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Underweight among rural Indian adults: burden, and predictors of incidence and recovery

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Abstract

Objective: To study the magnitude and predictors of underweight, incident underweight and recovery from underweight among rural Indian adults.

Design: Prospective cohort study. Each participant's BMI was measured in 2008 and 2012 and categorized as underweight (BMI < 18·5 kg/m^2), normal (BMI = 18·5–22·9 kg/m^2) or overweight/obese (BMI ≥ 23·0 kg/m^2). Incident underweight was defined as a transition from normal weight or overweight/obese in 2008 to underweight in 2012, and recovery from underweight as a transition from underweight in 2008 to normal weight in 2012. Bivariate and multivariable logistic regression analyses were employed.

Setting: The Birbhum Health and Demographic Surveillance System, West Bengal, India.

Subjects: Predominantly rural individuals (*n* 6732) aged ≥18 years enrolled in 2008 were followed up in 2012.

Results: In 2008, the prevalence of underweight was 46·5 %. From 2008 to 2012, 25·8 % of underweight persons transitioned to normal BMI, 12·9 % of normal-weight persons became underweight and 0·1 % of overweight/obese persons became underweight. Multivariable models reveal that people aged 25–49 years, educated and wealthier people, and non-smokers had lower odds of underweight in 2008 and lower odds of incident underweight. Odds of recovery from underweight were lower among people aged ≥36 years and higher among educated (Grade 6 or higher) individuals.

Conclusions: The current study highlights a high incidence of underweight and important risk factors and modifiable predictors of underweight in rural India, which may inform the design of local nutrition interventions.

Keywords
BMI
Incident underweight
Prospective cohort study
Nutritional epidemiology

Nutrition transition in developing countries is of considerable interest to international public health researchers and programme and policy makers. India is no exception, where despite an unacceptably high rate of underweight, rapid urbanization and a growing sedentary population have led to rising levels of overweight and obesity[1]. Although overweight and obesity remain a growing concern, addressing underweight is still an unfinished agenda in India[2–4], especially in rural settings; this poses a grave challenge to India's public health-care system[5]. Undernutrition increases one's susceptibility to infections, related morbidity, disability and mortality, leading to decreased national productivity and economic growth[6–8]. An undernourished woman with short stature, iron or protein deficiency, or other nutrient deficiencies has a greater risk of adverse pregnancy outcomes such as obstructed labour or postpartum haemorrhage, and of giving birth to a baby with low birth weight and ill health[9]. Underweight among men is indicative of poverty, food insecurity and inadequate health care[5,10].

A large body of research has empirically identified predictors of child undernutrition in India, but the dynamics of adult undernutrition are poorly understood. The determinants of undernutrition are widely studied in

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the global health literature. A framework developed by UNICEF describes poverty as the central underlying cause of undernutrition[11]. Many studies have shown socio-economic, demographic, physiological and behavioural factors associated with undernutrition in India[12–15]. However, these studies were conducted using cross-sectional survey data, which limits confidence in causal relationships; cross-sectional studies also preclude the ability to discern temporal relationships. Although one recent longitudinal study was conducted among Indian children[16], to our knowledge no longitudinal study on adult undernutrition has recently been conducted in India, especially in rural India where existing social welfare programmes to improve nutritional status have been generally ineffective[17].

Given these knowledge gaps, the present study used prospective cohort data (a baseline survey in 2008 and a follow-up survey in 2012) from a Health and Demographic Surveillance System, located in the Birbhum district of West Bengal, India, to assess the magnitude and predictors of underweight in 2008, and to analyse the predictors of incident underweight and recovery from underweight of 6732 individuals aged ≥18 years.

Methods

Study setting and data

The data used in the present study were drawn from a prospective cohort study conducted by the Society for Health and Demographic Surveillance (SHDS). SHDS is a Health and Demographic Surveillance System (HDSS) located in the Birbhum district of the state of West Bengal, India. The Birbhum Health and Demographic Surveillance System (BHDSS) consists predominantly of a rural population spread over four administrative blocks (Mohammad Bazar, Rajnagar, Sainthia and Suri I) and the project office of BHDSS is based in Suri I. At its inception in 2008, a sampling frame of the 2001 census was used to draw stratified self-weighted samples (where each household in a given sampling frame had the same chance of being selected as any other household) of 12 300 households and 54 585 individuals, applying a probability-proportional-to-size sampling method, with a 10 % expected dropout or non-participation rate[18]. Since 2008, BHDSS has gathered information on demographic processes, population health (including nutrition) and health-care utilization in this well-defined cohort. The information on demographic processes including vital events (fertility, mortality and migration) is collected routinely, while focused surveys, mostly longitudinal, are also an important component of BHDSS. The selected sample for BHDSS represents nearly 16 % of the population of Birbhum district and has a response rate of over 98 %. More details about the sampling procedure and BHDSS profile are available elsewhere[18].

