The Heights and Economic Well-Being of North Indians under British Rule

Introduction

In 1965 Morris David Morris, by questioning the view that British rule had led to the impoverishment of the Indian people, reopened the debate about the course of Indian economic welfare in the nineteenth century. Aspects of the question continue to concern scholars.

The debate about the British impact on the Indian economy has a number of elements. These include the effect of British competition on handicraft
production (Bagchi 1976), the significance of the "Home charges" paid by the Indian government for expenditures related to the government of India in Britain (Charlesworth 1982: 51-55), and most importantly for this paper, the experience of cultivators and laborers in an agricultural society changing through commercialization and railway expansion. Morris (1965) argued that political order led to greater stability of cultivation, increased irrigation reduced the extent of marginal land, and given a low rate of population growth, the extension of cultivation meant rising output per capita. His point that the expansion of domestic and foreign markets, along with improvements in transportation, encouraged regional specialization and, therefore, increased output was taken up by McAlpin (1983), who concluded that in western India the raw cotton producers benefited from access to world markets, and that the cultivators, rather than having to store some grain as famine insurance, were able to sell more of their crop. The outcome was that benefits became available for cultivators, agricultural laborers, and artisans, and that, with the assistance of new government relief systems, famine occurred less often.

The contrary view was put initially, and forcefully, by Bipan Chandra (1968) and Tapan Raychaudhuri (1968). Apart from questioning the extent of the Pax Britannica in the period up to the mutiny of 1857, they also argued that inhibitions such as heavy taxation, the tenurial system, and the expansion of moneylending prevented the cultivator (let alone the laborer) from securing a share of any surplus. They also argued that commercial non-food crops were only a small proportion of total production, and that income distribution in this sector was biased in favor of the nonproducing classes. More recently, Bayly (1983: 468) and Washbrook (1988: 80) have explained the expansion of cultivation from those born in the 1830s as the result of the movement into agriculture of those retrenched from the occupations that had surrounded the old regional regimes and those who had lived by pastoral and forest pursuits. One critic of McAlpin points out that while the growth of railways and of markets, both foreign and domestic, had taken place since the 1860s, there were substantial famines in the 1870s and 1890s (S. Guha 1986: 238). Others argue that no evidence is adduced that laborers benefited from the higher prices in the markets and that access to world markets for cash crops like cotton opened the way for wider price variation than previously and made the region dependent on grain imports (Bates 1985: 869; Appadurai 1984: 487-88). Commercialization of agriculture in North India focused on different crops from those in western India (sugar, wheat, indigo,
and opium rather than cotton) and may have been less significant in the agricultural economy, but the question of whether the process benefited the laborers and their families remains open. Did the growth of markets and increase in trade improve their condition or not?

The normal methods of settling such arguments by analyzing trends in economic conditions displayed by carefully collected figures of gross national product and per capita income are not possible in the Indian case. Alan Heston (1983: 379) and his predecessors have constructed tables for India as a whole that suggest that per capita income grew by about 0.5% per year between 1860 and 1920—that is, by at least 35%. But Irfan Habib (1985: 368–74) is critical of Heston’s calculations and argues that the evidence suggests that per capita income remained stable in the period 1875–1900. S. Guha (1992: 1–48), in a wide-ranging analysis of the patchy evidence available on agricultural productivity, concludes that between 1825 and 1891 it was unlikely the area under cultivation did more than keep up with population growth, and that productivity probably fell except on irrigated land. For the first half of the twentieth century Guha follows Blyn (1966), arguing that there was an initial growth in per capita food production during the first twenty years, followed by a quarter century in which population increased faster than agricultural production.

For North India between the Punjab and Bengal, there are also institutional studies of agrarian conditions such as those by Whitcombe (1972), Metcalf (1979), Chaudhuri (1983), Stokes (1983), Bayly (1983), and Reeves (1991), but there are no equivalents of Baker (1984) for South India or S. Guha (1985) for the Bombay Deccan, who explicitly chart the general economic trends for the nineteenth century. This paper, encouraged by the view of Heston (1983: 409) that there is a case for using measures based on nutrition and health to flesh out or correct economic and institutional data, discusses trends in height—as a proxy for childhood nutrition and health among men and women from North India during the nineteenth and twentieth centuries.

**Height and History**

Biologists have shown that although the explanation for the observed distribution of heights of a population at any point in time is partly genetic and partly environmental, changes in the distribution over time are mainly due
to environmental factors, such as changes in the nutritional status of mothers and their children and changes in the incidence of disease (as childhood morbidity can stunt growth). It is also well recognized that improvements in nutrition and the declining incidence of disease during the past century have brought about a secular increase in average height and the earlier maturation of children (so that their final height is reached earlier) in many populations (Eveleth and Tanner 1990).

Anthropologists have also used information on height and other anthropometric data to study the differences between social groups in a given population, and the differences between various peoples. One focus of their studies is on how the distribution of the heights of a people may reflect their morphological and physiological adaptation to environmental conditions such as climate, altitude, and so on (Basu 1990: 110–11, 209–10).

During the past decade or two, a number of economic historians have investigated the potential of data on height to illuminate trends in economic well-being over the past three centuries in a number of countries. They have used time-series data to trace the secular and cyclical patterns of average heights, and they have used cross-section data to show the variation in average height by region and social class (Fogel 1986; Komlos 1989; Floud et al. 1990; Nicholas and Steckel 1991). Up to the present, this research effort has been restricted to Europeans and the free and slave inhabitants of North America and the Caribbean.

In India, anthropologists have attempted to use anthropometric evidence to investigate the differences between India's various social groups: castes, religions, and tribes. The pioneers in this endeavor were Risley (1891, 1903) and Crooke (1896) for North Indians, and Thurston (1909) for South Indians. Most of their findings were incorporated in the census of 1901, as was B. S. Guha's (1935) survey in the census of 1931. Important surveys were also made in the United Provinces in 1941 (relating to 2,836 individuals from 22 social groups) and in Bengal in 1945 (relating to 3,240 individuals from 41 social groups); the raw data of these two surveys were included in published survey reports (Mahalanobis et al. 1949; Majumdar and Rao 1958). The summary statistics of most of these various studies have been brought together in Gupta and Dutta (1966) and discussed by Basu (1990) and Sen (1971), among others.

Whereas these studies were restricted to relatively small samples of
usually less than 100 adult males belonging to any one social group in particular localities, the first (and up to the present, the only) random sample of the entire Indian population was conducted by the Indian Council of Medical Research between 1956 and 1965. This survey covered both male and female children up to the age of 21 (ICMR 1972).

Although many anthropologists have speculated whether there has been secular change in Indian heights, only one scholar has made a reasonably systematic attempt to throw light on this issue. Drawing on earlier published studies, Ganguly (1979) compared the average height of 60 social groups at two points in time during the past century and concluded that there has been a secular decrease in heights. The decline, however, was not uniform all over the country but was more pronounced for North Indians than for South Indians. Caution should be used in generalizing on the basis of Ganguly's sample: the sample is not random, it is based on a relatively small number of individuals measured, and it is restricted to males. Clearly, more research is needed to make stronger inferences about possible secular changes in Indian heights.

This paper is part of a wider research project that attempts to help fill this gap in the literature. It expands the body of evidence available to evaluate Indian heights by drawing upon the previously untapped emigrant passes of Indian indentured workers who were measured at Calcutta, Madras, and Bombay as they departed for Mauritius, Natal, the Caribbean, and Fiji. Hundreds of thousands of Indian workers were measured between 1842 and 1916, and these measurements were recorded on emigrant passes. Most of the original documents are extant, deposited in the national or provincial archives of Mauritius, Fiji, Trinidad, Jamaica, and Natal. The present research project aims to computerize this entire body of evidence so that trends in the average height of Indians born from the first decade to the final decade of the nineteenth century can be traced and compared to more recent surveys conducted during the twentieth century.

In the first stage of the project, the data relating to Indian workers departing from Calcutta and Madras to Fiji between 1879 and 1916 are analyzed. The data for North Indians departing from Calcutta and South Indians departing from Madras are kept separate—mainly because there are important differences in the caste structure among North and South Indians—and are analyzed in separate papers. This paper evaluates the data on North
Indians, while companion papers address the South Indians (Brennan et al 1992a, 1992b).

