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# Understanding the Double Burden of Malnutrition among Women: Health Implications and Challenges

Snehprabha Surpam[1], Priyanka Dixit[2], Sowmya Ramesh[3], Punit Mishra[4]

*Keywords*

Double Burden of Malnutrition (DBM), Women, NFHS-5, NCDs

## Abstract

The double burden of malnutrition (DBM), characterized by the coexistence of undernutrition and overnutrition, remains a critical public health challenge, particularly among Indian women of reproductive age. This study utilizes data from the National Family Health Survey-5 (2019–2021) to explore the prevalence and health implications of DBM, focusing on its association with non-communicable diseases (NCDs) such as hypertension and high blood glucose (HBG). Findings reveal that 27.7% of women were classified as obese, 45.2% exhibited high-risk waist circumference, and over 58% had elevated waist-to-hip and waist-to-height ratios. The prevalence of hypertension and HBG was 12.7% and 8.8%, respectively, with significantly higher rates observed among women with both short stature and obesity. Bivariate and multivariate analyses underscore that DBM substantially increases the odds of hypertension and HBG, particularly among women with high BMI or central obesity markers. Short stature, often indicative of early-life nutritional deficits, coupled with obesity, emerged as a potent driver of adverse health outcomes. These findings highlight the urgent need for targeted interventions that address DBM through improved maternal nutrition, equitable healthcare access, and socioeconomically sensitive public health strategies. Addressing DBM is vital to reducing the burden of NCDs and advancing women's health outcomes in India.

[1] Tata Institute of Social Sciences, Mumbai. Email: dr.snehasurpam@gmail.com
[2] Tata Institute of Social Sciences, Mumbai. Email: priyanka.dixit@tiss.edu
[3] Population Council Institute, Delhi. Email: sramesh@pcinstitute.org.in
[4] PopulationCouncil Consulting Pvt. Ltd., Delhi. Email: punitrd@gmail.com

## Introduction

The double burden of malnutrition (DBM) poses a major public health challenge, with undernutrition and overnutrition occurring simultaneously. The phenomenon is especially acute among women of reproductive age, where the coexistence of high underweight rates and increasing obesity levels poses serious health consequences.

This issue is particularly severe in low-middle income countries (Were et al., 2021), as evidenced by sub-Saharan Africa, where around 8% of households experience DBM (Christian & Dake, 2021). In Asia, also, the prevalence is substantial, affecting 28% of women in South-Asia and 20% in South-East Asia (Biswas et al., 2019). A study from China also affirmed that underweight rates initially declined post-1991, and started rising again from 2004, whereas overweight or obesity rates have persistently increased since 1991 (Song et al., 2020). According to a projection, around 24 low- middle income countries are expected to face the DBM by 2030, with both underweight and overweight rates exceeding 20% (Hasan et al., 2021). In rural India, around 23% of women, and 13% of men experience the DBM (Little et al., 2020). Women from 11 Indian states are classified as experiencing a DBM based on Asian population-specific BMI cut-offs, marking these states as "double burden states" (Sengupta et al., 2014). Research indicates that malnutrition remains a leading health concern among Indian women, being disproportionately affected. A study highlighted that malnutrition, particularly underweight and anemia, is a top priority health condition for women, especially in impoverished urban areas (Abdi et al., 2018). This situation is exacerbated by socio-economic factors; wealthier women tend to experience lower risks of undernutrition but face increasing rates of overweight and obesity (Zhu, 2023). This duality reflects a complex interplay of dietary patterns, economic status, and cultural practices that contribute to the double burden of malnutrition (Kulkarni et al., 2014; Sanjeev et al., 2020).

The implications of this double burden are profound. The theory of developmental origins of chronic diseases suggests a biological link between early-life undernutrition, particularly during pregnancy or infancy, and an increased risk of developing obesity, diabetes, and hypertension in adulthood. This framework helps explain the co-occurrence of conditions like stunting and obesity in individuals. Women suffering from undernutrition are at a higher risk of giving birth to underweight children, perpetuating a cycle of malnutrition across generations (Khan & Mohanty, 2018). Conversely, the rising prevalence of obesity among women is linked to increased risks of non-communicable diseases such as diabetes and cardiovascular disorders, which are becoming significant health threats in

India (Bellundagi et al., 2022; Luhar et al., 2020). Furthermore, malnutrition in women is often compounded by inadequate access to healthcare services, particularly in rural areas where gender discrimination can hinder women's ability to seek necessary medical attention (Afsharinia & Gurtoo, 2022; Sims et al., 2021).

The nutritional status of women in India is also influenced by cultural practices and food taboos that affect dietary intake. For instance, certain traditional practices may lead to inadequate nutrition during critical periods such as pregnancy and lactation, further exacerbating malnutrition among both mothers and their children (Barla, 2022; Konduru & Kundargi, 2019). Moreover, the high prevalence of anemia among women, reported to affect about 70% of non-pregnant and 75% of pregnant women, underscores the urgent need for targeted interventions (Bharati et al., 2019; Dahiya & Viswanathan, 2015).