In 2008, measurement of BMI was taken for the full sample of 29 896 individuals aged ≥18 years, while in 2012, BMI measurement was taken for 8177 individuals who participated in blood sample and ultrasonography investigations in the same year. A total of 6732 individuals participated in both rounds of BMI measurement and are included in the current analysis. This analysis excludes women who were pregnant at the time of each survey round as well as women who gave birth during the two months preceding the survey. Data were collected from study participants by forty-four trained surveyors who had at least an undergraduate degree and at least five years of experience with large-scale sample surveys. The surveyors were native speakers of at least one of the local languages – Bengali and *Santhali* (a tribal language) – and were trained in a rigorous data collection and field monitoring protocol. In case of unavailability of a participant on the survey date, surveyors made every effort (e.g. consulting neighbours or household member, paying multiple visits to the household, and making a prior appointment by telephone) to follow up with the participant to avoid non-response and missing data. All data were double-checked for consistency before being determined ready for use[18].

Outcome events

BMI (kg/m^2) is a widely used indicator of adiposity and nutritional status. For Asian populations, the WHO defines a BMI of <18·5 kg/m^2 as underweight, a BMI of 18·5–22·9 kg/m^2 as normal and a BMI of ≥23·0 kg/m^2 as overweight or obese[19]. The present study focused on studying underweight: incident underweight was defined as a transition from normal BMI or overweight/obesity in 2008 to underweight in 2012, and recovery from underweight was defined a transition from underweight in 2008 to normal weight in 2012. To calculate BMI, height was measured using a standard anthropometric tape (Bioplus Stature Meter, model number IND/09/2005/815) and a certified electronic weighing scale (model number Omron HN-283) was used to measure weight.

Predictors

Guided by the existing literature on determinants of BMI, a range of potential predictors were selected for analysis. These included age group (in terms of completed years), sex, marital status, education status (in terms of highest grade of education attained), employment, social group, religion, household wealth quintile, administrative block of residence, current alcohol use, current smoking, current use of smokeless tobacco, availability of health insurance, and record of illness during a period of 30 d preceding the survey. Information for all predictors was collected in 2008, except for information on illness which was collected in 2012.

The unemployed category of income corresponds to non-household work without pay, permanently disabled persons and full-time students with no source of earnings.

Primary employment corresponds to individuals who were self-employed, or those who worked in agriculture (as employers), non-agricultural fields (as employers), share-croppers, agricultural labourers, non-agricultural labourers, income-earning household workers, or other earners of small income. If an individual had an income from a professionally skilled job, business or salary-based service, it was considered secondary or tertiary employment. Social group categories such as Scheduled Castes (SC) and Scheduled Tribes (ST) have been identified by the Government of India as socially and economically disadvantaged and needing protection from social injustice and exploitation. Other Backward Classes (OBC), as officially classified by the federal government, is a diverse collection of intermediate castes above the SC and ST[20]. The 'Other' social group category is a residual group which has historically enjoyed a higher status in the social hierarchy. To compute a composite proxy indicator of income, a relative index of household wealth quintile was estimated from a standard set of household assets, consumer goods and dwelling characteristics using principal component analysis[21]. Individuals were ranked on the basis of their household wealth scores and divided into wealth quintiles (from 1 = the poorest to 5 = the richest)[22]. If participants consumed alcohol and tobacco (smoking and smokeless) in the 30 d preceding the survey, they were classified as alcohol users[23] and tobacco users[24], respectively.

Statistical approach

Baseline sample characteristics, BMI categories, incident underweight and recovery from underweight within subgroups of the population were tabulated. The χ^2 test was used to test differences in proportions of underweight in 2008, incident underweight and recovery from underweight by selected background characteristics. Univariate and multivariable binary logistic regression models were applied to examine predictors of underweight in 2008, incident underweight and recovery from underweight. In bivariate analysis, variables found significant at $P < 0{\cdot}2$ in the χ^2 tests were included in the building of multivariate logistic regression analysis.

In multivariable regression models, the estimated coefficients may become unstable due to collinearity, resulting in inflated SE. To better understand correlation among variables, correlation coefficients were estimated for all three outcome events (see online supplementary material, Supplemental Tables 1, 2 and 3). Furthermore, as linear dependencies between three or more variables may exist in the presence of small bivariate intercorrelations, variance inflation factors were also estimated to assess multicollinearity[25]. All variance inflation factor values were less than 5·0 (Supplemental Table 4), suggesting that the possibility of high multicollinearity between analysed predictors was low.

Ethics of human subject participation

This study was conducted by the BHDSS of the SHDS. Ethical approval was obtained from the institutional ethics review board of BHDSS. Signed informed consent from study participants was obtained prior to enrolment.

