fig. 1), representing a decline unprecedented in speed and scale. More than 135 million individuals are estimated to have moved out of multidimensional poverty during this period.[1] Further, the World Bank has announced a major revision to global poverty estimates, raising the international poverty line (IPL) from $2.15/day [2017 purchasing power parity (PPP)] to $3.00/day (2021 PPP). While the change led to a global increase in the count of extreme poverty by 125 million, India emerged as a statistical outlier in a positive direction.[3]

This paper gives a comprehensive perspective on India's MPI journey. It analyzes the methodology, policy drivers, and emerging challenges and places India's progress within the global poverty landscape. At the same time, it highlights persistent deprivations, regional disparities, and the urgent need to protect gains from shocks such as the COVID-19 pandemic and climate change. Sustainable Development Goal (SDG) target 1.2 calls for cutting poverty in all its dimensions by half by 2030. India's experience shows how countries can achieve this through evidence-based and convergent action at scale.

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The Evolution of Multidimensional Poverty Measurement

For many years, poverty was measured mainly by monetary metrics, such as income or consumption per person. While useful, these measures often hid the real experience of deprivation by ignoring overlaps in health, education, and living standards. The Alkire–Foster methodology, which forms the basis of the MPI, changed this by combining multiple indicators into one measure. It captures not only how many people are poor but also how poor they are.

India's national MPI uses twelve indicators across three dimensions. Health includes nutrition, maternal and child health, and child mortality (Table 1). Education covers years of schooling

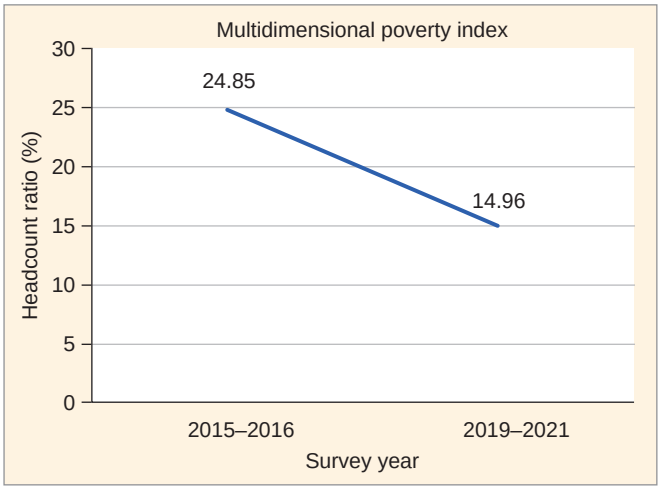

Fig. 1: India's multidimensional poverty headcount ratio declined from 24.85 to 14.96%

Table 1: The table presentation clarifies the breadth of India's MPI indicators and aligns with international standards

Dimension	*Indicators (India's MPI)*
Health	Nutrition; maternal and child health; and child mortality
Education	Years of schooling and school attendance
Living standards	Cooking fuel; sanitation; drinking water; electricity; housing; assets; and bank account access

and school attendance. Living standards include cooking fuel, sanitation, drinking water, electricity, housing, assets, and bank account access. A household is multidimensionally poor if it faces deprivations in at least one-third of these weighted indicators. This design follows international standards while adding elements relevant to India, such as bank account access. Importantly, the MPI can be broken down to the district level, which makes targeted planning and accountability possible.

India's Transformation: Patterns and Drivers

The reduction of multidimensional poverty in India between 2015–2016 and 2019–2021 is striking in both scale and breadth. The national headcount ratio fell by more than half in just 5 years. Rural areas, where poverty was historically concentrated, experienced a steep decline from approximately 32.59–19.28%. Urban poverty, though lower to begin with, also fell from nearly 9% to under 5%. The transformation was not confined to a few states; every state registered a decline, although with varying degrees of progress. States like Uttar Pradesh (UP), Bihar, Madhya Pradesh (MP), Odisha, and Rajasthan recorded the steepest decline in the number of MPI poor.[1]

Between 2015–2016 and 2019–2021, more than 135 million people moved out of multidimensional poverty[1] (Box 1). Under the Pradhan Mantri Ujjwala Yojana, over 96 million liquefied petroleum gas (LPG) connections were released to women beneficiaries. The Swachh Bharat Mission declared over 600 million people free from open defecation by constructing more than 110 million toilets.

Box 1: Top five policy drivers of MPI reduction in India

1. Ujjwala Yojana (clean cooking fuel)
2. Swachh Bharat Mission (sanitation)
3. Saubhagya (electricity)
4. Pradhan Mantri Awas Yojana (housing)
5. Jal Jeevan Mission (piped water supply)

The Saubhagya scheme provided electricity connections to 28.2 million households, while Pradhan Mantri Awas Yojana sanctioned over 22 million houses. These numbers illustrate how large-scale flagship programs reshaped the physical and social infrastructure of daily life.

A closer look at the contribution of indicators reveals that much of the decline was driven by improvements in living standards. Access to clean cooking fuel expanded dramatically through the Ujjwala Yojana, which provided subsidized LPG connections to millions of households. The Swachh Bharat Mission increased access to toilets and sanitation, while the Saubhagya scheme ensured near-universal household electricity coverage. Housing improvements under the Pradhan Mantri Awas Yojana and access to piped water through the Jal Jeevan Mission reinforced this momentum. Together, these initiatives reshaped the physical and social infrastructure of daily life for hundreds of millions of people.

At the same time, gains in health and education added to poverty reduction. Maternal health indicators improved through programs such as Janani Suraksha Yojana and Janani Shishu Suraksha Karyakram, complemented by the expansion of institutional deliveries. Immunization drives and the Prime Minister's Overarching Scheme for Holistic Nourishment (POSHAN) Abhiyaan targeted child nutrition, though malnutrition remains stubbornly high in certain regions. School attendance improved in many states, although learning outcomes and secondary school completion remain uneven. The cumulative impact of these sectoral interventions was amplified by convergence: Coordinated action across ministries and schemes created synergies that exceeded the sum of their parts.

Persistent Deprivations and Regional Disparities

Despite these achievements, MPI analysis shows persistent deprivation. Nutrition remains a major challenge, with high rates of child stunting, wasting, and maternal undernutrition in states such as Bihar, Jharkhand, and UP.[4] National Family Health Survey-5 reports that 35.5% of children under five are stunted, 19.3% are wasted, and 18.7% of women aged 15–49 have a body mass index (BMI) below 18.5 kg/m^2.[4] These indicators continue to drive multidimensional poverty and highlight the urgent need for targeted nutrition interventions. Sustained investments in food security, dietary diversity, and maternal health services are therefore essential.