Addressing the double burden of malnutrition requires a multifaceted approach that includes improving dietary diversity, enhancing women's access to healthcare, and promoting education on nutrition. Initiatives aimed at improving maternal nutrition through prenatal care and breastfeeding support are essential to break the cycle of malnutrition (Kumar et al., 2021; Sanjeev et al., 2020). Additionally, public health policies must consider the socio-economic determinants of health to effectively tackle the dual challenges of undernutrition and overnutrition among women in India (Ravishankar, 2012; Sengupta & Syamala, 2012).

It has been observed that most Indian studies on DBM have primarily examined diverse population groups and investigated this phenomenon at the national, regional, or household level (Dang & Meenakshi, 2017; Kulkarni et al., 2016; Nguyen et al., 2021; Ravishankar, 2012). However, scant attention has been given to investigating the DBM at the individual level and its relation with NCDs. Therefore, this study aims to address this research gap by examining the DBM and NCDs within women, thereby providing valuable insights into the Indian population.

## Data and Methodology

### Data Source

The present study utilized data from National Family Health Survey-5 (NFHS-5) conducted during 2019-21. NFHS is a nationwide, large-scale, multi-round sample survey. It gathers information from a representative sample of households at various levels such as national, states and districts. It uses a multistage stratified sampling technique to select the sample of households. NFHS-5 collected information from a huge sample of 724,115 ever-married women from 636,699 households, comprising 29 states 7 union territories, and 707 districts.

It was conducted under the Ministry of Health and Family Welfare (MoHFW), the government of India. The MoHFW has assigned the International Institute for Population Sciences (IIPS) as the nodal agency responsible for overseeing and conducting these surveys by providing coordination and technical guidance. The primary objective of this survey is to provide consistent and reliable estimates of fertility, mortality, family planning, child nutritional status, morbidity, utilization of maternal and child health care services, anaemia, utilization of health and family planning services, HIV/AIDS and sexual and reproductive health of women and other related indicators at the national, state and regional levels. The survey offers valuable insights into the overall health and well-being of the population.

In this analysis, ever-married women aged 20-49 were included, as it is generally accepted that most women's height stabilizes by age 18 to 20 (Centers for Disease Control and Prevention, 2000). This approach ensured that only women who had completed their growth were considered, resulting in a total sample size of 541,742. Pregnant women, those who had given birth in the previous two months, and women lacking available anthropometric measurements were excluded from the study. The analyses were conducted using STATA version 16.0, considering appropriate sampling weights.

## Variable description

This study examines two outcome variables: hypertension and high blood glucose (HBG). ***Hypertension*** is assessed based on the respondent's average systolic blood pressure (SBP) and diastolic blood pressure (DBP), in accordance with the criteria set by the World Health Organization. Specifically, a respondent is considered hypertensive if her SBP is ≥140 mmHg or her DBP is ≥90 mmHg at the time of the survey, or if she is currently taking medication to lower her blood pressure. Further, ***High blood glucose*** levels are evaluated following the guidelines from the Centers for Disease Control and Prevention (CDC). A random blood sugar level below 140 mg/dL is considered normal, levels between 140-199 mg/dL indicate prediabetes, and levels of 200 mg/dL or higher indicate diabetes. In this study, an individual is classified as having high blood glucose if her random blood glucose level exceeds 140 mg/dL.

### Predictor variables

*Short Stature:* This variable was defined based on the quartile distribution, where women in the first quartile were categorized as having short stature. This classification is supported by findings from existing literature and Demographic and Health Surveys (DHS) conducted in other countries.

*Obesity or High Body Mass Index (BMI):* We classified individuals into two groups:

non-obese (BMI < 25.0 kg/m²) and obese (BMI ≥ 25.0 kg/m²).

*Abdominal Obesity:* Abdominal obesity was measured using two standard metrics, in line with World Health Organization (WHO) guidelines: waist circumference (WC) and waist-to-hip ratio (WHR).

- *Waist Circumference*: Women with a waist circumference of ≥88 cm were considered to be at high risk.
- *Waist-to-Hip Ratio (WHR):* Calculated by dividing waist circumference (cm) by hip circumference (cm), with a WHR ≥0.85 indicating high risk.

*Waist-to-Height Ratio (WHtR):* WHtR was calculated as the ratio of waist circumference to height. Based on previous research by Hsieh et al. (2003) and McCarthy & Ashwell (2006), a WHtR > 0.5 was used as the threshold for identifying individuals at high risk.

**Combined Obesity and Short Stature Classification:** We created a combined classification of obesity and short stature, resulting in four distinct categories: (1) women with neither short stature nor obesity, (2) women without short stature but with obesity, (3) women with both short stature and obesity, and (4) women with short stature but without obesity.

### Control variables

To account for potential confounding factors arising from the combined effects of short stature and obesity on outcome variables, the relevant variables were included in the model, guided by evidence from existing literature. Various control variables were included, encompassing socioeconomic, demographic, and behavioural factors. These control variables comprised the mother's age (categorized as 20-29, 30-39, and 40-49 years), marital status (never married, currently married, and widowed/divorced/separated), number of children ever born (0, 1-2, and ≥3 children), caste and tribal status (Scheduled Caste [SC], Scheduled Tribe [ST], Other Backward Class [OBC], and Others), religion (Hindus, Muslims, and Others), and education level (no education, primary, secondary, and higher secondary). Additionally, place of residence (rural or urban) and regions (North, Central, East, North-East, West, and South) were considered. Economic variables included wealth quintiles (poorer, poor, middle, rich, and richest), and behavioral indicators encompassed tobacco and alcohol consumption.

