ORIGINAL RESEARCH ARTICLE

Triple Burden of Underweight, Anaemia and Overweight/Obesity Among the Tribal Maternal Women of West Bengal, India: A Cross Sectional Mixed-Methods Study

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ABSTRACT

Background: The triple burden of undernutrition, anaemia, and overweight/obesity poses a significant public health challenge in India, particularly among tribal maternal women. This paradox reflects the complex effects of socio-economic and nutritional transitions in low- and middle-income countries.

Methodology: The present cross-sectional mixed-methods study investigated the prevalence and determinants of this triple burden among 710 tribal women across three districts of West Bengal, using a multi-stage stratified cluster sampling technique. Data on socio-demographics, anthropometry, and haemoglobin levels were ethically collected using standardized tools.

Results: Results showed that 21.97% of women were underweight and 23.94% overweight or obese, indicating a dual burden of nutrition-related disorders. Alarmingly, 92.4% of participants suffered from anaemia, mostly mild to moderate, associated with poor dietary intake, early pregnancies, and limited healthcare access. Socio-demographic variables, lifestyle factors and food habits significantly influenced nutritional outcomes. Women on vegetarian diets showed higher odds of anaemia and undernutrition.

Conclusions: The findings reveal a complex nutritional crisis in tribal communities, underscoring the urgent need for culturally appropriate, targeted interventions. Strategies must focus on improving dietary diversity, strengthening maternal healthcare, and addressing structural determinants like poverty and education to break the intergenerational cycle of malnutrition.

Keywords: Triple burden malnutrition, Tribal maternal women, Socio-demographic characteristics, Dietary habits

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INTRODUCTION

Malnutrition, once considered a concern of underdeveloped nations plagued by food insecurity and poverty, has evolved into a multifaceted global health challenge. In recent decades, the world has witnessed a paradoxical phenomenon - coexistence of a complex and multifaceted the triple burden of malnutrition consisting of undernutrition, anaemia, and overweight/obesity within individuals, households, and communities. This triple burden, though seemingly contradictory, is particularly visible in low- and middle-income countries (LMICs) undergoing rapid economic, social, and nutritional transitions.[1-3] India, despite notable economic development and progress in public health, exemplifies this paradox. India, home to a significant tribal population, represents a stark example of this shift, where marginalized groups such as tribal maternal women are experiencing both extremes of the malnutrition spectrum.[4-5]

West Bengal, home to a diverse range of tribal groups including the Santals, Oraons, Mundas, and Bhumijs, has a tribal population of over five million, predominantly residing in districts such as Purulia, Bankura, Paschim Medinipur, Jalpaiguri, and Birbhum. These communities are often geographically isolated, socioeconomically disadvantaged, and face systemic barriers to healthcare, education, adequate nutrition, and social services. Tribal maternal women-pregnant and lactating mothers-constitute a particularly vulnerable demographic due to increased physiological demands, cultural practices, illiteracy, food insecurity, limited access to antenatal and postnatal care, deep-rooted poverty, and increasingly vulnerable to nutritional disorders.[6] Traditionally associated with chronic undernutrition, these communities are now showing increasing evidence of overweight and obesity, attributed to shifts in diet patterns, lifestyle changes, and urban exposure.[7-9]

Undernutrition among tribal women is well-documented and includes indicators such as low body mass index (BMI), anaemia, and micronutrient deficiencies due to poor dietary intake, inadequate healthcare access, and multiple pregnancies.[6,10-12] These conditions are linked to adverse maternal outcomes like low birth weight, preterm delivery, and increased maternal mortality.[7,13] The National Family Health Survey-5 (NFHS-5) data from 2019-21 reveals alarming rates of underweight and anaemia among tribal women in West Bengal, indicating significant nutritional deprivation.[12] On the other hand, emerging data suggest that a growing fraction of tribal women particularly those in peri-urban settings or with slightly better socioeconomic conditions are now experiencing overweight and obesity.[5,7] This shift is partly attributed to economic and lifestyle transitions, marked by urban migration, sedentary behavior, declining physical activity, increased consumption of high-calorie-low-nutrient foods, reliance on government-subsidized food grains with poor nutritional quality, and changes in traditional food habits.[4,5,7] Several recent studies have highlighted this evolving nutritional dichotomy.

