Socio-Economic Characteristics of the Tall and not so Tall Women of India

Brinda Viswanathan
Associate Professor, Madras School of Economics,
Email : brinda@mse.ac.in

and

Viney Sharma
Short Term Consultant, South Asia Social Protection Unit,
World Bank, New Delhi
Email: viney.shar@gmail.com

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MADRAS SCHOOL OF ECONOMICS
Gandhi Mandapam Road
Chennai 600 025
India

Phone: 2230 0304/ 2230 0307/2235 2157
Fax : 2235 4847 /2235 2155
Email : info@mse.ac.in
Website: www.mse.ac.in

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Abstract

New studies are increasingly appearing based on historical data across the world that better socio-economic status is associated with taller men and women. This study based on a recent Indian data analyses the variations in height among adult women. The main findings show that regional level differences in mean heights are prominent and contiguous regions show similar mean heights after controlling for socio-economic differences. Women from weaker socio-economic groups are shorter and so are women in rural areas though the rural-urban gap disappears after controlling for socio-economic variations. Women who have had at least one child during teenage have lower average heights but this difference is not statistically significant once differences in education are accounted for.

Keywords: Height, anthropometry, gender, education, poverty, India

JEL codes: J11, J16, I31, R11, R29

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1. INTRODUCTION

Adult heights are a useful indicator of well-being and unlike many other indicators is not only easy to measure but also captures well-being at the individual level. Several studies based on developed country data has shown that taller men and women tend to live longer and that adult heights have increased over time with the improvements in broad indicators of economic development like per capita GDP. There are exceptions like Africa where average heights are higher than in several other developing countries but so are the mortality rates. South Asia is another exception where mortality rates have declined over the decades and growth rates in per capita GDP have increased when compared to Africa but heights of women is improving more slowly than heights of men. Though no clear evidence has yet emerged on the reasons for these exceptions but point towards extreme deprivations and gender discrimination prevailing in Africa and South Asia respectively. Despite this exception in a broader international comparison, with the availability of more data from these regions, studies show that taller heights are associated with better social and economic conditions.

One of the commonly used measures of nutritional status is the body mass index (BMI) of adults which is the ratio of body weight (in kilogram) to squared height (in meter). BMI has been found to be mainly a function of body weight which can change in a shorter term due to inadequate or excess food intake on the one hand and changes in bodily physical activity on the other hand. In this sense BMI (and hence adult weights) is considered as a short-term measure of nutritional status as it can vary within a short period of time. The second commonly

[1] An individual is considered to be of normal nutritional status if the BMI value lies between 18.5 and 23. Those below the lower reference value are called chronically energy deficient (CED) and are undernourished while those above the upper reference value are considered malnourished due to overweight and obesity (BMI above 32).

used measure of nutritional status is adult height which is a long-term indicator as height reflects the net gain in nutrition over the growth period and cannot be altered in the later stages of growth. In this sense heights once attained by the age of 20 years do not change until the age of 40-45 years after which physical changes due to old age results in a 'decline'. Between weight and height, the latter is known to be more influenced by genetic factors as inherited from the parents. Despite the influence of genetic factors, average height attained by a population group can also change over time (with varying rates) due to factors that affect growth in childhood as well as the economic development of the region[2] . The changes in heights are more prominent over longer periods of time that is, from one generation to the next or in time gaps of usually a quarter of a century.

Nutritional status is broadly influenced by the food intakes consisting of a balanced diet needed at different stages of growth. There are several factors which influence quantity and quality of food intake as well as its absorption by the body. The economic, social and demographic characteristics of the households influence the awareness to a balanced diet as well as its affordability. Environmental conditions which include physical infrastructure like water and sanitation affect the morbidity rates and hence the ability to retain the nutrients in the body. The level of economic development of a country (or region) and the public policies influence access to well-balanced diets, and to physical and social infrastructure. Studies also show that regions with better nutritional status have higher agricultural productivity and labour incomes, indicating a causal link from individual health status to economic outcomes.

[2] While summarising the findings from several studies, Moradi and Guntupall (forthcoming), highlights that though adult heights are influenced by 'genetic, environmental and socioeco nomic factors during the growth period' but 'under circumstances of deprivation taller parents may produce a stunted child'

Studies on assessment of nutritional status based on adult heights are rare for developing countries due to paucity of data which has to be collected over a long period of time. Since the last two waves of demographic and health survey the information is now available across several developing countries (including India) on heights of women with the most recent survey having collected data also on heights of men. This study explores the changes in heights of adult women in India based on age cohorts. The study further assesses if there exists any systematic variation in heights across the economically and socially deprived sections of the population in the age group of 20 to 40 years. Section 2 discusses the recent studies on India that have carried out a similar analysis. Section 3 is on the database used and methodology of this study, Section 4 presents the findings and Section 5 concludes the study.

2. TREND AND VARIATIONS IN ADULT HEIGHTS IN INDIA

There has been a remarkable improvement in adult heights in particular in the 20th century in the developed nations. This change seems to be strongly influenced by the increased availability of food, scientific developments in the control of diseases and health care delivery systems, better environmental conditions and the level of income as measured by GDP (Fogel, 2004; Deaton, 2006; Baten, 2008; and Moradi and Guntupalli, forthcoming). Limited empirical evidence suggests that growth patterns and in particular, height distribution of affluent children in India are no different from children in United Kingdom and United States (Fogel, 2004)[3]. In recent times, the newly industrialised countries have been able to achieve the standards of adult heights similar to the developed nations in a much shorter span of time due to the influence of

[3] As Fogel argues that this only shows that 'environmental constraints' on children growing up in different parts of the world are similar to produce similar heights. However this neither indicates that the genetic potential of the population groups are similar nor does it indicate that using British and American standards is appropriate.

economic and environmental factors (Baten, 2008). Inter and intra regional variations in average heights are observed to be associated with variations in socio-economic status (Brennan, et. al, 1995 and 2005; Guntupalli and Baten, 2006).

Brennan, et. al, (1994) is among the more recent studies on India that evaluates the variations in height across social classes who belonged to the currently eastern districts of Uttar Pradesh and north - western districts of Bihar. The data used is rather historical - of men and women arriving in Fiji as indentured workers from Calcutta between 1876 and 1916, born between the years 1840-1894[4]. A preliminary analysis of the data showed that average heights of men and women from 'high caste Hindus' and 'Superior Sudras' were greater than the 'Inferior Sudras', untouchables, Muslims and tribals. The variation in heights across Hindu castes was lower among women than men. The men and women from Uttar Pradesh were taller than from Bihar. They observe an increase in heights among those born between 1840 and 1870 and a decline in heights for those born later than 1875. The changes are attributed to better economic conditions due to lesser famines in the earlier period while the later period also included higher incidence of cholera.