Education also presents a mixed picture. Enrollment has improved, but dropout rates, especially among adolescent girls, remain a concern. Unified District Information System for Education (UDISE) 2021–2022 shows that the gross enrollment ratio at the secondary level is 78.0%, but it falls sharply for girls in several states. Annual Status of Education Report (ASER) 2022 further shows that only 20% of class III children in government schools can read class II texts, pointing to a serious learning deficit. The quality of education,

as highlighted by ASER, lags behind enrollment gains, limiting its power to break the cycle of poverty.

Regional disparities add to the challenge. Southern and western states perform better, while northern and eastern states lag. District-level data reveal pockets of high deprivation even in relatively prosperous states, showing the need for hyper-localized planning and implementation.

A further limitation is that most NFHS-5 data were collected before the COVID-19 pandemic. The pandemic caused severe disruptions in livelihoods, schooling, and health services that are not fully reflected in MPI figures. While targeted relief prevented a dramatic reversal, the risk of setbacks underscores the importance of building resilient social protection.

India's Poverty in the Global Context

Globally, the 2024 MPI estimates that 1.1 billion people out of 6.1 billion across 110 countries are multidimensionally poor.[5] Sub-Saharan Africa and South Asia together account for more than four-fifths of this burden. India, despite its dramatic progress, still has around 234 million poor people, the largest absolute number of any country.[6] India's reduction accounted for over 30% of the total global decline in MPI poor between 2015 and 2021, making it a central driver of worldwide poverty. This duality, rapid reduction on the one hand and a large remaining burden on the other, places India at the heart of global poverty debates.

Comparisons highlight both progress and challenges. While India reduced MPI poverty at a record pace, countries affected by conflict, such as Afghanistan, have experienced reversals, with poverty incidence rising between 2015–2016 and 2022–2023.[6] In many low-income settings, data gaps hinder accurate measurement, as household surveys are outdated or incomplete, and displaced populations are often excluded. The global poverty picture is further complicated by shifts in monetary poverty lines: The World Bank's adoption of a $3.00 per day (2021 PPP) benchmark raised global poverty counts by more than 100 million people. In this context, India's MPI-driven achievements stand out as a beacon of possibility.

Policy Priorities for the Next Phase

India's next phase of poverty reduction must focus on deepening and consolidating gains. Nutrition and maternal health need urgent attention because they continue to drive deprivation. Malnutrition harms child development and locks families into intergenerational cycles of poverty. The World Bank estimates that malnutrition reduces India's gross domestic product (GDP) by 2–3% every year.[7] India must scale up fortified food distribution, expand community-based nutrition programs, and strengthen maternal health services, especially in lagging districts.

Education now needs a fresh focus on quality and completion, especially at the secondary level. India must invest in teacher training, infrastructure, and digital access so that children not only attend school but also gain skills relevant to the labor market. Girls' education requires special attention because it creates ripple effects across health, fertility, and economic participation.

At the same time, India must strengthen social protection and health coverage to protect households from shocks. The pandemic showed how quickly vulnerabilities can return when safety nets are weak. Expanding and integrating schemes such as Ayushman Bharat Pradhan Mantri Jan Arogya Yojana (PM-JAY) with wider welfare programs will help families avoid slipping back into poverty.

A cross-cutting priority is enhancing climate and disaster resilience in poverty programs. Integrating early warning systems, climate-adaptive infrastructure, and shock-responsive social protection will help prevent vulnerable households from sliding back into poverty in the face of future crises.

Institutionalizing the use of MPI at the district level can sharpen planning and accountability. Embedding MPI indicators into frameworks such as the Aspirational Districts Program and state-level SDG dashboards will ensure that interventions remain tailored, evidence-driven, and outcome-oriented.

Finally, innovation in data systems is essential. Traditional household surveys are invaluable but infrequent. Leveraging administrative data, satellite imagery, and digital platforms can enable near-real-time monitoring of deprivations. Ensuring that these innovations capture marginalized and mobile populations, such as migrants and displaced communities, will make poverty measurement more inclusive and responsive to crises.

Lessons for Global Policy and Research

India's experience offers several lessons of global importance. First, measurement matters. Robust, comparable, and disaggregated data allow governments to design targeted policies and monitor results effectively. Second, convergence across sectors multiplies impact. When housing, sanitation, health, and education programs work together, the outcomes are transformative. Third, protecting households from slipping back is as important as lifting them out. Health shocks, climate disasters, and economic crises can erase years of progress unless strong safety nets are in place. Fourth, embedding poverty measures into governance ensures that poverty reduction becomes an institutional process, not a one-time campaign. Fifth, linking poverty metrics to long-term national visions, such as India's Viksit Bharat @2047, can maintain political and administrative commitment across electoral cycles.

Global poverty reduction is slowing, but India shows that rapid progress is possible. At the same time, its case highlights the scale of the challenge. A country that moved 135 million people out of multidimensional poverty in just 5 years still has 234 million poor. This reality shows that global poverty eradication will need both ambition and realism.[1,5]

Conclusion

India's multidimensional poverty transition is both a national success and a global example. The fall in the headcount ratio from 24.85% (NFHS-4) to 14.96% (NFHS-5) within 5 years is among the fastest and largest poverty reductions in history. This progress came from combining rigorous measurement with large-scale policy action across health, education, and living standards.

Yet challenges remain. Malnutrition, low school completion, regional disparities, and household vulnerability to shocks continue to slow progress. India must now sustain the pace of poverty reduction, consolidate the gains, and make sure every group benefits. This aligns closely with the vision of Viksit Bharat @2047.

For the world, India shows how countries can cut multidimensional poverty at scale, even in complex socio-economic settings. With the 2030 SDG deadline approaching, the stakes are high. India's progress proves what is possible but also reminds us of what is still unfinished. Embedding MPI indicators

into national and state planning under Viksit Bharat @2047 will be key to protecting gains and ensuring no one is left behind.

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REVIEW PAPER

Anemia, Nutritional Factors, and Dietary Patterns among Indian Women of Reproductive Age: A Regional Analysis Using NFHS-4 and NFHS-5 Data

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Abstract

Anemia is a significant public health concern worldwide, affecting people across different age-groups, socioeconomic levels, and geographic regions. In India, the burden is especially severe among women and young children. This disease is characterized by a reduced red blood cell (RBC) count or a lower-than-normal hemoglobin (Hb) concentration. Nutritional deficiencies, particularly of iron, folic acid, and vitamin B12, are among the primary causes of anemia. Therefore, identifying common dietary patterns within specific population subgroups and analyzing their association with anemia prevalence is crucial for effective disease control.