The simultaneous presence of undernutrition and overnutrition within the same tribal communities, and sometimes even within the same household, underscores the complexity of the problem. This burden is not just a health issue but also a reflection of broader socio-economic inequalities, healthcare disparities, and gaps in policy implementation. It raises pertinent questions regarding the effectiveness of existing nutrition programs such as the Integrated Child Development Services (ICDS), Public Distribution System (PDS), Janani Suraksha Yojana (JSY) and National Nutrition Mission in addressing the nuanced needs of this vulnerable population. It poses unique challenges for public health policy and maternal care interventions. It is no longer sufficient to focus only on caloric deficiency; attention must also be given to diet quality, lifestyle factors, and emerging risks of non-communicable diseases such as hypertension and gestational diabetes among overweight pregnant women.[14] Despite the growing relevance of this issue, research focused specifically on the triple burden of underweight, anaemia and overweight/obesity among tribal maternal women in West Bengal remains limited. Most available studies either address underweight or anaemia or obesity in isolation. Thus, there is a critical need to investigate the patterns, determinants, and implications of this triple burden, with a special emphasis on maternal health outcomes. A deeper understanding of this phenomenon will inform targeted interventions, ensuring that nutrition policies are both inclusive and context-specific, thereby improving health equity among one of India's most marginalized populations.

METHODOLOGY

Study Design: This research employed a cross sectional mixed-methods approach to examine the extent and underlying causes of the triple burden of underweight, anaemia and overweight/obesity among tribal maternal women in West Bengal.

Study Area and Population: The investigation focused on eight tribal groups Bediya, Bhumij, Lohara, Mahali, Munda, Oraon, Sabar, and Santal from Hooghly, Paschim Medinipur, and South 24 Parganas districts of West Bengal. Conducted between January and December 2024, the study was set in one of India's most densely populated states, known for its rich ethnic diversity. Despite modernization, these tribal communities have maintained their distinct cultural identities. According to the 2011 Census, tribal groups make up 5.5% of the state's population. Traditionally forest dwellers, many now engage in agriculture and unskilled labor due to industrial expansion and lifestyle changes.[15]

Sampling technique and Sample size: A multistage stratified cluster sampling method, followed by

systematic random sampling, was used. Three districts were selected, with two blocks from each chosen based on tribal population density. Ten villages per block were selected, and 15 tribal women from each village were recruited using systematic sampling. The Cochran's formula of sample size was followed to determined sample size using a 16.17% obesity/overweight prevalence rate (NFHS-5, 2019–21)[16], a 95% confidence level, and a 4% margin of error, with a design effect of 2[17]. This narrower margin of error can minimize sampling error and enhance the statistical accuracy of this study. After adjusting for non-response and exclusion rates, the final sample size was rounded to 850. Eligibility criteria included women aged 15–49 years, in apparent good health, and without serious physical or mental illness. Participants with drug abuse history or acute/chronic illness were excluded. Of the initial participants, 710 (93.79% of qualified respondents) were included in the final analysis.

Ethical Considerations: Ethical clearance (PU/SOCL/DAIP-01/12-2024, Date: 24/12/2024) was granted by the Institutional Review Committee of Presidency University. The research team visited each village, met with local leaders and authorities, explained the study objectives, and obtained informed consent written or verbal (for illiterate participants) in the native language. For participants under 18, informed assent was taken from the individual and written consent from a parent or guardian. For illiterate participants, verbal consent was obtained in the presence of an impartial witness after reading the consent form aloud in the local language. The witness signed on behalf of the participant, confirming understanding of the study. This process followed ethical guidelines approved by the committee.

Study variables

Social demographic information: A well-designed, self-administered questionnaire comprising social demographic data like age and marital status, tribal community, monthly household income, education, family type, house condition, source of drinking water, food habits etc. was used to captured socio-demographic and lifestyle information, and dietary habits of the tribal women. This questionnaire was developed after carefully reviewing similar literatures. In the beginning, the questionnaire was set in English and then transformed into the local language (Bengali) by a bilingual public health expert and back-translated into English by another translator to ensure clarity and accuracy. Discrepancies were resolved through team discussions. The pre-final Bengali version was pre-tested on 50 tribal women (not in the final study) to assess clarity, cultural relevance, and understanding. Based on feedback, minor adjustments were made, ensuring the final version was both accurate and culturally appropriate.

Anthropometric measure: A computerised Soehnle scale was used to measure body weight in kilogrammes (kg). A stadiometer was used to measure the participant's height while they were standing straight, barefoot, and with their head in the Frankfurt plane. Body weight divided by height squared (kg/m^2) yielded the body mass index (BMI).

