

Double Burden of Malnutrition among The College Students: A Cross-Sectional Study in Bankura, India

Subhajit Mahanty¹, Nirmalya Kumar Sinha², Keshab Chakraborty³, Sudisha Samanta⁴, Md. Masum Molla⁵, Baibhab Mahanti⁶, Monisha Mahapatra⁷, Malay Kumar Patsa⁸, Surajit Majumder⁹

¹Department of Zoology, Bankura Sammilani College, Bankura, West Bengal, India. ORCID iD: 0009-0003-1146-5110

²Department of Nutrition and Department of NSS, Raja Narendra Lal Khan Women's College (Autonomous), Midnapore, West Bengal, India. ORCID iD: 0000-0002-2136-0588

³Department of Zoology, Bankura Sammilani College, Bankura, West Bengal, India. ORCID iD: 0009-0002-9121-5391

⁴Department of Zoology, Bankura Sammilani College, Bankura, West Bengal, India. ORCID iD: 0009-0008-7699-5901

⁵Department of Zoology, Bankura Sammilani College, Bankura, West Bengal, India. ORCID iD: 0009-0006-7917-5912

⁶Department of Zoology, Bankura Sammilani College, Bankura, West Bengal, India. ORCID iD: 0009-0008-9958-9711

⁷Department of Zoology, Bankura Sammilani College, Bankura, West Bengal, India. ORCID iD: 0009-0004-8823-3323

⁸Department of Paramedical and Allied Health Sciences, Midnapore City College, Midnapore, West Bengal, India. ORCID iD: 0000-0001-8526-706X

⁹Department of Zoology, Bankura Sammilani College, Bankura, West Bengal, India. ORCID iD: 0000-0002-1740-4496. surajitmajumder.sm@gmail.com (Corresponding Author)

ABSTRACT

Aim: This study aims to evaluate the nutritional status and socio-demographic factors affecting college students in Bankura, West Bengal, India.

Methods: A cross-sectional study was conducted with 220 college students selected through simple random sampling with proportional allocation. Nutritional status was assessed using World Health Organization cutoff points for underweight and overweight. Statistical analyses included Student's t-test, ANOVA for continuous variables and chi-square for categorical data with significance set at $p < 0.05$. Further analysis applied Dunnett's post hoc test for specific group comparisons.

Results: Among students aged 18-22, 27.3% were underweight and 10.9% were overweight. Binary logistic regression revealed that per capita income was significantly associated with chronic energy deficiency. The model showed significance underscoring a double burden of malnutrition linked to socio-demographic factors.

Conclusion: The study highlights a high prevalence of underweight and overweight status among college students with socio-demographic factors. Family income has a significant role in chronic energy deficiency. This study underscores the need for targeted nutritional interventions in this population.

Keywords: body mass index, nutritional status, malnutrition, students, socioeconomic factors, India

Date of submission: 27.08.2024 / **Date of acceptance:** 29.11.2024

How to cite: Mahanty S, Sinha NK, Chakraborty K, Samanta S, Molla M, Mahanti B, Mahapatra M, Patsa MK, Majumder S. Double burden of malnutrition among the college students: a cross-sectional study in Bankura, India. Euras J Fam Med 2024;13(4):195-208. doi:10.33880/ejfm.2024130407.

Conflict of interest: No conflict of interest was declared by the authors.

Financial disclosure: No financial disclosure was declared by the authors.

Introduction

The coexistence of undernutrition alongside overnutrition across various levels, from individual to international, is referred to as the double burden of malnutrition (DBM). This contemporary public health challenge arises from the consequences of nutritional transition (1). Addressing malnutrition in all its forms is a primary objective outlined in the UN Decade of Action on Nutrition (2). Globally, approximately 462 million adults are underweight while more than 1.9 billion adults aged 18 and above are overweight or obese (3). Overnutrition, characterized by dietary excess leading to issues such as overweight, obesity, and non-communicable diseases (NCDs), and undernutrition, marked by deficiencies in energy and micronutrients resulting in conditions like stunting, wasting, and anemia, have traditionally been viewed as separate concerns. Undernutrition remains a significant cause of ill health and premature mortality among children and adolescents in developing countries (4,5). Malnutrition burdens a substantial portion of this nation's population, particularly affecting its youngest members. The trend aligns with observations in other developing countries (6).

However, the emerging concept of the DBM, recognized by the WHO in 2017, highlights the reality that overnutrition and undernutrition often coexist within individuals, households and populations due to shared underlying drivers (7). The distribution of DBM varies significantly across different national contexts and socioeconomic strata, although this diversity has not been exhaustively investigated. For instance, low- and middle-income countries (LMICs) within the lowest-income quartile are more prone to experiencing population-level DBM compared to those in the middle- and high-income quartiles. Household-level DBM is the least prevalent in LMICs with both the lowest and highest levels of gross domestic product (8).

Through the Sustainable Development Goals, the global community aims to reduce malnutrition in all forms, including overweight and obesity, by 2030. However, achieving this goal in the next few years is highly unlikely due to slow progress in 2018, 2.01

billion adults were overweight and obese globally (9,10). Addressing the Double Burden of Malnutrition (DBM) is a crucial focus for intervention and action aimed at achieving the goal of eradicating all appearances of malnutrition (11). Generally, according to several studies conducted in global countries, the prevalence of DBM ranged from 5.6% to 49.8% (12-16). As economic prosperity flourishes across various regions such as China, India, Pakistan, and Indonesia, there's a concomitant increase in the prevalence of overweight and obesity. Notably, these countries are among the top 10 globally with the highest populations grappling with obesity (17).

The economic and medical consequences of DBM in the Asia-Pacific countries are significant. Malnutrition has resulted in marked losses in gross national product for Asian countries (18). Simultaneously, the negative impact of the increasing prevalence of obesity is also rising (19). Urbanization, poorly managed diet and lifestyle, obesity and related NCDs have escalated. The risks of adverse health outcomes, including serious cardiometabolic diseases and certain types of cancers are increasing (3). Reducing the Double Burden of Malnutrition (DBM) is a critical aspect of improving health outcomes in the Asia-Pacific region. This study aims to evaluate the nutritional status, socio-demographic characteristics and related influencing factors among college students in Bankura, West Bengal, India.

Methods

The study was approved by the Institutional Research Ethics Committee of Bankura University on 24 August 2023 based on a meeting held on 16 August 2024. Potential participants were provided with a comprehensive explanation of the study's significance, and only those students who provided written consent were enrolled in the study. Measures were taken to ensure the absolute preservation of participants' anonymity throughout the study process.

A community-based cross-sectional study was conducted from November 2023 to January 2024 among 220 college students aged 18-22 years residing in the Bankura district and its surrounding areas.

Inclusion criteria encompassed mentally competent, emotionally stable, and physically healthy young adult college students within the specified age range. Participants with prevalent health conditions such as diabetes, hypertension, or chronic infectious diseases were excluded from the study.

The minimal estimated sample size was calculated using the standard formula: $n=(z^2pq)/d^2$. The calculation $\{(1.96^2 \times 0.162 \times 0.838) / (0.08^2)\}$ was based on 16.2 % of prevalence (P) of underweight at the age of 18-25 years according to the recent report of the fifth National Family Health Study (NFHS-5) conducted during 2019-2021 in India, where $z=1.96$, $q=p-1$ and the desired precision (d) was ± 5 (20). Thus, the estimated sample size was 208 with a dropout rate of 5% was 219.

Anthropometric measurements were meticulously performed by trained professionals using standardized techniques (21). Height was measured in centimeters using Martin's anthropometric rod with precision to the nearest 0.10 cm. Participants stood erect on a flat surface, ensuring their heads were positioned in the Frankfort horizontal plane. Weight was recorded in kilograms while participants stood motionless on a digital body composition monitor manufactured by Omron. Waist circumference (WC) was measured in centimeters at the midpoint between the iliac crest and the lower margin of the ribs. Participants maintained a standing position with their feet together during this measurement. Hip circumference (HC) was measured in centimeters at the highest point of the buttocks, with participants wearing minimal clothing (22). Both WC and HC were assessed using a non-stretchable measuring tape without applying compression to the skin. Errors in measurements were diligently monitored to ensure adherence to acceptable limits (23). Anthropometric indices such as waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), percentage of body fat (PBF), conicity index (Cindex), total body water (TBW), fat mass (FM), fat-free mass (FFM), fat mass index (FMI), fat-free mass index (FFMI), body adiposity index (BAI) and a body surface index (ABSI) were calculated using standard formulas are shown in Table 1 (24-32).