For the purposes of this paper, North India refers to the present-day states of Uttar Pradesh (UP) and Bihar. The two major ecologies of North India are located in the Gangetic plain. In the districts of western UP the average annual rainfall runs from 50 inches near the foothills to 25 inches in the southwest, supporting an agriculture based on wheat, millets, and pulses on rainfed land, with sugarcane and rice on irrigated land. In eastern UP and Bihar, rainfall is more abundant, especially near the northern foothills, so that rice is the staple crop and sugarcane can grow without irrigation; other crops include wheat, millets, and pulses. Most of the emigrants to Fiji came from this region.

The fundamental agrarian structure in nineteenth-century UP comprised a fourfold division between landlords, who each held large numbers of villages; maliks, or landholders, who lived in and controlled the estates in which they had substantial shares; kisans, or cultivating peasants, who might be petty zamindars but in most cases cultivated land they held as tenants; and mazdurs, or cultivators of smallholdings, sharecroppers, and agricultural laborers (Reeves 1991: 25–27). Agricultural laborers were often linked by patron-client (jajmani) relationships to the maliks for whom they worked: in southern Bihar this took an extreme form between maliks and their bonded laborers (kamias), most of whom were low-caste Bhuiyas (Prakash 1992: 283–84). The indentured laborers who engaged to work in Fiji came from the last two of these classes: kisans who had lost or (less likely) renounced their cultivating rights, and agricultural laborers.

Data

The emigrant passes, which are deposited at the national archives of Fiji, include information on emigrants' age, sex, region of origin, and social group (caste, religion, tribe) as well as height. This set of information was collected for identification of workers who would eventually be eligible for a return passage to India.

There are a number of biases in the data that affect the representativeness of the sample. The emigrants came primarily from the eastern districts of the United Provinces and the northwestern districts of Bihar, and although
a wide variety of castes are represented among the emigrant population, the emigrants came from the most economically distressed strata of North Indian society, emigration usually being a response to famine and poor economic conditions (Grierson 1883: 21). As the emigrants had to pass a medical exam, however, they were not the weakest and sickest members of these lower strata.

To meet the required quota of 40 women to every 100 men, the medical exam was much more lax for women than men, and the instructions given to recruiters and medical examiners on physical standards of recruits related only to men (Shlomowitz 1987: 54). These instructions specified that chest circumference, rather than height, was to be the main indicator of the physical standard required to do heavy labor on overseas sugarcane plantations. In 1881, for example, the following instructions were given to surgeons for guidance when examining and selecting male recruits: "The chest should be round and well developed. Flat-chested men should be rejected"; "Dwarfs and scarecrows are not wanted, but short stature or slimness is not a fatal objection if the emigrant be wiry and tough and well able to handle agricultural implements" (Grierson 1883: Appendix IV). Similar instructions in 1909 specified the preferred build of emigrants: "Recruiters should endeavour to obtain strong men of good physical development with big and well developed chests. Short stature is not a fatal objection if the Emigrant is muscular and well proportioned." An inspection of the lower tails of the distributions of heights for each year of recruitment (presented in Appendix 2) showed no shortfall of short men or women, confirming that the instructions were followed.

We can conclude that the recruiting authorities used the information contained in the emigrant passes on height only for purposes of identification and that short recruits were not generally rejected. It follows that our data on the height of recruits would be representative of the height of the lower socioeconomic strata of the population of the eastern United Provinces and northwestern Bihar.

The measurements appear to have been carefully made, as they were either to the half or quarter inch (in 19 years to the half inch and in 16 years to the quarter inch). The data on height appear to be reasonably accurate, as they approximate a normal distribution, as in all other populations (see Appendix 2). Although a search through the voluminous records of emigration
from Calcutta has failed to yield information on how the recruits were measured, they were almost certainly measured without shoes—if for no other reason than few of these laborers would have possessed shoes.

The data on age are more problematic. Many Indians would not have known their exact age, and the imprecision in the age data is shown most simply in the heaping at ages 18, 20, 22, 24, and 30. Moreover, it is not clear if the age data relate to age at last birthday or age at next birthday, as both practices were variously used in India (Census of India 1905: 1(1): 473).

Despite these deficiencies, it can be suggested that some degree of confidence in the age data is warranted by findings that confirm a priori expectations (Brennan et al. 1992c: Table 1). First, average height increased steadily with age until the attainment of final adult height by about 25 years; thereafter, there was no further change in height until the age of 40, after which stature began to decline. This association between age and height was not simply due to ages being assigned on the basis of height, as there were substantial standard deviations for each height-by-age distribution (see Steckel 1979: 371). Second, females matured earlier than males, as in other populations: using the 98% criterion (that is, the age at which 98% of final height is attained), females reached their adult height at 18 and males at 19 (see Margo and Steckel 1982: 519). Third, adult height among these generally impoverished labor emigrants was attained much later than in well-fed Western populations today. These findings hold not only for the entire sample but for each year of recruitment between 1879 and 1916. Furthermore, as the main focus of this paper is on adult heights between the approximate ages of 24 and 40, errors in age within this age range will be of no consequence.

The data on the region of origin and on social groups are also likely to contain errors. Some recruits may have reported their place of recruitment as their region of origin, and some may have falsified their social group of origin. Some Hindus, for example, may have claimed a higher caste for purposes of prestige, while some high-caste Hindus may have claimed a lower caste, as high-caste Hindus without agricultural experience were less likely to be accepted.

For the purposes of the regression analysis below, the regions of origin were classified into five categories; the overwhelming majority of recruits came from the United Provinces, and they were taller on average than recruits from Bengal, Bihar, and Orissa but shorter on average than recruits
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from the Central Provinces, Central India, Rajputana, and the rest of India, which mainly included recruits from Delhi and Gurgaon (Brennan et al. 1992c: Table 2). These findings hold for both males and females and are roughly consistent with other evidence that there is a steady lowering of stature from the Punjab to Bengal. That the tallest Indians came from Punjab is explained in terms of the Punjab’s better food supply and in terms of genetic factors (Majumdar 1961: 48–49; Rakshit 1976: 168).4

For the purposes of the regressions below, social groups of origin were divided into seven groups: four Hindu caste categories (High Castes, Superior Sudras, Inferior Sudras, and Untouchables), Muslims, Tribals, and a final group comprising Christians and others who could not be classified in the above six groups (see Appendix 1). Although Hindu castes were classified on the basis of ritual purity, it is likely that members of the higher castes enjoyed, on average, a higher standard of living with a more secure access to food than did members of the lower castes. This proposition is borne out in the evidence: the average height of the High Caste and Superior Sudra recruits was greater than that of Inferior Sudras and Untouchables, and this finding holds for both males and females (Brennan et al. 1992c: Table 2). The average height of Muslims was less than that of High Caste Hindus but greater than that of the other Hindu castes. Tribals were shorter, on average, than Hindus and Muslims.

The average height of emigrants also varied by recruitment year. For both males and females, recruits were, on average, shortest in the period 1879–89 and tallest in the period 1890–1904. After 1904, the average height of recruits fell but not to the level of the early period 1879–89 (Brennan et al. 1992c: Table 3). These variations could reflect cycles in the average height of the wider Indian population from which these recruits came, and/or it could reflect changes in recruitment standards.