It is an overview of anemia, including its etiology, nutritional causes, diagnostic methods, prevalence, government initiatives aimed at reducing its burden, and regional dietary variations among women of reproductive age in India. The study focuses on trends observed in data from the National Family Health Surveys (NFHSs), specifically rounds 4 (2015–2016) and 5 (2019–2021). The analysis was conducted over five different states representing different regions of India, chosen at random—Haryana (North), Gujarat (West), Kerala (South), West Bengal (East), and Assam (Northeast), with emphasis on iron-rich food groups based on observations from the food frequency questionnaire (FFQ). It aims to explore the association between regional dietary patterns and the prevalence of anemia, highlighting nutrition as a major contributing factor. It also emphasizes the urgent need to enhance awareness of anemia among healthcare professionals and the general population, while simultaneously strengthening evidence-based program interventions such as the Anemia Mukt Bharat (AMB) initiative, for its effective prevention, control, and management of the disease burden of anemia in our nation.

Keywords: Anemia, Anemia Mukt Bharat, Dietary pattern, Dietary pattern among Indian women, Iron deficiency anemia, National Family and Health Survey, States of India.

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Introduction

Anemia is of public health concern globally, and it affects individuals belonging to different age-groups, social and economic groups, and geographic regions. It is an ailment characterized by a lower-than-normal count of red blood cells (RBCs) or the hemoglobin (Hb) concentration they contain, leading to impaired oxygen transport and various health consequences.[1] As stated by the World Health Organization (WHO), anemia is diagnosed when Hb levels drop beneath 11.0 gm/dL in expectant mothers, 12.0 gm/dL in non-pregnant women, and 13.0 gm/dL in adult males aged 15–65 years.[2] In 2021, the global prevalence across all age-groups was 24.3%.[3] According to NFHS-5 reports, 57% of women and 25.1% of men suffer from anemia in India.[4] Anemia results in a wide spectrum of clinical manifestations, including fatigue, weakness, dizziness, and breathlessness. The optimal Hb concentration required to meet physiologic needs varies by age, sex, elevation of residence, smoking habits, and pregnancy status. Anemia is caused due to various factors that include nutrient deficiencies through inadequate diets or inadequate absorption of nutrients, infections (e.g., malaria, parasitic infections, tuberculosis, HIV), inflammation, chronic diseases, gynecologic and obstetric conditions, and inherited RBC disorders. The most common nutritional cause of anemia is iron deficiency (ID). Other nutritional deficiencies leading to anemia include folate, vitamins B12, and A deficiency.[5,6]

India has a diverse and culturally rich cuisine, with dietary habits strongly influenced by social identity, religion, agricultural practices, and food availability.[7,8] Since nutritional deficiencies, particularly iron, folic acid, and vitamin B12, are among the primary causes of anemia, identifying common dietary patterns within specific population subgroups and analyzing their association with the prevalence of anemia is beneficial to combat the disease prevalence. This is important in countries like India, as it is going through a dietary shift from a traditional to more westernized dietary patterns.[9] This literature review aims to consolidate existing literature on dietary patterns among women of reproductive age (15–49 years) across different regions of India and examine their association with anemia prevalence, as reported in the NFHS-5 survey.

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Definition

Anemia is a condition in which the number of RBCs or the Hb concentration within them is lower than normal.[1] This leads to reduced oxygen carrying capacity, resulting in reduced work capacity in adults and decreased cognitive and motor development in children. Anemia, a word of Greek origin meaning "without blood," is defined as a reduction in the concentration of Hb, erythrocyte mass, or hematocrit in peripheral blood to a level below 2 standard deviations (–2 SD) from the average for the patient's age, sex, and ethnicity.[10] Anemia usually points to an underlying health issue and can be classified based on RBC size—as macrocytic, microcytic, or normocytic. This may result in varied symptoms, including dyspnea, tiredness, fatigue, reduced cognitive function, weakness, dizziness, etc. Symptoms tend to be more severe when Hb drops significantly or suddenly.

Etiology of Anemia: Biological and Socioeconomic Determinants

At a biological level, anemia develops due to an imbalance in erythrocyte loss relative to production. This may result from ineffective or deficient erythropoiesis. Myeloid progenitor cells in the bone marrow are responsible for the production of RBCs. This process requires an optimal bone marrow microenvironment and adequate substrates, including iron, vitamin B12, and folate, which are essential for Hb formation, protein, and DNA synthesis. Erythropoiesis refers to the formation of RBCs from hematopoietic stem cells in the bone marrow, a process regulated by the hormone EPO. Erythropoietin is synthesized by peri-tubular fibroblasts in the renal cortex in response to hypoxia.[11] Disruption in any of these physiological requirements can lead to the development of anemia.

Nutritional deficiencies are among the most common etiological factors of anemia. Iron deficiency impairs Hb synthesis, while deficiencies in vitamin B12 or B9 interfere with the DNA synthesis, resulting in ineffective erythropoiesis. Other contributing factors include renal disease (causing reduced EPO production), inflammation, genetic Hbopathies, and increased erythrocyte loss due to hemolysis or chronic blood loss.[12]

In addition to these proximal causes, a wide range of distal factors—including education, socioeconomic status, geography, and climate—also contribute indirectly to the burden of anemia. These influence more immediate determinants such as food security, access to clean water, sanitation, and healthcare.[12] Many of these factors are interrelated, and their impact varies by severity. The causes of mild and moderate anemia often differ from those of severe anemia, with more complex and multifactorial interventions.

Nutritional Deficiencies Contributing to Anemia

Anemia is caused due to various reasons, causing defects in the red cells. It includes factors affecting red cell production (aplastic anemia), maturation (megaloblastic anemia), Hb synthesis [iron deficiency anemia (IDA)], genetic maturation defects (thalassemia), or physical loss of red cells (hemolytic anemias). Nutritional anemias occur when the availability of essential hematopoietic nutrients, such as iron, vitamin B12, folate, and others, is inadequate to sustain normal erythropoiesis and RBC integrity.[13] Nutrient deficiencies may result from insufficient dietary intake, increased nutrient losses (such as blood loss due to parasitic infections, postpartum hemorrhage, or heavy menstrual bleeding), impaired nutrient absorption (for example, due to lack of intrinsic factor for vitamin B12 absorption, high dietary phytate content, or Helicobacter pylori infection interfering with iron absorption), or altered nutrient metabolism (as seen with vitamin A or riboflavin deficiencies that impair iron mobilization from stores). Although nutrient supplementation is a widely used approach for preventing and treating nutritional anemias—such as using iron supplements to prevent IDA—the effectiveness of these interventions may be limited by variations in the bioavailability and absorption of different supplement formulations. Iron deficiency is the main cause of nutritional anemia. Other nutrient deficiencies leading to nutritional anemia include vitamin A, B12, B9, B6, B2, C, D, E, copper, and zinc.[14] Their role in the body includes erythropoiesis (vitamin A, B6, B9, B12, B2), RBC protection due to antioxidant function (vitamin C, E). Trace elements such as copper and zinc are integral to enzymes involved in iron metabolism; for example, copper is a constituent of ceruloplasmin, an enzyme that plays a role in iron transport and homeostasis.[15] Copper may paradoxically contribute to the development of anemia by lowering EPO levels and impairing copper-dependent antioxidant enzymes, which in turn increases oxidative stress and reduces the lifespan of RBCs.[16] The exact mechanisms by which zinc deficiency contributes to anemia remain unclear, and the overall impact of each deficiency on global anemia prevalence is still under investigation.[16] While some nutrient deficiencies are uncommon and have limited global effects, deficiencies in multiple micronutrients likely interact synergistically, aggravating anemia.[12]