Table 1. Anthropometric indices used in the study

	Formula	References
BMI	Weight (kg)/Height ² (m)	Park 2005 (24)
WHR	Waist circumference (cm)/Hip circumference (cm)	WHO 2008 (25)
WHtR	Waist circumference (cm)/Height (cm)	Peng et al. 2015 (26)
PBF	$1.20 \times \text{BMI (kg/m}^2) + 0.23 \times \text{age (years)} - 10.8 \times \text{sex [Female=0, Male=1]} - 5.4$	Deurenberg et al. 1991 (27)
CIndex	$\text{WC (cm)} / [0.109 \times \sqrt{\text{Weight (kg)/Height (m)}}]$	Valdez et al. 1993 (28)
TBW	For Male = $2.447 - (0.09156 \times \text{Age in year}) + (0.1074 \times \text{Height in cm}) + (0.3362 \times \text{Body Weight in kg})$. For Female = $-2.097 + (0.1069 \times \text{height in cm}) + (0.2466 \times \text{weight in kg})$	Ghosh et al. 2018 (29)
FM	$\text{PBF}/100 \times \text{Body Weight (kg)}$	Kyle et al. 2004 (30)
FFM	Body Weight (kg) - Fat Mass (kg)	Kyle et al. 2004 (30)
FMI	$\text{FM} / \text{Height}^2 (\text{m})$	Ranasinghe et al. 2015 (31)
FFMI	$\text{FFM} / (\text{Height}^2 (\text{m}))$	Ranasinghe et al. 2015 (31)
BAI	$[\{\text{Hip circumference (m)}\} / \{\text{Height (m)} \times \sqrt{\text{Height (m)}}\}] - 18$	Bergman et al. 2011 (32)
ABSI	$\text{WC} / (\text{BMI}^{2/3} \times \text{H}^{1/2})$	Krakauer et al. 2012 (33)

BMI- Body Mass Index, WHR- Waist to Hip Ratio, WHtR- Waist to Height Ratio, PBF- Percentage of Body Fat, Cindex- Conicity Index, TBW- Total Body Water, FM- Fat Mass, FFM- Fat Free Mass, FMI- Fat Mass Index, FFMI- Fat Free Mass Index, BAI- Body Adiposity Index, ABSI- A Body Shape Index

Nutritional status was evaluated using internationally accepted World Health Organization BMI (kg/m²) guidelines (33). The following cut-off points were used: Chronic energy deficiency (CED)/Underweight: BMI<18.4; Normal: BMI=18.5 - 24.9; Overweight: BMI>25.0.

The process of sample selection and the development of meticulously crafted questionnaires played a crucial role in this research endeavor. These aspects not only elucidated the entire methodology but also significantly influenced the responses obtained. The evaluation of socioeconomic status (SES) was conducted using the revised Kuppuswamy socioeconomic status scale (34). The authors devoted careful attention to the creation of a standardized questionnaire, strategically designed to hold direct relevance and significance within the societal context.

Selected respondents actively participated in interviews, during which data were collected regarding various socioeconomic circumstances of the college students.

IBM SPSS Statistics 25 (2017, IBM Corporation, USA) was used for the statistical analysis. The anthropometric measurements were calculated for gender- and age-group-specific (18, 19, 20, >20 years) means and standard deviations of 220 college students. Continuous variables were analyzed using Student's t-test or analysis of variance (ANOVA) while applicable, and the chi-square test was used to analyze categorical variables. If the F value was significant ($p < 0.05$), Dunnett's post hoc test was performed to determine the differences between the pairs of means. Statistical results were considered to be significant at $p < 0.05$. The correlation coefficient was calculated to examine correlations between intra-parameters of anthropometric and sociodemographic measurements and the correlation matrix was developed using the "corrplot" package of R software (version 3.1.4). The empirical curve was developed with MINITAB 21 (2020, Minitab LLC, USA) statistical software.

Bibliometric analysis was used to do a literature review on the double burden of malnutrition using the Scopus database. The search strategy algorithms were TITLE-ABS-KEY (double-burden-of-malnutrition) AND (EXCLUDE (PUBYEAR, 2024)) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (LANGUAGE, "English")).

Results

The mean weight and height of the study group were 53.06 ± 11.12 kg and 159.54 ± 8.61 cm, respectively. The mean BMI of the studied group was 20.74 ± 3.79 kg/m². WC and HC were 73.03 ± 9.55 cm, and 87.97 ± 7.30 cm respectively. WHR and CIndex were 0.89 ± 0.06 and 1.16 ± 0.10 , respectively. WHtR was 0.82 ± 0.06 . PBF, TBW, and BAI were 19.08 ± 6.30 , 31.73 ± 6.82 liter, and 25.77 ± 0.10 respectively. FM, FFM, FMI, FFMI, and ABSI were 10.22 ± 4.51 kg, 42.84 ± 9.19 kg, 4.08 ± 1.95 , 16.66 ± 2.29 , and 0.07 ± 0.00 ,

respectively (Table 2).

Table 2. Descriptive statistics of the socio-demographic-economic and anthropometric

Parameters	Mean $\pm$ SD	95% CI
Age (years)	20.00 $\pm$ 1.07	19.86-20.14
Family Monthly Income (Rs.)	15618.02 $\pm$ 21224.87	12797.77-18438.28
Per Capita Income (Rs.)	3749.91 $\pm$ 5884.08	2968.06-4531.76
Height (cm)	159.54 $\pm$ 8.61	158.40-160.69
Weight (kg)	53.06 $\pm$ 11.12	51.58-54.54
BMI (kg/m ²)	20.74 $\pm$ 3.49	20.28-21.21
WC (cm)	73.03 $\pm$ 9.55	71.76-74.30
HC (cm)	87.97 $\pm$ 7.30	87.00-88.94
WHR	0.89 $\pm$ 0.06	0.82-0.84
WHtR	0.82 $\pm$ 0.06	0.82-0.83
PBF (%)	19.08 $\pm$ 6.30	18.24-19.93
CIndex	1.16 $\pm$ 0.10	1.15-1.18
BAI	25.77 $\pm$ 0.10	25.24-26.31
FM (kg)	10.22 $\pm$ 4.51	9.62-10.82
FFM (kg)	42.84 $\pm$ 9.19	41.62-44.05
TBW (lit)	31.73 $\pm$ 6.82	30.82-32.64
FMI (kg/m ²)	4.08 $\pm$ 1.95	3.82-4.33
FFMI (kg/m ²)	16.66 $\pm$ 2.29	16.36-16.97
ABSI	0.07 $\pm$ 0.00	0.07-0.07

BMI- Body Mass Index, WHR- Waist to Hip Ratio, WHtR- Waist to Height Ratio, PBF- Percentage of Body Fat, Cindex- Conicity Index, TBW- Total Body Water, FM- Fat Mass, FFM- Fat Free Mass, FMI- Fat Mass Index, FFMI- Fat Free Mass Index, BAI- Body Adiposity Index, ABSI- A Body Shape Index

Anthropometric parameters were significantly correlated with the sociodemographic parameters. A weak positive correlation was found between Per Capita Income (PCI) and BMI ($r=0.153$; $p < 0.05$) and SES and BMI ($r=0.201$; $p < 0.01$). FM was also correlated with SES ($r=0.230$; $p < 0.01$). The correlation matrix is shown in Fig. 1.