Recruitment standards could relate to the imposition of a minimum height restriction or to the selection of recruits from better-off or worse-off groups in the population. There is no evidence that these standards were related to changing colonial demands for different types of skills. A test of the hypothesis that minimum height restrictions were imposed can be made by considering changes in the distribution of heights over time and, in particular, if the distribution was truncated in the period 1890–1904, or more truncated in this period than in the other two periods. A consideration of
Table 1  Height of North Indians by year of birth, 1840–94

<table>
<thead>
<tr>
<th>Birth cohort</th>
<th>Males</th>
<th></th>
<th></th>
<th>Females</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean (in.)</td>
<td>Standard deviation (in.)</td>
<td>N</td>
<td>Mean (in.)</td>
<td>Standard deviation (in.)</td>
</tr>
<tr>
<td>1840–49</td>
<td>152</td>
<td>63.18</td>
<td>2.80</td>
<td>67</td>
<td>58.64</td>
<td>2.37</td>
</tr>
<tr>
<td>1850–54</td>
<td>444</td>
<td>63.80</td>
<td>2.74</td>
<td>190</td>
<td>59.18</td>
<td>2.43</td>
</tr>
<tr>
<td>1855–59</td>
<td>1,101</td>
<td>63.98</td>
<td>2.70</td>
<td>516</td>
<td>58.91</td>
<td>2.70</td>
</tr>
<tr>
<td>1860–64</td>
<td>1,056</td>
<td>64.29</td>
<td>2.46</td>
<td>476</td>
<td>59.40</td>
<td>2.47</td>
</tr>
<tr>
<td>1865–69</td>
<td>1,716</td>
<td>64.63</td>
<td>2.36</td>
<td>585</td>
<td>59.75</td>
<td>2.04</td>
</tr>
<tr>
<td>1870–74</td>
<td>1,806</td>
<td>64.83</td>
<td>2.26</td>
<td>676</td>
<td>59.70</td>
<td>2.17</td>
</tr>
<tr>
<td>1875–79</td>
<td>2,183</td>
<td>64.58</td>
<td>2.41</td>
<td>664</td>
<td>59.55</td>
<td>2.35</td>
</tr>
<tr>
<td>1880–84</td>
<td>1,865</td>
<td>64.21</td>
<td>2.43</td>
<td>632</td>
<td>59.35</td>
<td>2.38</td>
</tr>
<tr>
<td>1885–89</td>
<td>1,228</td>
<td>64.30</td>
<td>2.51</td>
<td>489</td>
<td>59.42</td>
<td>2.17</td>
</tr>
<tr>
<td>1890–94</td>
<td>319</td>
<td>64.44</td>
<td>2.33</td>
<td>168</td>
<td>59.42</td>
<td>2.24</td>
</tr>
</tbody>
</table>

Source: Emigrant passes.
Note: Restricted to age group 24–40.

The distribution of heights for the period 1890–1904 and the remaining years fails to show such truncation in the 1890–1904 period. This suggests that to the extent that recruitment standards were changed, it was not by imposing a height restriction but by selecting recruits from different socioeconomic groups in the population.

It can be suggested that recruitment standards reflected the forces of demand and supply. On the side of demand, when the overseas colonies increased their orders for recruits, ceteris paribus, recruitment standards may have been reduced as the emigration authorities attempted to meet the demand, and vice versa. On the side of supply, in times of famine and economic distress in India, ceteris paribus, recruitment standards may have been increased as the increase in supply of potential recruits enabled the emigration authorities to select a better class of recruits.

The recruit’s year of birth is obtained by subtracting the age of the recruit from the year of recruitment. Table 1 shows that for both males and females, the average height of recruits increased steadily from those born in the 1840s to the first half of 1870s, but thereafter there was a slight decline through to those born in the first half of the 1890s. The increase in the aver-
age male height from the 1840s to 1870–74 was 1.65 inches, while the decline thereafter was greatest to those born in 1880–84, at 0.62 inches.

Taken at face value, the increase in average height of birth cohorts between the 1840s and 1870–74 could indicate a substantial improvement in the economic well-being of North Indians during these decades, and the decline in average height of those born after 1874 could indicate a deterioration in economic well-being during the following two decades. These trends must be evaluated with caution, however, as they could reflect changes in recruitment standards over time. That this is likely is shown by the observation that the recruits who were born in the 1840s, 1850s, and 1860s were relatively short, and they were mostly recruited in the early period, 1879–89, when standards allowed for the selection of relatively short recruits. We will return to this issue in the regression analysis below.

It is also of interest to inquire whether the above-noted cyclical variations in average final height by year of recruitment and year of birth were matched by similar variations in the process of maturation (as indicated by the age at which 98% of final height is attained). The evidence shows that maturation was generally achieved earlier over time, whether indicated by year of recruitment or by birth cohort (Brennan et al. 1992c: Table 5).

Comparative perspectives can be gained by scaling the average height of our recruits relative to modern height distributions. The Indian Council of Medical Research (ICMR 1972: 67) has published modern all-India male and female height distributions, covering a broad cross-section of social classes, up to the age of 18. At this age, our recruits had reached the 28th centile for males and the 27th centile for females. The average of both male and female recruits at age 18, however, was well below the 3rd centile of the distribution of modern British heights reported by Tanner et al. (1966: 626–27); with continued growth after the age of 18, the final height attained by male and female recruits reached the 5th and the 3rd centiles of the modern British distributions, respectively. The difference in Indian and British heights is probably due to both environmental and genetic factors.

Some further perspectives can be obtained by comparing the findings on height with other anthropometric information on the recruits. In its annual reports on Indian immigration, the Fiji Department of Immigration included summary statistics of the mean chest circumference of males and the mean weights of males and females, measured on arrival in Fiji, for selected
voyages from Calcutta between 1894 and 1911 (Brennan et al. 1992c: Table 6). Height and weight are positively related (t ratios = males 3.06, females 1.61), but height and chest and chest and weight are, perhaps surprisingly, not correlated. This may be due to the aggregate nature of the data. For South Indians, we have individual-level data on chest circumference, which may be a more sensitive indicator of nutritional status than height (see Brennan et al. 1992a).

To describe the nutritional status of a population, biologists have used various indices of body mass. One popular index is Quetelet’s Index: weight (in kilograms) divided by the square of height (in centimeters), with the resulting quotient multiplied by 100 (Waaler 1984). Whereas for Western populations this index is usually between 0.236 and 0.252 (Rao et al. 1972), it was lower for our recruits: using data reported by Brennan et al. (1992c: Table 6) the unweighted means for 25 voyages for males, 1894–1911, and 23 voyages for females, 1899–1911, were 0.202 and 0.208, respectively. Yet these means were considerably higher than those obtained in the Bengal survey of 1945, where the average for adult males was 0.182 (calculated from data in Majumdar and Rao 1958), and in recent studies of rural villages in the vicinity of Hyderabad (Rao et al. 1972; Visweswara Rao et al. 1986). The body mass index is a particularly appropriate indicator as it measures current nutritional status, in contrast to height, which is a measure of past nutritional status. The relatively low value of the index for both our recruits and in more modern studies in India reflects the unchanging poverty experienced by the lower strata of Indian society.

Comparative perspectives can also be obtained by comparing our findings for North Indians with our previous findings for recruits from South India. Some studies have shown that the people of the United Provinces were taller, on average, than South Indians due to the lower living standards and, in particular, the lower consumption of milk and its products in the South (ICMR 1972: Tables 25, 26; Majumdar 1961: 49; Basu 1990: 111, 126, 135, 227–28). Rakshit (1976: 168), however, reports a more recent survey which shows that the people of Tamil Nadu were slightly taller than the people of the United Provinces. Our study, as shown by Brennan et al. (1992c: Table 7), gives some support for Rakshit: for Superior Sudras and Inferior Sudras, South Indians were taller than North Indians.

A temporal comparison of the average male height of sixty social groups has been made by Ganguly (1979), and ten of these groups are from the
United Provinces. Ganguly shows that for 9 of the 10 groups, average height declined between the 1880s/1890s and 1941, and the unweighted average height of the ten groups declined from 64.7 to 63.9 inches (see Brennan et al. 1992c: Table 8). Using our much larger sample of the people from the United Provinces based on the period 1879–1916 and data from the complete survey of 1941, this secular decline is confirmed: the average male height from 1879–1916 to 1941 declined from 64.4 to 64.0 inches for the age group 25–40 (see Brennan et al. 1992c: Tables 1, 9, 10), and this difference is statistically significant. This is moreover a lower bound on the extent of the overall decline, for while our sample relates to the most economically distressed groups between 1879 and 1916, the 1941 sample covered a broad spectrum of the population.

It is also possible to compare average heights of the age group 16–20 for the labor emigrants, 1879–1916, and the general population, 1956–65: the average heights for both boys and girls were significantly greater in the later period (Brennan et al. 1992c: Tables 1, 11). Interpreting this result is difficult, however. It could simply reflect the comparison of members of the population in economic distress in the early period to the general population in the later period, or it could reflect the earlier maturation of the Indian population and possibly also higher final heights.