Based on 2nd National Family Health Survey (henceforth NFHS-2) for the year 1998-99 mean height attained by women in India who had one or more child between the age of 12 and 19 years happened to be about 1-2 cm shorter than those who had the first child after 20 years of age (Brennan et al., 2005). Thus one finds that apart from

[4] The archives in Fiji included information on heights, sex, age, region of origin and social status as identified by caste, tribe and religion. Among several biases associated with this data, one of the expected ones given their indentured status is that they were from the lower socio-economic strata of their region of origin. However, since they were taken to perform manual labour they could not have been very weak physically. Further several cross-checks of the data as discussed in the study show that it was reliable enough to carry out a reasonable analysis.

regional level and social differences, final adult heights are also influenced by shocks during the later stages of growth.

The regional variation in heights among Indians is highlighted in the study by Guntupalli and Baten (2006) based on the all India anthropometric studies carried out in 1960. The analysis (based on this data) covered 10 states in northern, western and eastern India for men aged 20-49 years. North Indian men were among the tallest while east Indians were the shortest; similarly Sikhs were taller than the next tallest group, the upper castes by about 0.6 cms while the scheduled tribes were the shortest with an average height of about 161 cm. More noteworthy is the finding that the trend in average height for the Sikhs followed an inverted 'U' shape over this period: 166 cm in 1915, peaking to 172 cm in 1935 and then declining to 169 cm by 1940. On the other hand average heights for scheduled tribes shows a secular increase starting from a little above 160 cm to 162 cm while all other upper castes (though taller than the tribes) show very small improvement in heights during this period. Though the Sikh sample size was much smaller, the upward increase in heights of the Sikhs (as argued in their study) could be due to more liberalized trade regimes in the early 1920s and lower grain prices in the 1930s. Once these 'advantages' ceased the heights also seem to have declined. Men in occupations with better social and economic status had a height advantage in all the states. After controlling for regional factors, landholders, professionals and traders were among the tallest while agricultural labourers, weavers, potters and leather workers were among the shortest. The plausible reason for positive association of heights with better occupations is better nutritional intakes among these households with strong hereditary linkage to occupations.

In a comparison of adult heights across different geographic regions, it is found that India along with Bangladesh and Nepal has the

shortest women across all age cohorts (Deaton, 2007). The average heights of South Asian women was about 151 cm in the 1950s while that of the richer nations in the west range between 161-163 cm. Further, average heights of Indian women have improved marginally with recently born being taller with lower standard deviation.

Bhalotra (2007) also finds regional variations in heights. She finds significant impact of age and socio-economic conditions prevailing in the state during year of birth on heights of adult Indian women. On average, height at maturity of Indian women grew by 0.8 cm between 1950 and 1965 but stagnated for the cohorts born in 1965-1975. Based on NFHS-2 data, this study also shows that most states have changes similar to the country-average, with the exception of Kerala, showing a secular increase in heights while Punjab and Haryana, experience a decline though they start off as the tallest women. As for the determinants of this change, both between and within-state variation in height is inversely correlated with infant mortality rates. Per capita income of the state (of residence) during the year of birth of the woman is more strongly associated with adult height across states than within states.

Apart from the broad indicators of social and economic status a few studies have also analysed the impact of specific shocks on heights. Based on NFHS-2 data for women aged 15-49 years Pathania (2007) shows that in arid areas (where agriculture is rainfall dependent), women who were born in the year following the drought, are shorter by about 0.33 cm. However, when all agro-climatic regions are included with control factors for caste, religion and year of birth there is no significant (statistically) effect of drought on heights. There are of course two somewhat strange finding of this study: when no other explanatory variables are included heights increase in the year of drought and the year after the drought.

Similarly heights of scheduled tribe women in the arid regions born after a year of the drought are taller while the caste and drought interaction variables are not significant for all other castes.

Ghosh (2008) assesses impact of a positive shock like the land reforms laws on height. This study is also based on the NFHS-2 data for rural women between the age of 18 and 49 years. Land reform (measured in four different ways) is captured by a dummy variable which takes a value one if the woman was exposed to it before the age of 18. This study shows that land ceiling legislations led to increase in height of around 3.3 cm for cohorts experiencing such reforms before age 18. A more interesting find is that the impact on heights did not vary with the age at which the women were exposed to it. In a way the findings from this study seems to be in variance to the general findings that adult heights are influenced by interventions in early childhood. At the same time the results can also be considered a positive finding for policy intervention. That is, changes in economic opportunities even at older ages of child growth can influence final adult heights.

Deaton (2008) combines the information on adult heights from NFHS-3 and per capita consumption expenditure from the National Sample Survey (NSS) and finds that log of per capita expenditure (lnpce) has positive and significant effects on heights and more so for women than men. However, conditional on the standard of living (lnpce) inequality in per capita expenditure had an inverse effect that is regions with higher inequality have taller people. This study also highlights sexual dimorphism - men having grown taller than women over a period of 30 years though younger cohorts among both men and women are taller[5].

[5] In biological theory sexual dimorphism means that males are relatively larger in species that are relatively more polygamous as males become larger in response to the need to compete with other males for female partner (Deaton, 2008).

Moradi and Guntupalli (forthcoming) is a more detailed study on the gender gaps in height changes over time based on the rarely used National Nutrition Monitoring Bureau (NNMB) data. Five-year grouped data of men and women aged 20 to 50 years born between 1930 and 1975 for rural India in the seven select states forms the data base[6]. The sample shows that Kerala and Maharashtra are the two states where dimorphism decline for all the age-cohorts while in Orissa, it is increasing for all age cohorts. In all other states the gender gaps in heights vary from time-time. Gender dimorphism is measured as the mean difference in heights as a proportion of male heights. This variable is significantly affected by the state's developmental expenditures (rather than the state's per capita domestic product) and the rainfall rate in the monsoon months. Higher rice yields and volatility in rainfall seems to increase dimorphism.

Sharma (2008) shows the effect of various socio-economic factors on adult female heights for four states Punjab, Gujarat, Bihar and Tamilnadu and compared with all India; based on NFHS-3 data for women born between 1957 and 1991. This study is one of the few comparing rural and urban areas. As in other studies, the mean heights increase over the years and that the average height of the last decade of the cohorts is more than the first decade of cohorts by 0.5 cm. The results show that for all India and in the states of Tamilnadu and Gujarat, adult female heights for urban, first order stochastically dominates rural heights. In the state of Punjab rural female heights stochastically dominates the urban heights while in the state of Bihar no obvious ranking emerges as the cumulative distribution functions are very 'close'. The height of women who bear children before the age of 17 is stochastically dominated by the height of women who bear children at a later age. Richest adult-

[6] The information is available for a much longer duration so that data contains heights of women aged 30-35 years born in either of the years: 1945, 1955 or 1965 as the survey data is available for 1975-79, 1988-90 and 1996-97.

women are found to be at least 3 cm taller than the poorest for all India and in the state of Bihar and Tamilnadu. In the other two states also the difference is more than 2 cm. The regression results which include other control variables shows that statistically rural heights are more than the urban heights for all India and the states of Punjab and Gujarat. Further, at all India level Hindu adult women are shorter than non Hindu adult women by 0.67 cm, and women with higher education are 1.5 cm taller than uneducated ones at all India level while in Tamilnadu the difference is 2.91 cm.