Iron Deficiency

Iron deficiency develops when iron intake is consistently lower than the body's needs, especially during times of increased demand like infancy, adolescence, or pregnancy, or when iron losses, such as from bleeding, outweigh intake. Iron deficiency develops in three stages: First, the body's iron stores are depleted; next, RBC production becomes impaired due to insufficient iron; and finally, IDA occurs, characterized by both low iron levels and anemia.[17] The WHO recommends assessing iron status using serum ferritin or soluble transferrin receptor (sTfR).[18,19] Ferritin reflects iron stores but can rise during inflammation, while elevated sTfR indicates tissue-level deficiency, though it too may be influenced by inflammation or increased RBC production.[18,19] To interpret iron biomarkers accurately, it is important to also measure markers of inflammation, like C-reactive protein (CRP) and α-1-acid glycoprotein (AGP).[18]

Vitamin A Deficiency (VAD)

Vitamin A deficiency and anemia have long been observed together in various populations, with studies across different age-groups—children, adolescents, and adults—showing significant associations between vitamin A status and Hb levels.[20] Vitamin A supplementation has been found to improve Hb, hematocrit, and some iron-related markers, even without concurrent iron supplementation.[20,21] Vitamin A deficiency may contribute to anemia through several pathways, including its role in RBC production, immune function, and iron metabolism.[20] Unlike IDA, which involves depleted iron stores, VAD-related anemia is often characterized by elevated iron accumulation in the liver and spleen and increased serum ferritin.[22] This form of anemia may appear as hypochromic or microcytic-hypochromic, though overlapping factors like coexisting nutrient deficiencies or infections can lead to variable RBC findings.[20]

Deficiency of B Vitamins

Several B vitamins—such as riboflavin (B2), cobalamin (B12), and folate—play essential roles in Hb production and iron metabolism.

While vitamin B6 (pyridoxine) is also involved, its deficiency is uncommon and not discussed in this context.[21]

Vitamin B12 and folate deficiencies lead to macrocytic anemia by disrupting DNA synthesis and impairing normal cell division in the bone marrow. This often results in megaloblastic changes, such as hypersegmented neutrophils seen on a blood smear.[22] Folate deficiency may also shorten the lifespan of RBCs.

Vitamin B12 deficiency is mainly linked to low dietary intake, since its absorbable forms are found exclusively in animal-based foods in low- and middle-income countries. Other causes include malabsorption, particularly in older adults with gastric atrophy, pernicious anemia caused by intrinsic factor autoantibodies, and certain bacterial or parasitic infections.[23,24]

Folate deficiency is more prevalent in populations relying on unfortified wheat or rice and consuming few legumes or leafy greens.[23] Those at higher risk include pregnant women, preterm infants, and individuals in malaria-endemic areas, as folate also supports malaria parasite replication.[25] In early pregnancy, inadequate folate can cause megaloblastic anemia, which may worsen due to increased demands during late pregnancy and breastfeeding.[13] Interestingly, studies show that high rates of B12 or folate deficiency do not always correlate with anemia, except notably among B12-deficient vegetarian women and their children.[26]

Riboflavin functions as a key redox cofactor in iron metabolism. Its deficiency may impair iron absorption, hinder release from stores, increase iron loss, and disrupt globin synthesis.[21,27] Some studies suggest that combining riboflavin with iron improves Hb levels more effectively than iron alone, particularly in children and pregnant women, though results vary.[28]

Undernutrition

Some studies have shown associations between anemia and stunting, wasting, and underweight, but not all.[29,30] These indicators of undernutrition are linked to anemia by underlying common factors—including maternal nutrition, insufficient complementary feeding, the low intake of micronutrients and animal-source foods, poor sanitation, unsafe drinking water, suboptimal breastfeeding practices, and infection rates—rather than by a direct causal link.[31]

Overweight/Obesity

Anemia and overweight or obesity are assumed to be related through hepcidin, a liver peptide that regulates homeostasis of iron and increases in response to inflammation.[32] In people who are overweight or have obesity, there is chronic low-grade inflammation, which increases hepcidin and subsequently decreases iron absorption.[33] Nevertheless, Hb concentrations frequently remain normal.[32,33]

Diagnosis of IDA

According to the WHO, anemia is defined as a state when Hb concentration is below 130 gm/L in men, 120 gm/L in non-pregnant women, and 110 gm/L in pregnant women and preschool-aged children.[2] Among the various causes of anemia, ID remains the most prevalent, particularly in low- and middle-income countries. Iron deficiency anemia is not only highly common but also largely preventable and treatable through timely nutritional and therapeutic interventions. It could be a sign of other underlying issues. Microcytic or hypochromic anemia—reflected by reduced mean corpuscular volume (MCV) or mean corpuscular hemoglobin (MCH)—is often due to ID, but other causes like thalassemia should be considered, particularly in areas where it is more prevalent.[34]

Iron status should be assessed through iron studies, weighed against red cell measures. Of the markers available, serum ferritin is the most sensitive and readily accessible to a clinician to detect an ID.[35] All the assay methods available, whether they are radiometric or non-radiometric or based on agglutination, are equally good as long as they were calibrated with WHO reference standards. If the same assay method is employed at both the individual and the community level of follow-up, this will help to ensure good comparability between results.[36]

According to WHO, in adults with anemia, a ferritin level below 15 gm/L is used to confirm ID.[36] For infants and young children, a slightly lower cut-off of 12 gm/L is used to confirm ID.[36] Although ferritin is a key biomarker of iron storage, its role as an acute-phase reactant means it can be elevated during systemic inflammation, infections, or chronic diseases, complicating the diagnosis of ID.[34] In such cases, a ferritin level below 70 gm/L is considered indicative of ID.[36] Inflammation markers like CRP and AGP may also be checked for proper diagnosis. Serum iron levels are unsuitable for diagnosis as they fluctuate throughout the day and drop during both ID and inflammation.

