

PERSISTENT GEOGRAPHIC DISPARITIES IN ADULT HEIGHT ACROSS INDIA: EVIDENCE FROM NATIONAL FAMILY HEALTH SURVEY

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ABSTRACT

Objective: The present study aimed to assess regional and interstate variations in average adult height among Indian men and women using National Family Health Survey (NFHS) data across multiple survey rounds.

Methods: Secondary analysis, Cross-sectional, observational study using data of NFHS-2 (1998-1999), NFHS-3 (2005-2006), NFHS-4 (2015-2016) and NFHS-5 (2019-2021) in a nationally representative sample of adult men (aged 20 to 54 years) and women (aged 20 to 49 years) was used. Adult men and women from all states and union territories with valid anthropometric measurements were included in the study. Mean height and standard deviation (SD) were calculated separately for men and women across states, regions, and NFHS rounds.

Results: Significant regional and interstate differences in adult height were observed among both men and women ($p < 0.001$). Among men, the highest mean height was observed in Punjab (167.6 ± 6.83 cm), followed by Haryana (167.0 ± 6.57 cm) and Kerala (166.3 ± 6.92 cm), whereas the lowest mean height was recorded in Meghalaya (158.7 ± 6.21 cm). Among women, Jammu and Kashmir reported the highest mean height (155.6 ± 6.37 cm), while Tripura, Bihar, and Jharkhand exhibited the lowest values (149.8 – 149.9 cm). Regionally, the highest average stature for both men and women was observed in the northern region while relatively lower mean heights were observed in eastern and north-eastern regions. Temporal analysis across NFHS rounds showed modest improvements in women height in several states and regions, whereas men height showed stagnation or slight decline in some areas.

Conclusion: The study reveals considerable regional and inter-state differences in adult stature in India. The northern and southern states tended to have taller populations, the eastern and some north-eastern states consistently lower mean height. Although women stature improved slightly over time, differences are still significant across regions.

KEYWORDS: Adult height, NFHS, Survey, Secondary analysis, Population, India

INTRODUCTION

Adult height is a well-known indicator of long-term nutritional status, health conditions and socioeconomic development, in anthropometric terms. It is the net effect of genetic potential and environmental exposures in childhood and adolescence. Hence, differences in adult stature at the population level are considered sensitive markers of human development and social inequality [1, 2]. Worldwide secular height trends have been used to evaluate improvements in nutrition, public health, and socioeconomic conditions across generations [3, 4]. In many developed and developing countries, adult height has increased substantially over time as a result of improved living standards and health care [5]. But the scale and direction of these trends differ widely between populations as a function of economic growth, food security, disease burden and social inequalities [6].

India's regions, socio-economic characteristics and culture are highly diverse, and this has a large effect on growth outcomes. Adult height in India is highly heterogeneous across states, regions, gender and socioeconomic groups, reflecting long-standing disparities in nutrition and development. Earlier studies based on NFHS data have shown a higher average stature in northern states like Punjab and Haryana while eastern states like Bihar and Jharkhand are generally characterized by lower mean height [7]. The National Family Health Survey (NFHS) is one of the largest nationally representative health surveys in India, which has reliable anthropometric data collected using standardized measurement protocols. Previous studies based on NFHS-2, NFHS-3 and NFHS-4 data have shown modest secular increases in height among Indian adults but stagnation or even decrease in height over time has been observed in some regions and population groups [8].

Mamidi et al. reported the average height of Indian adult men and women as approximately 165 cm and 152 cm, respectively, with large interstate differences [9]. Similarly, Choudhary et al. reported uneven trends in adult height across NFHS rounds and noted that improvements in stature in India have been relatively slow compared to many other developing countries [7]. Genes do have some influence on how tall you are as an adult, but environmental factors also have an impact. These include the child's nutrition, the mother's health, quality of diet, sanitation, infectious diseases, and socioeconomic factors. Studies have shown that better socioeconomic status, improved maternal education, and higher intake of animal-source foods are positively associated with adult stature in India [10].

Although several studies have examined adult height patterns in India, limited literature is available comparing regional and interstate trends across multiple NFHS rounds using pooled data for both men and women [11]. Understanding these variations is important for evaluating long-term nutritional transition and identifying populations vulnerable to poor growth outcomes. Therefore, the present study was undertaken to assess regional and interstate variations in adult height among Indian men and women using pooled NFHS data across multiple survey rounds. The study also aimed to examine temporal trends in stature across regions and states in order to better understand patterns of growth across India.

METHODOLOGY

Study Design and Data Source

The present study was a secondary data analysis based on data obtained from multiple rounds of the National Family Health Survey (NFHS) conducted in India. For this analysis, we obtained permission for all five rounds of Indian national family health survey (NFHS) from the Demographic and Health Survey Program [8, 12-14] but later we excluded NFHS-1 from the analysis as they did not capture the data for adult height in it. The Data for anthropometric measurements were available for females only in the NFHS-2. From NFHS-3 onwards, they started capturing anthropometric measurements for males.