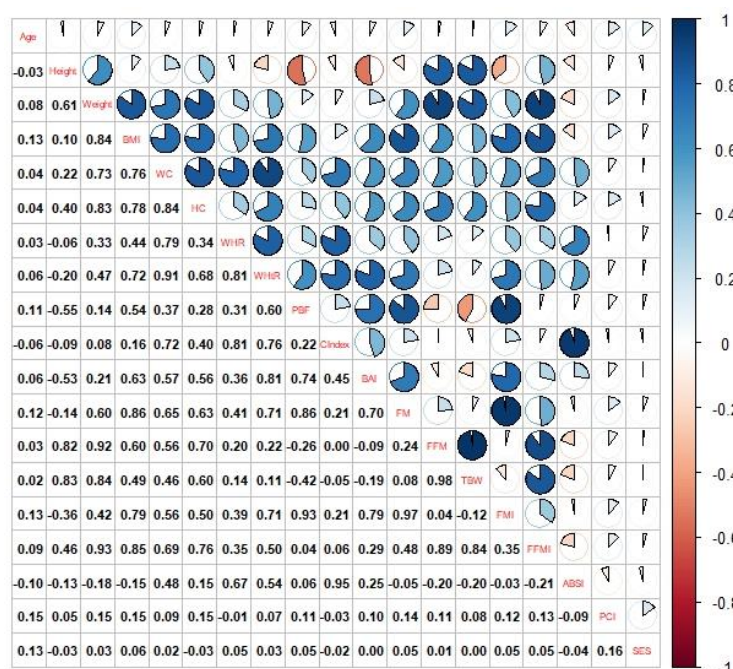


Figure 1. Correlation matrix of anthropometric indices with sociodemographic parameters.

BMI- Body Mass Index, WHR- Waist to Hip Ratio, WHtR- Waist to Height Ratio, PBF- Percentage of Body Fat, Cindex- Conicity Index, TBW- Total Body Water, FM- Fat Mass, FFM- Fat Free Mass, FMI- Fat Mass Index, FFMI- Fat Free Mass Index, BAI- Body Adiposity Index, ABSI- A Body Shape Index, PCI- Per Capita Income, SES- Socioeconomic Status

Table 3 presents the distribution of anthropometric variables categorized by different age and sex groups. The study population of female was separated into four groups, according to their age viz. 18 years, 19 years, 20 years and above 20 years. The data were subjected to ANOVA to investigate age-related differences and Student's t-test to explore sex-related distinctions. In cases where the F values were found to be statistically significant ($p < 0.05$), Dunnett's post hoc test was sensibly employed to discern variations between pairs of means. The age difference in height ($F = 4.932$; $p < 0.01$) was significantly notable in males but such association was not found in females. PBF ($F = 2.973$; $p < 0.05$) was gradually increased with the increasing age in both males and females but significance was noted among only the females. Age difference in the ABSI ($F = 3.155$; $p < 0.05$) was found only in females. Additionally, the PBF ($F = 2.973$; $p < 0.05$) and ABSI ($F = 3.155$; $p < 0.05$) for males were significantly lower compared to females. Age differences were noted among all the anthropometric indices except WHR and ABSI.

Table 3. Effect of age and gender on the anthropometric parameters of college students

	Male						Female					
	18 years	19 years	20 years	>20 years	Age combined	F	18 years	19 years	20 years	>20 years	Age combined	F
N	21	27	35	19	102		24	36	35	23	118	
Height	169.94±4.96 ^c	163.46±6.74 ^{c‡}	166.02±6.35 ^c	166.36±4.73 ^c	166.21±6.25 ^c	4.718**	154.08±5.18	153.97±6.75	153.86±5.65	153.08±4.99	153.79±5.74	0.149
Weight	61.17±9.93 ^c	56.56±10.85 ^b	58.80±10.30 ^c	60.53±10.85 ^c	59.01±10.47 ^c	0.928	44.77±8.52	48.32±10.54	48.35±6.88	49.96±9.02	47.93±8.91	1.467
BMI	21.15±3.15 ^a	21.07±3.35	21.26±3.03	21.79±3.35	21.29±3.16 ^a	0.210	18.85±3.40	20.33±3.99	20.44±2.82	21.45±4.45	20.28±3.71	2.028
WC	74.33±8.06	73.65±9.22	74.13±8.73	77.53±8.83	74.68±8.73 ^b	0.852	72.13±10.01	71.88±10.41	70.76±8.69	71.97±11.79	71.62±10.03	0.120
HC	91.57±5.90	88.74±6.84	89.97±6.19 ^a	91.08±6.52	90.18±6.36 ^c	0.932	84.91±6.59	86.25±8.43	86.30±7.15	86.59±7.94	86.06±7.54	0.238
WHR	0.81±0.05 ^c	0.83±0.06	0.82±0.06	0.85±0.05	0.83±0.06	1.797	0.85±0.07	0.83±0.07	0.82±0.06	0.83±0.08	0.83±0.07	0.830
WHtR	0.44±0.05	0.45±0.06	0.45±0.05	0.47±0.05	0.45±0.05 ^b	1.157	0.47±0.06	0.47±0.07	0.46±0.06	0.47±0.08	0.47±0.07	0.138
PBF	13.44±3.79 ^c	13.56±4.01 ^c	14.01±3.64 ^c	14.92±3.99 ^c	13.94±3.81 ^c	0.620	21.51±4.09	23.46±4.81	23.85±3.41	25.29±5.32	23.54±4.51	2.973*
CIndex	1.14±0.06 ^b	1.15±0.07	1.14±0.07	1.18±0.06	1.15±0.07 ^b	1.631	1.23±0.12	1.18±0.13	1.16±0.10	1.16±0.13 [‡]	1.18±0.12	2.206
BAI	23.37±2.88 ^b	24.50±3.06 ^b	24.10±2.77 ^c	24.44±2.52 ^b	24.12±2.82 ^c	0.726	26.48±4.03	27.21±4.42	27.30±4.18	27.83±4.97	27.21±4.35	0.376
FM	8.56±3.65	8.05±3.88 ^b	8.57±3.68 ^c	9.42±4.06 ^a	8.59±3.77 ^c	0.487	9.95±4.06	11.79±5.61	11.73±3.22	13.07±5.11	11.64±4.64	1.849
FFM	52.61±6.45 ^c	48.51±7.27 ^c	50.23±6.84 ^c	51.11±6.96 ^c	50.43±6.95 ^c	1.465	34.83±4.62	36.54±5.38	36.62±3.91	36.89±4.12	36.28±4.59	1.041
TBW	39.37±3.66 ^c	37.14±4.12 ^c	38.15±3.97 ^c	38.40±4.03 ^c	38.18±3.98 ^c	1.274	25.41±2.33	26.28±2.99	26.27±1.98	26.59±2.15	26.16±2.43	1.046
FMI	2.96±1.24 ^b	2.99±1.42 ^c	3.09±1.25 ^c	3.38±1.41 ^c	3.09±1.31 ^c	0.423	4.19±1.68	4.95±2.31	4.97±1.41	5.65±2.37	4.94±2.00	2.160
FFMI	18.20±1.91 ^c	18.09±1.95 ^c	18.17±1.79 ^c	18.41±1.96 ^c	18.20±1.86 ^c	0.116	14.66±1.74	15.37±1.74	15.47±1.43	15.80±2.10	15.34±1.75	1.842
ABSI	0.075±0.004	0.076±0.004	0.075±0.004	0.076±0.004 [‡]	0.075±0.004	1.309	0.083±0.009	0.078±0.008	0.076±0.006	0.076±0.009	0.078±0.008	3.155*

Level of significance in Sexual dimorphism as a ($p < 0.05$); b ($p < 0.01$); c ($p < 0.001$) and age difference as * $p < 0.05$; ** $p < 0.01$; ANOVA (F value) followed by Dunnett post hoc test significance level ‡ $p < 0.001$; BMI- Body Mass Index, WHR- Waist to Hip Ratio, WHtR- Waist to Height Ratio, PBF- Percentage of Body Fat, Cindex- Conicity Index, TBW- Total Body Water, FM- Fat Mass, FFM- Fat Free Mass, FMI- Fat Mass Index, FFMI- Fat Free Mass Index, BAI- Body Adiposity Index, ABSI- A Body Shape Index

The analysis revealed a discernible correlation between sociodemographic and economic indices and the BMI among the participants under study, as depicted in Fig. 2. Among the studied population, the majority of them (156 that is 70.91%) belong to a lower socioeconomic group (Group V) and the rest (64 that is 29.09%) belong to the middle socio-economic group (Group IV) according to revised Kuppaswamy's socio-economic status. In the case of PCI majority of the students (167 that is 75.91%) belong to $PCI \geq Rs. 1001.00$ and the rest (53 which is 24.09%) belong to

$PCI < Rs. 1001.00$. Notably, individuals classified as underweight accounted for a higher proportion (31.41%) within the lower SES category ($\chi^2 = 5.63$; $p > 0.05$). Furthermore, a substantial portion (43.40%) of students falling under the lower PCI category ($< Rs. 1001.00$) were identified as underweight ($\chi^2 = 9.75$; $p < 0.01$). Additionally, the mean BMI values for males, females, and both sexes combined were calculated as $21.23 \pm 3.16 \text{ kg/m}^2$, $20.28 \pm 3.72 \text{ kg/m}^2$, and $20.75 \pm 3.75 \text{ kg/m}^2$ respectively.