### Statistical analysis

To comprehensively investigate the associations between short stature, obesity, and health outcomes, the study employed a robust analytical approach. Recognizing the complexity of factors influencing hypertension and high blood glucose, both bivariate and multivariate analyses were utilized. Bivariate analysis was conducted to estimate the prevalence of hypertension and high blood glucose across different combinations of the four stature and obesity categories. Additionally, chi-square tests were performed to examine the associations between the outcome and explanatory variables. To further understand these relationships while adjusting for potential confounders, multivariate analysis was applied.

To examine the association between outcome variables (hypertension and HBG, respectively) and the combined variables of short stature and obesity, a binomial logistic regression model was employed. Four combinations were examined: short stature with general obesity, short stature with waist circumference, short stature with waist-to-hip ratio, and short stature with waist-to-height ratio. Sixteen multivariate models were constructed to calculate unadjusted (uORs) and adjusted (aORs) Odds ratios. The models were adjusted for sociodemographic and behavioural indicators. Through these analytical approaches, the study aimed to evaluate the relationship between the outcome and composite variables of short stature and obesity while considering potential confounding factors represented by the adjusted models.

The background characteristics of women aged 20-49 years is shown in **Table 1**. Most women (37 percent) belong to the age-group 20-29 years, whereas 33.9 and 29.1 percent belong to the age-group 30-39 years, and 40-49, respectively. The majority of the sample consists of currently married women (83.6 percent), women residing in rural areas (67.3 percent), and those practising the Hindu religion (82.3 percent). Regarding education, approximately 43.3 percent of women have completed education, whereas one-fourth of women were illiterate (26.7 percent). In study population, 2.7 percent of women belonged to the OBC category, while only 9.4 percent were STs. Central, East, and Southern regions individually constitute approximately 68 percent of the study sample. Consumption of tobacco and alcohol was reported with 4.9 and 0.9 percent, respectively. Further, over a quarter of women had short stature (26.7 percent) and were obese (27.7 percent). Moreover, 45.2 percent of women had a high-risk waist circumference, while 58.6 and 58.5 percent had a high risk of the waist-to-hip and waist-to-height ratio, respectively. The prevalence of hypertension and high blood glucose levels was 12.7 and 8.8 percent, respectively.

## Results

### Table 1. Background characteristics of women aged 20-49, NFHS-5 (2019-21), India

| | Sample (N) | Weighted (%) |
|---|---|---|
| **Total** | **541682** | |
| **A) Sociodemographic characteristics** | | |
| **Age group** | | |
| 20-29 | 201177 | 37.0 |
| 30-39 | 184255 | 33.9 |
| 40-49 | 156250 | 29.1 |
| **Marital status** | | |
| Never married | 67906 | 11.0 |
| Currently Married | 445279 | 83.6 |
| Widowed /Divorced/Separated | 28497 | 5.3 |
| **Place of residence** | | |
| Urban | 135794 | 32.7 |
| Rural | 405888 | 67.3 |
| **Education level** | | |
| Illiterate | 148576 | 26.7 |
| Primary | 71759 | 13.4 |
| Secondary | 238918 | 43.3 |
| Higher secondary and more | 82429 | 16.7 |
| **Religion** | | |
| Hindu | 411480 | 82.3 |
| Muslim | 63397 | 12.5 |
| Other | 66805 | 5.2 |
| **Caste** | | |
| Scheduled caste | 103146 | 21.8 |
| Scheduled tribe | 102363 | 9.4 |
| OBC | 205820 | 42.7 |

| | | |
|---|---|---|
| Other | 130353 | 26.2 |
| **Wealth Index** | | |
| Lowest | 108265 | 17.7 |
| Second | 118008 | 19.7 |
| Middle | 114339 | 20.8 |
| Fourth | 107026 | 21.3 |
| Highest | 94044 | 20.4 |
| **Region** | | |
| Northern | 109981 | 14.0 |
| Central | 120079 | 23.4 |
| Eastern | 86709 | 22.6 |
| North-Eastern | 79486 | 3.8 |
| Western | 56028 | 14.6 |
| Southern | 89399 | 21.7 |
| **B) Behavioural Characteristics** | | |
| **Consume Tobacco (includes both smoke and smokeless)** | | |
| No | 500731 | 95.1 |
| Yes | 40951 | 4.9 |
| **Consume Alcohol** | | |
| No | 529625 | 99.1 |
| Yes | 12057 | 0.9 |
| **C) Reproductive Characteristics** | | |
| **Total children ever born** | | |
| No child | 97078 | 16.6 |
| 1-2 Children | 249130 | 48.9 |
| 3+ Children | 195474 | 34.9 |
| **D) Predictor Variable -Undernutrition** | | |
| **Short Stature** | | |
| No short stature | 403376 | 73.3 |