We analyzed data from NFHS-2, NFHS-3, NFHS-4 and NFHS-5 to assess regional and interstate variations and temporal trends in adult height among Indian men and women.

Study Population and Sample Size

Of the 1488752, 231610 (15.5%) were men and 1257142 (84.5%) were women. The study population consisted of adult men (20–54 years) and women (20–49 years) from all the states and union territories of India for whom valid anthropometric measurements were available in the NFHS datasets. Participants without height data or with incomplete height data were excluded from the analysis.

The pooled sample comprised participants from different geographical regions of India (i.e., North, Central, East, North-East, West, and South regions). State-wise analysis was also carried out to find the interstate variation in adult stature.

Variables Included

The primary outcome variable for the study was adult height measured in centimetres (cm). Height measurements were collected during NFHS surveys using standardized anthropometric procedures and calibrated measuring instruments by trained field investigators. Their height was measured using an adjustable wooden measuring board specially designed to provide accurate measurements (to the nearest 0.1 cm) of women and men in a field situation. The height of adults was measured with the Seca 213 stadiometer [12,13].

The following variables were included in the analysis:

- ☐ Region and state/union territory
- ☐ Sex (men and women)
- ☐ Height (cm)

Regional Classification

States and union territories were grouped into six geographical regions:

1. North: States include Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, Chandigarh, Uttarakhand.
 2. Central: Uttar Pradesh, Madhya Pradesh, Chattisgarh
 3. East: Bihar, Orissa, West Bengal, Jharkhand, Andaman, And Nicobar Island
 4. North East: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura
 5. West: Goa, Gujrat, Maharashtra, Daman and Diu, Dadar & Nagar
 6. South: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Lakshadweep, Puducherry, Telengana
- This classification was used to evaluate regional differences in mean adult height.

Statistical Analysis

Descriptive statistical analysis was performed to calculate mean height and standard deviation for men and women separately across states, regions, and NFHS rounds using IBM SPSS 20 [15]. Pooled analyses were conducted using combined data from all NFHS rounds to assess overall patterns.

Comparisons of mean height across regions and NFHS survey rounds were performed using inferential statistical tests. Statistical significance was assessed using p-values, with $p < 0.001$ considered statistically significant.

Temporal trends in height across NFHS rounds were evaluated to examine secular changes in adult stature over time. State-wise and regional comparisons were interpreted to identify geographical disparities and trends in anthropometric outcomes.

All results were presented as mean $\pm$ standard deviation (SD). Data were organized in tabular form for state-wise and regional interpretation.

RESULTS

Men

State wise outcome:

The state-wise analysis of pooled NFHS data demonstrated substantial variation in mean adult men height across India and across different NFHS survey rounds. Overall, the highest mean men height was observed in Punjab (167.6 ± 6.83 cm), followed by Haryana (167.0 ± 6.57 cm), Chandigarh (166.7 ± 7.23 cm), Kerala (166.3 ± 6.92 cm), and Jammu and Kashmir (166.0 ± 7.49 cm). In contrast, the lowest mean heights were reported in Meghalaya (158.7 ± 6.21 cm), Sikkim (159.9 ± 6.65 cm), Arunachal Pradesh (159.9 ± 6.37 cm), Tripura (160.8 ± 6.37 cm), and Ladakh (160.8 ± 7.02 cm). These

findings indicate a clear geographical variation, with northern states generally exhibiting greater average stature compared to eastern and north-eastern states (Table-1).

Across NFHS rounds, a gradual decline in mean men height was observed in several states. In Jammu and Kashmir, the mean height decreased from 167.0 ± 6.83 cm in the earlier NFHS round to 166.9 ± 7.22 cm and further to 164.0 ± 7.76 cm in the most recent round. Similar declining trends were observed in Uttar Pradesh, where the mean height reduced from 164.7 ± 6.42 cm to 163.7 ± 6.65 cm and subsequently to 162.7 ± 6.96 cm. Bihar also showed a decline from 163.7 ± 6.65 cm to 161.8 ± 7.01 cm and 161.5 ± 6.99 cm across successive NFHS rounds. (Table-1).

Northern states such as Punjab and Haryana consistently maintained higher mean heights across all survey rounds. Punjab showed only a slight reduction from 168.6 ± 6.83 cm to 167.6 ± 6.52 cm and 167.3 ± 7.12 cm, while Haryana demonstrated relatively stable values ranging between 168.1 ± 6.55 cm and 167.3 ± 6.95 cm. Kerala also maintained a consistently high mean stature across rounds, with minimal variation.