The rural urban differences for men using the NFHS-3 data are analysed in Viswanathan (2008a). For all India, urban men are taller than rural men and though both show an increase in heights over time urban heights have improved faster resulting in an increase in gap between rural and urban heights. However, in Punjab there is not much difference between rural and urban heights and these do not change over time. In Bihar the urban heights increase much slower than rural so that a catching up effect appears. For both Gujarat and Tamil Nadu the gap in heights between rural and urban is increasing with a larger observed gap between rural and urban areas in Tamil Nadu. As in Sharma (2008) for women, the regression results here show that if the person is residing in rural area then he is taller than his urban counterpart. However, the coefficient of rural dummy variable is negative till the point when wealth variables are introduced in the regression model. There is a gradation in heights across wealth categories: in comparison with the 'middle' category, the poorest are shorter by about 0.96 cm, the poor by 0.34, while the rich are taller by 0.82 cm and richest by 2.2 cm. The magnitude of the differences in heights across states is quite substantial compared to most other socio-economic variables.

Viswanathan (2008b) further explores the rural-urban differences in the states of Punjab and Tamil Nadu for women in the age

of 20-40 years using the same NFHS-3 data. Probability density functions (PDFs) of SCST women in Tamil Nadu and Punjab are compared with those of other caste women in rural and urban areas separately. PDF of average heights of SCST is leftward in both the states only in rural areas. Further, the 'other' castes in Tamil Nadu have a very similar distribution as the SCST of Punjab and this could be because average heights in Tamil Nadu are lower than that in Punjab. The urban picture is very different from rural in that the density functions for 'others' in both the states are very similar. The gap of SCST women with others is lower in the case of Punjab and higher for Tamil Nadu, though not as large as in the rural areas. Similar results are also reported when the women in 'poorest' wealth categories are compared with the 'richest' wealth categories in the two states separately for rural and urban areas. This study discusses in detail the impact of education in explaining the variations in heights. Once education is controlled for, the magnitude of the dummy coefficients for caste and wealth status comes down in rural areas of Tamil Nadu and the effect of age on heights disappears when education is controlled for, in urban Tamil Nadu. This reflects that over time education has improved which has had an impact on the nutritional status and the age coefficient was capturing the effect of 'development'. In urban areas the dummy coefficients for caste shows a similar result as in rural but the wealth coefficients are not significant anymore that is, education seems to plays a major role in eliminating the effect of wealth. If a woman belonged to a (natal) household where education of the girl child was given some importance, then childhood deprivations are likely to be lesser but this advantage seems to be prominent only in the case of the current urban residents which may be a reflection of the average educational attainment being lower in rural areas.

Most studies discussed above relate differences in heights to social and economic status as well as the determinants that affect the changes in heights. A relatively rare study in India links the differentials in wage earnings of coal miners to differences in heights (Dinda et. al, 2006). Men who are taller earn about 6-13% more and those who are shorter earn 3-5% less when compared to those within the range of reference height (155.0–164.99 cm).

3. OBJECTIVE, DATABASE AND METHODOLOGY OF THE STUDY

Thus the recent and historical evidence illustrates that there is a relationship between heights and socio-economic status as well as economic fluctuations. This study is an attempt to explore this linkage further based on the NFHS-3 data with a focus on inter-regional variations in adult heights for women. By focussing on women we are perhaps looking at the lower bound of the nutritional status in the Indian society as their height is more likely to be sensitive to any changes in the variable affecting it (Borooah 2004; Sahn and Younger, 2008).

The unit level data from the 3rd national family health survey for 2005-06 (henceforth NFHS-3) is used for the analysis. The data covers all states of India as well as both rural and urban areas for women aged 15-49 years.

A preliminary analysis is carried out for a comparison of mean heights across age cohorts, separately for rural and urban areas and for each state and union territory for which data is provided by NFHS-3. The analysis is expanded further using individual heights to understand the variations in height of women in India. Adult height of a woman is usually achieved by late teens and after the age of 40 years there is some shrinkage with age due to stooping of backbone. Hence the final analysis focuses on variations in adult height for women aged 20 and 40 years. Within this age-group also heights are likely to decline with age and

typically interpreted as a cohort effect. Later born people in a growing economy, experience better nutritional and epidemiological environments in childhood as well as better access to health care, and hence are likely to be taller.

4. VARIATIONS IN HEIGHTS OF INDIAN WOMEN: GEOGRAPHY AND SOCIO-ECONOMIC STATUS

4.1 Variations in mean height: graphical analysis

A graphical analysis of average heights of the cohorts against their year of birth is shown in Figure 1. For all India urban heights are above rural heights over the entire period and there is an increase in heights among urban than rural. At the state level there are variations which can be typecast into following groups:

(a) In Haryana and Punjab rural heights are more than urban for almost the entire time-period. There is also no visible trend in heights.

(b) In the following states urban heights improved compared to the rural after some time point (year of birth) – Tamil Nadu and Uttar Pradesh in sixties; Bihar, Chattisgarh, Jharkhand and Maharshtra in mid seventies; Himachal Pradesh, Jammu and Kashmir, Karnataka, Madhya Pradesh, Kerala, and Orissa in mid eighties.

(c) In Assam and West Bengal, urban heights are more than rural for most of the times.

(d) In Andhra Pradesh, Gujarat, Rajasthan and Uttaranchal rural and urban heights do not appear different. But with the exception of Rajasthan in all these states there is a small upward trend in heights.

Another feature to be noted is the variation in the range of heights that is women in Punjab are taller than women in Orissa and so on.

The rural-urban difference is similar to that in Sharma (2008) only for Punjab due to the difference in the methodology used for comparing. In this study rural - urban comparison is based on each age cohort while in that study the cumulative density functions are compared for rural and urban by pooling all the women born between the age of 20 and 40 years.

4.2 Variations in age-specific heights: econometric analysis

The graphical analysis sets the benchmark to further explore the changes in average heights across year of birth for each state as well as the rural - urban comparisons. The econometric model used for this purpose is as follows:

$$h_t = \beta_0+\beta_1 (age_t)+\beta_2 (drur_t)+ \beta_3 (drur\_age_t)+\varepsilon_t \quad t= 1956,...,1991. \quad (1)$$

The dependent variable h_t is the average height of all those women born in the t^{th} year, age_t is their age during the time of survey and a statistically significant negative coefficient attached to it indicates improvements in average heights over the time; drurt is the dummy variable for rural residence at the time of survey and the associated coefficient (if significant) captures current difference in average heights in rural areas when compared to urban and $drur\_age_t$ is the interaction of rural dummy variable with age - if significant ascertains that changes in heights in rural areas are different from that in urban. This analysis is carried out for all India and separately for the 20 states mostly large states of India. The list of states used in this analysis is indicated in Table 1 and in Appendix Table A1.

Since heights are known to be associated with better living conditions so one expects women in urban areas to be an on average taller than rural areas due to better access to social and physical

infrastructure in urban areas. However we only know the current residence of a particular women and not of her early childhood. In this sense there are two cautionary remarks while making a rural-urban distinction in the population particularly over time:

(a) While carrying out this analysis one must keep in mind that the process of urbanisation itself is not static and that large parts of the currently urban areas would have been rural in the earlier years. Given this, we may not expect a significant difference in heights between rural and urban residents among older women than among the younger ones who may have either grown up entirely in rural or entirely in urban areas.