| | | |
|---|---|---|
| Short stature < 148.4 cm | 138306 | 26.7 |
| **E) Predictor Variable -Overnutrition** | | |
| **Obesity (BMI >=25 Kg/m$^2$)** | | |
| No | 403188 | 72.4 |
| Yes | 137918 | 27.7 |
| **High-Risk Waist Circumference (WC> 80 cm)** | | |
| No | 309760 | 54.8 |
| Yes (waist circumference > 80 cm) | 231922 | 45.2 |
| **High-Risk Waist to Hip Ratio (WHR >=0.85)** | | |
| No | 218452 | 41.4 |
| Yes (waist-hip ratio ≥0.85) | 323230 | 58.6 |
| **High-Risk Waist to Height Ratio (WHtR>=0.5)** | | |
| No | 237719 | 41.5 |
| Yes (waist to height ratio > 0.5) | 303963 | 58.5 |
| **C) Outcome Variable: NCD** | | |
| **Hypertension** | | |
| No | 471781 | 87.3 |
| Yes | 69901 | 12.7 |
| **High Blood Glucose Level** | | |
| No | 499304 | 91.3 |
| Yes | 42378 | 8.8 |

Note: Short stature is defined according to the first quartile cut-off of height measurement. The first quartile cut-off for height measurement in the present study is >=148.3 cm. A woman is considered short-stature if her height is >=148.3 cm; Obesity (BMI): in the present study, obesity (BMI) is defined as BMI >= 25 kg/m$^2$; High-Risk Waist Circumference: According to WHO report, a woman with waist circumference > 80 cm is considered as high-risk; High-Risk Waist-to-Hip Ratio: According to WHO report, a woman with waist-to-hip ratio ≥0.85 is considered for high-risk; High-Risk Waist-to-Height Ratio: The waist-to-height ratio > 0.5 is considered as high-risk.

**Table 2. Prevalence of NCDs by sociodemographic and predictor variables among women aged 20-49, NFHS-5 (2019-21), India**

| | Hypertension | | High Blood Glucose | |
|---|---|---|---|---|
| | (%) (95% CI) | P-value | (%) (95% CI) | P-value |
| **A) Sociodemographic characteristics** | | | | |
| **Age group** | | | | |
| 20-29 | 5.37 (5.23, 5.52) | 0.000 | 1.5 (1.45, 1.55) | 0.000 |
| 30-39 | 11.82 (11.59, 12.05) | | 2.84 (2.77, 2.91) | |
| 40-49 | 23.02 (22.7, 23.34) | | 4.41 (4.33, 4.5) | |
| **Marital status** | | | | |
| Never married | 5.3 (5.05, 5.56) | 0.000 | 3.67 (3.46, 3.9) | 0.000 |
| Currently Married | 13.23 (13.07, 13.4) | | 1.5 (9.04, 9.32) | |
| Widowed /Divorced/Separated | 19.57 (18.93, 20.23) | | 2.84 (11.94, 13.07) | |
| **Place of residence** | | | | |
| Urban | 13.63 (13.32, 13.94) | 0.000 | 9.63 (9.36, 9.9) | 0.000 |
| Rural | 12.24 (12.09, 12.4) | | 8.32 (8.19, 8.45) | |
| **Education level** | | | | |
| Illiterate | 15.95 (15.69, 16.21) | 0.000 | 9.59 (9.38, 98100) | 0.000 |
| Primary | 14.99 (14.61, 15.38) | | 10.49 (10.15, 10.84) | |
| Secondary | 11.78 (11.57, 11.98) | | 8.79 (8.6, 8.98) | |
| Higher | 8.02 (7.74, 8.32) | | 5.9 (5.65, 6.15) | |
| **Religion** | | | | |
| Hindu | 12.38 (12.23, 12.54) | 0.000 | 8.57 (8.43, 8.7) | 0.002 |
| Muslim | 13.67 (13.23, 14.12) | | 9.78 (9.39, 10.18) | |
| Other | 15.32 (14.7, 15.89) | | 9.15 (8.68, 9.63) | |
| **Caste** | | | | |
| Scheduled caste | 12.19 (11.91, 12.49) | 0.000 | 8.39 (8.14, 8.65) | 0.000 |
| Scheduled tribe | 12.99 (12.6, 13.4) | | 6.79 (6.51, 7.08) | |
| OBC | 12.52 (12.32, 12.72) | | 8.67 (8.5, 8.85) | |
| Other | 13.3 (13, 13.6) | | 9.87 (9.6, 10.14) | |
| **Wealth Index** | | | | |
| Lowest | 11.37 (11.1, 11.64) | 0.000 | 7.74 (7.49, 7.99) | 0.000 |
| Second | 11.74 (11.47, 12.02) | | 7.99 (7.75, 8.23) | |
| Middle | 12.86 (12.57, 13.15) | | 8.72 (8.48, 8.97) | |
| Fourth | 13.39 (13.09, 13.69) | | 9.7 (9.42, 9.99) | |
| Highest | 13.88 (13.54, 14.23) | | 9.4 (9.1, 9.71) | |
| **Region** | | | | |
| North | 12.75 (12.45, 13.05) | 0.000 | 5.87 (6.46, 6.08) | 0.000 |
| Central | 12.99 (12.73, 13.26) | | 6.66 (10.59, 6.86) | |
| East | 11.69 (11.37, 12.02) | | 10.91 (9.18, 11.23) | |
| North East | 13 (12.6, 13.42) | | 9.54 (7.69, 9.92) | |
| West | 11.99 (11.53, 12.46) | | 8.04 (10.65, 8.41) | |
| South | 13.81 (13.49, 14.15) | | 10.95 (10.65, 11.25) | |
| **B) Behavioral Characteristics** | | | | |
| **Consume tobacco (includes both smoke and smokeless)** | | | | |