Econometric Analysis

In a multivariate regression analysis, male and female heights are related to age, year of birth, social group, region of origin, and recruitment standards (see Tables 2 and 3). Whereas Appendix 2 gives a technical presentation of the regression analysis, only the main findings are highlighted here.

A number of the main findings of the econometric analysis are unambiguous and consistent with expectations: average height increased with age until the attainment of adult height; there were regional differences in average height, with recruits from the United Provinces being taller on average than recruits from Bihar and Orissa and from Bengal; and high-caste recruits were taller on average than recruits from the lower castes. The variation in average height by class (as indicated by Hindu caste in our study) was much greater for males than for females, a finding similar to that reported for other populations (Eveleth and Tanner 1990: 200; Bielicki 1986: 298).

We showed in Table 1 that the average height of recruits by year of birth
### Table 2  Male height least squares regressions

<table>
<thead>
<tr>
<th></th>
<th>Specification A with recruitment year variables</th>
<th>Specification B with demand and supply variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regression coefficient estimates (t ratios)</td>
<td>Regression coefficient estimates (t ratios)</td>
</tr>
<tr>
<td>Intercept</td>
<td>59.76  232.4&quot;</td>
<td>60.71  224.8&quot;</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–19</td>
<td>1.12   14.0&quot;</td>
<td>1.04   12.9&quot;</td>
</tr>
<tr>
<td>20–21</td>
<td>1.92   24.6&quot;</td>
<td>1.76   22.7&quot;</td>
</tr>
<tr>
<td>22–23</td>
<td>2.31   27.9&quot;</td>
<td>2.13   26.6&quot;</td>
</tr>
<tr>
<td>24–40</td>
<td>2.49   27.9&quot;</td>
<td>2.34   29.5&quot;</td>
</tr>
<tr>
<td><strong>Birth cohort</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1850–54</td>
<td>0.42   1.6</td>
<td>0.39   1.5</td>
</tr>
<tr>
<td>1855–59</td>
<td>0.47   2.0&quot;</td>
<td>0.48   2.1&quot;</td>
</tr>
<tr>
<td>1860–64</td>
<td>0.40   1.7</td>
<td>0.52   2.3&quot;</td>
</tr>
<tr>
<td>1865–69</td>
<td>0.22   0.9</td>
<td>0.90   3.9&quot;</td>
</tr>
<tr>
<td>1870–74</td>
<td>0.08   0.3</td>
<td>1.00   4.4&quot;</td>
</tr>
<tr>
<td>1875–79</td>
<td>0.06   0.2</td>
<td>0.93   4.1&quot;</td>
</tr>
<tr>
<td>1880–84</td>
<td>0.12   0.4</td>
<td>0.81   3.6&quot;</td>
</tr>
<tr>
<td>1885–89</td>
<td>0.18   0.6</td>
<td>0.67   2.9&quot;</td>
</tr>
<tr>
<td>1890–94</td>
<td>0.36   1.2</td>
<td>0.70   3.0&quot;</td>
</tr>
<tr>
<td>1895–99</td>
<td>0.56   1.8</td>
<td>0.71   2.9&quot;</td>
</tr>
<tr>
<td><strong>Social group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Caste</td>
<td>1.29   11.8&quot;</td>
<td>1.21   11.1&quot;</td>
</tr>
<tr>
<td>Superior Sudras</td>
<td>0.68   6.3&quot;</td>
<td>0.62   5.8&quot;</td>
</tr>
<tr>
<td>Inferior Sudras</td>
<td>0.23   2.1&quot;</td>
<td>0.16   1.5</td>
</tr>
<tr>
<td>Untouchables</td>
<td>0.30   2.8&quot;</td>
<td>0.25   2.3&quot;</td>
</tr>
<tr>
<td>Muslims</td>
<td>0.77   7.0&quot;</td>
<td>0.71   6.5&quot;</td>
</tr>
<tr>
<td>Others</td>
<td>0.57   3.7&quot;</td>
<td>0.53   3.5&quot;</td>
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<tr>
<td><strong>Region</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Provinces</td>
<td>0.40   8.5&quot;</td>
<td>0.40   8.5&quot;</td>
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<td>Central</td>
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<td>0.88   13.0&quot;</td>
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<td>Rest of India</td>
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<td>1.54   17.6&quot;</td>
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<td>0.04   0.3</td>
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<td><strong>Recruitment year</strong></td>
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<tr>
<td>1885–89</td>
<td>0.43   5.5&quot;</td>
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</tr>
<tr>
<td>1890–94</td>
<td>1.12   11.2&quot;</td>
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Table 2  (Continued)

<table>
<thead>
<tr>
<th></th>
<th>Specification A with recruitment year variables</th>
<th>Specification B with demand and supply variables</th>
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<tr>
<td></td>
<td>Regression coefficient estimates (t ratios)</td>
<td>Regression coefficient estimates (t ratios)</td>
</tr>
<tr>
<td>1895–99</td>
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<td>1900–1904</td>
<td>1.13</td>
<td>1.13</td>
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<td>1905–9</td>
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<tr>
<td>1910–16</td>
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<td>Total emigration ex-Calcutta</td>
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<td>9.4**</td>
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<td>Famine years supply variable</td>
<td>0.21</td>
<td>5.6**</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.107</td>
<td>0.101</td>
</tr>
<tr>
<td>$s$</td>
<td>2.29</td>
<td>2.30</td>
</tr>
</tbody>
</table>

Note: The dependent variable is height in inches. $N = 29,107$. Chi square tests for significant factor effects were all significant at the 1% level. The intercept in specification A is an estimate of the mean height of a male aged 16–17 years from the 1840–49 birth cohort who was Tribal, from the Bengal, Bihar, and Orissa region, recruited during 1879–84. $R^2$ is the coefficient of determination adjusted for degrees of freedom, and $s$ the estimated standard error of the disturbances.

* Indicates significant at the 5% significance level.

** Indicates significant at the 1% significance level.

Height, Economics, North Indians, and British Rule

Table 2 (Continued)

exhibited a cyclical path, initially rising and then falling, and this pattern is confirmed at a disaggregated level for the six largest social groups (there is also no significant temporal change in differences in average height among leading castes). We also showed that the average height of recruits by year of recruitment exhibited a cyclical path. It is clear that the variables relating to year of birth and year of recruitment are interconnected—the relatively short recruits born in the 1840s, 1850s, and 1860s, for example, were mostly recruited in the 1880s, when average height by year of recruitment was lowest—and this makes it difficult to determine whether these patterns were due to changes in recruitment standards or to changes in the average height of the underlying population groups from which recruits were procured. Unfortunately, we have no documentary evidence on changes in recruitment standards that could resolve this issue.