The north-eastern states generally demonstrated lower average heights and modest declines over time. For instance, Nagaland showed a reduction from 163.1 ± 6.08 cm to 161.4 ± 5.71 cm, while Tripura declined from 161.4 ± 6.03 cm to 159.8 ± 6.58 cm. Meghalaya consistently recorded the lowest mean height among all states across survey periods. (Table-1).

States from southern India such as Andhra Pradesh, Karnataka, Tamil Nadu, and Kerala showed relatively stable mean heights across NFHS rounds, with only marginal fluctuations. Andhra Pradesh declined slightly from 165.2 ± 6.73 cm to 163.6 ± 6.59 cm, while Tamil Nadu maintained values close to 164 cm throughout the survey periods. (Table-1).

Table 1: Distribution of Mean height (unweighted) of men (20-54 years) across various states

State	ALL NFHS		NFHS III		NFHS IV		NFHS V		p-value
	MEN (n=231610)								
	N	MEAN±SD	N	MEAN±SD	N	MEAN±SD	N	MEAN±SD	
Jammu and Kashmir	8259	166±7.49	779	167±6.83	4891	166.9±7.22	2589	164±7.76	<0.001
Himachal Pradesh	4054	165.6±6.75	815	165.5±6.80	2004	166.4±6.58	1235	164.3±6.80	<0.001
Punjab	6336	167.6±6.83	1034	168.6±6.83	2749	167.6±6.52	2553	167.3±7.12	<0.001
Chandigarh	172	166.7±7.23	-	-	93	166.8±7.11	79	166.5±7.41	<0.001
Uttarakhand	3615	164.5±6.53	734	164.9±6.20	1701	163.8±6.50	1180	165.2±6.68	<0.001
Haryana	6310	167±6.57	851	168.1±6.55	3002	166.5±6.19	2457	167.3±6.95	<0.001
NCT of Delhi	2435	165±6.85	763	165.5±6.53	419	164.3±6.29	1253	164.9±7.20	<0.001
Rajasthan	11383	165.7±6.71	1172	167.2±6.65	5168	166±6.82	5043	165±6.53	<0.001
Uttar Pradesh	28525	163.6±6.73	8253	164.7±6.42	11118	163.7±6.65	9154	162.7±6.96	<0.001
Bihar	9188	161.9±7.00	944	163.7±6.65	4675	161.8±7.01	3569	161.5±6.99	<0.001
Sikkim	1825	159.9±6.65	653	160.1±7.10	763	159.6±6.28	409	160.1±6.58	<0.001
Arunachal Pradesh	4789	159.9±6.37	556	161.5±6.15	1782	160.2±6.37	2451	159.3±6.35	<0.001
Nagaland	5626	162.6±6.07	3082	163.1±6.08	1264	162.4±6.23	1280	161.4±5.71	<0.001
Manipur	5749	163±5.93	3108	163.3±5.96	1634	162.8±5.85	1007	162.6±5.91	<0.001
Mizoram	2981	162.1±5.90	546	162.4±5.87	1489	162.2±5.68	946	162±6.24	<0.001
Tripura	2204	160.8±6.37	586	161.4±6.03	751	161.3±6.25	867	159.8±6.58	<0.001
Meghalaya	2915	158.7±6.21	481	158.1±6.41	976	158.9±6.82	1458	158.8±5.69	<0.001
Assam	8659	161.5±6.70	1019	163.2±6.74	3479	161.8±6.53	4161	160.9±6.74	<0.001
West Bengal	6949	162.3±6.58	2178	163.6±6.44	2254	162.1±6.35	2517	161.4±6.72	<0.001
Jharkhand	6791	161±6.79	749	162.9±6.41	3354	160.6±6.71	2688	160.9±6.90	<0.001
Orissa	8518	162.1±6.56	1268	163.1±6.31	3947	162.2±6.55	3303	161.7±6.62	<0.001
Chhattisgarh	7790	162.2±6.67	1115	163.4±6.21	3255	162.5±6.22	3420	161.6±7.15	<0.001
Madhya Pradesh	16332	164.6±6.78	2237	165.6±6.52	8563	164.5±6.78	5532	164.4±6.85	<0.001
Gujrat	10575	164.1±6.93	1161	165.5±6.62	4924	164.4±6.94	4490	163.3±6.90	<0.001
Daman & Diu	342	161.9±6.95	-	-	342	161.9±6.95	-	-	<0.001
Dadra & Nagar Haveli	170	160.8±7.24	-	-	170	160.8±7.24	-	-	<0.001
Maharashtra	15006	164.1±7.12	6589	165.3±6.72	3927	163.4±7.29	4490	162.9±7.26	<0.001