(b) Further many of these women are likely to have migrated from rural to urban areas and studying their current urban status may not be appropriate as final heights attained are affected by nutritional status during the phase of physical growth which would actually have been in the rural (place of birth) rather than in urban (current residence).

Despite the conceptual problem in assessing the rural-urban difference, the graphical analysis in the earlier section clearly indicates gaps in heights and the need to have a variable that captures rural-urban differences in an econometric model.

Table 1 shows that age coefficient is not statistically significant across all states. At the all India level there is an increase of about 0.03 cm in a year and the southern state of Kerala shows the largest improvement in heights followed by another southern state, Tamil Nadu. Only six other states show an improvement overt time and with the exception of Chattisgarh, others are large states. One expects geographic differences in heights to arise either due to climatic conditions or due to variations in the genetic composition of population residing in different regions especially for a large country like India. However, these geographic differences do not seem to persist over time. The results here seem to suggest a pattern of convergence in heights across states[7]: a 45 year old woman currently living in urban area has an average heighst of about 154-155 cm in the states of Jammu and Kashmir, Himachal Pradesh, Haryana, Rajasthan and Punjab. This has more or less remained the same or declined a bit for a 20 year old woman in a similar place (state) of residence. In comparison to this the average height increased from about 152 cm (for a 45 year old woman) to about 155 cm (for a 20 year old woman) in the states of Kerala and Tamil Nadu.

After controlling for variations in heights across year of birth average heights in rural is significant at 10% level of significance (p-value less than or equal to 0.10) for about 11 states and for all India. Among these in Jharkhand, Karnataka and Tamil Nadu women in urban areas are taller by about 2cms or more while in other states with significant coefficients the gap is somewhat lesser.

Finally, the interaction coefficient of age with rural being positive (negative) and significant along with a negative and significant coefficient separately for age and rural, highlights that gap in average heights increases (decreases) overt time for current residents in rural when compared to current urban residents. Among the states with all significant coefficients and the signs as mentioned above, in Jharkhand, Jammu and Kashmir, Karnataka, Tamil Nadu, Uttar Pradesh and all India the rural-urban gaps increase over time. In contrast to this, Haryana, Madhya Pradesh, Punjab, Orissa and Rajasthan none of the coefficients are significant. For the remaining states, either there is no change in heights over time (Assam, and Bihar) or there is no rural-urban difference (Andhra Pradesh and Gujarat) or that the interaction coefficient is not significant (Chattishgarh, Himachal Pradesh, Kerala and Maharashtra.

[7] All India includes all regions of India like the north eastern states and other states and union territories not separately reported in this table

There is a lot of heterogeneity between and within states as reflected in the values of adjusted R^2 across states for this model specification. In states where none of the coefficients are significant except the intercept in Punjab about 22% of the variation is explained by the model while in Rajasthan it is about 4%. Among the states where all the coefficients are significant the variation is from about 67% for all India, 44% for Tamil Nadu and 22% for Karnataka. The other state where the model explains more than 50% of the variations in heights is the state of Kerala. Despite averaging the heights for a given year of birth (which takes away a large variation) there is still substantial amount of variation unexplained by the regression model and that this unexplained variation differs across states.

4.3 Variations in Individual Heights: Econometric Analysis

Using individual level data on heights there is scope for some improvement on the choice of variables that would capture variations in height but there are several limitations in this analysis as well. Firstly, heterogeneity across individuals is likely to be higher and hence model fit will be poor. Secondly heights attained depend on nutritional status and the factors that influence it in the early phases of growth and there are very few variables in the database that capture these aspects as most variables in the model refer to the current status. In this sense the econometric model is a framework that does not ascertain a cause - and - effect relationship and is only indicative of how mean heights are found to vary across an indicator of well-being while controlling for other aspects of well-being.

4.3.1 Difference across regions and over time

The same regression model as in equation 1 is now estimated but with individual level data and this is referred as model 2 with results reported in Table 2. Thus as in model 1, age, a rural dummy variable and an interaction variable between these two are the independent variables along with dummy variables (fixed effects) for states[8]. This model has the state of Punjab as the base state and from the results one observes that in many states average heights are lower than in this state. Women from Jammu and Kashmir, Haryana and Rajasthan have average heights not significantly different from Punjab. It may be noted that these states share a common boundary with Punjab. It is also important to note that Himachal Pradesh which also shares a common boundary with Punjab, the average height is lower by about 0.82 cm which is much lower than in other remaining states where the gap is at least 2 cm. However, in Kerala a non-contiguous state with Punjab the gap in average heights is less than 2 cm. Among the bigger states Bihar and Uttar Pradesh show a gap of about 3 cm or more and so do the eastern and the north eastern states and union territories. These results on the hand are suggestive of the fact that regional differences in heights exist which could be due to variations in climatic conditions, food habits, and also genotypes. However it is also not easy to ignore the differences in overall well-being between the states with shorter women and Punjab[9]. Compared to the coefficients for state level differences, age and place of residence have a much smaller magnitude and about 6% of the variation is explained by this model.

4.3.2 Wealth, Education and Social Status

Education, unlike several other independent variables used in this analysis, is associated with a woman's childhood. It is highly likely that woman with higher education level would have grown up in a household

[8] The regressions are estimated using national weights as suggested in NFHS-3 and the union territory of Delhi has been omitted due to several missing observations.

[9] The rural and urban combined poverty rates in Uttar Pradesh is 32.8% and Bihar is 41.4% in 2004-05 and is among the highest while Punjab has a poverty rate of 8.4% (GOI, 2007), the HDI ranking for these states are 15, 16 and 3 respectively among 16 large states (http://www.indiastat.com/).

with better awareness of aspects that will positively influence childhood nutritional status. Similarly caste and religion of the woman will have a large probability to remain the same since her birth. Dummy variables representing caste - scheduled caste, scheduled tribe and other backward class (OBC) - represents the deprivation associated with lower social status accorded to them in the society and the 'other' caste is taken as the base group. Religion on other hand may capture differences in dietary habits as some religious groups on an average consume more of non-vegetarian food like egg and meat which may have some positive impact on the child's growth early on. Under these assumptions likely systematic differences in heights across caste and religious groups are testable propositions. Current status based on (a) rural-urban residence, (b) wealth status of the household and (c) possession of below poverty line card (BPL) is included to test if there are systematic differences in heights across these groups[10]. Wealth status is measured by an index and based on it households are grouped as poorest, poorer, middle, rich and richest as reported in NFHS-3. Dummy variables are used to capture these groups with the base group as the middle wealth group. Also, those without a BPL card and those currently living in urban areas are the base groups for the respective dummy variables. This regression model is referred as model 3.