| | | | | |
|---|---|---|---|---|
| No | 12.53 (12.38, 12.68) | 0.000 | 8.69 (8.57, 8.82) | 0.000 |
| Yes | 15.97 (15.38, 16.58) | | 9.81 (9.35, 10.29) | |
| **Consume Alcohol** | | | | |
| **No** | 12.64 (12.5, 12.79) | 0.000 | 8.75 (8.63, 8.88) | 0.725 |
| Yes | 18.67 (17.5, 19.89) | | 8.32 (7.5, 9.22) | |
| **C) Reproductive Characteristics** | | | | |
| **Total children ever born (Parity)** | | | | |
| No child | 6.91 (6.68, 7.15) | 0.000 | 4.68 (4.48, 4.89) | 0.000 |
| 1-2 Children born | 12.29 (12.08, 12.49) | | 8.98 (8.79, 9.16) | |
| 3+ Children born | 16.03 (15.79, 16.27) | | 10.37 (10.17, 10.57) | |
| **D) Predictor Variable Combinations** | | | | |
| **Short Stature with BMI (Obese >=25 Kg/m2)** | | | | |
| Not short and no Obese | 9.28 (9.12, 9.44) | 0.000 | 6.27 (6.13, 6.41) | 0.000 |
| Not short but obese | 20.9 (20.52, 21.28) | | 14.38 (14.06, 14.71) | |
| Short and no Obese | 10.07 (9.82, 10.32) | | 7.04 (6.81, 7.28) | |
| Short and Obese | 21.55 (20.93, 22.2) | | 15.53 (14.97, 16.11) | |
| **Short stature with high waist circumference ( WC>80 cm)** | | | | |
| Not short and no high-risk WC | 8.17 (7.99, 8.34) | 0.000 | 5.33 (5.19, 5.48) | 0.000 |
| Not short and high-risk WC | 17.08 (16.81, 17.35) | | 11.88 (11.65, 12.11) | |
| Not short and no high-risk WC | 9.34 (9.09, 9.6) | | 6.33 (6.1, 6.57) | |
| Short and high-risk WC | 20.17 (19.63, 20.72) | | 14.82 (14.34, 15.31) | |
| **Short stature with high waist-to-hip ratio (WHR >=0.85)** | | | | |
| Not short and no high-risk WHR | 9.82 (9.61, 10.04) | 0.000 | 6.3 (6.13, 6.48) | 0.000 |
| Not short and high-risk WHR | 14.33 (14.1, 14.55) | | 10.03 (9.84, 10.23) | |
| Short and no high-risk WHR | 10.68 (10.33, 11.04) | | 6.82 (6.51, 7.13) | |
| Short and high-risk WHR | 15.21 (14.84, 15.58) | | 11.34 (11.01, 11.69) | |
| **Short stature with high waist-to-height ratio (WHtR>=0.5)** | | | | |
| Not short and no high-risk WHtR | 7.81 (7.62, 8) | 0.000 | 5.05 (4.9, 5.2) | 0.000 |
| Not short and high-risk WHtR | 15.91 (15.67, 16.15) | | 11.04 (10.83, 11.24) | |
| Short and no high-risk WHtR | 8.08 (7.79, 8.39) | | 5.38 (5.13, 5.64) | |
| Short and high-risk WHtR | 16.66 (16.28, 17.05) | | 12.05 (11.7, 12.41) | |

Note: Short stature is defined according to the first quartile cut-off of height measurement. The first quartile cut-off for height measurement in the present study is >=148.3 cm. A woman is considered short-stature if her height is >=148.3 cm; Obesity (BMI): in the present study, obesity (BMI) is defined as BMI >= 25 kg/m²; High-Risk Waist Circumference: According to WHO report, a woman with waist circumference > 80 cm is considered as high-risk; High-Risk Waist-to-Hip Ratio: According to WHO report, a woman with waist-to-hip ratio ≥0.85 is considered for high-risk; High-Risk Waist-to-Height Ratio: The waist-to-height ratio > 0.5 is considered as high-risk

The percentage distribution of occurring hypertension and HBG, respectively, with respect to the population sub-groups of socio-demographic, behavioral, reproductive, and nutritional characteristics is shown in **Table 2**. Results indicate that prevalence of both NCDs (i.e., hypertension and HBG) rises with increasing age among women. Specifically, the highest rates of hypertension (23.02 percent) and HBG (4.41 percent) were observed among women aged 40-49 years, while the lowest rates were found in the group of 20-29 years (5.37 percent for hypertension and 1.50 percent for the HBG). Moreover, the prevalence of hypertension was highest among widowed/ divorced/separated (19.57 percent), whereas the HBG percentage was observed highest among unmarried women (3.67 percent). Widowed/divorced/separated women had the highest prevalence of hypertension (19.57 percent), whereas unmarried women exhibited the highest percentage of HBG (3.67 percent). The result revealed little variations in the prevalence of NCDs based on place of residence, religion and caste.