Results

Figure 1 summarizes changes in nutritional status of 6732 individuals between 2008 and 2012. In 2008, the prevalence of underweight and overweight/obesity was estimated at 46·5 and 11·5 %, respectively, whereas in 2012 prevalence was 39·8 and 16·9 %, respectively. From 2008 to 2012, incident underweight was 10·2 %, while recovery from underweight was 25·8 %. The prevalence of overweight/obesity in 2008 was 11·5 %, and incident overweight/obesity (from 2008 to 2012) was 7·7 %. From 2008 to 2012, 25·8 % of

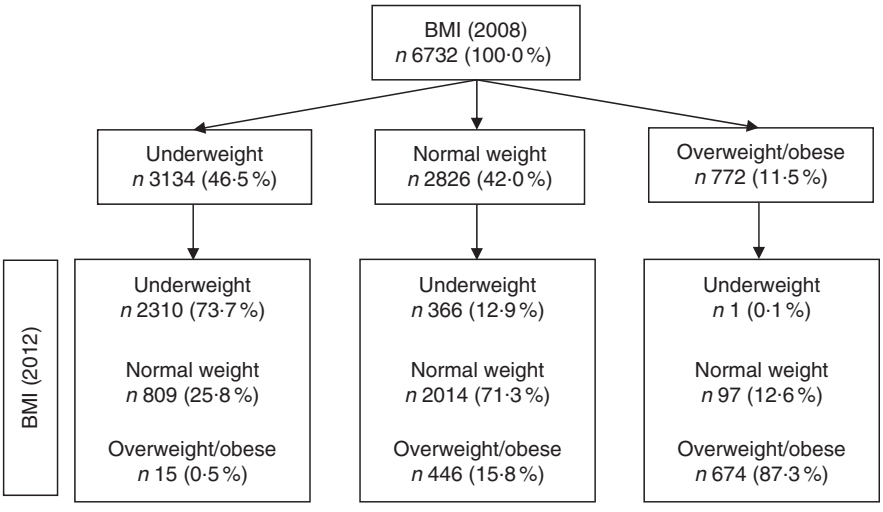

Fig. 1 Baseline distribution and dynamics of BMI categories from 2008 to 2012 among predominantly rural individuals (*n* 6732) aged ≥18 years, Birbhum Health and Demographic Surveillance System, West Bengal, India

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Table 1 Underweight in 2008, incident underweight (transition from normal weight or overweight/obese in 2008 to underweight in 2012) and recovery from underweight (transition from underweight in 2008 to normal weight in 2012), according to baseline characteristics, among predominantly rural individuals (*n* 6732) aged ≥18 years, Birbhum Health and Demographic Surveillance System, West Bengal, India