In an attempt to separate trends in average height by year of birth
<table>
<thead>
<tr>
<th></th>
<th>Specification A with recruitment year variables</th>
<th>Specification B with demand and supply variables</th>
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<td>Regression coefficient estimates (t ratios)</td>
<td>Regression coefficient estimates (t ratios)</td>
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<tr>
<td>Intercept</td>
<td>55.95 171.0*</td>
<td>56.77 164.4*</td>
</tr>
<tr>
<td>Age (years)</td>
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<td></td>
</tr>
<tr>
<td>18-19</td>
<td>1.04 8.9*</td>
<td>0.97 8.4*</td>
</tr>
<tr>
<td>20-21</td>
<td>1.60 14.3*</td>
<td>1.48 13.7*</td>
</tr>
<tr>
<td>22-23</td>
<td>2.02 16.5*</td>
<td>1.86 16.6*</td>
</tr>
<tr>
<td>24-40</td>
<td>2.14 16.0*</td>
<td>2.01 18.0*</td>
</tr>
<tr>
<td>Birth cohort</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1850-54</td>
<td>0.48 1.5</td>
<td>0.42 1.3</td>
</tr>
<tr>
<td>1855-59</td>
<td>0.01 0.1</td>
<td>0.10 0.3</td>
</tr>
<tr>
<td>1860-64</td>
<td>-0.15 0.5</td>
<td>0.09 0.3</td>
</tr>
<tr>
<td>1865-69</td>
<td>-0.11 0.4</td>
<td>0.71 2.5*</td>
</tr>
<tr>
<td>1870-74</td>
<td>-0.20 0.6</td>
<td>0.76 2.6*</td>
</tr>
<tr>
<td>1875-79</td>
<td>-0.05 0.1</td>
<td>0.75 2.6*</td>
</tr>
<tr>
<td>1880-84</td>
<td>-0.03 0.1</td>
<td>0.63 2.2*</td>
</tr>
<tr>
<td>1885-89</td>
<td>0.13 0.3</td>
<td>0.64 2.2*</td>
</tr>
<tr>
<td>1890-94</td>
<td>0.03 0.1</td>
<td>0.37 1.3</td>
</tr>
<tr>
<td>1895-99</td>
<td>0.35 0.8</td>
<td>0.54 1.7</td>
</tr>
<tr>
<td>Social group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Caste</td>
<td>0.44 3.3*</td>
<td>0.40 2.9*</td>
</tr>
<tr>
<td>Superior Sudras</td>
<td>0.22 1.7</td>
<td>0.20 1.5</td>
</tr>
<tr>
<td>Inferior Sudras</td>
<td>0.11 0.8</td>
<td>0.09 0.6</td>
</tr>
<tr>
<td>Untouchables</td>
<td>0.17 1.3</td>
<td>0.16 1.2</td>
</tr>
<tr>
<td>Muslims</td>
<td>0.21 1.6</td>
<td>0.17 1.3</td>
</tr>
<tr>
<td>Others</td>
<td>0.27 1.4</td>
<td>0.25 1.3</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Provinces</td>
<td>0.18 2.8*</td>
<td>0.17 2.7*</td>
</tr>
<tr>
<td>Central</td>
<td>0.59 6.3*</td>
<td>0.58 6.3*</td>
</tr>
<tr>
<td>Rest of India</td>
<td>1.08 5.9*</td>
<td>0.95 5.2*</td>
</tr>
<tr>
<td>Unidentified/Nepal</td>
<td>0.22 1.0</td>
<td>0.27 1.2</td>
</tr>
<tr>
<td>Recruitment year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1885-89</td>
<td>0.73 6.2*</td>
<td></td>
</tr>
<tr>
<td>1890-94</td>
<td>1.42 9.6*</td>
<td></td>
</tr>
</tbody>
</table>
Table 3 (Continued)

<table>
<thead>
<tr>
<th>Year</th>
<th>Regression coefficient estimates</th>
<th>t ratios</th>
<th>Year</th>
<th>Regression coefficient estimates</th>
<th>t ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>1895-99</td>
<td>1.45</td>
<td>8.0**</td>
<td>1895-99</td>
<td>-0.000032</td>
<td>4.2**</td>
</tr>
<tr>
<td>1900-04</td>
<td>1.09</td>
<td>5.2**</td>
<td>1900-04</td>
<td>0.22</td>
<td>3.5**</td>
</tr>
<tr>
<td>1905-09</td>
<td>0.89</td>
<td>3.7**</td>
<td>1905-09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1910-16</td>
<td>0.79</td>
<td>2.9**</td>
<td>1910-16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total emigration ex-Calcutta</td>
<td>-0.000032</td>
<td></td>
<td>s</td>
<td>0.060</td>
<td></td>
</tr>
<tr>
<td>Famine years supply variable</td>
<td>0.22</td>
<td></td>
<td>s</td>
<td>2.23</td>
<td>2.27</td>
</tr>
</tbody>
</table>

Note: The dependent variable is height in inches. N = 11,512. Chi square tests for significant factor effects were all significant at the 1% level. The intercept in specification A is an estimate of the mean height of a female aged 16-17 years from the 1840-49 birth cohort who was Tribal, from the Bengal, Bihar, and Orissa region, recruited during 1879-84. R² is the coefficient of determination adjusted for degrees of freedom, and s the estimated standard error of the disturbances.

*Indicates significant at the 5% significance level.
**Indicates significant at the 1% significance level.

from trends in average height by year of recruitment, three separate procedures are followed in the regression analysis. In the first (specification A), dummy variables for the year of recruitment are included. In the second (specification B), demand and supply variables to capture changes in recruitment standards are included: the total number of labor emigrants from Calcutta each year for all overseas colonial destinations is the proxy variable for demand, while dummy variables for years of major famine and economic distress in North India (1890-92, 1896-97, and 1899-1900) serve as the proxy variable for supply. In the third, separate regressions are run for each of the relatively homogeneous periods of recruitment: 1879-89, 1890-1904, and 1905-16.6

In Appendix 2 it is suggested that, due to the interconnection between the variables relating to the year of birth and the year of recruitment, less weight should be placed on specification A and more weight placed on speci-
The main conclusions that follow from Tables 2 and 3 are that average height of those born in 1870–74 was between three-quarters of an inch and one inch taller than those born in the 1840s, and for those born in the quarter century after 1870–74, average height declined by up to one-third of an inch. A cyclical pattern is confirmed when separate regressions are run for each of the relatively homogeneous recruitment periods, 1879–89, 1890–1904, and 1905–16 (see Tables 4 and 5).

Discussion

The recruiters believed the indentured laborers were able to perform the arduous tasks associated with the cultivation of sugarcane. Therefore, we can assume that recruits were neither weak nor sick and represented a reasonable sample of the poorer sections of society. The results of the regression analysis indicate that among this section of society from western Bihar and eastern UP there was a substantial increase in height among those born in the early 1870s over those born in the 1840s, and that subsequently height declined somewhat until the last years of the century. This suggests that between the mid-1840s and mid-1870s the economic condition of the poorer tenants and agricultural laborers in western Bihar and eastern UP improved substantially, and that from the peak of 1875 there was a shallower decline in their prosperity. Data from the mid-twentieth century indicate that this shallow decline continued until the early 1940s. How well does this fit the current interpretations of North Indian economic history?

One of the problems in dealing with the economic history of the Gangetic plain is that it cannot be analyzed as a whole. We have therefore to consider it in two broad categories, determined by ecology and history: eastern UP and Bihar, and western UP. The first is the most significant for our purposes because the majority of the indentured laborers came from districts in these regions.

The shifts and developments of the UP agricultural economy for the bulk of the nineteenth century have been delineated most clearly by Bayly (1983). In his view, from the mid-1820s to the mid-1840s conditions deteriorated, to be followed by a decade of relative prosperity punctuated by the rebellion of 1857–58. Subsequently, the internal trade and prosperity of North India was positively influenced by reductions in taxes; British
military and civil expenditures after 1858; links made with European mar-
kets by the development of the railway, the telegraph, and the steamship;
and the growth of population, estimated as 1% per year between 1840 and
1870 (Bayly 1983: 427–30). But the impact of these developments was much
greater in the western districts, with their expanses of uncultivated land,
low population density, and benefits from the extension of irrigation, than
in Bihar and the eastern districts of UP where population growth had been
less disturbed in the previous century, where there was much less free land,
and where improvements in irrigation were not so important as in the west
(Bayly 1983: 430–31). That is, Bayly argues that the prosperity of the period
was felt mainly in the western Gangetic plain, whereas in the east the in-
crease in population brought more pressure on the land so that marginal
lands were brought under the plow, and there was a reduction in produc-
tivity. Chaudhuri (1983: 325–27) points out that the growth of commercial
agriculture in eastern India, including Bihar, did not stimulate the peasant
economy, because the Europeans who were largely responsible for the indigo
industry manipulated their control over land and debt to coerce the culti-
vators to grow indigo, even though the cultivation regime involved reduced
profitability of their other crops; similarly, opium production, controlled by
the government, was not as profitable to the growers as it could have been.
In eastern UP, Amin (1982: 80–85) has shown that the timing of the revenue
and rental demands in the crop year and the poverty of many of the cultiva-
tors ensured that the grain- and moneylenders profited most from the main
cash crop, sugar.