Andhra Pradesh	8148	164.8±6.78	5602	165.2±6.73	1268	164.3±6.99	1278	163.6±6.59	<0.001
Karnataka	11246	164±7.16	4166	165.1±6.80	3426	163.1±7.45	3654	163.7±7.12	<0.001
Goa	1932	164.5±7.05	942	164.7±6.77	730	164±7.04	260	165±7.96	<0.001
Lakshadweep	273	163±6.41	-	-	155	164.4±5.95	118	161.1±6.56	<0.001
Kerala	3946	166.3±6.92	934	166.3±6.86	1794	166.2±6.85	1218	166.2±7.07	<0.001
Tamil Nadu	12132	164.2±6.99	4727	164.7±6.58	4536	163.5±6.99	2869	164.4±7.54	<0.001
Puducherry	1055	164.7±7.14	-	-	600	163.8±7.08	455	165.8±7.05	<0.001
Andaman & Nicobar Islands	745	162.7±7.03	-	-	409	162.6±7.19	336	162.8±6.84	<0.001
Telangana	4020	163.3±7.18	-	-	894	164.6±6.69	3126	162.9±7.28	<0.001
Ladakh	273	160.8±7.02	-	-	-	-	273	160.8±7.02	<0.001
Daman & Diu and Dadar & Nagar Haveli	342	162.1±9.61	-	-	-	-	342	162.1±9.61	<0.001

Overall, the findings reveal persistent interstate disparities in adult men height in India. Northern states consistently exhibited taller populations, whereas eastern and north-eastern states recorded comparatively shorter average stature. The temporal decline observed in several states may reflect continuing nutritional inequalities, socioeconomic disparities, and variations in public health and living conditions across regions of the country.

Regional outcome:

Among all regions, men from the northern region had the highest mean height (166.0 ± 6.94 cm), followed by the western (164.1 ± 7.05 cm), southern (164.4 ± 7.05 cm), and central regions (163.7 ± 6.78 cm). The lowest mean height was observed among men from the eastern region (161.9 ± 6.77 cm), followed closely by the north-eastern region (161.4 ± 6.44 cm). The regional analysis of pooled NFHS data demonstrated significant differences in mean height among men across different regions of India ($p < 0.001$) (Table 2).

A comparison across NFHS rounds showed a gradual decline in mean men height in most regions over time. In the northern region, the mean height decreased from 166.8 ± 6.77 cm in NFHS III to 166.3 ± 6.80 cm in NFHS IV and further to 165.4 ± 7.11 cm in NFHS 5. Similarly, in the central region, the mean height declined from 164.7 ± 6.45 cm in NFHS-3 to 163.8 ± 6.67 cm in NFHS-4 and 163.0 ± 7.04 cm in NFHS-5 (Table 2).

In the eastern region, mean height showed a slight reduction from 163.4 ± 6.45 cm in NFHS-3 to 161.7 ± 6.75 cm in NFHS-4 and remained nearly stable at 161.4 ± 6.82 cm in NFHS-5. The north-eastern region also demonstrated a decreasing trend, with mean height reducing from 162.5 ± 6.33 cm in NFHS-3 to 161.4 ± 6.39 cm in NFHS-4 and 160.5 ± 6.43 cm in NFHS-5 (Table 2).

Among western states, the mean men height decreased marginally from 165.3 ± 6.72 cm in NFHS-3 to 163.9 ± 7.12 cm in NFHS-4 and 163.2 ± 7.12 cm in NFHS-5. In contrast, the southern region showed relatively stable mean height across survey rounds, with values of 165.1 ± 6.72 cm in NFHS-3, 164.0 ± 7.14 cm in NFHS-4, and 164.0 ± 7.26 cm in NFHS-5 (Table 2).

Table 2: Distribution of Mean height (unweighted) of men (20-54 years) across Indian Regions

	ALL NFHS		NFHS III		NFHS IV		NFHS V		p-value
Region	MEN (n=231610)								
	N	MEAN±SD	N	MEAN±SD	N	MEAN±SD	N	MEAN±SD	
North	42837	166±6.94	6148	166.8±6.77	20027	166.3±6.80	16662	165.4±7.11	<0.001
Central	52647	163.7±6.78	11605	164.7±6.45	22936	163.8±6.67	18106	163±7.04	<0.001
East	32191	161.9±6.77	5139	163.4±6.45	14639	161.7±6.75	12413	161.4±6.82	<0.001
North East	34748	161.4±6.44	10031	162.5±6.33	12138	161.4±6.39	12579	160.5±6.43	<0.001
West	28367	164.1±7.05	8692	165.3±6.72	10093	163.9±7.12	9582	163.2±7.12	<0.001
South	40820	164.4±7.05	15429	165.1±6.72	12673	164±7.14	12718	164±7.26	<0.001

Overall, the findings indicate significant regional disparities and temporal variations in men height across India, with northern populations consistently exhibiting greater average stature than eastern and north-eastern populations

Women

State wise outcome:

The state-wise analysis of pooled NFHS data among women revealed considerable variation in mean adult women height across India and across successive NFHS survey rounds. Overall, the highest mean women height was observed in Jammu

and Kashmir (155.6 ± 6.37 cm), followed by Punjab (155.2 ± 5.73 cm), Haryana (154.9 ± 5.78 cm), Kerala (154.6 ± 6.18 cm), and Rajasthan (154.7 ± 5.61 cm). In contrast, the lowest mean women heights were reported in Tripura (149.8 ± 5.70 cm), Bihar (149.9 ± 5.83 cm), Jharkhand (149.9 ± 5.56 cm), and Meghalaya (149.9 ± 5.63 cm). (table 2) These findings demonstrate clear geographical disparities, with northern states generally showing greater average women stature compared to eastern and some north-eastern states.