The results reported in Table 2 for model 3 though show similar inter-state differences in heights as in model 2 but the magnitude of gap with Punjab has reduced substantially for most states. In the western states of Gujarat and Maharashtra as well as in the four southern states of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu women are shorter

[10] Family cards are issued by the state which gives them access to limited quantities of basic cereals and cooking fuel at a subsidized price and the eligibility criterion is based on wealth status of the household as well as income level and nature of livelihood of the household members

on an average by about 1-2 cm than those in Punjab while in most other states the gap with Punjab is more than 2 cm. Compared to the earlier model, average heights of women in Haryana and Rajasthan are higher than those in Punjab with the gap being less than a centimetre. Younger women are taller than older women but the magnitude has come down substantially compared to model 2. A major change now is in reversal of results for rural women who are now taller compared to their urban counterparts in a model which has other control variables. A preliminary analysis of the data shows that women who belong to households with currently high standards of living have the highest proportion of them with more years of education[11]. Despite this positive association between education and wealth status, education has a separate 'influence' on heights. An additional year of education 'adds on to heights' though the magnitude is not large compared to those of state-level dummy coefficients. However, if education is graded into levels then the average heights of women with higher secondary education and above is about 1-2 cm more than those without any education (results not reported here). Gap in heights is highest for scheduled caste, followed by tribes and then by OBCs when compared to 'other' castes. Gaps in heights are statistically significant (albeit very small in magnitude) for women following Islam and other religion when compared to Hindu women but not so for Christian women. Average heights are significantly different (statistically) across each of the wealth index group with gap in average heights being highest for the poorest and progressively improving with the richest showing a positive gap of more than 1cms. The dummy for BPL households is negatively significant even though wealth index controls for economic

[11] Among the women with no education about 60% belong to the poorest and the poorer households and among those who have completed higher secondary level and above about 80% belong to the richest households and a mere 1.3% belong to the poorest and the poorer households. Education level also improves inversely with age with about 31% of women in the age-group 20-24 years having completed higher secondary level and above while about 5% in the age-group 45-49 years have similar education levels.

status and women of such households are on an average shorter than other households. Overall one finds that in this model the magnitude of state-fixed effect coefficients is higher than those of the socio - economic variables.

4.3.3 Teenage childbirth and average adult heights

One other variable that affects adult heights of women is having at least one child during teenage. First a regression model is estimated allowing only for state fixed effects and teenage child birth dummies (regression model 4). This analysis is restricted to only ever - married women (in the age-group of 20 to 40 years) as one observes that the proportion of women having a child without a marriage is negligible in the sample. Restricting it to ever married women allows us to use variables related to spouse, like education status etc. Results for model 4 in Table 3 shows that average heights are lower for women who have had one child or more during their teenage when compared to women who have had their first child after 19 years of age. Moreover, this gap reduces as age increases among the teens. Regression model 5 adds additional variables and is based on the model by Brennan et al, (2005) which is henceforth referred to as BRS. Their study uses the 1998-99 data (NFHS -2) and similar estimations are repeated here with a more recent data for comparability over time of the broad results.

The differences in average heights across states are similar to the model versions discussed in this study. Jammu and Kashmir is no different from Punjab while Haryana and Rajasthan have marginally higher average heights than Punjab. However, one now finds that the age coefficient though negative is not significant any more; all teenage child birth coefficients are significant with average heights for 12-13 years being higher (of lower magnitude) than 14-15 and the gap with other women decreases thereafter; the result on wealth status is also similar. However, rural dummy coefficient is significant with a positive sign (compared to the results in the previous model) indicating that women in rural areas are on an average taller than urban given these set of control variables. One finds that the results of this study are very similar to BRS in terms of the significance of coefficients and the sign. For instance, for the teen-age birth variables where we find that the 12-13 age group has lower gap than 14-15 and thereafter the gap decreases progressively with age. The rural results (BRS use an urban dummy variable in their model which is negatively significant) are also similar to BRS and so is the R^2 of about 7 percent (!). A further similarity arises in the inter-state variations though the magnitudes are different due to samples being different including the fact that all states are used in this study while BRS study is restricted to the larger states. In BRS Bihar is the base state and the intercept is 149.2 cm with women in Punjab and Haryana being taller by about 3.6 cm followed by Kerala women with a height gain of 2.91 cm. In comparison to this we find that average heights of women in Bihar and Uttar Pradesh are lower by 2.8-2.9 cm and in Kerala by 1.3 cm with average height in Punjab at about 153.35 cm (intercept in this model).

4.3.4 Education and Teenage Childbirth

Regression model 6 is estimated using all the variables as in models 3 and 5 along with a few additional variables. An important addition here is the education variable. The dummy variables capturing teenage child birth are now reduced to two – tbrth1 for at least one child born by the age of 15 years and tbrth2 for at least one child born between 16 and 19 years. Three additional variables when compared to model 3 are also included.

(a) dothrmarst: A dummy variable for marital status which takes a value one if the woman is a widow, separated or divorced

and zero otherwise. In Table 10.22.1 of IIPS (Vol.1, 2007) the proportion of women below 145 cm in height among the widows is reported as 14.8% and among divorced / departed / separated as 16% while that for currently married women it is 11.4%. This prompted the use of marital status as a control variable in this study. Two reasons why this difference could exit for the widowed women: firstly these women could be more among the poorer sections as the age gap with the spouse could be large coupled with the fact that life expectancy is likely to be lower resulting in more number of women with a widowhood status. Alternatively, they could be among the older women so that with age the heights are known to decline. So after age and economic status are controlled for one expects that average heights of such women should not be significantly different when compared to other married women.

(b) peduyrs: for spouse's education in completed years; given that most marriages in India are arranged by the parents, partner's education would reflect on average a continuation of the socio- economic status of the natal home and thereby one expects an added effect on heights similar to one's own education.

(c) chmort: the number of children borne by the woman who have died. This variable is included which reflects health deprivations as captured by child mortality - Bhalotra (2007) finds that in regions with lower infant mortality rates average heights are more than in regions with higher infant mortality.

The results for regression model 6 is reported in Table 4 and summarised as follows. Both age and rural residence are not significant any more. A woman with one additional year of education is taller by about 0.08 cm. Further teenage child birth variables are not significant any more and this is influenced by inclusion of the education variable. This is an expected result: marriage/child birth will be postponed if the girl has been attending school during that age. Even if several girls are withdrawn from school before teenage but not necessarily married off, a few years of additional schooling is a reflection of an 'added' awareness towards better nutritional care by the parents of the woman during her childhood showing up as an addition to height. The results on height differences due to differences in wealth status are rather robust in the sense that addition or deletion of other variables does not change the significance or sign of these coefficients. However what is worth observing is that gaps in heights between wealth groups reduces when education variable is included in the model as in models 3 and 6 when compared to the gaps one observes in model 5 (without education). In fact the gap in heights of the richest (with respect to the middle status women) is only 1.3 cm compared to 2.1 cm in a model without education. The model used here does not allow effect of education to vary across regions in this study. In a regression model estimated separately for rural and urban areas Viswanathan (2008b) finds that the 'gain' in height due to education is higher in urban than in rural and holds true for both Punjab and Tamil Nadu. Further whether it is rural or urban residence the 'gain' in heights due to better education is higher in Tamil Nadu than in Punjab[12].