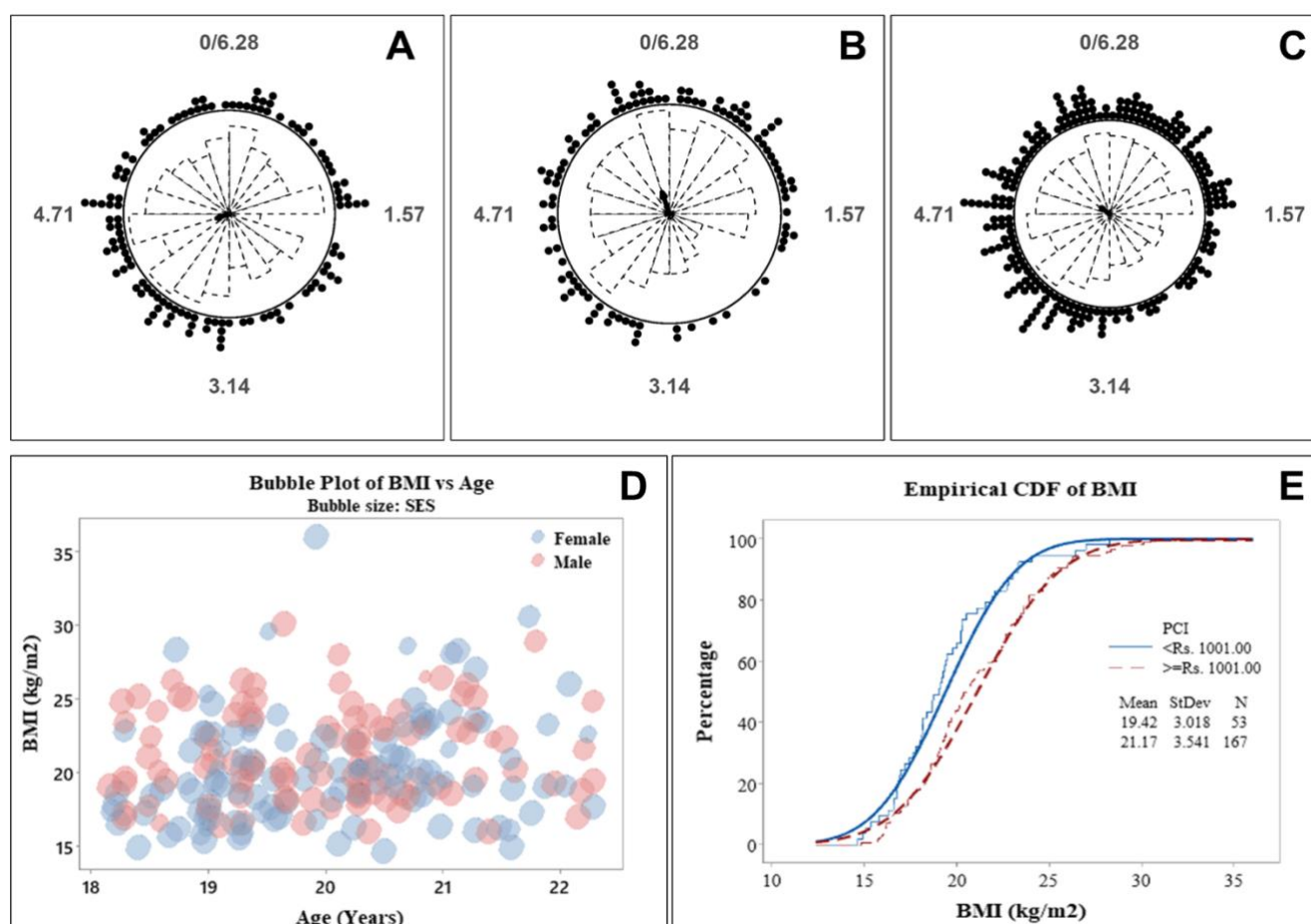


Figure 2. Effect of demographic and socioeconomic indices on BMI of the college students. Circular Descriptive Plots of the BMI (kg/m^2) for (A) Female, (B) Male, (C) Sex combined. Bubble plot of BMI (kg/m^2) and Age (years) (D) and Empirical CDF of BMI in different PCIs (E).

The study delved into exploring the ramifications of PCI on a spectrum of anthropometric indices, elucidating noteworthy correlations between income levels and metrics. These findings eloquently underscore the profound impact of economic determinants on physical health indicators. Moreover, the study observed a discernible disparity in PCI concerning various anthropometric parameters (Fig 3). For instance, among individuals with PCI less than Rs.

1001.00, WHR and CIndex were notably higher in females ($p < 0.01$), while in males, BMI exhibited a higher propensity ($p < 0.01$) among those with PCI equal to or greater than Rs. 1001.00. These findings accentuate the nuanced interplay between economic status and physical health metrics, manifesting in gender-specific variations within different income brackets.