Several states showed a gradual increase in mean women height across NFHS rounds. In Jammu and Kashmir, the mean height increased consistently from 153.4 ± 5.77 cm in NFHS-2 to 154.4 ± 5.84 cm in NFHS-3, 155.3 ± 6.09 cm in NFHS-4 and 156.3 ± 6.68 cm in NFHS-5. Similar increasing trends were observed in Himachal Pradesh and Rajasthan which indicates progressive improvement in women stature over time (Table 3).

The average women's height remained relatively high in Punjab and Haryana in all survey rounds. Punjab: It increased from 154.5 ± 5.51 cm in NFHS-2 to 155.6 ± 5.50 cm in NFHS-4 and slightly decreased to 155.1 ± 5.93 cm in NFHS-5. The values in Haryana were comparatively stable and ranged from 154.4 ± 5.68 cm to 155.3 ± 5.58 cm in different periods of survey (Table 3).

In the eastern states, women were comparatively shorter in all the rounds of the survey. Uttar Pradesh had a marginal increase from 150.5 ± 5.75 cm in NFHS-2 to 151.0 ± 5.82 cm in NFHS-5. Bihar also showed little change with mean height increasing from 149.5 ± 5.67 cm to 150.0 ± 5.83 cm over survey rounds. Jharkhand and Tripura also showed a persistently low mean stature (Table 3).

Moderate variation was seen in the north-eastern states across survey rounds. Nagaland has recorded an increase in mean height from 151.8 ± 5.27 cm in NFHS-2 to 154.4 ± 5.24 cm in NFHS-5. Mizoram and Manipur have also shown relatively stable values around 152 cm. Meghalaya had always been lower in mean heights than rest of the north-eastern states (Table 3).

Among the southern states Kerala consistently showed one of the highest mean heights of women from 152.5 ± 5.80 cm in NFHS-2 to 155.0 ± 6.06 cm in NFHS-5. Gradual improvements were also observed in Tamil Nadu, Karnataka and Andhra Pradesh over the survey rounds. Mean height of women in NFHS-5 was relatively high in Lakshadweep (154.2 ± 6.25 cm) (Table 3)

Table 3: Distribution of Mean height (unweighted) of Women (20-49 years) across various states

State	ALL NFHS		NFHS II		NFHS III		NFHS IV		NFHS V		p-value
	WOMEN (n=1257142)										
	N	MEAN±SD	N	MEAN±SD	N	MEAN±SD	N	MEAN±SD	N	MEAN±SD	
Jammu and Kashmir	40827	155.6±6.37	2375	153.4±5.77	2351	154.4±5.84	18371	155.3±6.09	17730	156.3±6.68	<0.001
Himachal Pradesh	21942	154±5.65	2757	152.8±5.17	2501	153.8±5.55	8095	154.1±5.74	8589	154.3±5.70	<0.001
Punjab	38195	155.2±5.73	2473	154.5±5.51	2849	154.7±5.82	15924	155.6±5.50	16949	155.1±5.93	<0.001
Chandigarh	1085	153.2±6.17	-	-	-	-	548	153.1±6.14	537	153.3±6.21	<0.001
Uttarakhand	25479	153±5.64	-	-	2154	152.7±5.58	13168	152.8±5.56	10157	153.4±5.72	<0.001
Haryana	38322	154.9±5.78	2492	154.4±5.68	2077	155±5.88	16976	155.3±5.58	16777	154.5±5.94	<0.001
NCT of Delhi	16237	152.6±5.98	2049	152.5±5.93	2009	153.6±6.43	3892	152.4±5.91	8287	152.5±5.89	<0.001
Rajasthan	72232	154.7±5.61	5281	153.5±5.67	2885	154.5±5.99	31655	154.5±5.57	32411	155±5.57	<0.001
Uttar Pradesh	149703	151±5.79	5257	150.5±5.75	7946	151.2±5.75	69786	150.9±5.77	66714	151±5.82	<0.001
Bihar	70184	149.9±5.83	5483	149.5±5.67	2569	150.6±5.60	32576	149.9±5.87	29556	150±5.83	<0.001
Sikkim	9449	152.3±5.55	905	150.1±5.57	1565	151.3±5.61	4263	153.1±5.08	2716	152.4±5.93	<0.001
Arunachal Pradesh	27963	151.3±5.43	-	-	1173	150.9±6.47	11099	151.3±5.55	15691	151.4±5.35	<0.001
Nagaland	19658	153.5±5.29	649	151.8±5.27	2841	152.9±5.57	8366	153±5.11	7802	154.4±5.24	<0.001
Manipur	21976	152±5.08	1244	151.5±5.26	3405	152±5.11	10849	152±5.14	6478	152±4.94	<0.001
Mizoram	17966	152.2±5.07	904	151.7±5.40	1395	151.7±5.12	9752	152.3±5.04	5915	152.4±5.05	<0.001