Haemoglobin determination: The haemoglobin status of the participants was assessed using a finger-prick capillary blood sample, which was immediately analyzed with a portable hemoglobinometer (HemoCue photometer), following standard procedures. Anaemia was diagnosed based on haemoglobin concentration, using WHO (2011) guidelines to categorize severity. According to these standards, mild anaemia was defined as haemoglobin levels between 10–12.9 g/dl, moderate anaemia as 7–9.9 g/dl, and severe anaemia as less than 7 g/dl.[18]

Quality Control: Two ASHA (Accredited Social Health Activists) workers were recruited per block to collect socio-demographic data. In India, ASHAs are trained female health workers who link communities with healthcare services like immunisation, antenatal and postnatal checkups, ICDS, sanitation, etc. All anthropometric data were collected by an anthropologist trained under the principal investigator to ensure accuracy. A single individual handled data entry to minimize bias, and the same equipment was used throughout to maintain consistency.

Statistical Analysis: Descriptive statistics (mean, SD, frequencies, percentages) were used to summarize the data. Student's t-tests and Chi-square tests evaluated differences in continuous and categorical variables. Logistic regression was employed to assess associations between nutritional status and socio-demographic/dietary factors. A significance threshold of $P<0.05$ was maintained. All analyses were performed using SPSS software.

RESULTS

The baseline characteristics of the study participants, including age, height, weight, and BMI, are illustrated in Table 1. The mean age of the women was 26.34 ± 6.1 years. Their average BMI was 22.08 ± 4.64 kg/m^2, which falls within the normal BMI range, with approximately 54% of the women maintaining a normal BMI, as shown in Table 2.

Table 1: The physical and physiological characteristics of Tribal maternal Women

Parameters	Mean ± SD
Age (years)	26.34±6.1
Height (cm)	147.07±11.17
Weight (kg)	47.18±8.34
BMI (kg/m^2)	22.08±4.64
Haemoglobin (g/dl)	10.39±1.06

However, 23.94% were identified as overweight or obese, while 21.97% were undernourished. The mean haemoglobin level was 10.39 ± 1.06 g/dl, with only 7.61% of the participants exhibiting normal haemoglobin levels. A large proportion over 78%

were found to be mildly anaemic, 13% had moderate anaemia, and 1.27% were categorized as severely anaemic (Table 2).

Table 2: Distribution of tribal maternal women having different categories of BMI and anaemia

Categories (cut-off values)	Women (%)
BMI categories	
Underweight (BMI <18.5 kg/m^2)	156 (21.97)
Normal (BMI 18.5 to 24.9 kg/m^2)	384 (54.08)
Overweight (BMI 25 to 29.9 kg/m^2)	126 (17.75)
Obese (BMI ≥30 kg/m^2)	44 (6.2)
Anaemia categories	
Severe Anaemia (Hb <7 g/dl)	9 (1.27)
Moderate Anaemia (Hb.7-9.9 g/dl)	93 (13.1)
Mild Anaemia (Hb.10-12 g/dl)	554 (78.03)
Non-Anaemia (Hb.>12 g/dl)	54 (7.61)

The logistic regression analysis reveals significant associations between socio-demographic characteristics and the nutritional status (under-nutrition and over-nutrition) as well as anaemia prevalence among tribal maternal women in West Bengal (Table 3). Younger women under 20 years showed a significantly higher prevalence of undernutrition (37%), with more than three times greater odds compared to those over 30 years, while anaemia was alarmingly high across all age groups, particularly among the youngest (95.24%). In contrast, overweight and obesity were more common among older women, especially those over 30 years (35.4%). Joint family women were more likely to be anaemic (92%, OR=3.1, p=0.000) but less likely to be overweight/obesity (OR=0.49, p=0.005) compared to nuclear families. A significant trend was observed across drinking water sources, with Panchayat water users showing a very high anaemia rate (97%, p=0.000). Low-income groups (≤5000 Rs) were more likely to be underweight (OR=3.5, p=0.000) and anaemic (OR=3.2, p=0.001) compared to higher-income counterparts. Undernutrition was more prevalent among women who married before 18 years (24.57%). Similarly, early marriage (below 18 years) was significantly associated with anaemia (95.69%, OR=6.88, p=0.000), suggesting a vulnerability linked to adolescent marriage. Women living in thatched or temporary shelters showed poorer nutritional outcomes, and lower education levels were associated with higher odds of being anaemic. Occupation also played a role; housewives and women engaged in forest produce collection were more prone to undernutrition, while service holders had significantly higher odds of overweight/obesity (OR=2.67, p=0.003). Socio-economic status (SES) further confirmed the trend; women from lower SES groups (Class V and IV) were at greater risk of being undernourished compared to those in lower middle class (Class III). For instance, women in the lowest SES class had 3.98- and 3.34-times higher odds of undernutrition and anaemia. Conversely, overweight/ obesity was significantly prevalent among women of higher SES (Class III).