Women in households with a BPL card (dpl1) are on average shorter and it appears that the wealth status variables do not adequately capture the poverty status of the household so that one observes this coefficient to be significant despite controlling for wealth status. Similarly women belonging to the socially backward groups are shorter on average with scheduled caste (dsch) women being shorter by about 1.2 cm while the scheduled tribes (dstr) are shorter by about 0.5 cm and seem to be

[12] The ranking of Punjab based on education is 8 while that of Tamil Nadu is 3 in 2000 (http://www.indiastat.com/)

marginally worse off compared to the women from other backward classes (dobc). Muslim (dislam) and other religious groups (dothrel) which include Sikhs, Jains and Parsis are taller while Christian (dchrstn) women are not different from Hindu women.

With the inclusion of education the teenage child birth variables are not significant any more when compared to the results in models 4 and 5. However, the average heights of women who have lost at least one child or more (chmort) are shorter. It could be a reflection of her poor nutritional status and that women who are undernourished are likely to have lost a child (or more) provided that child mortality is largely due to the child's poor nutritional status inherited from her/his mother. Alternatively (or even additionally) these women may be from lower economic status where child mortality is higher due to poor nutritional status as well poor environment conditions and health care access. If the latter argument is likely to be true then poor wealth status (dpoorst), having a BPL card (dbpl1) and having lost a child (chmort) perhaps capture different dimensions of economic deprivation and hence are all individually significant.

The coefficient for other marital status (dothmarst) is significant despite controlling for poverty and economic status as well as age and these women are on an average shorter than currently married women. Finally the variable partner's education (peduyrs) is significant and reduces the gap in average height only by miniscule centimetres (capturing it as categorical variables rather than as in years of education perhaps may highlight the gap better).

As emphasized earlier the regression models are not a cause-effect relationship between independent variables and heights but to assess the gaps in heights after incorporating control variables representing social and economic deprivations. The results here clearly highlight that better educated woman and those who have borne their first child after teenage have a height advantage. These two variables can largely be associated with their upbringing as discussed earlier and hence influence the physical growth during early childhood. Similarly differences in average heights across caste variables reflect early childhood deprivations that are associated with social deprivations. Can it also be that the genetic compositions of these groups are different given the historic background of the formation of these groups?[13] The evidence on this seems limited from the given database. For instance, Viswanathan (2008b) compares probability density functions (PDF) of heights of scheduled caste and tribe women with other caste women for Tamil Nadu and Punjab in rural and urban areas separately. In rural areas PDF of scheduled caste and tribe women is to the left of the other caste women showing lower average heights for the former group in each of the states though the PDF of other caste women of Tamil Nadu nearly overlaps with the PDF of scheduled caste women of Punjab. However, and more importantly in urban areas the distributions of the two groups in the two states overlap indicating very little (visual) difference. That is, scheduled castes and tribes in rural areas of these two states are worse off than the other castes while in urban areas the gap in heights is not glaring.

5. CONCLUSION

Several studies from other parts of the world, like Komlos (1985) and Baten and Murray (2000), indicate shorter adult heights to be associated with socio-economic deprivations. More recent among these is the study of adult height variations in the two Koreas after the war in 1972 (Pak, 2004). This study compares the current heights of North Korean men and women who were born around the time of the partition of the country. The results indicate that the North Koreans who migrated to the south during this period are taller by about 3 cm compared to those

[13] As Brennan et. al (1994) indicates that the tribes in northern India during the nineteenth century were among the shortest though they were growing taller at a slow pace.

who did not migrate at that time. Given the well known contrast in living standards and the achievements in human development indicators that exist between these two regions currently this finding is an addition to the evidence that despite similar genetic composition living conditions during the phase of human growth influence adult heights.

Several results from this study seem to support the association between heights and socio-economic status. The not so tall women in India are those with less education, are from households that are less wealthy (now) and the socially disadvantaged groups. With the exception of Punjab rural women are shorter than urban women but rural/ urban differences in heights are eliminated when variations in educational attainment, wealth and social status are accounted for. A reduction in teenage childbirth would improve the nutritional status and has to be focussed upon in its own right. An effective instrument through which this can be achieved is improvement in education levels. In this study some of the control variables particularly those pertaining to wealth status reflect the current status of the women and not of the economic status during the period of physical growth. Despite this limitation in modelling what is important to note is that differences in wealth status are also reflected in height differences with the richest women being much tall compared to the other wealth status groups.

The results of the study could be strengthened further by adding other variables that capture economic conditions and/or other dimensions of well-being like child mortality or average literacy rate of the state during time-of birth and development expenditures over time. The advantage is that state fixed-effects would be reflected through the variations in social and economic aspects and its changes over time rather than a single dummy variable that accounts for only qualitative differences across states.

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Table 1 :Variations in Average Heights of Women Across Age Cohorts and Rural Urban Differences Based on Regression Model : Select States in India

	Age		drur		drur-age		Intercept		RSqrd
States	Coeff.	pvalue	Coeff.	pvalue	Coeff.	pvalue	Coeff.	pvalue	
AI	-0.029	0.000	-1.624	0.000	0.024	0.003	153.309	0.000	0.6702
AP	-0.041	0.015	-1.104	0.155	0.023	0.334	153.078	0.000	0.0910
AS	-0.017	0.293	-1.283	0.092	0.020	0.375	151.552	0.000	0.0747
BH	-0.006	0.651	-1.846	0.005	0.040	0.043	151.078	0.000	0.1421
CH	-0.042	0.013	-1.647	0.036	0.017	0.479	153.388	0.000	0.2805
GJ	-0.038	0.013	-0.987	0.167	0.022	0.303	153.902	0.000	0.0829
HP	-0.031	0.025	-1.249	0.051	0.015	0.432	155.326	0.000	0.2122
HR	0.002	0.914	-0.373	0.724	0.052	0.109	154.030	0.000	0.1950
JH	-0.029	0.129	-2.982	0.001	0.060	0.027	151.657	0.000	0.1976
JM	-0.076	0.000	-1.767	0.013	0.043	0.043	157.155	0.000	0.3166
KA	-0.051	0.000	-1.938	0.004	0.042	0.034	154.490	0.000	0.2256
KE	-0.114	0.000	-1.493	0.037	0.023	0.272	157.123	0.000	0.5941
MH	-0.042	0.006	-1.152	0.098	0.009	0.663	153.554	0.000	0.2702
MP	0.021	0.125	-0.421	0.510	-0.011	0.568	152.497	0.000	0.1726
OR	-0.001	0.969	-1.017	0.150	0.008	0.697	151.541	0.000	0.1156
PJ	-0.007	0.689	1.102	0.174	0.003	0.889	154.101	0.000	0.2229
RJ	0.012	0.440	0.888	0.218	-0.011	0.598	153.896	0.000	0.0428
TN	-0.086	0.000	-2.281	0.002	0.041	0.062	155.807	0.000	0.4415
UC	-0.036	0.070	-1.126	0.224	0.029	0.298	154.039	0.000	0.0148
UP	-0.027	0.016	-1.434	0.007	0.023	0.143	152.080	0.000	0.2372
WB	0.016	0.252	0.179	0.787	-0.043	0.033	150.891	0.000	0.3296

Source : Author's own calculations based on regression of average heights (of women) for different years of birth

Note : (1) The expansion of abbreviations for the states is given in Appendix Table A1 and the description of variables is given in Appendix Table A2.