Tripura	1213 9	149.8±5. 70	922	149.3±5. 85	141 2	149.7±5. 77	387 2	149.5±5. 64	593 3	150±5.69	<0.0 01
Meghalay a	1834 6	149.9±5. 63	651	150.9±8. 09	144 3	149.4±5. 62	662 9	149.2±5. 50	962 3	150.4±5. 45	<0.0 01
Assam	5577 3	150.8±5. 70	276 9	150.1±5. 44	285 3	150.6±5. 68	224 01	150.9±5. 73	277 50	150.9±5. 70	<0.0 01
West Bengal	3981 5	150.7±5. 68	368 8	150.3±5. 87	524 6	151.2±5. 56	138 48	150.7±5. 64	170 33	150.6±5. 69	<0.0 01
Jharkhand	4394 1	149.9±5. 56	-	-	205 4	150.2±5. 49	219 28	149.9±5. 38	199 59	150±5.75	<0.0 01
Orissa	5658 7	150.7±5. 61	378 7	150.6±5. 45	341 7	151±5.43	266 91	150.8±5. 63	226 92	150.7±5. 64	<0.0 01
Chhattisga rh	4393 2	151.4±5. 68	-	-	280 1	151.4±5. 70	192 51	151.4±5. 21	218 80	151.4±6. 06	<0.0 01
Madhya Pradesh	9396 8	152.4±5. 67	543 5	151.8±5. 49	489 9	152.9±5. 71	476 95	152.2±5. 64	359 39	152.7±5. 73	<0.0 01
Gujrat	5055 9	152.7±5. 87	325 4	151.9±5. 61	287 5	152.6±5. 79	179 46	152.7±5. 91	264 84	152.9±5. 88	<0.0 01
Daman & Diu	1095	152.9±6. 04	-	-	-	-	109 5	152.9±6. 04	-	-	<0.0 01
Dadra & Nagar Haveli	625	151.4±5. 22	-	-	-	-	625	151.4±5. 22	-	-	<0.0 01
Maharasht ra	6099 0	152.1±5. 84	450 3	151.6±5. 61	646 3	151.9±5. 85	231 46	151.9±5. 64	268 78	152.4±6. 03	<0.0 01
Andhra Pradesh	2607 7	152.1±5. 87	341 9	151.2±5. 59	535 3	152.1±5. 91	823 8	152±5.62	906 7	152.5±6. 12	<0.0 01
Karnataka	5320 6	152.5±5. 99	360 7	151.9±5. 59	433 3	152.6±6. 03	210 54	152.7±5. 90	242 12	152.5±6. 11	<0.0 01
Goa	6951	152.6±6. 15	113 6	151.8±6. 04	273 6	152.4±6. 32	142 1	152.5±6. 07	165 8	153.5±5. 90	<0.0 01
Lakshadw eep	1881	153.5±5. 90	-	-	-	-	894	152.7±5. 39	987	154.2±6. 25	<0.0 01
Kerala	2349 2	154.6±6. 18	256 4	152.5±5. 80	288 6	152.9±6. 19	912 9	155.2±6. 18	891 3	155±6.06	<0.0 01
Tamil Nadu	5374 6	152.6±6. 07	414 7	151.5±5. 63	480 7	152.4±6. 16	237 67	152.6±5. 89	210 25	153±6.29	<0.0 01
Puducherr y	6335	154.2±6. 17	-	-	-	-	330 5	153.6±5. 77	303 0	154.8±6. 51	<0.0 01
Andaman & Nicobar Islands	4375	153.7±6. 12	-	-	-	-	232 0	154±6.54	205 5	153.4±5. 59	<0.0 01
Telengana	2809 7	151.6±6. 23	-	-	-	-	590 9	151.8±5. 96	221 88	151.5±6. 30	<0.0 01
Ladakh	1842	154.3±6. 86	-	-	-	-	-	-	184 2	154.3±6. 86	<0.0 01
Daman & Diu and Dadar & Nagar Haveli	2152	152.4±7. 23	-	-	-	-	-	-	215 2	152.4±7. 23	<0.0 01

Overall, our results suggest persistent interstate differences in women height in India. In general, northern and southern states had taller women populations, while eastern states consistently had lower mean stature. The gradual improvement in height over NFHS rounds observed in a few states

Regional outcome:

Analysis of pooled NFHS data among women revealed significant regional differences in mean height across India ($p < 0.001$). Overall, women from the northern region had the highest mean height (154.6 ± 5.89 cm), whereas women from the eastern region had the lowest mean height (150.4 ± 5.73 cm). Women from the southern and western regions also exhibited comparatively higher mean stature than those from the central and north-eastern regions (Table 4).