	Underweight in 2008 (*n* 6732)		Incident underweight (*n* 3598)		Recovery from underweight (*n* 3134)	
Baseline characteristic	*n*	%	*n*	%	*n*	%
Age (years)	$\chi^2=49{\cdot}7$; $P<0{\cdot}001$		$\chi^2=18{\cdot}2$; $P<0{\cdot}001$		$\chi^2=108{\cdot}0$; $P<0{\cdot}001$	
18–24	1111	16·5	543	15·1	568	18·1
25–35	2076	30·8	1153	32·1	923	29·5
36–49	2134	31·7	1233	34·3	901	28·8
≥50	1411	21·0	669	18·6	742	23·7
Sex	$\chi^2=0{\cdot}1$; $P=0{\cdot}723$		$\chi^2=2{\cdot}6$; $P=0{\cdot}103$		$\chi^2=11{\cdot}8$; $P=0{\cdot}001$	
Male	2936	43·6	1562	43·4	1374	43·8
Female	3796	56·4	2036	56·6	1760	56·2
Marital status	$\chi^2=7{\cdot}1$; $P=0{\cdot}029$		$\chi^2=3{\cdot}5$; $P=0{\cdot}177$		$\chi^2=27{\cdot}3$; $P<0{\cdot}001$	
Never married	469	7·0	223	6·2	246	7·9
Married	5595	83·1	3013	83·7	2582	82·4
Widow/widower/divorced/separated	668	9·9	362	10·1	306	9·8
Highest grade of education attained	$\chi^2=211{\cdot}2$; $P<0{\cdot}001$		$\chi^2=48{\cdot}1$; $P<0{\cdot}001$		$\chi^2=35{\cdot}7$; $P<0{\cdot}001$	
Illiterate	2817	41·8	1276	35·5	1541	49·2
1–5	1365	20·3	704	19·6	661	21·1
6–10	1960	29·1	1184	32·9	776	24·8
≥11	590	8·8	434	12·1	156	5·0
Employment	$\chi^2=49{\cdot}6$; $P<0{\cdot}001$		$\chi^2=14{\cdot}4$; $P=0{\cdot}001$		$\chi^2=13{\cdot}5$; $P<0{\cdot}001$	
Unemployed	3319	49·3	1816	50·5	1503	48·0
Primary	3013	44·8	1510	42·0	1503	48·0
Secondary/tertiary	400	5·9	272	7·6	128	4·1
Social group	$\chi^2=127{\cdot}0$; $P<0{\cdot}001$		$\chi^2=92{\cdot}5$; $P<0{\cdot}001$		$\chi^2=22{\cdot}2$; $P<0{\cdot}001$	
Scheduled Caste	2274	33·8	1022	28·4	1252	40·0
Scheduled Tribe	543	8·1	261	7·3	282	9·0
Other Backward Classes	487	7·2	268	7·5	219	7·0
Other	3428	50·9	2047	56·9	1381	44·1
Religion	$\chi^2=33{\cdot}0$; $P<0{\cdot}001$		$\chi^2=6{\cdot}6$; $P=0{\cdot}010$		$\chi^2=17{\cdot}9$; $P<0{\cdot}001$	
Hindu	4678	69·5	2392	66·5	2286	72·9
Muslim or other	2054	30·5	1206	33·5	848	27·1
Wealth quintile	$\chi^2=370{\cdot}3$; $P<0{\cdot}001$		$\chi^2=61{\cdot}0$; $P<0{\cdot}001$		$\chi^2=17{\cdot}1$; $P=0{\cdot}002$	
Poorest	1423	21·1	583	16·2	840	26·8
Poorer	1190	17·7	538	15·0	652	20·8
Middle	1281	19·0	647	18·0	634	20·2
Richer	1446	21·5	796	22·1	650	20·7
Richest	1392	20·7	1034	28·7	358	11·4
Block of residence	$\chi^2=56{\cdot}8$; $P<0{\cdot}001$		$\chi^2=3{\cdot}6$; $P=0{\cdot}311$		$\chi^2=2{\cdot}1$; $P=0{\cdot}556$	
Mohammad Bazar	2003	29·8	1070	29·7	933	29·8
Rajnagar	721	10·7	348	9·7	373	11·9
Sainthia	2621	38·9	1322	36·7	1299	41·5
Suri I	1387	20·6	858	23·9	529	16·9
Alcohol use	$\chi^2=7{\cdot}7$; $P=0{\cdot}006$		$\chi^2=22{\cdot}4$; $P<0{\cdot}001$		$\chi^2=20{\cdot}3$; $P<0{\cdot}001$	
No	6334	94·1	3412	94·8	2922	93·2
Yes	398	5·9	186	5·2	212	6·8
Smoking	$\chi^2=38{\cdot}0$; $P<0{\cdot}001$		$\chi^2=21{\cdot}3$; $P<0{\cdot}001$		$\chi^2=30{\cdot}2$; $P<0{\cdot}001$	
No	5350	79·5	2961	82·3	2389	76·2
Yes	1382	20·5	637	17·7	745	23·8
Smokeless tobacco use	$\chi^2=3{\cdot}2$; $P=0{\cdot}073$		$\chi^2=0{\cdot}2$; $P=0{\cdot}624$		$\chi^2=10{\cdot}8$; $P=0{\cdot}001$	
No	5329	79·2	2878	80·0	2451	78·2
Yes	1403	20·8	720	20·0	683	21·8
Health insurance	$\chi^2=39{\cdot}6$; $P<0{\cdot}001$		$\chi^2=2{\cdot}6$; $P=0{\cdot}269$		$\chi^2=4{\cdot}8$; $P=0{\cdot}090$	
No	4563	67·8	2556	71·0	2007	64·0
Public insurance	2103	31·2	1016	28·2	1087	34·7
Private insurance	66	1·0	26	0·7	40	1·3
Illness (last 30 d)	NC*		$\chi^2=2{\cdot}2$; $P=0{\cdot}328$		$\chi^2=11{\cdot}8$; $P=0{\cdot}003$	
No			2834	78·8	2375	75·8
Acute			543	15·1	560	17·9
Chronic			221	6·1	199	6·4

Percentages may not add to 100 due to rounding.
*Information on illness during 30 d preceding the survey was not collected in 2008.

underweight individuals recovered, 12·9 % of normal-weight individuals became underweight and 0·1 % of overweight/obese individuals became underweight.

In Table 1, baseline characteristics of the study population, prevalence of underweight in 2008 and incident/recovery from underweight between 2008 and 2012 are

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presented. Of the total sample in 2008, 62·5 % of participants were aged 25–49 years, 41·8 % were illiterate and 49·3 % were unemployed. Of underweight persons at baseline, 49·2 % were illiterate. The prevalence of smoking and smokeless tobacco use was higher than that of alcohol consumption across categories of outcome events.

There were no missing data for any predictor variable. In the χ^2 test for associations with underweight in 2008, sex had a P value of more than 0·2. The χ^2 test for variables associated with incident underweight indicated that all the variables were associated at $P < 0·2$ except for the block of residence, smokeless tobacco use, health insurance availability, and illness in the 30 d preceding the survey. Similarly, all variables except block of residence were associated with recovery from underweight at $P < 0·2$.

