Obesity Transition Across Reproductive Stages of Women and its Link with Non-Communicable Diseases in India: An Analysis Using South and Southeast Asia DHS Surveys

Introduction

Stature is widely regarded as one of the key measures of physical health and biological quality of life within a population (Steckel, 1983, 1995, 2009). It has been observed that existing literature primarily focuses on malnutrition or overnutrition among children and either malnutrition and non-communicable diseases (NCDs) or overnutrition and NCDs among adults. However, limited research simultaneously explores undernutrition and overnutrition(Wells et al., 2018a, 2018b; Zeba et al., 2012). Additionally, most studies on the double burden of malnutrition in India 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 double burden of malnutrition at the individual level and its relation with NCDs. It is worth noting that no studies have been conducted in the Indian context. Thus, this study aims to address this research gap by examining the dual burden of malnutrition and NCDs within the same individuals, thereby providing valuable insights into the Indian population.

Data and Methodology:

The present study utilized data from South and Southeast Asia Demography Health Survey conducted during 2000-2023. In relation to the analysis, women aged 20-49 were included in the study after considering their complete height growth until age twenty, as most women's height does not increase significantly after age 18 to 20 (Centers for Disease Control and Prevention, 2000); Consequently, a total of 541,742 ever-married women within this age range were part of the analysis. Pregnant women, those who had given birth in the preceding two months, and women without available anthropometric measurements were excluded from the study. The analyses were conducted using STATA version 16.0, considering appropriate sampling weights.

Outcome Variable

This study has two outcome variables: hypertension and high blood glucose.

Measuring hypertension

Respondents whose average systolic blood pressure (SBP) was >=140 mm Hg and/or whose average diastolic blood pressure (DBP) was >=90 mm Hg (World Health Organization). In the present study, an individual is classified as having hypertension if she has SBP ≥140 mmHg or DBP ≥90 mmHg at the time of the survey, or she is currently taking medicine to lower her blood pressure.

Measuring high blood glucose

According to the Centre for Disease Control and Prevention (CDC), a random blood sugar level below 140mg/dL or below indicates a normal glucose level, 140-199 mg/dL indicates prediabetes, and 200 mg/dL or higher indicates diabetes. In the present study an individual is classified as having high blood glucose if she has a random blood glucose level of more than 140 mg/dL.

predictor variables

In this study, we defined four variables to represent the double burden of malnutrition, incorporating short stature as the predictor variable for undernutrition and four obesity indicators as a predictor variable for overnutrition: Body Mass Index (BMI), Waist Circumference (WC), Waist-to-Hip Ratio (WHR), and Waist-to-Height Ratio (WHtR).

The variables are defined as follows: 1) short stature: This variable was determined based on quartile distribution, categorizing women falling within the first quartile as having short stature. This definition draws upon findings from existing literature and DHS surveys conducted in other countries (Florêncio et al., 2004; Marbaniang et al., 2022; Shivakumar et al., 2018). 2) Obesity or high Body Mass Index (BMI): We categorized individuals into two groups—no obesity (BMI < 25.0 kg/m²) and obesity (BMI > 24.9 kg/m²). Abdominal obesity: According to WHO standard measurements, waist circumference (WC) and waist–to–hip (WHR) ratio were used to measure abdominal obesity. 3) waist circumference ≥88cm for women with high-risk and 4) WHR (measured by dividing waist circumference cm by hip measurement cm) ≥0.85 for women who were considered a high-risk group. 5) Waist-to-height ratio (WHtR): WHtR was calculated by dividing the waist circumference by height measurements. Previous research by Hsieh et al. (2003) and McCarthy & Ashwell (2006) recommended using a WHtR>0.5 as a threshold for identifying individuals at high risk.

We categorized individuals based on a combination of obesity and short stature into four groups. The first group consists of women who are neither short in stature nor obese, serving as our reference category. The second group includes women who are not short in stature but are classified as obese. The third group comprises women who are short in stature but do not fall under the category of obesity. Lastly, the fourth group consists of women who are both short in stature and obese. The last group exemplifies the phenomenon of the double burden of malnutrition, signifying individuals grappling with the coexistence of short stature and obesity concurrently.

Control variable

To ensure that potential confounding factors resulting from the combined effects of short stature and obesity on outcome variables were accounted for, relevant variables were incorporated into the model based on existing literature. Various factors, including socioeconomic, demographic, and behavioural indicators, were considered control variables. The control variables are mothers' age (20-29, 30-39 and 40-49), marital status (never married, currently married and widowed/divorced/separated), children ever born (0, 1 or 2 and 3 or more

than three children), caste and tribal status (Scheduled Caste (SC), Scheduled Tribe (ST), Other Backward Class (OBC) and others), religion (Hindu, Muslim and others), women education (no education, primary, secondary and higher secondary), place of residence (rural and urban), regions including North, Central, East, North-East, West and South. Economic variables include wealth quintile (poorer, poor, middle, rich and richest). Behavioural indicators include the consumption of tobacco and consumption of alcohol.