The results of the regression analyses suggest that the condition of the
lower sectors of society in Bihar and eastern UP improved more during the
period between the 1840s and 1870s than the literary evidence suggests. That
is, despite the increasing population densities and the imbalanced rewards
of the commercialization of the economy, these people experienced superior
nutrition and health during their formative years. One reason why there was
a greater improvement than might have been predicted is that during this
period famine was not a serious problem for this region. By the last half
of the 1860s, however, there were signs that the trends were shifting: there
were famines in parts of Bihar, and these were accompanied by outbreaks of
cholera.

According to the regression analyses of heights, the living conditions of
<p>| Table 4  Male height least squares regressions for three recruitment periods |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 1879–89                         | 1890–1904                       | 1905–16                         |
|                                  | Regression coefficient estimates | t ratios/ (chi-squares)         | Regression coefficient estimates | t ratios/ (chi-squares)         | Regression coefficient estimates | t ratios/ (chi-squares)         |
| Intercept                       | 57.76                           | 82.3**                          | 61.15                           | 200.7**                         | 61.63                           | 163.4**                         |
| Age (years)                     |                                 |                                 |                                 |                                 |                                 |                                 |
| 18–19                           | 2.11                            | 4.4**                           | 1.12                            | 9.4**                           | 1.09                            | 9.8**                           |
| 20–21                           | 3.11                            | 6.6**                           | 1.88                            | 16.1**                          | 1.95                            | 17.9**                          |
| 22–23                           | 3.65                            | 7.7**                           | 2.28                            | 18.9**                          | 2.30                            | 20.1**                          |
| 24–40                           | 3.89                            | 8.2**                           | 2.52                            | 20.9**                          | 2.45                            | 20.8**                          |
|                                 | (169.09)**                      |                                 | (574.98)**                      |                                 |                                 | (679.89)**                      |
| Birth cohort                    |                                 |                                 |                                 |                                 |                                 |                                 |
| 1850–54                         | 0.42                            | 1.6                             |                                 |                                 |                                 |                                 |
| 1855–59                         | 0.56                            | 2.4**                           |                                 |                                 |                                 |                                 |
| 1860–64                         | 0.58                            | 2.4**                           | 0.33                            | 1.2                             |                                 |                                 |
| 1865–74                         | 0.74                            | 2.9**                           | 0.14                            | 0.5                             |                                 |                                 |
| 1865–69                         |                                 |                                 | 0.11                            | 0.4                             |                                 |                                 |
| 1870–74                         |                                 |                                 | 0.09                            | 0.3                             | −0.63                           | 2.2*                            |
| 1875–79                         |                                 |                                 | 0.08                            | 0.3                             | −0.63                           | 2.3*                            |
| 1880–84                         |                                 |                                 | 0.28                            | 0.9                             | −0.60                           | 2.2*                            |
| 1885–89                         |                                 |                                 |                                 |                                 | −0.41                           | 1.5                             |
| 1890–94                         |                                 |                                 |                                 |                                 | −0.21                           | 0.8                             |
| 1895–99                         |                                 |                                 |                                 |                                 | (9.62)*                         | (5.95)                          |
|                                 |                                 |                                 |                                 |                                 |                                 | (31.28)**                       |</p>
<table>
<thead>
<tr>
<th>Social Group</th>
<th>High Caste</th>
<th>Superior Sudras</th>
<th>Inferior Sudras</th>
<th>Untouchables</th>
<th>Muslims</th>
<th>Others</th>
<th>(88.10)**</th>
<th>(294.74)**</th>
<th>(301.91)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Caste</td>
<td>1.77</td>
<td>3.6&quot;</td>
<td>1.29</td>
<td>10.0&quot;</td>
<td>0.91</td>
<td>4.0&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Superior Sudras</td>
<td>1.23</td>
<td>2.5&quot;</td>
<td>0.73</td>
<td>5.8&quot;</td>
<td>0.24</td>
<td>1.1</td>
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</tr>
<tr>
<td>Inferior Sudras</td>
<td>0.74</td>
<td>1.5</td>
<td>0.30</td>
<td>2.3&quot;</td>
<td>-0.20</td>
<td>0.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untouchables</td>
<td>0.96</td>
<td>1.9</td>
<td>0.57</td>
<td>2.8&quot;</td>
<td>-0.16</td>
<td>0.7</td>
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<td></td>
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</tr>
<tr>
<td>Muslims</td>
<td>1.31</td>
<td>2.7&quot;</td>
<td>0.78</td>
<td>5.9&quot;</td>
<td>0.37</td>
<td>1.6</td>
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<tr>
<td>Others</td>
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<td>2.4&quot;</td>
<td>0.55</td>
<td>2.8&quot;</td>
<td>0.19</td>
<td>0.6</td>
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<table>
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<tr>
<th>Region</th>
<th>United Provinces</th>
<th>Central</th>
<th>Rest of India</th>
<th>Unidentified/Nepal</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>0.64</td>
<td>0.79</td>
<td>1.49</td>
<td>0.22</td>
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<tr>
<td></td>
<td>7.2&quot;</td>
<td>3.1&quot;</td>
<td>8.4&quot;</td>
<td>0.9</td>
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<tr>
<td></td>
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<td>1.39</td>
<td>-0.54</td>
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<td>4.8&quot;</td>
<td>11.1&quot;</td>
<td>3.4&quot;</td>
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<td></td>
<td>0.49</td>
<td>1.23</td>
<td>1.53</td>
<td>1.48</td>
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<tr>
<td></td>
<td>5.5&quot;</td>
<td>10.5&quot;</td>
<td>8.8&quot;</td>
<td>4.6&quot;</td>
</tr>
</tbody>
</table>

(89.94)**          (165.23)**   (168.28)**

$R^2$ | 0.077 | 0.091 | 0.104
$s$  | 2.42  | 2.26  | 2.28

Note: In all three regressions, the dependent variable is height in inches. $N = 4,585$ in the first regression, $N = 12,807$ in the second, and $N = 11,715$ in the third. The chi-square statistics are test statistics for significant factor effects, the number of degrees of freedom of the statistics being equal to the number of coefficients describing the factor. The intercept in the regression relating to the 1879–89 recruitment period is an estimate of the mean height of a male aged 16–17 years from the 1840–49 birth cohort who was Tribal, from the Bengal, Bihar, and Orissa region, recruited during 1879–89. The intercept in the regression relating to the 1890–1904 period is an estimate of the mean height of a male with similar characteristics except that the birth cohort is 1850–59 (and the male was recruited during 1890–1904). For the intercept in the regression relating to the 1905–16 recruiting period, the birth cohort characteristic is 1865–74. $R^2$ is the coefficient of determination adjusted for degrees of freedom, and $s$ the estimated standard error of the disturbance. All test statistics are heteroskedastic-consistent test statistics.

*Indicates significant at the 5% significance level.

**Indicates significant at the 1% significance level.
Table 5  Female height least squares regressions for three recruitment periods