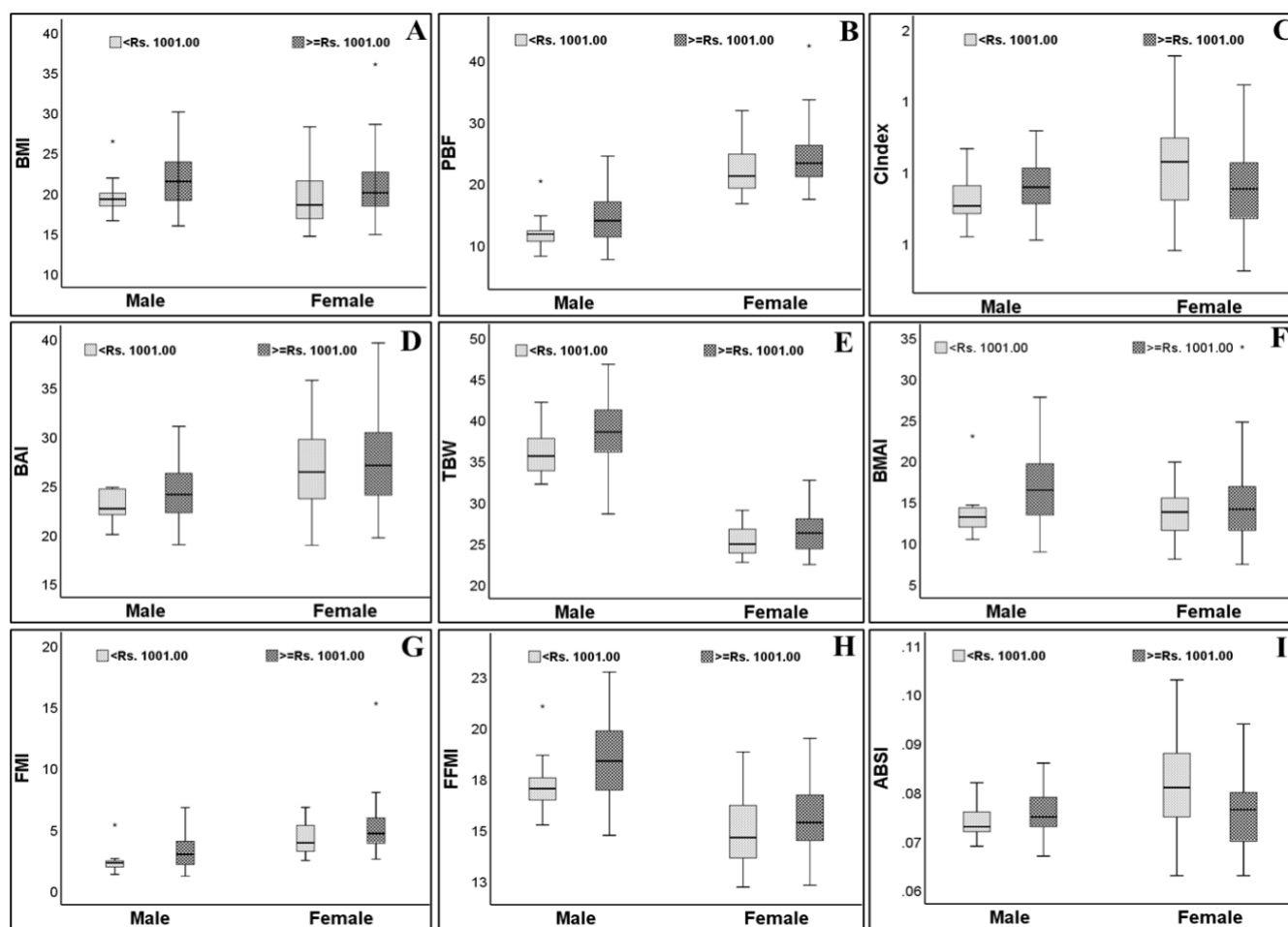


Figure 3. Effect of PCI on the anthropometric parameters of male and female college students. It denotes the mean±SD of different anthropometric and sociodemographic parameters with gender.

Analysis of the dataset unveiled a substantial correlation between socio-demographic-economic conditions and nutritional status, as depicted in Figure 4. Notably, a significant age-specific association with DBM was identified ($\chi^2=9.530$; $p<0.05$). Among the students, those aged 19 years exhibited a higher prevalence of DBM, accounting for 43.66% compared to other age groups, while 20-year-old students appeared to be at a lower risk. Furthermore, female students demonstrated a higher prevalence of DBM at 41.53%. Interestingly, DBM was found to be more prevalent among individuals belonging to lower PCI (<Rs. 1001.00) and lower SES groups, constituting 49.06% and 40.38% respectively. However, no statistically significant associations were observed between DBM and gender, PCI, or SES.

Discussion

In this study, anthropometric parameters and sociodemographic factors were significantly correlated. The weak positive correlation between BMI and both PCI and SES suggests that individuals with higher income or socioeconomic status may have a slightly higher BMI. This study aligns with McLaren (35), who found that higher socioeconomic status is linked to higher BMI because of better access to resources like healthy food and physical activity options. The correlation between FM and socioeconomic status further supports the notion that socioeconomic factors may influence body composition. This finding is consistent with previous research indicating that individuals with lower socioeconomic status may face barriers to maintaining a healthy weight due to factors such as limited access to nutritious foods, higher stress levels, and fewer opportunities for physical activity (36).

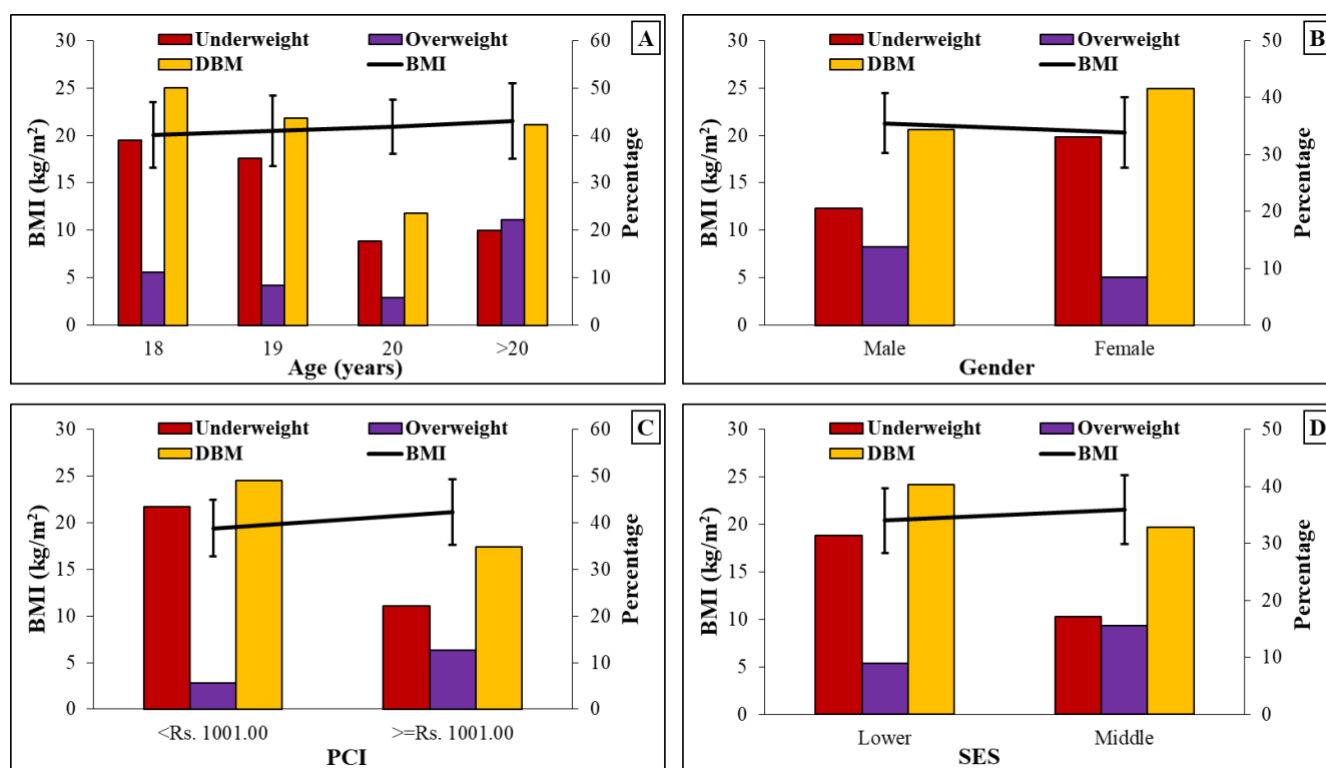


Figure 4. Effect of socio-demographic-economic condition on nutritional status

The findings of the statistical analyses conducted in this study shed light on notable sex-related distinctions and age-related differences in anthropometric parameters. These results provide valuable insights into how gender and age can influence various aspects of body composition. The observed significant difference in average height between males and females is consistent with well-established biological differences. On average, males tend to be taller than females due to genetic and hormonal factors (37). This finding validates existing literature on sexual dimorphism in human stature. The lower PBF and ABSI values observed in males compared to females align with known differences in body composition between genders. Males typically have lower percentages of body fat and different fat distribution patterns compared to females, which can be attributed to hormonal and physiological differences (38). The significant differences observed in BMI, WHR, and Cindex between males and females aged 18 years suggest age-related variations in body composition within each gender. These findings may reflect differences in growth patterns, hormonal changes, or lifestyle factors between males and females during adolescence (39).

The study revealed a significant correlation between SES and BMI, with individuals classified as underweight being more prevalent in lower SES categories. Similar findings have been reported in previous research, emphasizing the impact of socioeconomic factors on nutritional status and body composition (40). These results highlight the importance of addressing socioeconomic inequalities in health promotion efforts to improve overall well-being. Significant correlations were observed between PCI and various anthropometric parameters, indicating the profound influence of economic determinants on physical health indicators. The substantial portion of underweight individuals among those with lower PCI levels highlights the association between poverty and malnutrition, a well-documented phenomenon in public health literature (41). Additionally, disparities in anthropometric parameters such as WHR and Cindex based on PCI levels further emphasize the nuanced interplay between economic status and body composition. Employing binary logistic regression, the study demonstrated a robust association between PCI and CED, indicating that lower income levels are associated with a higher risk of nutritional deficiencies.