(2) All coefficients with p-value below 0.01 is significant at 1% level, with p-value below 0.05 is significant at 5% level and with p-value below 0.1 is significant at 10%.

Table 2 :Variation in Heights Acros States and Socioeconomic Categories

Variables	Model 2 Coeff.	Model 2 pvalue	Model 3 Coeff.	Model 3 pvalue
AP	-2.964	0.000	-1.752	0.000
AS	-4.088	0.000	-3.362	0.000
BH	-4.276	0.000	-2.986	0.000
CH	-3.228	0.000	-1.763	0.000
GJ	-2.076	0.000	-1.359	0.000
HP	-0.819	0.000	-0.809	0.000
HR	0.197	0.187	0.704	0.000
JH	-4.773	0.000	-3.406	0.000
JM	-0.076	0.599	0.185	0.134
KA	-2.092	0.000	-1.013	0.000
KE	-1.571	0.000	-1.762	0.000
MH	-2.772	0.000	-2.093	0.000
MP	-2.085	0.000	-0.738	0.000
OR	-3.662	0.000	-2.405	0.000
RJ	-0.122	0.376	1.087	0.000
TN	-2.117	0.000	-1.013	0.000
UC	-1.892	0.000	-1.502	0.000
UP	-3.900	0.000	-2.754	0.000
WB	-3.904	0.000	-2.877	0.000
Drur	-0.032	0.000	-0.221	0.139
Age	-1.257	0.000	-0.024	0.000
Drur_age	0.023	0.000	0.029	0.000
Eduyrs			0.103	0.000
Dsch			-1.320	0.000
Dstr			-0.637	0.000
Dobc			-0.452	0.000
Dislam			0.406	0.000
Dchrstn			0.195	0.189
Dothrel			0.658	0.000
Dpoorst			-0.466	0.000
Dpoor			-0.315	0.000
Drich			0.371	0.000
Drichst			1.334	0.000
Dbpl1			-0.309	0.000
Intercept	156.012	0.000	153.704	0.000
R-Squared	0.0538		0.0884	
No. of Observations	116217		116217	

Source : Author's own calculations based on regression of individual heights of women

Note : Same as Table 1.

Table 3 :Teenage Child Birth and Heights

Variables	Model 4 Coeff.	Pvalue	Model 5 Coeff.	pvalue
AP	-2.625	0.000	-1.903	0.000
AS	-4.021	0.000	-3.020	0.000
BH	-3.932	0.000	-2.929	0.000
CH	-2.912	0.000	-1.732	0.000
GJ	-2.039	0.000	-1.565	0.000
HP	-0.936	0.000	-0.810	0.000
HR	0.429	0.025	0.725	0.000
JH	-4.283	0.000	-3.115	0.000
JM	-0.210	0.288	0.278	0.157
KA	-1.841	0.000	-1.074	0.000
KE	-1.361	0.000	-1.308	0.000
MH	-2.456	0.000	-1.918	0.000
MP	-1.824	0.000	-0.716	0.000
OR	-3.511	0.000	-2.379	0.000
RJ	0.069	0.699	0.849	0.000
TN	-1.958	0.000	-1.087	0.000
UC	-1.780	0.000	-1.418	0.000
UP	-3.745	0.000	-2.805	0.000
WB	-3.610	0.000	-2.630	0.000
teenb12_13	-0.882	0.000	-0.360	0.065
teenb14_15	-0.945	0.000	-0.420	0.000
teenb16_17	-0.708	0.000	-0.275	0.001
teenb18_19	-0.431	0.000	-0.146	0.044
Drur			0.622	0.049
Age			-0.009	0.300
drur_age			0.002	0.863
Dpoorst			-0.859	0.000
Dpoor			-0.590	0.000
Drich			0.548	0.000
Drichst			2.125	0.000
Intercept	154.805	0.000	153.349	0.000
R-Squared	0.0533		0.0737	
No. of Observations	65707		65707	

Source : Author's own calculations based on regression of individual heights of women

Note : Same as Table 1.

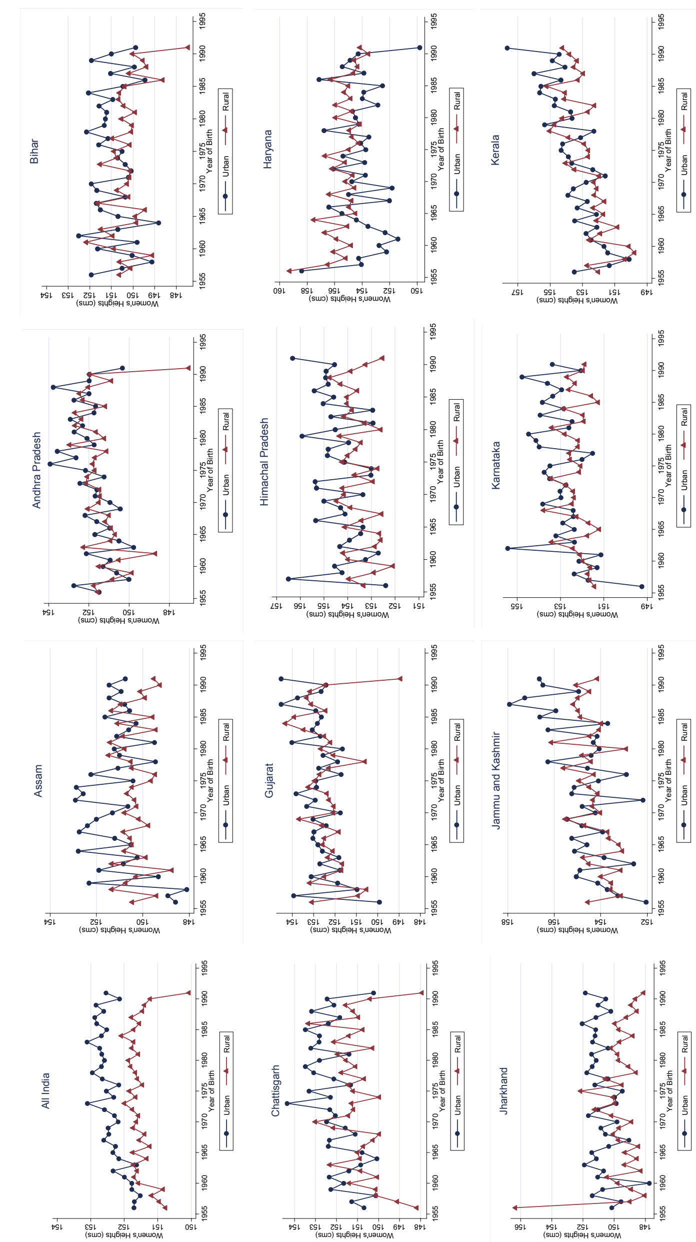
Table 4 : Teenage Child Birth, Education (in years) and Heights