Dietary patterns also showed significant associations with nutritional outcomes (underweight, overweight/obesity, and anaemia) (Table 4). Vegetarian women had significantly higher odds of anaemia (OR=3.17, p=0.001) and underweight (OR=1.54) compared to non-vegetarians. Women who never consumed fish had significantly 2.8 times higher odds of being underweight (p=0.004) and higher risk of anaemia (OR=5.44). Infrequent wheat consumers (monthly/occasionally) showed lower odds of underweight (OR=0.3, p<0.001) and significantly higher odds of anaemia (OR=3.65, p<0.001) compared to daily consumers. Similarly, women who never ate meat had over twice the risk of being underweight (OR=2.37, p=0.008) and were more likely to be anaemic (OR=2.44). Lack of vegetable consumption increased the odds of overweight/obesity (OR=2.77, p=0.042). Notably, women who never consumed honey had six times higher odds of anaemia (OR=6.0, p<0.001), highlighting its potential protective role.

Discussion

The findings of this study present a comprehensive picture of the nutritional and anaemia status of tribal maternal women in West Bengal, revealing a concerning co-existence of undernutrition, anaemia, and overweight/obesity a classic case of the triple burden of malnutrition. Although the average BMI falls within the normal range, only about 54% of the women maintained a normal weight. The remainder were divided almost equally between the undernourished (21.97%) and those who were overweight or obese (23.94%), indicating a dual burden of under- and over-nutrition within the same population. This reflects the on-going nutrition transition in marginalized populations, where traditional food patterns are being replaced by energy-dense but nutrient-poor diets.[19,20] The average haemoglobin level is below the normal threshold, and only 7.6% of women had normal haemoglobin levels. Alarmingly, over 92% suffered from some degree of anaemia mostly mild but also moderate and severe highlighting a serious public health concern. Anaemia in tribal women has been previously attributed to poor dietary iron intake, parasitic infections, early pregnancies, and lack of antenatal care.[14,21,22]

This study reveals a complex interplay of socio-demographic, economic, and dietary factors contributing to this triple burden of malnutrition among tribal women. Age was found to be a significant determinant of nutritional status. Younger women, particularly those under 20, were more likely to be undernourished (37%) and anaemic (95.24%), consistent with previous studies which highlight adolescence and early adulthood as critical periods for nutritional vulnerability due to high physiological demands and socio-cultural barriers.[9,23,24]

Table 3: Association of socio-demographic characteristics and state of under-nutrition (underweight and anaemia) and over-nutrition (overweight/obesity) of tribal maternal women of West Bengal