This finding is consistent with previous research highlighting the socioeconomic gradient in health outcomes, including nutritional status and food insecurity (42). The findings of this study underscore the importance of addressing socioeconomic disparities in health promotion strategies and policy interventions. Targeted efforts aimed at improving access to nutritious food, education, and employment opportunities are crucial for mitigating the adverse effects of poverty on health outcomes (43). Future research should continue to explore the mechanisms underlying the relationship between socioeconomic factors and anthropometric indices to inform more effective interventions and policies. Results shed light on the complex interplay between various factors influencing DBM and underscore the importance of addressing socio-economic determinants of nutritional status. Individuals belonging to PCI and lower SES groups were found to have a higher prevalence of DBM. Specifically, 49.06% of individuals with PCI less than Rs. 1001.00 and 40.38% of those in the lower SES group engaged in DBM (44). These findings underscore the influence of socioeconomic factors on dietary behaviors and nutritional status. Limited

access to nutritious foods, financial constraints, and environmental factors associated with lower socioeconomic status may contribute to unhealthy dietary patterns and DBM. A significant age-specific association with DBM was identified, with individuals aged 19 years exhibiting a higher prevalence compared to other age groups ($p < 0.05$). Specifically, 43.66% of 19-year-old students were found to engage in DBM, while 20-year-old students appeared to be at a lower risk. This observation aligns with previous research indicating that dietary habits may vary across different stages of adolescence and young adulthood (45). Different studies throughout different zones of India also validate our findings. The highest prevalence of underweight (46.52%) was reported from the Panvel district of Maharashtra and the lowest (6%) from Chandigarh (46,47). Similarly, the highest prevalence of overweight/obesity (29%) was reported from Punjab and the lowest (4.43%) from Nagpur (48,49). The present study revealed that among the college students of the Bankura district of West Bengal, 27.27% and 10.91% are underweight and overweight/obese respectively. The results from different studies are summarised in Table 4 (48-60).

Table 4. Zone wise prevalence of underweight and overweight/obesity of India

Zone	State	Place	Age (years)	Underweight	Overweight/ Obesity	References
Northern	Punjab	Sgrdimsar	17-19	18	29	Kaur et al. 2015 (49)
	Punjab	Chandigarh	18-24	6	15	Naveen et al. 2021 (47)
	Delhi	Delhi	18-21	13.7	11.7	Chhabra et al. 2006 (51)
	Haryana	Karnal	18-24	13.66	11.66	Kaur 2021 (52)
Eastern	Bihar	Samastipur	18-24	13.66	11.66	Priya et al. 2020 (53)
	Bihar	Arrah	20-24	9.68	20.39	Pandit et al. 2014 (54)
	West Bengal	Medinipur	18-20	19.27	20.57	Mandal et al. 2011 (55)
	West Bengal	Bankura	18-22	27.27	10.91	Present Study
Western	Maharashtra	Panvel	18-23	46.52	4.54	Prabhakar et al. 2020 (47)
	Maharashtra	Nagpur	15-21	30.37	4.43	Ashwita et al. 2018 (50)
	Gujrat	Ahmedabad	18-23	43.4	18.8	Solanki et al. 2023 (56)
Southern	Telangana	Sainikpuri	18-22	17.44	16.92	Sai Padma et al. 2016 (57)
	Tamil Nadu	Coimbatore	18-25	15	43.9	Hasani and Geetha 2022 (58)
Central	Uttar Pradesh	Prayagraj	18-23	14	18	Pal et al. 2020 (59)
	Uttar Pradesh	Allahabad	18-22	13.3	10	Gupta and Gupta 2018 (60)
	Chhattisgarh	Raipur	18-26	23	13	Joglekar et al. 2016 (61)

Factors such as increased autonomy in food choices and peer influences during this transitional period can contribute to variations in dietary behaviors among individuals of different ages. Moreover, DBM was found to be more prevalent among individuals belonging to lower PCI (<Rs. 1001.00) and SES groups, constituting 49.06% and 40.38%, respectively. These findings underscore the impact of socioeconomic factors on dietary behaviors and nutritional status. Due to lack of having nutritious foods, financial constraints, and environmental factors associated with lower socioeconomic status may contribute to unhealthy dietary patterns and DBM among adult populations (61). Employing a binary logistic regression through a forward stepwise (Wald) approach within CED, Gender, PCI and SES the analysis revealed a robust and statistically significant association between PCI and CED (Wald = 8.804; $p < 0.01$). The model itself exhibited substantial

significance ($\chi^2 = 8.630$; $p < 0.01$), with Cox and Snail R^2 indicating a modest explanatory power of 0.038. The odds ratio (OR) indicates that females have almost double the risk of CED compared to males with $OR = 1.904$ (95% CI: 1.030-3.520) and the relative risk (RR) = 1.605 (95% CI: 1.014-2.542) with $\chi^2 = 4.284$; $p < 0.05$. The odds ratio for PCI < Rs. 1001.00 compared to $\geq$ Rs. 1001.00 is 2.694 (95% CI: 1.400-5.183), indicating that individuals with PCI < Rs. 1001.00 have 2.694 times higher odds of having CED compared to those with PCI $\geq$ Rs. 1001.00 with $RR = 1.959$ (95% CI: 1.289-2.977) and $\chi^2 = 9.151$; $P < 0.01$. The OR for the lower SES group compared to the middle SES group is 2.206 (95% CI: 1.061-4.588), indicating that individuals in the lower SES group have 2.206 times higher odds of having CED compared to those in the middle SES group with a $RR = 1.828$ (95% CI: 1.017-3.282) with $\chi^2 = 4.628$; $p < 0.05$.

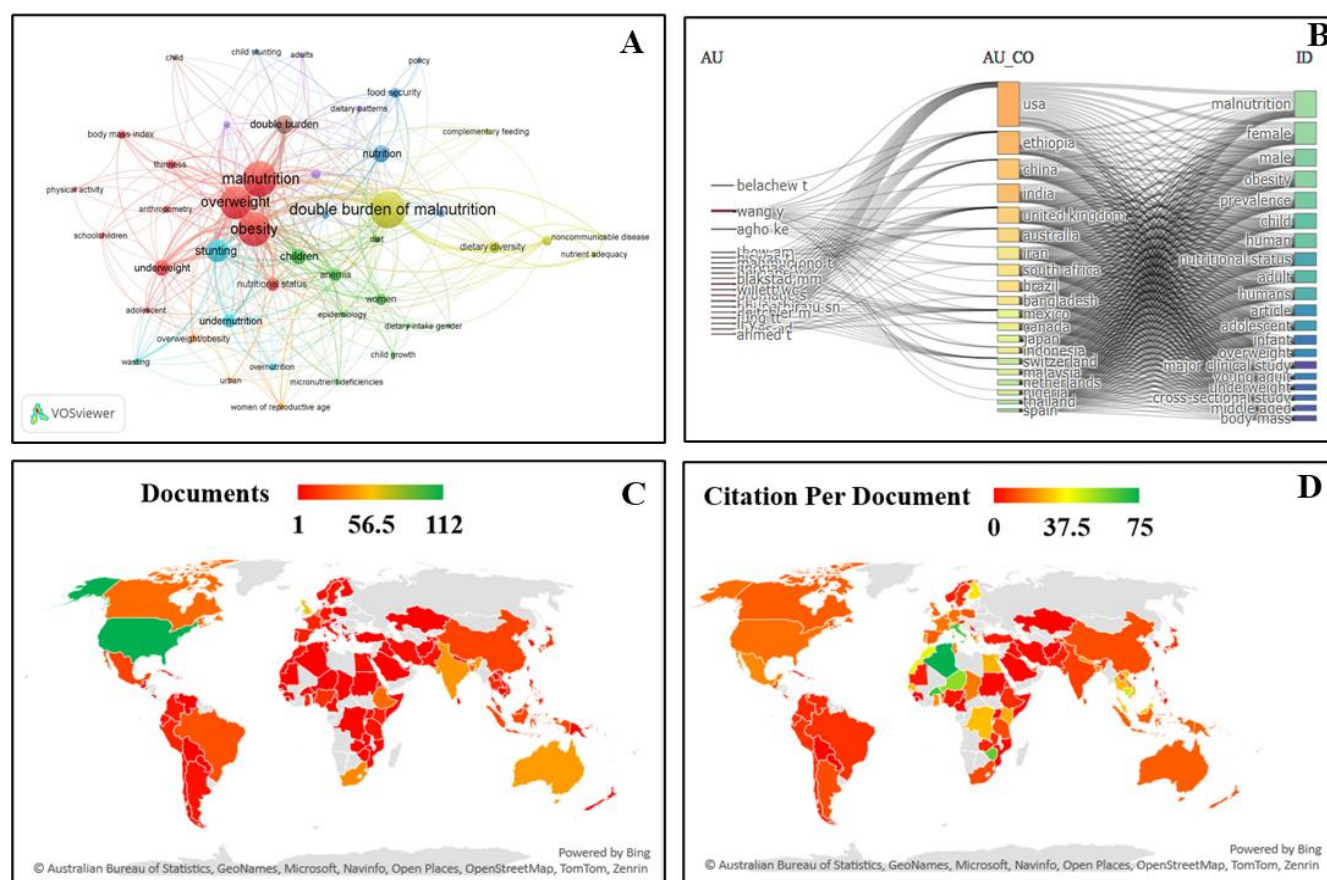


Figure 5. Bibliometric analysis. It shows the keyword-wise network analysis (A), three field plots of authors, countries and keyword plus (B), the total number of documents produced in the world from 2004-2023 (C), and country-wise citation per document (D).