<table>
<thead>
<tr>
<th>Birth cohort</th>
<th>1879–89</th>
<th>1890–1904</th>
<th>1905–16</th>
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<tr>
<td></td>
<td>Regression coefficient estimates</td>
<td>t ratios/ (chi-squares)</td>
<td>Regression coefficient estimates</td>
</tr>
<tr>
<td>Intercept</td>
<td>53.10</td>
<td>58.4 **</td>
<td>57.98</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–19</td>
<td>1.39</td>
<td>2.0 *</td>
<td>0.90</td>
</tr>
<tr>
<td>20–21</td>
<td>2.63</td>
<td>3.9 **</td>
<td>1.44</td>
</tr>
<tr>
<td>22–23</td>
<td>3.20</td>
<td>4.7 **</td>
<td>1.68</td>
</tr>
<tr>
<td>24–40</td>
<td>3.96</td>
<td>5.7 **</td>
<td>1.76</td>
</tr>
<tr>
<td></td>
<td>(83.82) **</td>
<td></td>
<td>(118.01) **</td>
</tr>
<tr>
<td>Birth cohort</td>
<td>1850–54</td>
<td>0.50</td>
<td>1.4</td>
</tr>
<tr>
<td>1855–59</td>
<td>0.16</td>
<td>0.5</td>
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<tr>
<td>1860–64</td>
<td>0.42</td>
<td>1.3</td>
<td></td>
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<tr>
<td>1865–74</td>
<td>1.32</td>
<td>3.4 **</td>
<td></td>
</tr>
<tr>
<td>1865–69</td>
<td></td>
<td></td>
<td>-0.10</td>
</tr>
<tr>
<td>1870–74</td>
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<td>-0.25</td>
</tr>
<tr>
<td>1875–79</td>
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<td></td>
<td>-0.24</td>
</tr>
<tr>
<td>1880–84</td>
<td></td>
<td></td>
<td>-0.42</td>
</tr>
<tr>
<td>1885–89</td>
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<td></td>
<td>-0.56</td>
</tr>
<tr>
<td>1890–94</td>
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<td>-0.10</td>
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<tr>
<td>1895–99</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>(24.30) **</td>
<td>(9.09)</td>
<td>(9.61) *</td>
</tr>
<tr>
<td>Social group</td>
<td>United Provinces</td>
<td>Central</td>
<td>Rest of India</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------</td>
<td>---------</td>
<td>---------------</td>
</tr>
<tr>
<td>High Caste</td>
<td>1.61</td>
<td>1.46</td>
<td>1.12</td>
</tr>
<tr>
<td>Superior Sudras</td>
<td>1.12</td>
<td>2.6**</td>
<td>0.06</td>
</tr>
<tr>
<td>Inferior Sudras</td>
<td>1.34</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Untouchables</td>
<td>1.07</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Muslims</td>
<td>1.07</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Others</td>
<td>1.07</td>
<td>0.4</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Note:**
- Region
  - United Provinces: 0.42, 0.01, 0.1, 0.14, 1.2
  - Central: 0.86, 0.28, 2.2*, 0.82, 4.6**
  - Rest of India: 1.28, 0.77, 2.4*, 1.03, 3.3**
  - Unidentified/Nepal: 0.27, 0.12, 0.4, 0.13, 0.2

- **R²:**
  - 0.069
  - 0.059
  - 0.052

- **s:**
  - 2.49
  - 2.15
  - 2.29

Note: In all three regressions, the dependent variable is height in inches. N = 1,754 in the first regression, N = 5,248 in the second, and N = 4,910 in the third. The chi-square statistics are test statistics for significant factor effects, the number of degrees of freedom of the statistics being equal to the number of coefficients describing the factor. The intercept in the regression relating to the 1879–89 recruitment period is an estimate of the mean height of a female aged 16–17 years from the 1840–49 birth cohort who was Tribal, from the Bengal, Bihar, and Orissa region, recruited during 1879–89. The intercept in the regression relating to the 1890–1904 period is an estimate of a female with similar characteristics except that the birth cohort is 1850–64 (and the female was recruited during 1890–1904). For the intercept in the regression relating to the 1905–16 recruiting period, the birth cohort characteristic is 1865–79. R² is the coefficient of determination adjusted for degrees of freedom, and s the estimated standard error of the disturbance.

*Indicates significant at the 5% significance level.

**Indicates significant at the 1% significance level.
the poorer sections of the rural community deteriorated from 1875 to the mid-1890s. This does not coincide fully with the view taken by the historians of real wages. M. Mukherjee charts a substantial decline of real agricultural wages in India as a whole from 1871–72 to 1878–79, and then a recovery and improvement of real wages between 1880 and 1890–91, followed by a depressed period through most of the 1890s (Heston 1983: Table 4A.11, 445). Heston’s own figures avoid the trough of the 1870s but follow the subsequent trends in Mukherjee’s table (Heston 1983: 445). The difference between the two indexes of real wages and the height analysis may be due to the regional influences on the latter figures, but it is difficult to accept Heston’s sanguine view of the 1870s for India as a whole. As well as the droughts and famines that struck the subcontinent in the decade, the British “forward policy” in Afghanistan was a financial as well as military disaster, and the effects of the decline of the value of silver against gold began to be felt as India imported inflation, pushing up the domestic price of foodgrains while they remained the cheapest on the world market (Rothermund 1983: 12). By the 1870s further population growth in eastern UP and Bihar could not be accommodated within the agrarian system that supported the political and economic demands of the British.

A significant part of the decline in the nutrition of those born after 1875 was due to the famines of the 1870s and 1890s. Despite the increasing capacity of the state to intervene, its effectiveness varied between districts, and millions were deprived of normal food supplies during these crises (Brennan et al. 1984). The famines of the 1870s were also significant because they boosted food prices that in the context of the declining price of silver, did not return to their earlier levels. But the evidence that there was a reduction in the heights of those born in the 1880s—when there were no widespread famines—indicates that the decline in living conditions was also related to general economic forces. That is, segments of the population were not benefiting from the increase in trade and transport during the period.

There were a number of other factors at work in the region. As slow as population growth was in the last quarter of the nineteenth century, it brought pressure on resources, rents increased, and it became more difficult to find new land to cultivate. Malaria and gastroenteric illnesses affected many among the population, including the children. It is not difficult to understand reduced final adult heights, given low childhood growth rates
arising from illness and uneven food supply and compounded by problematic nutrition into the early adult years.

The above outline of factors influencing the economic conditions in North India suggests that from mid-century to the early 1870s there was an expansion of the economy, especially in the western districts, followed by a period of stagnation until the middle of the first decade of the twentieth century, when climatic and financial conditions improved. After the First World War, the economy went into decline, a decline accentuated by the low commodity prices during the depression of the 1930s and only relieved by the high prices of the 1940s. It is problematic whether these wide fluctuations in commodity prices were to the advantage of the laborers and cultivators. The latter were devastated by the depression, which caught them paying high rents to the zamindars, and the rise in population after 1921 brought extra pressure to bear on the laborers, especially those in eastern UP and Bihar where population densities had been substantial in the nineteenth century.

Economic stress was accompanied by tensions in the social and administrative infrastructure of North Indian society. Whitcombe (1972:274), discussing UP in the last forty years of the nineteenth century, argues that "[t]he expansion of agriculture, the flourishing trade in agricultural products, the scientific principles of the revenue assessments and the inflexibility of their operation in practice, modernization of the judicial machinery and the structure of Government in line with equitable abstractions — every innovation made demands on existing institutions far out of proportion to their capacity." That is, there were increasing strains upon the means by which the people of North India ordered their relationships. These strains and their economic counterparts were reflected in the willingness of large numbers of people to leave their homes and risk an ocean voyage to lands and work about which they knew little, but hoped much. As Sheel (1992: 345–46) points out, however, there was a tradition of migration in some of the districts of the region, and this needs to be factored into the explanation of migration as well as the push factors indicated above.

**Conclusions**

This study indicates that agricultural laborers in Bihar and eastern UP, after initially benefiting from the commercialization of agriculture and expansion
of transport, experienced a gradual decline in nutrition and health conditions from the mid-1870s until the late 1890s, and that this downward trend continued in the twentieth century.

These conclusions are drawn from only one indicator of economic well-being and are specific to a particularly disadvantaged area. But if we keep these caveats in mind, the evidence suggests that the model of increasing opportunity and growth advanced by Morris and McAlpin does not seem to have persisted after the mid-1870s among the laborers in this region.

Appendix I

Contemporaries and later scholars have grappled with ways in which castes should be grouped to assist in their analysis. One contemporary official, Grierson (1883: 35–36), divided 1,226 entries from emigration registers into Hindus (962) and Muslims (264), and among the Hindus, those “of higher social position” (231), such as the Chhatri (123) and Brahman (81); “of medium social position” (454), such as the Gowala (163); and “of lower social position” (277), such as the Chamar (54). By showing that about “two-thirds of the Hindus recruited belonged to castes of higher and medium social position,” Grierson could refute “the fallacy of one very current idea about emigration . . . that only the lowest castes emigrate.”

Emigration authorities in Calcutta also attempted to summarize the data on caste and religion that they collected. In the annual reports on emigration to British and foreign colonies of the Bengal Department of Emigration, recruits were divided into Muslims, Christians, and four Hindu categories; unfortunately no list was given of the castes making up each category. For recruits bound for Fiji between 1879 and 1916, 16.2% were classified as “Brahmans and other High castes”; 31.5% as “Agriculturist”; 6.6% as “Artisan”; 30.9% as “Low Caste”; 14.7% as Muslims; and 0.1% as Christians.