Variables	n (%)	Underweight				Overweight/obesity				Anaemia			
		f (%)	χ^2 (P value)	OR (95% CI)	p	f (%)	χ^2 (P value)	OR (95% CI)	p	f (%)	χ^2 (P value)	OR (95% CI)	p
Age (years)													
<20 years	105 (14.79)	39 (37.14)	17.845	3.07 (1.72-5.46)	0.000	14 (13.33)	18.763	0.28 (0.15-0.54)	0.001	100 (95.24)	4.04	2.68 (0.97-7.4)	0.058
20-30 years	444 (62.54)	91 (20.5)	(0.000)	1.34 (0.83-2.16)	0.233	99 (22.3)	(0.000)	0.52 (0.35-0.77)	0.001	396 (89.19)	(0.133)	1.1 (0.63-1.94)	0.73
>30 years	161 (22.68)	26 (16.15)		Reff.		57 (35.4)		Reff.		142 (88.2)		Reff.	
Type of family													
Joint	474 (66.76)	115 (24.26)	4.495	1.39 (0.76-2.53)	0.284	103 (21.73)	7.943	0.49 (0.29-0.81)	0.005	436 (91.98)	13.279	3.1 (1.65-5.81)	0.000
Extended	156 (21.97)	26 (16.67)	(0.105)	0.87 (0.43-1.75)	0.689	38 (24.36)	(0.018)	0.57 (0.32-1.01)	0.055	139 (89.1)	(0.001)	2.2 (1.06-4.6)	0.035
Nuclear	80 (11.27)	15 (18.75)		Reff.		29 (36.25)		Reff.		63 (78.75)		Reff.	
Marital Status													
Widow, Deserted	84 (11.83)	21 (25.0)	0.509	1.21 (0.71-2.06)	0.476	20 (23.81)	0.001	0.99 (0.58-1.69)	0.975	79 (94.05)	1.83	1.89 (0.74-4.84)	0.182
Married	626 (88.17)	135 (21.57)	(0.475)	Reff.		150 (23.96)	(0.975)	Reff.		559 (89.3)	(0.176)	Reff.	
Source of drinking water													
Well	66 (9.3)	11 (16.67)	22.884	0.48 (0.24-0.95)	0.036	22 (33.33)	4.102	1.65 (0.93-2.93)	0.084	48 (72.73)	47.694	0.1 (0.04-0.23)	0.000
Taps	218 (30.7)	28 (12.84)	(0.000)	0.35 (0.22-0.56)	0.000	47 (21.56)	(0.251)	0.91 (0.6-1.37)	0.659	190 (87.16)	(0.000)	0.21 (0.1-0.44)	0.000
Bore wells	90 (12.68)	18 (20.0)		0.6 (0.34-1.05)	0.076	23 (25.56)		1.13 (0.66-1.94)	0.643	74 (82.22)		0.14 (0.06-0.32)	0.000
Panchayat water	336 (47.32)	99 (29.46)		Reff.		78 (23.21)		Reff.		326 (97.02)		Reff.	
Monthly income (Rs)													
Rs: ≤5000	244 (34.37)	64 (26.23)	21.934	3.5 (1.85-6.62)	0.000	65 (26.64)	5.003	0.95 (0.6-1.51)	0.828	230 (94.26)	16.838	3.2 (1.59-6.45)	0.001
Rs: 5001-10000	143 (20.14)	43 (30.07)	(0.000)	4.23 (2.16-8.3)	0.000	32 (22.38)	(0.172)	0.75 (0.44-1.29)	0.305	134 (93.71)	(0.001)	2.9 (1.29-6.52)	0.009
Rs: 10001-20000	182 (25.63)	36 (19.78)		2.43 (1.23-4.78)	0.01	34 (18.68)		0.6 (0.35-1.01)	0.057	156 (85.71)		1.17 (0.63-2.15)	0.615
Rs: >20000	141 (19.86)	13 (9.22)		Reff.		39 (27.66)		Reff.		118 (83.69)		Reff.	
Age at the time of marriage													
<18 years	232 (32.68)	57 (24.57)	1.459	1.18 (0.72-1.93)	0.508	29 (12.5)	72.05	1.37 (0.7-2.68)	0.363	222 (95.69)	39.679	6.88 (3.29-14.39)	0.000
18-20 years	330 (46.48)	67 (20.3)	-0.482	0.92 (0.57-1.48)	0.742	127 (38.48)	(0.000)	5.99 (3.31-10.84)	0.000	303 (91.82)	(0.000)	3.47 (2.01-6)	0.000
After 20 years	148 (20.85)	32 (21.62)		Reff.		14 (9.46)		Reff.		113 (76.35)		Reff.	
House condition													
Thatched	121 (17.04)	26 (21.49)	6.54	0.88 (0.54-1.42)	0.599	29 (23.97)	0.320	0.98 (0.62-1.56)	0.935	113 (93.39)	2.768	1.8 (0.83-3.87)	0.134
Tiled, Terse,Tripal	75 (10.56)	8 (10.67)	(0.038)	0.38 (0.18-0.82)	0.014	16 (21.33)	(0.851)	0.84 (0.47-1.52)	0.572	69 (92.0)	(0.096)	1.46 (0.61-3.52)	0.396
Asbestos	514 (72.39)	122 (23.74)		Reff.		125 (24.32)		Reff.		456 (88.72)		Reff.	
Education													
Illiterate	124 (17.46)	30 (24.19)	2.235	1.43 (0.83-2.47)	0.203	26 (20.97)	16.846	0.5 (0.3-0.85)	0.01	116 (93.55)	2.264	1.82 (0.78-4.23)	0.162
Primary School	389 (54.79)	90 (23.14)	(0.327)	1.35 (0.87-2.07)	0.177	76 (19.54)	(0.000)	0.46 (0.31-0.68)	0.000	347 (89.2)	(0.123)	1.04 (0.6-1.79)	0.891
High School or above	197 (27.75)	36 (18.27)		Reff.		68 (34.52)		Reff.		175 (88.83)		Reff.	
Occupation													
House wife	188 (26.48)	48 (25.53)	17.135	Reff.		48 (25.53)	18.429	Reff.		166 (88.3)	36.902	Reff.	
Agricultural worker/Daily Wage Labours	337 (47.46)	60 (17.8)	(0.000)	0.63 (0.41-0.97)	0.036	76 (22.55)	(0.000)	0.85 (0.56-1.29)	0.441	316 (93.77)	(0.000)	1.99 (1.06-3.73)	0.031
Forest produce collector	139 (19.58)	44 (31.65)		1.35 (0.83-2.19)	0.224	24 (17.27)		0.61 (0.35-1.05)	0.076	126 (90.65)		1.28 (0.62-2.65)	0.497
Service Holders	46 (6.48)	4 (8.7)		0.28 (0.09-0.81)	0.019	22 (47.83)		2.67 (1.37-5.2)	0.003	30 (65.22)		0.25 (0.12-0.53)	0.000
SES													
Lower (V)	194 (27.32)	58 (29.9)	13.345	3.98 (1.62-9.75)	0.002	37 (19.07)	8.438	0.4 (0.21-0.75)	0.004	181 (93.3)	8.318	3.34 (1.44-7.78)	0.005
Upper Lower (IV)	454 (63.94)	92 (20.26)	(0.001)	2.37 (0.99-5.67)	0.05	110 (24.23)	(0.015)	0.54 (0.31-0.95)	0.031	407 (89.65)	(0.004)	2.08 (1.03-4.18)	2.05
Lower Middle (III)	62 (8.73)	6 (9.68)		Reff.		23 (37.1)		Reff.		50 (80.65)		Reff.	