The unadjusted and adjusted odds, with 95 % CI, of underweight in 2008, incident underweight from 2008 to 2012, and recovery from underweight from 2008 to 2012 are presented in Tables 2, 3 and 4, respectively. Compared with people aged 18–24 years, people aged 36–49 years had lower adjusted odds of underweight in 2008 (OR = 0·65; 95 % CI 0·55, 0·77; $P < 0·001$), incident underweight (OR = 0·58; 95 % CI 0·40, 0·85; $P = 0·005$) and recovery from underweight (OR = 0·56; 95 % CI 0·43, 0·74; $P < 0·001$). Compared with those who were illiterate, people with a Grade 6 education or higher had lower adjusted odds of underweight in 2008 and incident underweight, and higher adjusted odds of recovery from underweight. People belonging to ST had increased adjusted odds of incident underweight (OR = 2·44; 95 % CI 1·55, 3·23; $P < 0·001$) compared with SC. Muslims had lower adjusted odds of underweight (OR = 0·67; 95 % CI 0·57, 0·78; $P < 0·001$) and higher odds of recovery from underweight (OR = 1·47; 95 % CI 1·15, 1·89; $P = 0·002$) compared with Hindus. Adjusted odds of underweight in 2008 were lower among people of the middle, richer and richest wealth quintiles, whereas the richest had lower adjusted odds of incident underweight than the poorest (OR = 0·58; 95 % CI 0·38, 0·90; $P = 0·014$). Current consumption of alcohol was negatively associated with underweight in 2008 (OR = 0·76; 95 % CI 0·60, 0·97; $P = 0·028$), whereas smoking was associated with increased adjusted odds of underweight (OR = 1·42; 95 % CI 1·23, 1·63; $P < 0·001$) and incident underweight (OR = 1·76; 95 % CI 1·26, 2·47; $P = 0·001$). The rate of recovery was higher among individuals suffering from acute illness during the 30 d prior to the 2012 survey wave (OR = 1·25; 95 % CI 1·01, 1·55; $P = 0·037$) than among people who reported no illness.

Discussion

Using prospective cohort data from a Health and Demographic Surveillance System in Birbhum, West Bengal, India, a high burden of underweight (46·5 %) for adults was estimated in 2008. According to the 2015–16 National Family Health Survey (NFHS) conducted in West Bengal[26], the prevalence of underweight among men and women aged 15–49 years was 19·9 and 21·3 %, respectively, which is a substantial reduction from NFHS 2005–06 estimates (35·2 and 39·1 % for men and women, respectively). In our rural setting in Birbhum, we recorded a modest decline in underweight to nearly 40 % in 2012.

Findings reveal that the odds of underweight in 2008 and incident underweight were lower in the 25–35 and 36–49 years age groups, as compared with people of the 18–24 years age group, whereas odds of recovery from underweight were lower in the 36–49 and ≥50 years age groups, indicating that changes in BMI are less volatile as age advances[27]. Studies have documented that BMI change in later adulthood has less to do with age than with social, environmental and cultural conditions that significantly influence energy consumption[28,29]. The present analysis also reveals that people who experienced acute illness in the 30 d preceding the 2012 survey date had higher odds of recovery from underweight. This could be attributed to the care and comfort received by these individuals during the treatment of their illness (e.g. food and nutrient supplementation, long period of resting, medication). However, this finding warrants further investigation. Having health insurance did not appear to have any bearing on recovery from underweight in the present study. This may be due to that fact that having insurance does not guarantee better access to or quality of care, and that the operational definition of the insurance variable was therefore inadequate. In addition, the majority of people in the study population have public health insurance that covers costs of hospitalization but covers only selected medicines, which do not include nutritional or food supplements. The study also reveals that smokers were more likely to experience underweight in 2008 and incident underweight than non-smokers, whereas recovery from underweight was not associated with smoking status. This finding is supported by local evidence from a study conducted in an urban Indian population, which indicated that any type of smoking could be a risk factor for underweight[30], as well as international studies that have explored the complex pathways of smoking-related physiological changes (direct pathways affecting appetite or other aspects of physiology, or indirect pathways decreasing the amount of money available for food) which might increase the probability of underweight[31]. Studies of the same population indicated that the joint effect of underweight and smoking could be especially deleterious to human health[32]. In our study, alcohol users were less likely to be underweight compared with non-users, which also concurs with other studies in India[33] and elsewhere[34] that show alcohol consumption could increase the risk of overweight and obesity.

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Table 2 Predictors of underweight in 2008 among predominantly rural individuals (*n* 6732) aged ≥18 years, Birbhum Health and Demographic Surveillance System, West Bengal, India