Furthermore, regarding women's education, the prevalence of NCDs was highest among women with no or primary education and lowest among women with higher secondary-and above education level. However, the prevalence of NCDs increased as the wealth quintile increased, although the difference was slight. In terms of geographical regions, the prevalence of hypertension ranged from 11.69 percent in the eastern region to 13.81 percent in the southern region. Conversely, the prevalence of HBG varied from 5.87 percent in the northern region to 10.95 percent in the southern region. Moreover, women who consumed tobacco and alcohol exhibited a higher percentage of hypertension than non-consumers. In the case of HBG, its prevalence was higher among tobacco consumers, while the prevalence remained similar among alcohol consumers and non-consumers; additionally, the chi-square test yielded insignificant results. However, for all variables, chi-square showed significant results. Interestingly, the prevalence of NCDs increased in women with no children (6.91 percent for hypertension and 4.68 percent for HBG) and in women with three or more three children (16.03 percent for hypertension and 10.37 percent for HBG).

**Table 3. Unadjusted and adjusted Odds Ratio of the association between NCDs and DBM among women aged 20-49, NFHS-5 (2019-21), India**

| Predictor Variable Combinations | Hypertension | | High Blood Glucose Level | |
|---|---|---|---|---|
| | uOR ( 95% CIs) | aOR ( 95% CIs) | uOR ( 95% CIs) | aOR ( 95% CIs) |
| **Short Stature with BMI (Obese >=25 Kg/m²)** | | | | |
| Not short and no Obese *(ref.)* | 1 | 1 | 1 | 1 |
| Not short but obese | 2.58***(2.51,2.66) | 2.18***(2.11,2.25) | 2.51*** (2.43,2.60) | 2.03***(1.96,2.10) |
| Short and no Obese | 1.09***(1.06,1.13) | 1.06***(1.02,1.09) | 1.13*** (1.09,1.18) | 1.05*(1.01,1.10) |
| Short and Obese | 2.69***(2.58,2.80) | 2.17***(2.08,2.26) | 2.75*** (2.62,2.89) | 2.10***(2.00,2.21) |
| **Short stature with high waist circumference ( WC>80 cm)** | | | | |
| Not short and no high-risk WC*(ref.)* | 1 | 1 | 1 | 1 |
| Not short and high-risk WC | 2.32*** (2.25,2.39) | 1.89*** (1.83,1.95) | 2.39***(2.31,2.48) | 1.90***(1.83,1.97) |
| Not short and no high-risk WC | 1.16*** (1.12,1.20) | 1.10*** (1.06,1.15) | 1.20***(1.14,1.26) | 1.10***(1.05,1.15) |
| Short and high-risk WC | 2.84*** (2.73,2.96) | 2.19*** (2.10,2.28) | 3.09***(2.94,3.24) | 2.24***(2.13,2.36) |
| **Short stature[a] with high waist-to-hip ratio (WHR >=0.85)** | | | | |
| Not short and no high-risk WHR*(ref.)* | 1 | 1 | 1 | 1 |
| Not short and high-risk WHR | 1.53*** (1.49,1.58) | 1.36*** (1.32,1.40) | 1.55*** (1.52,1.59) | 1.46***(1.41,1.51) |
| Short and no high-risk WHR | 1.10*** (1.05,1.15) | 1.07** (1.03,1.12) | 1.09*** (1.05,1.13) | 1.04(0.99,1.10) |
| Short and high-risk WHR | 1.65***(1.59,1.71) | 1.47*** (1.41,1.53) | 1.76*** (1.71,1.82) | 1.62***(1.54,1.70) |
| **Short stature[a] with high waist-to-height ratio (WHtR>=0.5)** | | | | |
| Not short and no high-risk WHtR*(ref.)* | 1 | 1 | 1 | 1 |
| Not short and high-risk WHtR | 2.23*** (2.17,2.30) | 1.79*** (1.73,1.85) | 2.33*** (2.25,2.42) | 1.80***(1.74,1.87) |
| Short and no high-risk WHtR | 1.04 (0.99,1.09) | 1.02 (0.98,1.08) | 1.07* (1.01,1.13) | 1.02(0.96,1.08) |
| Short and high-risk WHtR | 2.36*** (2.27,2.45) | 1.87*** (1.80,1.95) | 2.58***(2.46,2.70) | 1.92***(1.83,2.01) |

Note: a: Short stature is defined according to the first quartile cut-off of height measurement. The first quartile cut-off for height measurement in the present study is >=148.3 cm. A woman is considered short-stature if her height is >=148.3 cm; Obesity (BMI): in present study, obesity (BMI) is defined as BMI >= 25 kg/m²; High-Risk Waist Circumference: According to a WHO report, a woman with waist circumference > 80 cm is considered as high-risk; High-Risk Waist-to-Hip Ratio: According to WHO report, a woman with waist-to-hip ratio ≥0.85 is considered for high-risk; High-Risk Waist-to-Height Ratio: The waist-to-height ratio > 0.5 is considered as high-risk; *(ref.)* :Reference category; uOR: unadjusted Odds Ratio; aOR: adjusted Odds Ratio adjusted for age group, marital status, place of residence, education level, religion, caste, wealth index, region, consumption of tobacco, consumption of alcohol, total children ever born; level of significance: ***p < .01, **p < .05;* <0.1