Table 4: Association of dilatory habits and state of under-nutrition (underweight and anaemia) and over-nutrition (overweight/obesity) of tribal maternal women of West Bengal

Variables	n (%)	Underweight				Overweight/obesity				Anaemia			
		f (%)	χ^2	OR (95% CI)	p	f (%)	χ^2	OR (95% CI)	p	f (%)	χ^2	OR (95% CI)	p
Food Habits													
Vegetarian	208 (29.3)	57 (27.4)	5.063 (0.024)	1.54 (1.05-2.24)	0.025	50 (24.04)	0.001	1.01 (0.69-1.47)	0.969	199 (95.67)	10.912	3.17 (1.55-6.5)	0.001
Non-vegetarian	502 (70.7)	99 (19.72)		Reff.		120 (23.9)	-0.969	Reff.		439 (87.45)	-0.001	Reff.	
Food Consumption: Rice													
Never/Monthly/ Occasionally	30 (4.23)	10 (33.33)	2.358 (0.124)	1.83 (0.84-3.99)	0.13	5 (16.67)	0.91	0.62 (0.23-1.66)	0.344	27 (90.0)	0.001	1.02 (0.3-3.44)	0.979
Daily/Weekly	680 (95.77)	146 (21.47)		Reff.		165 (24.26)	-0.344	Reff.		611 (89.85)	-0.979	Reff.	
Food Consumption: Wheat													
Never	47 (6.62)	12 (25.53)	39.204	0.7 (0.35-1.41)	0.323	4 (8.51)	21.143	0.42 (0.14-1.22)	0.113	44 (93.62)	24.615	2.95 (0.88-9.86)	0.079
Monthly/Occasionally	364 (51.27)	46 (12.64)	0	0.3 (0.2-0.44)	0	112 (30.77)	0	2.02 (1.39-2.91)	0	345 (94.78)	0	3.65 (2.1-6.34)	0
Daily/Weekly	299 (42.11)	98 (32.78)		Reff.		54 (18.06)		Reff.		249 (83.28)		Reff.	
Food Consumption: Vegetables													
Never	17 (2.39)	1 (5.88)	2.786 (0.248)	0.22 (0.03-1.67)	0.143	7 (41.18)	12.57	2.77 (1.03-7.42)	0.042	16 (94.12)	0.805	1.87 (0.24-14.3)	0.546
Monthly/Occasionally	53 (7.46)	13 (24.53)		1.14 (0.59-2.19)	0.694	20 (37.74)	0	2.4 (1.33-4.32)	0.003	49(92.45)	-0.369	1.43 (0.5-4.09)	0.502
Daily/Weekly	640 (90.14)	142 (22.19)		Reff.		129 (20.16)		Reff.		573 (89.53)		Reff.	
Food Consumption: Fish													
Never	38 (5.35)	14 (36.84)	19.687 (0.001)	2.8 (1.39-5.65)	0.004	7 (18.42)	5.068	0.63 (0.3-1.46)	0.279	37 (97.37)	11.548	5.44 (0.73-40.4)	0.097
Monthly/Occasionally	196 (27.61)	60 (30.61)		2.12 (1.44-3.12)	0.001	37 (18.88)	-0.079	0.65 (0.43-0.97)	0.038	186 (94.9)	-0.001	2.73 (1.37-5.45)	0.004
Daily/Weekly	476 (67.04)	82 (17.23)		Reff.		126 (26.47)		Reff.		415 (87.18)		Reff.	
Food Consumption: Meat													
Never	48 (6.76)	18 (37.5)	7.448	2.37 (1.25-4.5)	0.008	9 (18.75)	11.793	0.55 (0.26-1.18)	0.127	45 (93.75)	11.77	2.44 (0.73-8.16)	0.147
Monthly/Occasionally	305 (42.96)	66 (21.64)	-0.006	1.09 (0.75-1.59)	0.642	56 (18.36)	-0.003	0.54 (0.37-0.78)	0.001	286 (93.77)	-0.001	2.45 (1.41-4.26)	0.001
Daily/Weekly	357 (50.28)	72 (20.17)		Reff.		105 (29.41)		Reff.		307 (85.99)		Reff.	
Food Consumption: Fruits													
Never	37 (5.21)	7 (18.92)	4.635 (0.098)	1.37 (0.51-3.65)	0.528	9 (24.32)	1.313	0.82 (0.35-1.93)	0.649	33 (89.19)	2.866	1.4 (0.44-4.5)	0.568
Monthly/Occasionally	563 (79.3)	133 (23.62)		1.82 (1.03-3.19)	0.038	130 (23.09)	-0.519	0.765 (0.48-1.21)	0.253	511 (90.76)	-0.09	1.67 (0.92-3.05)	0.094
Daily/Weekly	110 (15.49)	16 (14.55)		Reff.		31 (28.18)		Reff.		94 (85.45)		Reff.	
Food Consumption: Honey													
Never	229 (32.25)	68 (29.69)	11.87 (0.002)	2.17 (0.92-5.12)	0.076	40 (17.47)	9.386	0.39 (0.19-0.81)	0.011	218 (95.2)	16.361 (0.000)	6 (2.37-1.524)	0