		Underweight in 2008					
		Unadjusted			Adjusted		
	No. of events (*n* 3134)	OR	95 % CI	*P*	OR	95 % CI	*P*
Age (years)							
18–24	568	1·00	Ref.		1·00	Ref.	
25–35	923	0·77	0·66, 0·89	<0·001	0·71	0·60, 0·84	<0·001
36–49	901	0·70	0·60, 0·81	<0·001	0·65	0·55, 0·77	<0·001
≥50	742	1·06	0·91, 1·24	0·466	0·98	0·80, 1·18	0·798
Marital status							
Never married	246	1·00	Ref.		1·00	Ref.	
Married	2582	0·78	0·64, 0·94	0·009	1·00	0·81, 1·23	0·973
Widow/widower/divorced/separated	306	0·77	0·60, 0·97	0·027	1·13	0·85, 1·50	0·399
Highest grade of education attained							
Illiterate	1541	1·00	Ref.		1·00	Ref.	
1–5	661	0·78	0·68, 0·88	<0·001	0·85	0·74, 0·98	0·022
6–10	776	0·54	0·48, 0·61	<0·001	0·68	0·59, 0·79	<0·001
≥11	156	0·30	0·24, 0·36	<0·001	0·50	0·39, 0·64	<0·001
Employment							
Unemployed	1503	1·00	Ref.		1·00	Ref.	
Primary	1503	1·20	1·09, 1·33	<0·001	0·97	0·86, 1·09	0·559
Secondary/tertiary	128	0·57	0·46, 0·71	<0·001	0·75	0·59, 0·96	0·055
Social group							
Scheduled Caste	1252	1·00	Ref.		1·00	Ref.	
Scheduled Tribe	282	0·88	0·73, 1·06	0·189	0·86	0·70, 1·06	0·156
Other Backward Classes	219	0·67	0·55, 0·81	<0·001	1·17	0·93, 1·47	0·182
Other	1381	0·55	0·49, 0·61	<0·001	1·01	0·86, 1·18	0·925
Religion							
Hindu	2286	1·00	Ref.		1·00	Ref.	
Muslim or other	848	0·74	0·66, 0·82	<0·001	0·67	0·57, 0·78	<0·001
Wealth quintile							
Poorest	840	1·00	Ref.		1·00	Ref.	
Poorer	652	0·84	0·72, 0·98	0·029	0·88	0·75, 1·03	0·119
Middle	634	0·68	0·58, 0·79	<0·001	0·73	0·62, 0·86	<0·001
Richer	650	0·57	0·49, 0·66	<0·001	0·67	0·57, 0·79	<0·001
Richest	358	0·24	0·20, 0·28	<0·001	0·31	0·26, 0·38	<0·001
Block of residence							
Mohammad Bazar	933	1·00	Ref.		1·00	Ref.	
Rajnagar	373	1·23	1·04, 1·46	0·018	1·10	0·92, 1·33	0·300
Sainthia	1299	1·13	1·00, 1·27	0·044	1·03	0·91, 1·17	0·633
Suri I	529	0·71	0·62, 0·81	<0·001	0·75	0·65, 0·88	<0·001
Alcohol use							
No	2922	1·00	Ref.		1·00	Ref.	
Yes	212	1·33	1·09, 1·63	0·006	0·76	0·60, 0·97	0·028
Smoking							
No	2389	1·00	Ref.		1·00	Ref.	
Yes	745	1·45	1·29, 1·63	<0·001	1·42	1·23, 1·63	<0·001
Smokeless tobacco use							
No	2451	1·00	Ref.		1·00	Ref.	
Yes	683	1·11	0·99, 1·25	0·073	1·00	0·88, 1·14	0·962
Health insurance							
No	2007	1·00	Ref.		1·00	Ref.	
Public insurance	1087	1·36	1·23, 1·51	<0·001	0·99	0·88, 1·11	0·819
Private insurance	40	1·96	1·19, 3·22	0·008	2·38	1·37, 4·13	0·052

Ref., reference category.
'Adjusted' models are adjusted for all variables found significant at $P < 0·2$ in χ^2 tests (Table 1).

The current results indicate that with increasing years of education, the prevalence of underweight in 2008 (Grade 1 or higher) and incident underweight (Grade 6 or higher) was likely to decrease, and the recovery from underweight was likely to increase with education (Grade 6 or higher). Educated people are expected to be relatively more aware of their nutrition than the uneducated[35], which may increases their chances of recovery from underweight. The observed effect of education could also be due to residual confounding by wealth. Even after controlling for wealth, education is related to better life choices in general[8], not just knowledge of normal BMI, and such choices may inevitably lead to improved nutrition. Social group appeared to be a significant predictor of recovery from underweight. As compared with people from the SC community, ST had higher odds of incidence of

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Table 3 Predictors of incident underweight (transition from normal weight or overweight/obese in 2008 to underweight in 2012) among predominantly rural individuals (*n* 6732) aged ≥18 years, Birbhum Health and Demographic Surveillance System, West Bengal, India