Functional iron deficiency (FID) refers to a state in which iron stores are adequate, but iron is not effectively mobilized for erythropoiesis. It is most likely to occur due to elevated levels of hepcidin. This condition is frequently observed in individuals with end-stage kidney disease, where the response to EPO-stimulating agents (ESAs) tends to improve when serum ferritin levels exceed 200 ng/mL.[37] Functional ID is also implicated in anemia associated with chronic inflammatory conditions, such as rheumatoid arthritis.

Assessment of FID can be supported by hematologic markers, including the percentage of hypochromic red cells and reticulocyte Hb content, which are available on certain automated analyzers and offer insight into functional iron availability in patients undergoing ESA therapy. Soluble transferrin receptor levels also serve as a useful indicator, as they increase in response to tissue-level ID and are unaffected by inflammatory states.[38] The sTfR/log ferritin ratio has shown a positive correlation with total body iron stores. However, the clinical utility of sTfR is limited by inter-assay variability, restricted availability, and slower turnaround times in some laboratories. In diagnostically complex cases, bone marrow iron assessment remains the gold standard for confirming IDA.

Disease Burden of Anemia

Global Level

In 2021, the prevalence of anemia across all ages was found to be 24.3% globally, a decrease from 28.2% in 1990. The prevalence of severe anemia was 0.9%, moderate anemia was 9.3%, and mild anemia was 14.1%. Due to population growth, the number of people suffering from anemia increased from 1.5 billion in 1990 to 1.92 billion in 2021. The years lived with disability (YLD) due to anemia rose from 46.6 million in 1990 to 52.0 million in 2021. Anemia was less common in males than in females across all age-groups. In 2021, 17.5% of males and 31.2% of females of all ages were affected by anemia. Sex difference in anemia prevalence was highest among adolescents and adults aged 10–64 years. In contrast, although children under 5 had a high overall prevalence of 41.4%, the gap between males and females was relatively smaller. In 2021, anemia prevalence was highest in western sub-Saharan Africa (47.4%), followed by South Asia (43.0%) and central sub-Saharan Africa (35.7%). In contrast, the lowest anemia prevalence in 2021 was

observed in Australasia (5.7%), Western Europe (6.0%), and high-income North America (6.8%). Anemia prevalence disparities were more significant at the country level in 2021. Mali, Zambia, and Togo had the highest burden, each with an anemia prevalence exceeding 50%, while Iceland, Norway, and Monaco had the lowest burden, with anemia prevalence below 5%.[3]

National Level

According to National Family Health Survey (NFHS) 5 (2019–2021) report, the prevalence of anemia among men (15–49 years) is 25%, 57% among women (15–49 years), 31.1% among adolescent boys (15–19 years), 59.1% among adolescent girls (15–19 years), 52.2% among pregnant women (15–49 years) and 67.1% among children (6–59 months).[4]

In contrast as per the NFHS-4 (2015–2016), the prevalence of anemia among men (15–49 years) is 22.7%, 53% among women (15–49 years), 29.1% among adolescent boys (15–19 years), 54% among adolescent girls (15–19 years), 50.3% among pregnant women (15–49 years), and 58.4% among children (6–59 months).[4]

India had been making progress in tackling anemia, but NFHS-5 marked a reversal, showing higher prevalence rates in every age and gender group compared to NFHS-4. A study by Sachdev et al. raises concerns about the accuracy of anemia estimates, attributing possible overestimation to the use of inappropriate diagnostic criteria.[39] Using adjusted cut-offs (10.8 gm/dL), the observed prevalence in children aged 0–19 dropped by nearly 19.2% compared to estimates based on WHO definitions (11.5 gm/dL for children and 12.0 gm/dL for adolescents). Since WHO-defined cut-offs are largely based on White adult populations, multiple studies have demonstrated ethnic differences in anemia prevalence.

Another factor found responsible for the rise is that NFHS relies on capillary blood for Hb testing with a portable HemoCue Hb 201+ analyzer, which is known to provide higher Hb readings compared to venous blood samples.[40] The effect of the COVID-19 pandemic, coupled with the widespread fear of contracting the virus, could have influenced the surveyors' approach and the overall methods used during the survey.

Despite the NFHS data being collected in two phases, the anemia prevalence in the first phase (pre-COVID) closely matched the final survey results. Poverty, along with food and nutrition insecurity, is key factor influencing undernutrition. During 2014–2019, high unemployment rates and rising food prices likely worsened anemia prevalence among many Indian households. The economic situation deteriorated further after the onset of the COVID-19 pandemic in 2019.[41]

Government Initiative to Combat Anemia

Anemia Mukt Bharat (AMB)

The reduction of anemia is a key objective of the POSHAN Abhiyaan, launched in March 2018. In line with the targets set by POSHAN Abhiyaan and the National Nutrition Strategy of NITI Aayog, the Ministry of Health and Family Welfare introduced the AMB initiative in 2018. Designed to achieve the World Health Assembly target of a 50% reduction in anemia among women of reproductive age by 2025, and to meet POSHAN Abhiyaan's goal of reducing anemia prevalence among young children (6–59 months), adolescents, and women (15–49 years) by 3% points annually, AMB adopts a focused and strategic approach.

The Government of India had launched a strategy in 2018 with the aim to reduce anemia by providing a preventive and curative mechanism by the name AMB.[5] The 6X6X6 strategy includes six beneficiary age-groups—Children: 6–59 months, children: 5–9 years, adolescents: 10–19 years, women of reproductive age (15–49 years), pregnant women and lactating women through implementation of six interventions: Prophylactic iron–folic acid supplementation; periodic deworming; intensified year-round behavior change communication campaign; testing of anemia using digital invasive Hbometer and point of care treatment; mandatory provision of iron–folic acid fortified foods in public health programs; addressing non-nutritional causes of anemia in endemic pockets, via six institutional mechanisms—Inter-ministerial coordination; convergence with other ministries; strengthening supply chain and logistics; engaging national center of excellence and advanced research on anemia control for capacity building of healthcare providers; and monitoring using AMB dashboard.[6]

Methodology

The available information and literature on anemia have been explored for this secondary research. A systematic approach was adopted to search and analyze NFHS-4 and 5 reports and peer-reviewed articles. A detailed search was carried out using electronic databases. Keywords like "anemia," "causes of anemia," "nutritional causes of anemia," "iron deficiency anemia," "dietary patterns of India," and "dietary pattern in different states of India" were searched on data portals, including PubMed, Google Scholar, Science Direct, and Research Gate. NFHSs – rounds 4 (2015–2016) and 5 (2019–2021) were taken as the source for analyzing the prevalence of anemia across five states of India from five different zones and the dietary patterns of women (highlighting iron-rich food groups), based on the food frequency questionnaire (FFQ), across the selected states of India, including Haryana (North), Gujarat (West), Kerala (South), West Bengal (East), and Assam (Northeast). The NFHS datasets were chosen due to their national representativeness, standardized uniform data collection methods, and availability of relevant variables related to anemia status and dietary patterns. Data was studied and analyzed to compare the prevalence of anemia across different regions and to examine potential dietary associations.