Statistical analysis

The present study utilized both bivariate and multivariate analyses. Bivariate analysis was employed to determine the prevalence of hypertension and high blood glucose across a different combination of the four stature and obesity variables. A chi-square test was also conducted to assess the association between the outcome and explanatory variables.

To estimate the association between outcome variables (hypertension and high blood glucose) 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.

Priliminary analysis is based on India NFHS data only

Result

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		
North	109981	14.0
Central	120079	23.4
East	86709	22.6
North East	79486	3.8
West	56028	14.6
South	89399	21.7
B) Behavioral 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 1 represents the background characteristics of women aged 20-49. Most women (37 percent) belong to the age group 20-29, whereas 33.9 and 29.1 percent belong to the age group 30-39 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).

Table 2: The 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/m$^{2)}$				
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)	
Short No 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/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 presents an analysis of the relationship between sociodemographic and predictor variables with the occurrence of hypertension and high blood glucose. The results indicate that the prevalence of non-communicable diseases (NCDs) rises with increasing age among women. Specifically, the highest rates of hypertension (23.02 percent) and high blood glucose (4.41 percent) were observed among women aged 40-49, while the lowest rates were found in the 20-29 age group (5.37 percent for hypertension and 1.50 percent for high blood glucose). Moreover, the prevalence of hypertension was highest among widowed/ divorced/separated (19.57 percent), whereas the high blood glucose percentage was highest among unmarried women (3.67 percent). Additionally, widowed/divorced/separated women had the highest prevalence of hypertension (19.57 percent), whereas unmarried women exhibited the highest percentage of high blood glucose (3.67 percent). The result revealed little variations in the prevalence of NCDs based on place of residence, religion and caste.

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

	Hypertension		High Blood Glucose Level	
	uOR (95% CIs)	**aOR (95% CIs)**	**uOR (95% CIs)**	**aOR (95% CIs)**
Predictor Variable Combinations				
Short Stature with BMI (Obese >=25 Kg/m$^{2)}$				
Not short and no Obese ®	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®	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)
Short No 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®	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®	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/m^2; 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; ®: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

Table 3 presents the unadjusted and adjusted association between the combined stature and obesity with non-communicable diseases (hypertension and high blood glucose). The unadjusted odds ratio indicates that women with (hypertension-uOR: 2.69 (2.58, 2.80); high blood glucose-uOR: 2.75 (2.62, 2.89)) and without (hypertension-uOR: 2.58 (2.51, 2.66); high blood glucose-uOR: 2.5 (2.43, 2.60)) short stature combined with obesity had a higher likelihood of developing hypertension and high blood glucose than women without short stature and obesity. Further, this association remained significant even after controlling for other variables for hypertension (short and high-risk WC-uOR:2.84 (2.83, 2.96); aOR:2.19 (2.10, 2.28) and not-short and high WC-uOR:2.32 (2.25, 2.39); aOR:1.89 (1.83, 1.95)) and high blood glucose (short and high-risk WC-uOR:3.09 (2.94, 3.24); aOR:2.24 (2.13, 2.36) and not-short and high-risk WC-uOR:2.39 (2.31, 2.48); aOR:1.90 (1.83, 1.97)). Similarly, when stature was combined with waist circumference, the unadjusted analysis revealed that women with and without short stature and high waist circumference had an increased risk of NCDs compared to women without short stature and obesity. Moreover, the odds ratio decreased after adjusting for control variables, but the association remained statistically significant. Similar patterns were observed when stature was combined with waist-to-height (hypertension (short stature and high-risk WHR- uOR:1.65 (1.59, 1.71); aOR:1.47 (1.41,1.53); short stature and high-risk WHtR high blood glucose-uOR:1.76 (1.71, 1.82); aOR:1.62 (1.54, 1.70)) and waist-to-hip ratios (hypertension- uOR:2.36 (2.27, 1.45); aOR:1.87 (1.80,1.95); high blood glucose-uOR:2.58 (2.46, 2.70); aOR:1.92 (1.83, 2.01)), indicating a significant association with NCDs.

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:

In the present study, short stature was defined as individuals who fell within the first quartile of the height distribution, Consequently, it was determined that over one-quarter of women aged 20-49 had a short stature. Furthermore, an Indian study conducted between 1998 and 2015 examined the decline in height among women aged 15-25, providing additional insights into the long-term trend and patterns of height variation (Choudhary et al., 2021). Moreover, Deshpande et al. reported a dependence of BMI on height, a significant increase in weight compared to height and increased BMI among women aged 15-30.