		Incident underweight					
		Unadjusted			Adjusted		
	No. of events (*n* 367)	OR	95 % CI	*P*	OR	95 % CI	*P*
Age (years)							
18–24	78	1·00	Ref.		1·00	Ref.	
25–35	105	0·60	0·44, 0·82	0·001	0·61	0·43, 0·87	0·006
36–49	104	0·55	0·40, 0·75	<0·001	0·58	0·40, 0·85	0·005
≥50	80	0·81	0·58, 1·13	0·217	0·82	0·55, 1·24	0·348
Sex							
Male	174	1·00	Ref.		1·00	Ref.	
Female	193	0·84	0·67, 1·04	0·103	0·84	0·59, 1·19	0·321
Marital status							
Never married	21	1·00	Ref.		1·00	Ref.	
Married	299	1·06	0·67, 1·69	0·807	1·37	0·83, 2·26	0·220
Widow/widower/divorced/separated	47	1·44	0·83, 2·47	0·193	1·84	0·96, 3·52	0·066
Highest grade of education attained							
Illiterate	181	1·00	Ref.		1·00	Ref.	
1–5	78	0·75	0·57, 1·00	0·050	0·80	0·59, 1·09	0·162
6–10	89	0·49	0·38, 0·64	<0·001	0·60	0·43, 0·84	0·003
≥11	19	0·28	0·17, 0·45	<0·001	0·36	0·20, 0·65	0·001
Employment							
Unemployed	171	1·00	Ref.		1·00	Ref.	
Primary	182	1·32	1·06, 1·64	0·014	0·79	0·58, 1·07	0·133
Secondary/tertiary	14	0·52	0·30, 0·91	0·023	0·61	0·33, 1·13	0·116
Social group							
Scheduled Caste	132	1·00	Ref.		1·00	Ref.	
Scheduled Tribe	65	2·24	1·60, 3·13	<0·001	2·24	1·55, 3·23	<0·001
Other Backward Classes	13	0·34	0·19, 0·62	<0·001	0·59	0·32, 1·10	0·098
Other	157	0·56	0·44, 0·72	<0·001	0·86	0·60, 1·23	0·402
Religion							
Hindu	266	1·00	Ref.		1·00	Ref.	
Muslim or other	101	0·73	0·57, 0·93	0·010	0·76	0·54, 1·08	0·124
Wealth quintile							
Poorest	86	1·00	Ref.		1·00	Ref.	
Poorer	62	0·75	0·53, 1·07	0·112	0·79	0·55, 1·14	0·206
Middle	96	1·01	0·73, 1·38	0·966	1·19	0·86, 1·65	0·302
Richer	71	0·57	0·41, 0·79	0·001	0·86	0·60, 1·23	0·398
Richest	52	0·31	0·21, 0·44	<0·001	0·58	0·38, 0·90	0·014
Alcohol use							
No	329	1·00	Ref.		1·00	Ref.	
Yes	38	2·41	1·66, 3·50	<0·001	0·82	0·52, 1·29	0·383
Smoking							
No	270	1·00	Ref.		1·00	Ref.	
Yes	97	1·79	1·39, 2·30	<0·001	1·76	1·26, 2·47	0·001

Ref., reference category.
'Adjusted' models are adjusted for all variables found significant at $P < 0·2$ in χ^2 tests (Table 1).

underweight. ST are considered the most underserved among social groups with limited or no access to productive resources. Persistent discrimination in several other domains of social and economic status[36], which can also be attributed to their food insecurity, may explain their higher probability of being underweight. With lower odds of being underweight in 2008, recovery from underweight was higher among Muslims than Hindus. Animal-based protein intake is known to have a better impact on nutritional status in the short term[37]. Therefore, one could expect a low prevalence and better recovery status among Muslims whose consumption of meat is relatively higher compared with Hindus[38]. Economic status was also associated with underweight status: compared with the poorest quintile of wealth, the middle, richer and richest economic groups had lower odds of being underweight in 2008, and the richest quintile had lower odds of incident underweight. However, recovery from underweight was not affected by wealth quintile. Poverty is associated with increased odds of underweight[35] and economically better-off individuals are more likely to gain weight in India[13]. Poverty restricts access to food to meet daily requirements or ensure dietary diversity, which could lead to undernutrition[39]. During epidemiological transition, changing food consumption and physical activity patterns that have led to

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Table 4 Predictors of recovery from underweight (transition from underweight in 2008 to normal weight in 2012) among predominantly rural individuals (*n* 6732) aged ≥18 years, Birbhum Health and Demographic Surveillance System, West Bengal, India