Further, the occurrence of NCDs with the combined effects of stature and each obesity indicator among women were examined. Findings revealed that women with obesity (BMI), regardless of their stature (21.55 and 15.53 percent for short stature and 20.9 and 14.38 for not short stature combined with obesity for hypertension and HBG, respectively), had a higher prevalence of NCDs than women without obesity. Similarly, women with high-risk waist circumference (20.17 and 14.82 percent for short stature and 17.08 and 11.88 percent for not short stature combined with a high risk of WC for hypertension and HBG, respectively), waist-to-hip ratio (15.21 and 11.34 percent for short stature and 14.33 and 10.03 percent for not short stature combined with high risk of WHR for hypertension and HBG, respectively), and waist-to-height ratio (16.66 and 12.05 percent for short stature and 15.91 and 11.04 percent for not short stature combined with a high risk of WHtR for hypertension and HBG, respectively), had a higher prevalence of NCDs than women without short stature and any risk of any high-risk obesity.

The unadjusted and adjusted odds ratios, along with their corresponding 95% confidence intervals (CIs), for different combinations of predictor variables in relation to hypertension and high blood glucose levels (see **Table 3)**. The results of the variable combination of stature and BMI with NCDs indicate that women who were not short and not obese served as the reference group. The unadjusted and adjusted odds ratio shows that women who were not short but obese had significantly higher odds of hypertension (uOR: 2.58, CI: 2.51,2.66 and aOR:2,18, CI:2.11, 2.25) and high blood glucose (uOR = 2.51, CI:2.43, 2.60 and aOR:2.03, CI:1.96, 2.10) compared to the reference group. Similarly, women who were short but not obese had slightly elevated odds of hypertension (uOR:1.09, CI:1.06, 1.13 and aOR:1.06, CI:1.02, 1.09) and high blood glucose (uOR:1.13, CI:1.09, 1.18 and aOR:1.05, CI:1.01, 1.10). The highest odds were observed for women who were both short and obese, with substantially increased odds of hypertension (uOR:2.69, CI:2.58, 2.80 and aOR:2.17, CI:2.08, 2.26) and high blood glucose (uOR:2.75, CI:2.62, 2.89 and aOR:2.10, CI:2.00, 2.21).

Examining the combination of stature and waist circumference indicators, the reference group comprised women who were not short and without high WC. Women who were not short but had a risk of high WC showed significantly higher odds of hypertension (uOR:2.32, CI:2.25, 2.39) and high blood glucose (uOR:2.39, CI:2.31, 2.48). Similarly, short women without risk of high WC exhibited slightly elevated odds of hypertension (uOR:1.16, CI:1.12, 1.20) and high blood glucose (uOR = 1.20). The highest odds were observed for women who were both short and had a risk of high WC, with substantially increased odds of hypertension (uOR:2.84, CI:2.73, 2.96) and high blood glucose (uOR:3.09, CI:2.94, 3.24). Moreover, all regression analyses were adjusted for the control variables; even after controlling, it remained significant.

Furthermore, regarding the variable combination of stature and WHR with NCDs, the unadjusted and adjusted analysis shows that women who were not short but had a risk of high WHR displayed significantly higher odds of hypertension (uOR:1.53, CI:1.49, 1.58) and high blood glucose (uOR:1.55, CI:1.52, 1.59), further even after adjusting for the control variables the association remained significant. Short women without risk of high WHR exhibited slightly elevated odds of hypertension (uOR:1.10, CI:1.05, 1.15) and high blood glucose (uOR:1.09, CI:1.05, 1.13). The highest odds for adjusted and unadjusted odds ratios were observed for women who were both short and had a risk of high WHR, with substantially increased odds of hypertension (uOR:1.65, CI:1.59, 1.71) and high blood glucose (uOR:1.76, CI:1.71, 1.82).

Lastly, for the variable combination of stature and waist-to-height ratio, the unadjusted and adjusted association with NCDs shows that women who were not short but had a risk of high WHtR showed significantly higher odds of hypertension (uOR:2.23, CI:2.17, 2.30 and aOR:1.79, CI:1.73, 1.85) and high blood glucose (uOR:2.33, CI:2.25, 2.42 and aOR:1.80, CI:1.74, 1.87) compared to women with short stature and without high WHtR. Moreover, the highest odds were observed for women who were both short and had high WHtR, with substantially increased odds of hypertension (uOR:2.36, CI:2.27, 2.45 and aOR:1.87, CI:1.80, 1.95) and high blood glucose (uOR:2.58, CI:2.46, 2.70, aOR:1.92, CI:1.83, 2.01).

## Discussion

Present study aimed to bring the issue of short stature among women is a significant public health concern that warrants comprehensive discussion, given its potential long-term implications on health outcomes. This study found that over one-quarter of women aged 20-49 years were found to be short stature. Eight in 1000 married nulliparous women aged 20-24 years in India were short, thin, and young, with a prevalence of 26% (Sethi et. al., 2019). According to a study, the average height of Indian women aged 15-25 showed a decline by 0.12 cm between NFHS-3 and NFHS-4, while the 26-50 years age-group showed a significant improvement in height by 0.13 cm (Choudhary et al., 2021). An increasing trend in BMI was observed across all birth cohorts for Indian women aged 15-30 years, with a lower rate of increase for height than weight (Deshpande et al. 2021).