Monthly/Occasionally	438 (61.69)	81 (18.49)		1.17 (0.5-2.71)	0.72	115 (26.26)	-0.009	0.66 (0.34-1.29)	0.226	387 (88.36)		2.3 (1.07-4.94)	0.033
Daily/Weekly	43 (6.06)	7 (16.28)		Reff.		15 (34.88)		Reff.		33 (76.74)		Reff.	

Conversely, overweight and obesity were more prevalent among older women, particularly those over 30 years, aligning with patterns observed in other low- and middle-income settings where increasing age correlates with weight gain due to metabolic shifts and lifestyle changes.[9,24,25]

Socio-economic factors such as income and housing conditions significantly influenced undernutrition. Women from households earning less than ₹10,000 per month and living in kutcha or asbestos-roofed houses had a higher risk of being underweight. Household structure emerged as another influencing factor: joint family women were more likely to be anaemic (OR=3.1), possibly due to unequal food distribution, limited autonomy in food choices, or increased household burdens. Meanwhile, they were less likely to be overweight/obese, which may relate to increased physical activity and restricted food intake. These findings are supported by prior research that identifies poverty, inadequate housing, and food insecurity as primary contributors to chronic energy deficiency among tribal populations.[9] Moreover, early marriage emerged as a crucial factor, with women married before the age of 18 showing a higher prevalence of undernutrition. Early marriage often interrupts education, limits autonomy, and restricts access to adequate health and nutrition services, especially among tribal women.[26] While education level did not show a significant association with undernutrition and anaemia, it had a notable influence on overweight and obesity. Women with high school education and above were more likely to be overweight or obese. This may be attributed to increased sedentary behaviors and dietary shifts associated with higher educational attainment and urbanization, as noted in studies from similar socio-cultural contexts.[27] Occupation also showed distinct trends. Housewives were more prone to both undernutrition and overweight/obesity, while service holders showed significantly higher odds of obesity and lower odds of anaemia, likely reflecting a more sedentary lifestyle and greater purchasing power, leading to consumption of energy-dense diets.[27] Socio-economic status (SES) provided further insights. Women from the lowest SES classes (V and IV) had significantly higher risks of being undernourished (OR=3.98) and anaemic (OR=3.34). This reflects the persistent social and economic disparities within tribal communities that constrain access to quality food, healthcare, and sanitation factors crucial for maintaining nutritional well-being. Meanwhile, overweight/obesity was more common among women from higher SES groups (Class III), indicating a nutrition transition occurring within tribal populations where economic improvements lead to unhealthy dietary changes rather than better nutritional outcomes.[6]