		Recovery from underweight					
		Unadjusted			Adjusted		
	No. of events (*n* 809)	OR	95 % CI	*P*	OR	95 % CI	*P*
Age (years)							
18–24	214	1·00	Ref.		1·00	Ref.	
25–35	286	0·74	0·60, 0·93	0·008	0·83	0·65, 1·06	0·140
36–49	199	0·47	0·37, 0·59	<0·001	0·56	0·43, 0·74	<0·001
≥50	110	0·29	0·22, 0·37	<0·001	0·36	0·26, 0·50	<0·001
Sex							
Male	313	1·00	Ref.		1·00	Ref.	
Female	496	1·33	1·13, 1·57	0·001	1·23	0·94, 1·60	0·132
Marital status							
Never married	41	1·00	Ref.		1·00	Ref.	
Married	658	1·71	1·21, 2·42	0·002	1·07	0·73, 1·58	0·721
Widow/widower/divorced/separated	110	2·81	1·86, 4·22	<0·001	1·15	0·70, 1·89	0·572
Highest grade of education attained							
Illiterate	345	1·00	Ref.		1·00	Ref.	
1–5	159	1·10	0·89, 1·36	0·394	0·90	0·71, 1·13	0·370
6–10	247	1·62	1·33, 1·96	<0·001	1·29	1·02, 1·65	0·037
≥11	58	2·05	1·45, 2·90	<0·001	1·59	1·02, 2·48	0·040
Employment							
Unemployed	432	1·00	Ref.		1·00	Ref.	
Primary	351	0·76	0·64, 0·89	0·001	1·01	0·81, 1·26	0·915
Secondary/tertiary	26	0·63	0·41, 0·99	0·043	0·73	0·45, 1·19	0·203
Social group							
Scheduled Caste	290	1·00	Ref.		1·00	Ref.	
Scheduled Tribe	52	0·75	0·54, 1·04	0·086	0·84	0·59, 1·19	0·320
Other Backward Classes	66	1·43	1·04, 1·96	0·027	1·19	0·82, 1·73	0·349
Other	401	1·36	1·14, 1·62	0·001	0·99	0·76, 1·29	0·954
Religion							
Hindu	544	1·00	Ref.		1·00	Ref.	
Muslim or other	265	1·46	1·22, 1·73	<0·001	1·47	1·15, 1·89	0·002
Wealth quintile							
Poorest	193	1·00	Ref.		1·00	Ref.	
Poorer	155	1·05	0·82, 1·33	0·718	1·01	0·79, 1·29	0·949
Middle	154	1·08	0·84, 1·37	0·556	1·03	0·80, 1·32	0·845
Richer	199	1·48	1·17, 1·86	0·001	1·27	0·98, 1·64	0·068
Richest	108	1·45	1·10, 1·91	0·009	1·20	0·85, 1·69	0·305
Alcohol use							
No	782	1·00	Ref.		1·00	Ref.	
Yes	27	0·40	0·26, 0·60	<0·001	0·79	0·50, 1·25	0·311
Smoking							
No	674	1·00	Ref.		1·00	Ref.	
Yes	135	0·56	0·46, 0·69	<0·001	0·85	0·65, 1·11	0·237
Smokeless tobacco use							
No	666	1·00	Ref.		1·00	Ref.	
Yes	143	0·71	0·58, 0·87	0·001	0·92	0·74, 1·16	0·494
Health insurance							
No	543	1·00	Ref.		1·00	Ref.	
Public insurance	255	0·83	0·70, 0·98	0·029	0·92	0·77, 1·11	0·411
Private insurance	11	1·02	0·51, 2·06	0·950	1·04	0·48, 2·24	0·922
Illness (last 30 d)							
No	607	1·00	Ref.		1·00	Ref.	
Acute	167	1·24	1·01, 1·52	0·040	1·25	1·01, 1·55	0·037
Chronic	35	0·62	0·43, 0·91	0·013	0·70	0·48, 1·04	0·077

Ref., reference category.
'Adjusted' models are adjusted for all variables found significant at $P<0·2$ in χ^2 tests (Table 1).

increasing sedentarism, especially among wealthy people, have contributed to the rise of an obesity epidemic[40].

The results of the present study should be interpreted in the light of its limitations. First, data on dietary intake would have provided more insight in understanding change in nutritional status. Second, the predictors of prevalence, incident and recovery from overweight/obesity were not assessed in the study and have been reserved for future analysis. Also, a more comprehensive characterization of dynamics in nutritional status (from

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undernutrition to overnutrition) was deemed insufficient with existing data. Third, the study included only anthropometric measurements (BMI) as an indicator of undernutrition and excluded biochemical or clinical indicators (e.g. iron-deficiency anaemia) or social indicators (e.g. food security or dietary diversity) of undernutrition. Fourth, as it is an observational study, our results are inevitably affected by an intractable measure of confounding. Despite these limitations, the availability of a large sample size and absence of missing data in predictor variables have brought more power to the study, while prospective assessment of the issue helped strengthen the study findings.

Conclusion

In conclusion, a high burden of underweight was found in the study population. An urgent need for local nutrition interventions to curb the level of underweight is warranted. While designing an intervention, focusing on improving nutrition education could be an effective strategy[41], as adjusted odds of recovery from underweight was more likely among educated people. However, a careful measure of intervention with both wealth and education might be needed, as the effect of education on nutrition could be subject to residual confounding by an individual's income. Wealth provides resources to secure food while education is needed to better utilize health care, increase dietary diversity, improve household sanitation and hygiene, and make better overall health choices. The intervention could have some special arms to it, such as counselling for quitting smoking, which could also prove effective in curbing the level of underweight in this community. Programmes could incorporate modification of risk factors into new or existing conventional nutrition interventions (such as culturally sensitive food supplementation), targeting those subgroups in which the incidence of malnutrition is particularly high.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1368980017003081

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