Across NFHS rounds, variations in mean women height were observed in all regions. In the northern region, the mean height increased progressively from 153.6 ± 5.66 cm in NFHS-2 to 154.1 ± 5.91 cm in NFHS-3, 154.6 ± 5.76 cm in NFHS-4, and 154.7 ± 6.02 cm in NFHS-5, indicating a gradual improvement in stature over time. A similar increasing trend was

observed in the southern region, where mean height rise from 151.7 ± 5.66 cm in NFHS-2 to 152.4 ± 6.06 cm in NFHS-3 and further to 152.9 ± 5.97 cm in NFHS-4, remaining relatively stable at 152.7 ± 6.30 cm in NFHS-5 (Table 4). In the central region, mean women height remained relatively stable across survey rounds, increasing slightly from 151.2 ± 5.66 cm in NFHS-2 to 151.8 ± 5.78 cm in NFHS-3, followed by a marginal decline to 151.5 ± 5.68 cm in NFHS-4 and NFHS-5. Women from the eastern region consistently recorded the lowest mean heights across all NFHS rounds, although a small improvement was observed from 150.1 ± 5.68 cm in NFHS-2 to 150.9 ± 5.53 cm in NFHS-3. Subsequently, the mean height declined slightly to 150.4 ± 5.73 cm in NFHS-4 and 150.3 ± 5.77 cm in NFHS-5 (Table 4). In the north-eastern region, mean women height increased from 150.6 ± 5.78 cm in NFHS-2 to 151.3 ± 5.58 cm in NFHS-3 and remained nearly stable thereafter. Similarly, the western region demonstrated a gradual increase in mean height from 151.7 ± 5.67 cm in NFHS-2 to 152.2 ± 5.95 cm in NFHS-3 and 152.6 ± 6.01 cm in NFHS-5 (Table 4).

Table 4: Distribution of Mean height (unweighted) of Women (20–49 years) across Indian Regions

	ALL NFHS		NFHS II		NFHS III		NFHS IV		NFHS V		p- valu e
Regi on	WOMEN (n=1257142)										
	N	MEAN± SD	N	MEAN± SD	N	MEAN± SD	N	MEAN± SD	N	MEAN± SD	
North	2561 61	154.6±5. 89	1742 7	153.6±5. 66	1682 6	154.1±5. 91	1086 29	154.6±5. 76	1132 79	154.7±6. 02	<0.0 01
Centr al	2876 03	151.5±5. 77	1069 2	151.2±5. 66	1564 6	151.8±5. 78	1367 32	151.5±5. 68	1245 33	151.5±5. 88	<0.0 01
East	2149 02	150.4±5. 73	1295 8	150.1±5. 68	1328 6	150.9±5. 53	9736 3	150.4±5. 73	9129 5	150.3±5. 77	<0.0 01
North East	1832 70	151.4±5. 57	8044	150.6±5. 78	1608 7	151.3±5. 58	7723 1	151.4±5. 53	8190 8	151.4±5. 58	<0.0 01
West	1223 72	152.4±5. 91	8893	151.7±5. 67	1207 4	152.2±5. 95	4423 3	152.2±5. 79	5717 2	152.6±6. 01	<0.0 01
South	1928 34	152.7±6. 12	1373 7	151.7±5. 66	1737 9	152.4±6. 06	7229 6	152.9±5. 97	8942 2	152.7±6. 30	<0.0 01

These results indicate persistent regional differences in women height in India. Higher average heights were always observed in the northern and southern regions and lower values were observed in the eastern and central regions. The time trends show moderate increases in women height in some regions which may reflect improved nutrition, access to healthcare, maternal health and socioeconomic development over time. However, the continuing lower mean stature in eastern and some central regions points to continuing inequalities in nutritional and health outcomes for women in India.

DISCUSSION

The present study analysed adult height patterns across India from multiple rounds of the National Family Health Survey (NFHS). The findings revealed significant regional and interstate variations in mean adult height among both men and women, with statistically significant differences observed across regions and survey rounds ($p < 0.001$).

One of the major findings of the study was the consistent regional difference in adult stature. Northern states such as Punjab, Haryana, Jammu and Kashmir, and Himachal Pradesh exhibited the highest mean heights among both men and women, whereas eastern and several north-eastern states including Bihar, Jharkhand, Meghalaya, and Tripura showed comparatively lower mean heights.