A bibliometric analysis of 1008 published articles in national and international journals over the last 20 years (2004-2023) sheds light on the significance of the double burden of malnutrition among adult students globally (Fig 5). The analysis included a network analysis of authors' keywords, with a criterion of at least five keywords per article. Results revealed 45 distinct keywords clustered into eight groups, with notable terms including 'malnutrition', 'overweight', 'obesity', 'double burden of malnutrition, and 'underweight'.

Among the countries contributing to the research landscape, the United States of America emerged with the highest number of published documents, accounting for 112 articles. Following closely, India secured the fourth position with 44 articles. However, when considering citation per document (CPD) as a measure of impact, Algeria ranked first with 75 CPD, while India was positioned 62nd with 9.14 CPD. The variation in publication output and citation impact across countries reflects differences in research priorities, funding availability, and academic infrastructure. While countries like the United States lead in terms of publication volume, others like

Algeria demonstrate high citation impact relative to their publication output. This may indicate the quality and impact of research originating from these regions.

Conclusion

This study highlights the pressing issue of malnutrition among college students in Bankura, West Bengal revealing a notable dual challenge of undernutrition and overweight within this population. The findings emphasize the complex influence of socioeconomic factors on students' nutritional health with income emerging as a significant determinant of energy sufficiency. Addressing this issue requires a multi-faceted approach such as health education programs focused on nutrition awareness and lifestyle choices are essential to promote balanced diets and healthier habits among students. In addition, enhancing socio-economic support can be instrumental in tackling chronic energy deficiencies. Together, these efforts can play a vital role in fostering a healthier student community and mitigating the broader impact of malnutrition on young adults' well-being and future potential.

References

1. Development Initiatives [Internet]. Global nutrition report 2020: Action on equity to end malnutrition [cited 2024 Mar 9]. Available from: <https://globalnutritionreport.org/reports/2020-global-nutrition-report/>
2. United Nations [Internet]. Decade of action on nutrition 2016–2025 [cited 2024 Mar 9]. Available from: <https://www.un.org/nutrition/about>
3. GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the global burden of disease study 2017. *Lancet* 2019;393(10184):1958-72. doi: 10.1016/S0140-6736(19)30041-8
4. Nandy S, Irving M, Gordon D, Subramanian SV, Smith GD. Poverty, child undernutrition, and morbidity: New evidence from India. *Bull World Health Organ* 2005;83(3):210-6. PMID: 15798845
5. Bose K, Bisai S, Mukherjee S. Anthropometric characteristics and nutritional status of rural school children. *Internet J Biol Anthropol* 2007;2(1):1-6.
6. Chatterjee S, Saha S. A study on knowledge and practice of mothers regarding infant feeding and nutritional status of under-five children attending immunization clinic of a medical college. *Internet J Nutr Wellness* 2007;5(1):1-9.
7. World Health Organization [Internet]. The double burden of malnutrition: policy brief [cited 2024 Feb 10]. Available from: <https://www.who.int/publications/i/item/WHO-NMH-NHD-17.3>
8. Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet* 2020;395(10217):65-74. doi: 10.1016/S0140-6736(19)32497-3

9. International Food Policy Research Institute [Internet]. Global nutrition report 2015: Actions and accountability to advance nutrition & sustainable development [cited 2024 Feb 12]. Available from: <https://globalnutritionreport.org/reports/2015-global-nutrition-report/>
10. Gavin-Smith B, van ZK, Kraemer K. Double burden of malnutrition: Crisis and opportunity of the double burden or the new norm. *Sight Life Mag* 2018;32:10-202.
11. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 2013;382(9890):427-1. doi:10.1016/S0140-6736(13)60937-X
12. UNICEF/WHO/World Bank Group [Internet]. Levels and trends in child malnutrition: UNICEF/WHO/World Bank group joint child malnutrition estimates. Key findings of the 2020 edition [cited 2024 Feb 10]. Available from: <https://data.unicef.org/wp-content/uploads/2020/03/Joint-Malnutrition-Estimates-2020-brochure>
13. Kinyoki D, Osgood-Zimmerman A, Pickering B, Schaeffler L, Ausloos M, Herteliu C, et al. Mapping child growth failure across low- and middle-income countries. *Nature* 2020;577(7789):231-4. doi: 10.1038/s41586-019-1878-8
14. Giao H, Le An P, Truong Vien N, Van Khanh T, Quang Vinh B. Stunting and overweight among 12–24-month-old children receiving vaccination in Ho Chi Minh City, Vietnam. *Biomed Res Int* 2019;2019:1547626. doi: 10.1155/2019/1547626
15. Tanwi TS, Chakrabarty S, Hasanuzzaman S. Double burden of malnutrition among ever-married women in Bangladesh: A pooled analysis. *BMC Womens Health* 2019;19(1):24. doi: 10.1186/s12905-019-0725-2
16. Salehiniya H, Yazdani K, Barekati H, Asadi Lari M. The prevalence of overweight and obesity in children under 5 years in Tehran, Iran, in 2012: A population-based study. *Res Cardiovasc Med* 2016;5(1):1-10 doi: 10.5812/cardiovascmed.30425
17. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the global burden of disease study 2013. *Lancet* 2014;384(9945):766-81. doi: 10.1016/S0140-6736(14)60460-8
18. Horton S, Steckel RH. Malnutrition: Global economic losses attributable to malnutrition 1900–2000 and projections to 2050. In: Lomborg B, editor. *The economics of human challenges*. Cambridge, UK: Cambridge University Press; 2013:34-56.
19. Dobbs R, Sawers C, Thompson F, Manyika J, Woetzel J, Child P, et al. *Overcoming obesity: An initial economic analysis*. London: McKinsey Global Institute; 2014. 120 p.
20. Ministry of Health and Family Welfare [Internet]. National family health survey (NFHS-3) 2005-06 [cited 2024 Feb 23]. Available from: <https://dhsprogram.com/pubs/pdf/FRIND3/FRIND3-Vol1%5BOct-17-2008%5D.pdf>
21. Lohman TG, Roche AF, Martorell R. *Anthropometric standardization reference manual*. Chicago: Human Kinetics Books; 1998. 184 p.
22. World Health Organization. *Waist circumference and waist–hip ratio: Report of a WHO expert consultation, Geneva, 8-11 December 2008*. Geneva: World Health Organization; 2011.
23. Ulijaszek SJ, Kerr DA. Anthropometric measurement error and the assessment of nutritional status. *Br J Nutr* 1999;82:165-77. doi: 10.1017/s0007114599001348
24. Park K. *Park's textbook of preventive and social medicine*. 18th ed. Jabalpur, India: M/S Banarsidas Bhanot; 2005:317-8.