Studies and reports published between 2000 and 2025, written in English, and focusing on the Indian population were included. Both primary research articles and review papers were considered. Articles focusing on anemia due to non-nutritional causes, non-Indian populations, written in regional languages, were excluded.

Prevalence of Anemia and Dietary Habits in Different States of India

Five states—Haryana (North), Gujarat (West), Kerala (South), West Bengal (East), and Assam (Northeast)—were randomly selected from five regions of India for detailed analysis. The prevalence of anemia among women and their dietary intake patterns were assessed using a qualitative food frequency method based on NFHS-5 data. The survey captures key food groups (milk/curd, pulses, green leafy vegetables (GLVs), fruits, eggs, meat, fish) that were consumed by women aged 15–49 years at least once a week. This method is useful for assessing dietary patterns and diversity, but it does not provide quantitative intake, portion sizes, or details on nutrient bioavailability, such as the presence of iron absorption inhibitors (e.g., phytates, tannins) or enhancers (e.g., vitamin C).

Assam (North East)

A total of 65.9% women aged between 15 and 49 are suffering from anemia in Assam, according to NFHS-5 data. In contrast, only 46% were suffering from anemia as per the data recorded in NFHS-4.

Assamese cuisine reflects the diverse ethnic composition of the region, resulting in a rich variety of distinctive flavors. A defining characteristic of the cuisine is its minimal use of spices and preference for low-heat cooking techniques. Indigenous fruits and vegetables, whether fresh, dried, or fermented, are commonly incorporated, contributing to the unique nutritional and flavor profile of Assamese meals. Mustard oil is the primary cooking medium in most households.[42]

The Assamese diet primarily revolves around rice, which serves as the staple food. It is complemented by food from various food groups. A traditional meal often includes bhaat (rice), dail (lentils), masor jhol (fish curry), maangkho (meat curry), and xaak bhaji (leafy green vegetables). Commonly consumed meats include duck, mutton, chicken, pigeon, and pork.[42]

Leafy vegetable preparations, especially xaak bhaji, have been reported to be rich in key micronutrients such as calcium, β-carotene, retinol, and vitamin C. In addition to the main components, meals are frequently accompanied by side dishes such as aloo pitika (mashed roasted potatoes), pura maas or maas patot diya (roasted fish), kosu patot diya, maandonia chutney, pura bengena pitika, aloo bilahi pitika bor, kharisa, and kharoli. These accompaniments enhance both the nutritional content and cultural richness of Assamese meals.[42]

As per the data reported in NFHS-5, the percentage of women of Assam aged between 15 and 49 years consuming the food groups rich in iron at least once a week is as follows: 92.3% (pulses or beans); 86.3% (dark GLVs); 57.5% (chicken or meat).

West Bengal (East)

According to NFHS-5 data, 71.4% women aged between 15 and 49 were suffering from anemia in contrast to 62.5% recorded in NFHS-4 suffering from anemia in West Bengal.

A traditional Bengali diet includes rice, accompanied by mildly spiced lentils and bitter vegetables, followed by complex vegetable dishes, fish, then meat, and ending with chutneys and sweets. Mustard oil is the primary cooking medium, and preparation is detailed, focusing on ingredient freshness and cutting techniques. Fish is highly valued, especially hilsa, with every edible part used. Common dishes include steamed fish (bhapey), banana-leaf wrapped fish (paturi), coconut-based prawn curry (malaikari), slow-cooked meat (kosha mangsho), and mixed vegetable dishes like ghonto and dalna. Lentil fritters (bora), sour stews (ambol), and sweets like mishti doi, rossogolla, and sandesh are also key. Over 40 types of freshwater fish, red lentils, moong dal, mustard paste, poppy seeds, coconut, and mangoes are staples.[43,44]

As per the data reported in NFHS-5, the percentage of women of West Bengal aged between 15 and 49 years consuming the food groups rich in iron at least once a week is as follows: 92.9% (pulses or beans); 97.5% (dark GLVs); 63.5% (chicken or meat).

Gujarat (West)

A total of 65% women aged between 15 and 49 are suffering from anemia in Gujarat, according to NFHS-5 data. In contrast, only 54.9% were suffering from anemia as per the data recorded in NFHS-4.

Gujarati cuisine is primarily lactovegetarian, consisting of vegetables and dairy products, while excluding meat, fish, and eggs. It is popular for its sweetness and generous use of oil or ghee in cooking. Sweets and desserts are a staple, often included in every meal, even breakfast. Dairy products are widely favored, and meals typically end with buttermilk. "Farsans"—snacks like dhokla, khaman, kachoris, and samosas—are commonly served as appetizers or eaten between meals. However, in rural areas, the intake of sugar, sweets, and farsans is limited. Instead, diets emphasize fresh fruits, vegetables, and dairy, with carbohydrates mainly coming from mixed grains and bajra. Religious beliefs also shape food habits. Jainism, prevalent in Gujarat, avoids onions, garlic, and root vegetables. In contrast, the Parsi community includes meat in their diet, especially at dinner. A signature Parsi dish is "Dhanshak," a lentil and meat preparation served with rice or roti.[45]

As per the data reported in NFHS-5, the percentage of women of Gujarat aged between 15 and 49 years consuming the food groups rich in iron at least once a week is as follows: 93.5% (pulses or beans); 90.3% (dark GLVs); 16.5% (chicken or meat).

Kerala (South)

A total of 36.3% women aged between 15 and 49 are suffering from anemia in Kerala, according to NFHS-5 data. In contrast, only 34.2% were suffering from anemia as per the data recorded in NFHS-4.

Rice, the primary staple food consumed in Kerala, is consumed in various forms like boiled rice, parboiled rice, kanji (rice gruel), and dishes like puttu, idiyappam, and appam. Tapioca (Cassava) is commonly consumed as a substitute for rice. Coconut is extensively used in cooking preparations. Coconut oil is used for cooking. A wide variety of vegetables are consumed daily in the diet, including snake gourd, drumstick, raw banana, etc. A large consumption of fish is observed along the coast. Pulses, legumes, meat, and chicken are commonly consumed.

As per the data reported in NFHS-5, the percentage of women of Kerala aged between 15 and 49 years consuming the food groups rich in iron at least once a week is as follows: 90% (pulses or beans); 62.4% (dark GLVs); 48% (chicken or meat).