This study also assessed the obesity burden and observed that more than a quarter of women had high BMI level (i.e. 27.7 percent). Besides, the results demonstrated that around 45 percent of women had high waist circumferences, while nearly 59 and 58 percent had high waist-to-hip and waist-to-height ratios, respectively. These findings are so evident from earlier studies (Balarajan & Villamor, 2009; Luhar et al., 2020; Wang et. al., 2009). For instance, a study found that overweight being more prevalent among females (Wang et. al., 2009), and it increased from 10.6% to 14.8% between 1996 and 2006 among women of reproductive age (Balarajan & Villamor, 2009). There is a common misconception that obesity is primarily a problem affecting developed countries. However, recent findings reveal that obesity is increasingly prevalent in developing nations as well. India, for instance, is now facing a growing obesity burden despite the persistent issues of malnutrition and hunger (Dutta et al., 2019). Researchers attribute this trend to the rapid pace of global transition and urbanization, which drive significant lifestyle and dietary changes in developing regions. These shifts are recognized as key contributors to the dual challenge of malnutrition—both undernutrition and overnutrition—that many developing countries, including India, now face (Jones et al., 2016).

Further, this study employed bivariate analysis to assess the burden of NCDs (hypertension and HBG) in relation to socio-demographic, behavioural, and reproductive characteristics. Age, marital status (widowed, divorced, or separated), lower education (primary or none), and high parity were linked to higher prevalence rates of hypertension and high blood glucose, aligning with previous findings (Dey et al., 2022; Liew et al., 2019; Vasudevan et al., 2022).

The study also examined the double burden of malnutrition (DBM)—the combination of short stature and obesity—and its association with NCDs. Results indicated that women with both short stature and high obesity, as well as women without short stature but with high obesity (analysed separately by each obesity indicator), had higher rates of hypertension and HBG than their counterparts. Likewise, unadjusted and adjusted multivariate analyses showed that women without short stature or obesity had lower odds of NCDs than those with short stature and/or obesity, particularly those with DBM. Notably, higher odds were observed in women with short stature and high BMI or waist-to-height ratio.

These findings suggest that DBM may contribute to the development of NCDs. Short stature, a marker of childhood development, malnutrition, and a component of BMI, has been linked to obesity (Rani et al., 2021; Bosy-Westphal et al., 2009; Jang et al., 1998; Moses & Mackay, 2004). Short stature may result from nutritional deficits during growth or hormonal and genetic factors that influence growth signals (Frelut, 2015). Growth hormone insufficiency can slow growth and increase body fat, leading to obesity, a known NCD risk factor (Misra & Khurana, 2011; Nethan et al., 2017; Webber et al., 2012). Additionally, studies show an inverse relationship between height and risks for high blood glucose (Bozorgmanesh et al., 2011; Sicree et al., 2008; Snijder et al., 2003; Wang et al., 1997) and hypertension (Choudhary et al., 2021; Hoque et al., 2014).

Overall, this study has effectively demonstrated the strong relationship between the double burden of malnutrition (DBM)—particularly the combination of short stature and obesity—and the prevalence of non-communicable diseases (such as high blood pressure and elevated blood glucose levels). The findings underscore the importance of understanding these connections and developing targeted interventions in public health policies to address this dual burden and reduce the risk of NCDs.

This study benefits from a large, nationally representative sample, allowing for a robust analysis of anthropometric measurements and proxy measures of NCDs (i.e., hypertension and HBG). The accuracy of the anthropometric data was enhanced by the use of standardized digital equipment operated by trained personnel, ensuring reliable measurements. Additionally, hypertension and HBG levels were measured using blood pressure and blood samples to minimize measurement bias and error. However, a few limitations should also be acknowledged. Firstly, the cross-sectional design of the study restricts its ability to capture changes over time, limiting any causal inferences. This design also prevents assessment of the potential impact of lifestyle modifications on the observed associations.

## Conclusion

The study concludes that the double burden of malnutrition may significantly contribute to the development of hypertension and high blood glucose levels. Obesity emerges as a key factor in the progression of NCDs, regardless of short stature. While these results provide valuable insights, further longitudinal research is needed to deepen our understanding of the relationships between stature, obesity, and NCDs over time.

Also, stature is influenced by both genetic and non-genetic factors. While genetic aspects are beyond control, non-genetic factors—such as maternal tobacco and alcohol use, prenatal and postnatal care, childhood nutrition, and illness—can be managed to some extent through a healthy lifestyle. Rising obesity rates in India have become a growing concern, as obesity is increasingly linked to NCD risk. Fortunately, obesity is reversible, and maintaining a healthy weight through regular exercise, a balanced diet, and avoidance of harmful habits can significantly lower the risk of NCDs and promote long-term health.

## Declarations

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### Ethical declarations

The present study utilizes a secondary dataset available in the public domain for legitimate research purposes with no identifiable information on the survey participants. Hence, there is no requirement for any additional ethical approval.

### Consent for publication

Not applicable. No details, images or videos related to individual participants were obtained. In addition, data are available in the public domain.

### Competing interests

The authors declare no competing interests.

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