	Model 6				
Variables	**Coeff.**	*pvalue*	**Variables**	**Coeff.**	*pvalue*
AP	-1.595	0.000	**age**	0.006	0.453
AR	-2.738	0.000	**drur**	0.394	0.210
AS	-3.264	0.000	**drur_age**	0.008	0.411
BH	-2.757	0.000	**eduyrs**	0.079	0.000
CH	-1.587	0.000	**dpoorst**	-0.449	0.000
GJ	-1.336	0.000	**dpoor**	-0.378	0.000
GO	-2.333	0.000	**drich**	0.226	0.011
HP	-0.786	0.000	**drichst**	1.279	0.000
HR	0.901	0.000	**dbpl1**	-0.246	0.001
JH	-3.125	0.000	**dsch**	-1.234	0.000
JM	0.121	0.582	**dstr**	-0.522	0.000
KA	-0.914	0.000	**dobc**	-0.470	0.000
KE	-1.504	0.000	**dislam**	0.400	0.000
MG	-4.537	0.000	**dchrstn**	0.115	0.582
MH	-1.951	0.000	**dothrel**	0.637	0.000
MN	-2.224	0.000	**tbrth1**	-0.016	0.867
MP	-0.557	0.004	**tbrth2**	0.009	0.885
MZ	-2.440	0.000	**chmort**	-0.316	0.000
NA	-1.302	0.000	**dothmarst**	-0.507	0.000
OR	-2.281	0.000	**peduyrs**	0.009	0.008
RJ	1.169	0.000	**Intercept**	152.935	0.000
SK	-2.882	0.000			
TN	-0.913	0.000			
TR	-3.812	0.000			
UC	-1.360	0.000			
UP	-2.637	0.000			
WB	-2.785	0.000			
R-Squared	0.0849				
No. of Observations	65571				

Source : Author's own calculations based on regression of individual heights of women

Note : Same as Table 1.

Figure 1 : Average Heights Across Year of Birth: Rural / Urban and States of India, 2004 - 05



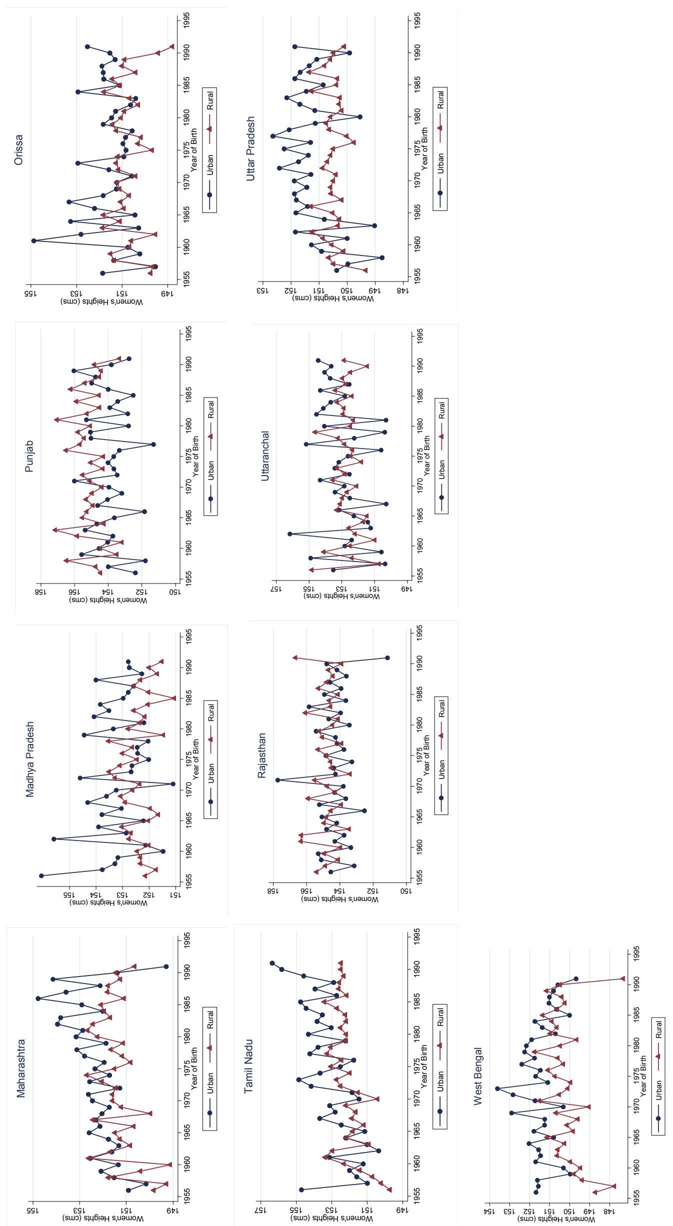


Figure 1 : Average Heights Across Year of Birth: Rural / Urban and States of India, 2004 - 05 (Contd.)

APPENDIX

Table A1: Expansion of State Names

[hp]	Himachal Pradesh	[mg]	Meghalaya
[pj]	Punjab	[as]	Assam
[uc]	Uttaranchal	[wb]	West Bengal
[hr]	Haryana	[jh]	Jharkhand
[dl]	Delhi	[or]	Orissa
[rj]	Rajasthan	[ch]	Chhattisgarh
[up]	Uttar Pradesh	[mp]	Madhya Pradesh
[bh]	Bihar	[gj]	Gujarat
[sk]	Sikkim	[mh]	Maharashtra
[ar]	Arunachal Pradesh	[ap]	Andhra Pradesh
[na]	Nagaland	[ka]	Karnataka
[mn]	Manipur	[go]	Goa
[mz]	Mizoram	[ke]	Kerala
[tr]	Tripura	[tn]	Tamil Nadu

Table A2: Description of Variables

Variables	Description
age	Age in completed years
eduyrs	Education in completed years
drur	Rural =1 and urban=0
drur-age	Interaction between rural dummy variable and age
chmort	number of children borne by the woman who have died
dothmarst	takes a value one if the woman is widowed, separated or divorced and zero otherwise
peduyrs	spouse's education in completed years
dbpl1	having a BPL card=1 and zero otherwise
Dummies for wealth index on the basis of groupings provided by NFHS with the 'middle' category taken as the base	
dpoorst	Poorest wealth category
dpoor	Poor
drich	Rich
drichst	Richest
Caste groups with 'others' as the base caste group	
dsch	Scheduled Castes
dstr	Scheduled Tribes
dobc	Other backward Classes
Religious groups with 'Hindu' as the base religious group	
dislam	Muslims
dchrstn	Christians
dothrel	Other religions
Teenage child birth related groups, base group is above 19 years	
teenb12_13	At least one child between age 12-13
teenb14_15	At least one child between age 14-15
teenb16_17	At least one child between age 16-17
teenb18_19	At least one child between age 18-19
tbrth1	at least one child born by the age of 15 years
tbrth2	at least one child born between 16 and 19 years

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