Women adhering to a vegetarian diet had significantly higher odds of anaemia (OR=3.17) and were more likely to be underweight (OR=1.54) compared to their non-vegetarian counterparts. This is consistent with earlier research suggesting that vegetarian diets, especially in resource-poor settings, may lack sufficient bioavailable iron, vitamin B12, and protein, which are primarily found in animal-source foods. Inadequate intake of these critical nutrients can increase the risk of anaemia and undernutrition, particularly during pregnancy and lactation when nutritional demands are elevated.[14,28]

Further, non-consumption of fish and meat emerged as significant risk factors. Women who never ate fish and meat had higher odds of being underweight and anaemia. Fish and meat are rich source of high-quality protein and essential micronutrients like iron, zinc, iodine, B-vitamins**,** and omega-3 fatty acids, which are known to support haemoglobin synthesis and overall nutritional health.[29,30] In tribal populations where fish is traditionally consumed, reduced intake may reflect a shift away from traditional diets, possibly due to economic constraints or changing food environments.

Interestingly, lack of vegetable intake was found to be significantly associated with overweight/obesity. This may reflect poor dietary quality among overweight individuals, who often consume more energy-dense, nutrient-poor foods and fewer fiber-rich vegetables. Vegetables not only provide micronutrients and antioxidants but also help in weight regulation through high satiety and low energy density. Low vegetable consumption may thus contribute to caloric excess and weight gain.[31]

A particularly striking finding was the relationship between honey consumption and anaemia. Women who never consumed honey had six times higher odds of anaemia. While the exact mechanism is unclear, this may reflect the broader nutritional benefits of honey, which can improve iron metabolism, enhance haemoglobin production, and support immune health due to its trace mineral and antioxidant content.[32,33] In traditional diets, honey is often used as a natural tonic during pregnancy and recovery.

This study has several important strengths. It provides a comprehensive picture of the triple burden of malnutrition undernutrition, anaemia, and overweight/obesity among tribal maternal women, a vulnerable and underrepresented group. The use of a large and diverse sample improves the reliability and generalizability of the findings within similar tribal populations. A broad range of socio-demographic, economic, and dietary factors were examined, offering a multidimensional understanding of nutritional status. The questionnaire was carefully developed, translated, and pre-tested to ensure cultural and linguistic relevance. Focusing on women aged 12–35 years allowed the study to capture critical phases of nutritional vulnerability, including adolescence and early motherhood.

However, the study is limited by its cross-sectional design, which restricts causal interpretation. Some information, especially dietary habits and income, was self-reported, introducing potential recall or re-

porting bias. Nutritional assessment was limited to BMI and haemoglobin levels, without biochemical indicators such as ferritin or vitamin B12. The data did not account for seasonal variation in food intake, which could influence nutritional outcomes. Lastly, while the findings are highly relevant to the study region, cultural and regional differences may limit generalizability to other tribal or rural populations in India.

Conclusion

In conclusion, this study underscores a critical public health concern the triple burden of malnutrition (undernutrition, overweight/obesity, and anaemia) among tribal maternal women in West Bengal. Despite an average BMI within the normal range, the near-equal prevalence of underweight and overweight/obesity highlights a significant nutrition transition within this vulnerable population. Anaemia, affecting over 92% of the women, remains alarmingly prevalent and is linked to poor dietary intake, early pregnancies, and inadequate healthcare access. Age, socio-economic status, housing, early marriage, household structure, occupation, and dietary habits emerged as major determinants. Particularly notable are the heightened risks of undernutrition and anaemia among vegetarians and those abstaining from fish, meat, vegetables, and honey pointing to the crucial role of both macro- and micronutrient-rich diets. While higher education was linked to overweight/obesity, low income and poor living conditions were associated with undernutrition and anaemia. These findings call for targeted, culturally sensitive interventions focusing on diet diversification, adolescent and maternal healthcare, and social determinants of health to break the intergenerational cycle of malnutrition in tribal communities.

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