Haryana (North)

A total of 60.4% women aged between 15 and 49 are suffering from anemia in Haryana, according to NFHS-5 data. In contrast, only 62.7% were suffering from anemia as per the data recorded in NFHS-4.

The traditional diet of Haryana is influenced by the seasonal variations and agriculture. Staple foods include rotis and paranthas made from wheat primarily, though other grains like bajra, maize, and barley are also consumed. Pulses such as lentils, chickpeas, and kidney beans, along with seasonal vegetables like tinda, ghia, and tori, are part of the daily diet. Dairy products, especially milk, curd, ghee, and homemade butter, hold both nutritional and cultural significance. Common dishes include dalia (broken wheat porridge), khichri (bajra with pulses), kari (gram flour-based curry), and raabdi (fermented flour fried in buttermilk). Though traditionally cooked in ghee, vegetable oil has become a common substitute for ghee.[46]

As per the data reported in NFHS-5, the percentage of women of Haryana aged between 15 and 49 years consuming the food groups rich in iron at least once a week is as follows: 94% (pulses or beans); 93.1% (dark GLVs); 5.7% (chicken or meat).

t-test: Paired two sample for means

	NFHS 5	NFHS 4
Mean	59.33333	52.21667
Variance	151.5907	117.3417
Observations	6	6
Pearson correlation	0.783987	
Hypothesized mean	0	
df	5	
t Stat	2.254066	
P(T≤t) one-tail	0.03695	
t Critical one-tail	2.015048	
P(T≤t) two-tail	0.073899	
t Critical two-tail	2.570582	

Fig. 1: Paired sample t-test comparing the prevalence of anemia in women of reproductive age between NFHS-5 and NFHS-4 across five Indian states

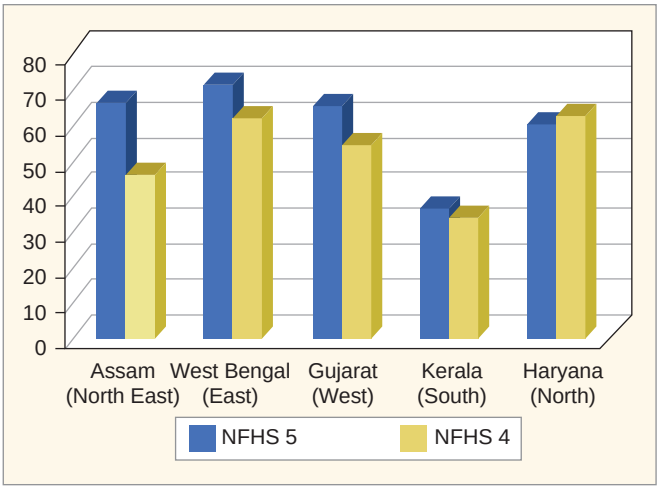

Fig. 2: Prevalence of anemia in women of reproductive age (15–49 years) comparison between NFHS-5 and NFHS-4

Association of Dietary Patterns of Women with Anemia in Given Five States of India

A paired sample *t*-test was conducted to compare the prevalence of anemia in women of reproductive age between NFHS-5 and NFHS-4 across five Indian states (Fig. 1). The analysis revealed a significant increase in anemia prevalence in NFHS-5 (M = 59.33) compared to NFHS-4 (M = 52.22); $t(5) = 2.25$, $p = 0.037$ (one-tailed). According to the data, at the national level, anemia prevalence increased from 53% in NFHS-4 to 57% in NFHS-5. State-wise, the trend varied in intensity. Assam (North East) exhibited a sharp increase from 46 to 65.9%, West Bengal (East) saw a notable increase from 62.5 to 71.4%, while Gujarat (West) experienced a moderate rise from 54.9 to 65%. Kerala (South) registered only a slight increase from 34.2 to 36.3%. Interestingly, Haryana (North) was the only state where a decline was observed, with anemia prevalence decreasing from 62.7 to 60.4% (Fig. 2). These findings highlight a concerning overall rise in anemia prevalence among women of reproductive age and the urgent need for targeted state-specific public health interventions.

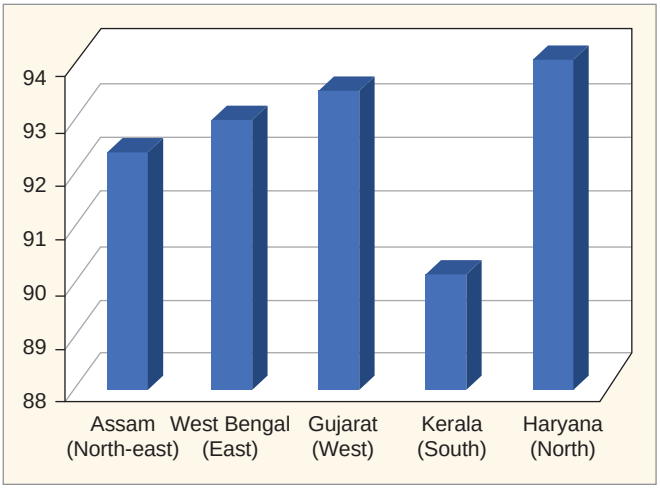

Fig. 3: Percentage of Indian women of reproductive age consuming pulses or beans at least once a week across five states of India

Percentage of Women of Reproductive Age-groups (15–49 years) Consuming Iron-rich Food Groups at Least Once a Week as per NFHS-5 Report

Pulses or Beans

The bar graph (Fig. 3) chart shows the percentage of Indian women of reproductive age consuming pulses or beans at least once a week across five states of India. The overall trend indicates a high frequency of consumption in most states, with some variation. Haryana (North) recorded the highest percentage, with 94% of women consuming pulses weekly, followed closely by Gujarat (West) at 93.5% and West Bengal (East) at 92.9%. Assam (North East) also shows a similar rate of consumption of 92.3%. However, Kerala (South) shows a comparatively lower percentage of 90%. Despite the generally high intake of pulses, the increase in anemia prevalence observed earlier, particularly in states like Assam and West Bengal, suggests that while the frequency of pulse consumption is good, it might not be sufficient in itself to combat anemia. Other factors such as quantity of intake, diversity of the diet, bioavailability of iron, and presence of other nutritional deficiencies could be influencing the anemia rates. Therefore, improving not just the frequency but also the overall nutritional quality of diets remains crucial in tackling the anemia burden among women.