25. Peng Y, Li W, Wang Y, Bo J, Chen H. The cut-off point and boundary values of waist-to-height ratio as an indicator for cardiovascular risk factors in Chinese adults from the PURE study. *PLoS One* 2015;10(12):e0144539. doi: 10.1371/journal.pone.0144539
26. Deurenberg P, Weststrate JA, Seidell JC. Body mass index as a measure of body fatness: Age- and sex-specific prediction formulas. *Br J Nutr* 1991;65(2):105-14. doi: 10.1079/BJN19910073
27. Valdez R, Seidell JC, Ahn YI, Weiss KM. A new index of abdominal adiposity as an indicator of risk for cardiovascular disease: A cross-population study. *Int J Obes* 1993;17(77):77-82. PMID: 8384168
28. Ghosh M, Bhandari S, Bose K. Anthropometric characteristics and nutritional status of adult Sabars of Bankura District, West Bengal. *Hum Biol Rev* 2018;7(1):71-83.
29. Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P, Elia M, Gómez JM, et al. Bioelectrical impedance analysis-part I: Review of principles and methods. *Clin Nutr* 2004;23(5):1226-43. doi: 10.1016/j.clnu.2004.06.004
30. Ranasinghe P, Jayawardena R, Gamage N, Wickramasinghe VP, Hills AP. The range of non-traditional anthropometric parameters to define obesity and obesity-related disease in children: A systematic review. *Eur J Clin Nutr* 2021;75(4):659-73. doi: 10.1038/s41430-021-00819-1
31. Bergman RN, Stefanovski D, Buchanan TA, Sumner AE, Reynolds JC, Sebring NG, et al. A better index of body adiposity. *Obesity (Silver Spring)* 2011;19(5):1083-9. doi: 10.1038/oby.2011.38
32. Krakauer NY, Krakauer JC. A new body shape index predicts mortality hazard independently of body mass index. *PLoS One* 2012;7(7):e39504. doi: 10.1371/journal.pone.0039504
33. World Health Organization. Physical Status: The use and interpretation of anthropometry. Report of a WHO Expert Committee. Technical Report Series No. 854. Geneva: World Health Organization; 1995.
34. Gunjan P, Dash P, Patnaik J, Pany G. Socioeconomic status scale-Modified Kuppaswamy Scale for the year 2022. *Int J Comm Dent* 2022;10(1):1-6. doi: 10.56501/intjcommunitydent.v10i1.26
35. McLaren L. Socioeconomic status and obesity. *Epidemiol Rev* 2007;29(1):29-48. doi: 10.1093/epirev/mxm001
36. Pampel FC, Krueger PM, Denney JT. Socioeconomic disparities in health behaviors. *Annu Rev Sociol* 2010;36:349-70. doi: 10.1146/annurev.soc.012809.102529
37. Silventoinen K. Determinants of variation in adult body height. *J Biosoc Sci* 2003;35(2):263-85. doi: 10.1017/s0021932003002633
38. Wells JC, Fewtrell MS. Measuring body composition. *Arch Dis Child* 2006;91(7):612-7. doi: 10.1136/adc.2005.085522
39. Viner RM, Cole TJ. Who changes body mass between adolescence and adulthood? Factors predicting change in BMI between 16 years and 30 years in the 1970 British Birth Cohort. *Int J Obes* 2006;30(9):1368-74. doi: 10.1038/sj.ijo.0803183
40. Lynch EB, Kane J. Body size perception among African American women. *J Nutr Educ Behav* 2014;46(5):412-7. <https://doi.org/10.1016/j.jneb.2014.03.002>
41. Finch BK, Do DP, Heron M, Bird CE, Seeman T, Lurie N. Neighborhood effects on health: Concentrated advantage and disadvantage. *Health Aff (Millwood)* 2020;39(8):1348-55. doi: 10.1016/j.healthplace.2010.05.009
42. Loopstra R, Lalor D. Financial insecurity, food insecurity, and disability: The profile of people receiving emergency food assistance from The Trussell Trust Foodbank Network in Britain. *Soc Policy Adm* 2017;51(3):364-82.
43. Bhattacharya J, Currie J, Haider S. Poverty, food insecurity, and nutritional outcomes in children and adults. *JAMA Pediatr* 2021;175(4):839-62. doi: 10.1016/j.jhealeco.2003.12.008

44. Lee Y, Mozaffarian D, Sy S, Huang Y, Liu J, Wilde PE, et al. Cost-effectiveness of financial incentives for improving diet and health through Medicare and Medicaid: A microsimulation study. *PLoS Med* 2020;17(10):e1002761. doi: 10.1371/journal.pmed.1002761
45. Nguyen HC, Nguyen MH, Do BN, Tran CQ, Nguyen TTP, Pham KM, et al. People with suspected COVID-19 symptoms were more likely depressed and had lower health-related quality of life: The potential benefit of health literacy. *J Clin Med* 2021;10(1):1-13. doi: 10.3390/jcm9040965
46. Pawar PR, Rokade AG, Supnekar SP, Meshram LN, Pawar NB. Assessment of body mass index (bmi) among entry level students in an undergraduate college in Panvel, Navi Mumbai, India. *Asian J Adv Res* 2020;4(2):35-41.
47. Singh A, Prashar N. Determinants of the status of health, nutrition profile, and leisure activities of students of Panjab University, Chandigarh. *J Postgrad Med Educ Res* 2021;55:109-13. doi: 10.5005/jp-journals-10028-1444
48. Kaur M, Singh A, Bassi R, Kaur H. Nutritional status and anaemia in medical students of SGRDIMSAR, Amritsar. *Natl J Physiol Pharm Pharmacol* 2015;5(1):35-49. doi: 10.5455/njppp.2015.5.180720141
49. Ashwita B, Jyoti M, Rohini G, Roja N, Varsha R, Sarika R. A study to assess food habits and nutritional status of nursing students in Nagpur City. *ICCRJNR* 2018;3(1):58-63. Available from: <http://www.iccrjnr.com/article/view/12345>
50. Chhabra P, Grover VL, Aggarwal K, Kannan AT. Nutritional status and blood pressure of medical students in Delhi. *Indian J Community Med* 2006;31(4):248.
51. Kaur L. Evaluation of nutritional status of college-girls in Haryana. *J Glob Values* 2021;12(1):13. doi: 10.31995/jgv.2021.v12i01.013
52. Priya R, Sinha M. Nutritional knowledge and nutritional status amongst university students. *IP J Nutr Metab Health Sci* 2020;3(1):22-5. doi: 10.18231/j.ijnmhs.2020.005
53. Pandit DN, Kumari P, Kumari S. Present scenario of health status of university students at Arrah (Bhojpur), Bihar. *Curr Res Nutr Food Sci* 2014;2(1):40-6. doi: 10.12944/CRNFSJ.2.1.06
54. Mandal S, Sinha NK, Samanta P, Das S, Bose K. Anthropometric assessment of nutritional status among college women of Midnapore, West Bengal, India. *Life Sci Biol Anthropol* 2011;1(1):L81-L87.
55. Solanki R, Shah H, Prajapati T. Exploring the relationship between body mass index (bmi), body weight perception, and weight change behavior among university students in Urban Gujarat, India: A Cross-Sectional Study. *Natl J Community Med* 2023;14(6):364-70. doi: 10.55489/njcm.140620232894
56. Sai Padma A, Sukumaran MK, Padma S, Rajani D, Vanitha S. Evaluation of nutritional status of college girl students in terms of hemoglobin levels and BMI. *JMSCR* 2016;4(9):12822-7. doi: 10.18535/jmscr/v4i9.84
57. Ahamada Hassani N, Geetha A. A comparative study of the nutritional status among college students from India and Comoros. *Int J Creative Res Thoughts* 2022;10(5):g699-g706.
58. Pal D, Gupta A, Bala N, Paul V. Assessment of nutritional status and obesity of college going girls in Transyamuna Area, Prayagraj. *Pramana Res J* 2020;10(1):88-96.
59. Gupta P, Gupta A. A study on the iron deficiency anemia and nutritional status among the college-going girls (age 18 to 22 years) of Allahabad District. *Pharma Innov J* 2018;7(7):996-1001.
60. Joglekar A, Bhoi S. Impact of nutrition education on nutritional status and daily dietary pattern of college going girls. *Int J Sci Res* 2016;5(5):2375-7.
61. Sharkey JR, Johnson CM, Dean WR. Less-healthy eating behaviors have a greater association with a high level of sugar-sweetened beverage consumption among rural adults than among urban adults. *Food Nutr Res* 2020;64(1):1-10. doi: 10.3402/fnr.v55i0.5819