Furthermore, the present study assessed the prevalence of obesity by various obesity indicators. It was observed that more than one-quarter of women had high BMI (27.7 percent). It has been reported that overweight and obesity have increased more than doubled in the last decade (Luhar et al., 2020). Additionally, other obesity indicators showed that 45.2 percent of women had high waist circumferences, while nearly 58.6 and 58.5 percent had high waist-to-hip and waist-to-height ratios, respectively. These findings indicate that the significant increase in obesity is not solely a problem in developed countries but is also prevalent in developing countries. India, where the double burden of malnutrition and hunger persists, is now experiencing a growing burden of obesity (Dutta et al., 2019). Studies and scholars have attributed this surge to the rapid global transition and urbanization, which are major drivers of the escalating transition in developing countries and are identified as primary contributors to the double burden of malnutrition (Jones et al., 2016).

Furthermore, a bivariate analysis was conducted in this study to assess the prevalence of NCDs with sociodemographic and predictor variables. The analysis revealed that age, marital status (specifically, being widowed, divorced, or separated), educational attainment (particularly, primary and no education), and high parity were associated with a higher prevalence of hypertension and high blood glucose when compared to their counterparts. These results are aligned with the previous studies (Dey et al., 2022; Liew et al., 2019; Vasudevan et al., 2022).

Moreover, the study explored the association between the double burden of malnutrition (the combined presence of short stature and obesity) with NCDs. The findings indicated that women who had both short stature and high obesity(DBM), as well as women without short stature but with high obesity (considering each obesity indicator separately), exhibited a higher percentage of hypertension and high blood glucose compared to their counterparts. Similarly, the unadjusted and adjusted multivariate analysis demonstrates that women without short stature and obesity had a lower likelihood of developing NCDs compared to women with or without short stature combined with obesity and women with short stature with no obesity. Likewise, the results were similar for all indicators of obesity. Interestingly the results consistently revealed that the women with short stature and obesity (DBM) had higher odds of developing NCDs than their counterparts, even after controlling for other variables. In addition, higher odds were observed for women with short with high BMI and waist-to-height ratio compared to other obesity indicators.

The study findings suggest that the combination of short stature and obesity (DBM) may contribute to the development of NCDs. Stature is an essential indicator of physical health that monitors childhood development and physical growth. It is also an indicator of malnutrition and one component of body mass index (Rani et al., 2021). Moreover, several studies have observed the association between short stature and the prevalence of obesity (Bosy-Westphal et al., 2009; Jang et al., 1998; Moses & Mackay, 2004). Regarding the association between short stature and high BMI (Frelut, 2015) explained that short stature might lead to nutritional issues during early growth or be influenced by hormones or genes that affect growth signals. Growth hormones play a crucial role in our body's growth and regulation of fat. Insufficient growth hormone levels can result in a slower growth rate and increased body fat, leading to varying degrees of weight gain, ranging from being slightly overweight to reaching obesity. It was well established that obesity is one of the risk factors for NCDs (Misra & Khurana, 2011; Nethan et al., 2017; Webber et al., 2012). In addition, some studies have even found the inverse relationship between height with a higher risk of 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).

This study has a notable strength as it utilizes a large nationwide sample, providing comprehensive information on anthropometric measurements and the occurrence of high blood pressure, hypertension and sociodemographic background of individuals. The anthropometric measurements were conducted by trained staff using digital machines during the survey, ensuring the accuracy of the measurements. Additionally, hypertension and high blood glucose levels were measured using blood pressure and blood samples to minimize measurement bias and errors. However, it is important to acknowledge the limitations of this study. Firstly, the data collected is cross-sectional, meaning that the survey information was gathered at a single point in time. It is worth noting that both obesity and hypertension are modifiable risk factors. Due to the cross-sectional nature of the survey, we cannot assess the changes in the association between these factors or determine whether obesity and non-communicable diseases (NCDs) have been reduced or increased over time.

Conclusion:

The evidence obtained from the study strongly indicates that the coexistence of short stature and obesity (DBM) may contribute to the development of hypertension and high blood glucose levels. Furthermore, it highlights that obesity plays a dominant role in the progression of non-communicable diseases (NCDs), regardless of women's shorter stature. While the current findings offer valuable insights, a longitudinal study that tracks participants over an extended period is necessary to gain deeper insights into the association between stature, obesity, and non-communicable diseases (NCDs). This longitudinal approach would provide a more comprehensive understanding of the relationship between these variables. ~~It is worth noting that more than one-quarter of the women in the study were found to have short stature.~~ Further, it is well-established that women with short stature are more likely to experience weight gain. In addition, It is important to consider that genetic and non-genetic factors influence stature. While genetic factors cannot be controlled, non-genetic factors such as the consumption of tobacco and alcohol during pregnancy, exposure to smoke during pregnancy, prenatal and

postnatal care, childhood illnesses, birth weight, and nutrition can be managed to some extent through adopting a healthy lifestyle. Moreover, Numerous researchers and scholars have expressed concern about the rising obesity rates in India, as it is considered a potential contributing factor to non-communicable diseases (NCDs). It is worth emphasizing that obesity is reversible, and maintaining a healthy weight can be achieved by following a healthy lifestyle. In brief, by adopting a healthy lifestyle, including regular exercise, a balanced diet, and avoiding harmful habits, individuals can take proactive steps to reduce the risk of NCDs and promote overall well-being.

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