The mean height obtained in the present study for Indian men and women is in close agreement with the findings reported by Mamidi et al. (2011). They analyzed data from NFHS-3 and reported that the mean height of Indian men and women was about 165 cm and 152 cm, respectively. The current findings are also supported by the study reporting a considerable variation among the states with a higher average stature in Punjab and Haryana and lower stature in the eastern states [9]. The findings from the present study are largely in agreement with previous national and regional studies using NFHS data reporting large variation in adult height across India, by state and region. Similar to the present analysis, the earlier studies have also consistently reported that the people of the northern states such as Punjab, Haryana and Jammu and Kashmir are taller, whereas the eastern states such as Bihar and Jharkhand and several north-eastern states have comparatively lower mean stature [7,9].

The present study also showed that northern populations had a consistently higher average stature across all NFHS rounds. The finding is in line with the results of the Longitudinal Aging Study in India (LASI), which found that people from Punjab were taller than those from other states, suggesting the role of regional differences in nutrition, education, and living conditions [16].

The present study found an important finding the stagnation or decline in men height in several states across NFHS rounds, especially in Uttar Pradesh, Bihar, Assam and Tripura. Choudhary et al. (2021) similarly observed only marginal improvements or even decline in adult height among certain population groups between NFHS-2 and NFHS-4. Despite rapid economic growth, secular gains in adult stature have been limited in India, they conclude [7]. The present analysis builds on the above observations by incorporating the NFHS-5 data and further establishing that such regional disparities still exist.

The gradual improvement in women height observed in the states of Jammu and Kashmir, Rajasthan, Kerala and Punjab also corroborates with earlier studies which reported modest secular increases in women stature over time. Mamidi et al.

reported a small secular trend in adult height of about 0.22 cm per decade in women and 0.50 cm per decade in men in India [9]. But the present study indicates that these gains are still unevenly distributed across regions and states. The better relative performance of southern states especially Kerala and Tamil Nadu is in line with previous evidence suggesting that better literacy, maternal health, nutrition awareness and public health infrastructure have positive effects on growth outcomes. Studies examining secular growth trends in rural India have similarly reported that improvements in socioeconomic and nutritional conditions are associated with better height outcomes over generations [17]. The lower mean heights observed in eastern states such as Bihar, Jharkhand, and Uttar Pradesh are also supported by previous literature linking poor growth outcomes with chronic undernutrition, poverty, recurrent infections, poor sanitation, and limited healthcare access. Choudhary et al. and Mamidi et al. both emphasized that socioeconomic inequality and dietary inadequacy remain important determinants of adult stature in India [7,9]. The present findings also correspond with international evidence showing that adult height is strongly influenced by environmental and socioeconomic conditions in addition to genetic factors [18]. Studies from other developing countries have shown positive secular trends in height associated with urbanization, improved education, and better nutritional status [19-21]. However, compared with several developing nations experiencing rapid increases in adult height, the secular improvement observed in India appears relatively modest, suggesting persistent inequalities in nutritional and health transitions.

CONCLUSION

The present findings are consistent with the existing evidence on the trends of adult height in India when compared with the earlier studies. The study reaffirms that large regional differences in stature persist, and notes that gains in adult height over time have been slow and uneven among states. The findings point to the need for continued policy attention to maternal and child nutrition, food security, sanitation, education and equitable access to health services in order to reduce the continuing regional disparities in growth and development.

LIMITATIONS

There are some limitations in the present study that need to be considered in the interpretation of the results. As the study was based on secondary analysis of cross-sectional NFHS data, causal relationships between adult height and socioeconomic or environmental factors could not be established.

Second, the analysis was mostly descriptive comparing mean height across states, regions and NFHS rounds and did not account for adjustment for possible confounding factors like age, socio-economic status, education, dietary intake, rural-urban residence, ethnicity or physical activity, all of which may influence adult height.

Third, NFHS uses standardized anthropometric measurement procedures but cannot completely rule out measurement error and inter-observer variation due to the large scale of the surveys.

Author Contributions:

The authors confirm contribution to the paper as follows: SK data collection, analysis and interpretation of results, draft manuscript; APS study conception, analysis and interpretation of results, supervision and final editing. All authors reviewed the results and approved the final version of the manuscript.

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Declarations

Competing interests: All authors declare that they have no competing interest

Ethical Considerations

The study utilized publicly available secondary data from NFHS surveys. Ethical approval for NFHS surveys had been obtained by the original survey agencies prior to data collection. Since the present study involved secondary analysis of anonymized data, no additional ethical clearance was required.

Consent to Participate: Not applicable

Consent for Publication: Not applicable

Data Availability: All data used in this analysis can be downloaded directly from the DHS program (after registration) at: <https://dhsprogram.com/data/available-datasets.cfm>.

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