Green Leafy Vegetables

The bar graph (Fig. 4) chart shows the percentage of Indian women of reproductive age consuming GLVs at least once a week across five states from different regions of India. The overall trend indicates a high frequency of consumption in most states, with notable variation. West Bengal (East) leads with the highest percentage of 97.5%, followed by Haryana (North) with 93.1% and Gujarat (West) with 90.3%. Assam (North East) also reports a strong intake of 86.3%. However, Kerala (South) stands out with a significantly lower percentage of 62.4%. In Kerala (South), the low weekly consumption of GLVs (62.4%) could be an important factor contributing to anemia, despite Kerala performing relatively better than other states; this highlights a possible gap in iron intake through diet. Green leafy vegetables, being rich sources of iron, play a vital role in preventing anemia. While most states show high weekly consumption, the continuing high anemia prevalence highlights that frequency alone is not enough. Hence, it is needful to improve the quantity, variety, and nutritional quality

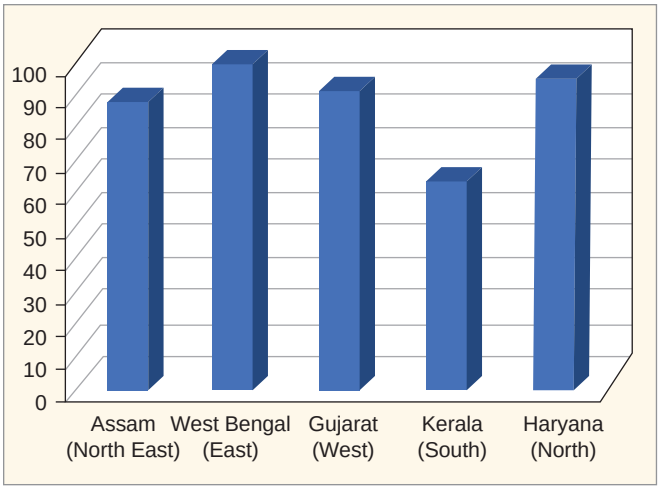

Fig. 4: Percentage of Indian women of reproductive age consuming GLVs at least once a week across five states from different regions of India

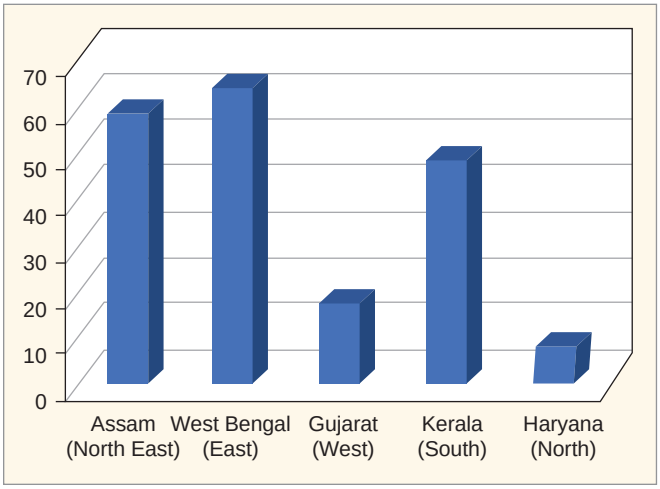

Fig. 5: Percentage of Indian women consuming chicken or meat at least once a week varies significantly across states

of GLV intake. Efforts should focus on increasing awareness about including GLVs rich in iron like Gogu leaves, Fenugreek, Agathi leaves, and Amaranth leaves in the daily diet, enhancing iron absorption through pairing GLVs with enhancers like vitamin C-rich foods, and adopting cooking methods that preserve iron content. In states like Kerala, where GLV consumption is relatively low, targeted nutrition programs, promotion of local iron-rich foods, and practical community interventions like home gardening are essential. Overall, boosting both the intake and bioavailability of iron from GLVs must be a core strategy to effectively combat anemia among Indian women.

Chicken or Meat

The bar graph (Fig. 5) chart shows that the percentage of Indian women consuming chicken or meat at least once a week varies significantly across states. West Bengal (East) reports the highest weekly intake of 63.5%, followed by Assam (North East) at 57.5% and Kerala (South) at about 48%. In contrast, Gujarat (West) and Haryana (North) show much lower rates, with only 16.5–5.7% women, respectively, consuming chicken or meat at least weekly. It is often believed that regular consumption of chicken or meat helps reduce anemia prevalence, given their rich heme iron content. However, the data tells a different story; the states with higher meat consumption continue to show higher rates of anemia, suggesting that simply eating meat more frequently may not be enough. Interestingly, Haryana, despite having very low levels of meat consumption, shows relatively better anemia outcomes compared to states like West Bengal and Assam, where meat consumption is much higher, suggesting other factors like dietary diversity, iron bioavailability, fortification practices, socioeconomic conditions, literacy rate, or supplementation might be playing a role. Since chicken and meat provide highly bioavailable heme iron that is more easily absorbed by the body compared to the non-heme iron in plant sources, their regular intake could be a valuable strategy for anemia prevention. However, simply increasing meat intake is not the best solution; improving the overall quality of diets, enhancing iron absorption through enhancers like vitamin C-rich foods, and avoiding consumption of iron inhibitors like phytates and tannins, together with iron-rich food. Also, addressing other deficiencies must go alongside to lower the anemia prevalence of this nation.

Conclusion

This paper highlights the regionally varied burden of anemia among Indian women of reproductive age-groups of 15–49 years. While states like Assam and West Bengal reported high consumption of iron-rich foods, they also experienced sharp increases in anemia prevalence, suggesting that food frequency alone does not ensure nutritional adequacy. In contrast, Kerala, with lower GLV intake, showed the lowest anemia rate, potentially due to better healthcare access, knowledge, and nutrition practices. Kerala's historically matrilineal social structure may also have positively influenced women's health outcomes, including lower anemia rates, by enabling greater control over dietary choices and healthcare access. Haryana showed a slight decline despite minimal meat intake, hinting at the role of a plant-based diet and the possible effectiveness of state-level interventions. These trends indicate that dietary patterns alone cannot explain the variation in anemia outcomes. Other factors such as nutrient bioavailability, food preparation methods, social and economic status, healthcare access, and public health efforts are also critical.

Way Forward

Addressing the growing anemia burden among women of reproductive age requires more than increasing iron-rich food intake. It involves improving diet quality, diet diversity, and iron bioavailability. Simple strategies like pairing iron sources with vitamin C-rich foods can enhance absorption, while reducing inhibitors like phytates can further support nutritional impact. At the policy level, strengthening the implementation of AMB initiative is the key. This involves expanding access to iron–folic acid supplements, scaling up food fortification, and ensuring effective screening and treatment through community health workers. Along with this, the success depends on tailoring interventions to reflect regional dietary habits, local food systems, and cultural practices. To reduce anemia, we need to combine better nutrition with strong healthcare support and implementation of policies that truly reflect the needs of local communities.

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