More recently, Lal (1983: 69–70) has computerized information, other than that of stature, from the emigrant passes of recruits departing from Calcutta to Fiji and has classified the information on social groups into the following ten categories: (1) Brahmans and allied castes (3.71%); (2) Kshatriya and allied castes (10.05%); (3) Bania and allied castes (3.50%); (4) Kayasths (0.33%); (5) middling agricultural and artisan castes (39.04%); (6) low, menial castes (21.93%); (7) tribal groups (2.9%); (8) Muslims (15.13%); (9) Christians (0.05%); and (10) miscellaneous groups (4.36%). Lal (1983: 70–71) also compared the contribution of the various castes to the emigrant population to their contribution to the overall population of the United Provinces in the census years 1891, 1901, and 1911 and
concluded "that for most castes, with the exception of Brahmans, there is a broad correlation between their numerical strength in the United Provinces and their contribution to the emigrating indentured population."

Both the Bengal Department of Emigration and Lal, accordingly, have employed classifications of caste that mix ritual and socioeconomic terminology. In our study, we have preferred to follow the *Census of India 1901* (1902, 16 [1]: 218–58), which classified Hindus in terms of the direction of the ritual pollution involved in any transaction of food and water between members of different castes. We have grouped the thirteen census categories for Hindus into four categories: (1) High Caste, such as Thakurs (3,274), Rajputs (1,739), and Brahmans (1,293); (2) Superior Sudras, such as Ahirs (3,935) and Kurmis (2,183); (3) Inferior Sudras, such as Koris (1,741) and Kahars (1,490); and (4) Untouchables, such as Chamars (5,262) and Pasis (905). Muslims numbered 4,931.

It should be emphasized that among anthropologists it is considered a particularly brave—or perhaps even foolhardy—task to construct a caste hierarchy because there can be large variations in a caste’s perceived standing from one district to another. For our purposes, however, we are only assuming that there is in very broad terms a positive association between ritual and socioeconomic status such that the recruits from the High Castes or Superior Sudras would have had a more favorable nutritional status in childhood than recruits who belonged to the Inferior Sudras or Untouchables.

Appendix 2

Regression analysis was used to estimate multivariate relationships between the height of recruits and factors associated with height. Two specifications were considered. In the first (specification A), height was related to age, birth cohort, social group, region of origin of the recruit, and year of recruitment. In the second (specification B), in place of recruitment year, a variable measuring the demand for recruits (the total emigration from Calcutta in the year to all foreign destinations) and a supply variable (taking the value one during the years of famine and economic distress, 1890–92, 1896–97, and 1899–1900, zero otherwise) were introduced. In both cases, age was measured in five groups (16–17 years, 18–19 years, 20–21 years, 22–23 years, and mature adults 24–40 years), birth cohort in 11 groups (1840–49, 1850–54, 1855–59, 1860–64, 1865–69, 1870–74, 1875–79, 1880–84, 1885–89, 1890–94, and 1895–99), social group in seven groups (High Caste Hindus, Superior Sudras, Inferior Sudras, Untouchables, Tribals, Muslims, and Christians and others, including unidentified), and region in five groups (United...
Provinces; Central Provinces, Central India, and Rajputana; Bengal, Bihar, and Orissa; the rest of India, mainly Delhi and Gurgaon; and unidentified and Nepal). In specification A, recruitment years were grouped into seven groups (1879–84, 1885–89, 1890–94, 1895–99, 1900–1904, 1905–9, and 1910–16). The male height regressions were based on 29,107 observations, and the female regressions on 11,912 observations.

Turning first to the male heights, the range of the height distribution is from 43 to 76 inches, the mean 64.01 inches and median and mode 64 inches. The standard deviation is 2.43 inches. Although the data were measured to the half inch some years, and quarter inch in others, there is clear heaping at whole inches. The distribution is not significantly skewed but has significantly greater kurtosis than a normal distribution with the same variance. Chi-square goodness of fit and Jarque-Bera Lagrangian multiplier normality tests indicate a nonnormal distribution at the 1% significance level. A quantile-quantile normal probability plot indicates the approximation to the normal is good in the middle of the distribution and that a poor correspondence in the tails is responsible for rejection.

The distribution of adult males (aged 24–40 years), based on 11,870 observations, possesses similar characteristics, although the mean is a little greater (64.41 inches).

The male height (least squares) regression estimates are reported in Table 2. Diagnostic tests indicate significant heteroskedasticity in the disturbances, so heteroskedasticity-consistent test statistics (including those for total factor effects) were calculated. The intercept in the first regression (59.76 inches) gives an estimate of the average height of a male aged 16–17 from the 1840–49 birth cohort who was a tribal from the Bengal, Bihar, and Orissa region, recruited during 1879–84. The estimate alongside “age 18–19 years” (1.12 inches) indicates that a male with the same characteristics, except that age was 18–19 years, was on average 1.12 inches taller. The t ratio (14.0) indicates this difference in height is highly significant. (It is significant at the 1% level.) The chi-square statistic relating to age (1,093.57) indicates that the age factor has a highly significant effect on height. (On the null, the statistic is distributed as a chi-square with four degrees of freedom; this is significant at the 1% level.)

The specification A regression (with recruitment year variables) indicates a significant increase in height with age, with 18–19-year-old males being just over an inch taller on average than 16–17-year-olds, 20–21-year-olds just under two inches taller than 16–17-year-olds, 22–23-year-olds 2.31 inches taller, and adults 24–40 years old about two and a half inches taller on average.

The birth cohort factor is also significant, with the earliest cohort (1840–49) being shortest, those in the 1850–64 cohorts about half an inch taller on average,
males in the 1865–89 cohorts less than a quarter of an inch taller than the earliest cohort, and males in the 1890–99 cohort about half an inch taller.\textsuperscript{10} The social group factor is highly significant, High Caste Hindus being about one and a quarter inches taller, on average, than Tribals; Superior Sudras about two-thirds of an inch taller; Inferior Sudras and Untouchables about a quarter of an inch taller; Muslims three-quarters of an inch taller; and Christians and others about half an inch taller. It is surprising that Untouchables were, on average, taller than Inferior Sudras.

The region effect is also highly significant, with males from the Bengal, Bihar, and Orissa region and the unidentified and Nepal group shortest, United Provinces males about half an inch taller on average, males from the central region a little less than an inch taller, and the males from the rest of India more than one and a half inches taller.

Finally, the recruitment year factor is also highly significant, males recruited during 1890–1904 being on average more than an inch taller than those recruited during 1879–84.

Although all five factors are highly significant, there remains considerable variation in height for males with the same characteristics. This is indicated by the $R^2$ value (just over 0.1) and the standard deviation about the mean estimate (approximately 2.30 inches).

The alternative regression specification without the recruitment year variables but with the demand and supply variables (specification B) exhibits very similar age, social group, and region effects. In this regression, the intercept cannot be interpreted as the estimated average height of a particular group of males because the demand and supply variables also make a contribution to estimated height. When they are allowed for, estimated heights are very similar. For example, the estimated mean height of a male recruited in 1884 aged 16–17 years from the 1840–49 cohort who was Tribal and from the Bengal, Bihar, and Orissa region is 59.81. (This compares with an estimate of 59.76 generated by specification A.) Notice that in specification B the birth cohort effects are more significant. The effects for the 1850–64 cohorts and 1885–99 cohorts are similar, but now, for the 1865–84 cohorts, average height increases by between three-quarters to one inch. Both the demand for recruits variable (total emigration from Calcutta in the year) and the supply variable (the dummy variable for famine years) have expected signs (negative and positive, respectively) and are highly significant. The $R^2$ value is very slightly lower for this specification.

The female heights display similar characteristics to those for males. For the full sample of 11,912 observations, height ranged from 48 to 71.75 inches, with a mean of 59.08 inches, median of 59 inches, and a mode of 60 inches. The stan-
standard deviation is 2.34 inches. There is heaping on whole inches, little evidence of skewness, but significant kurtosis. The distribution is significantly nonnormal, principally because of poor correspondence in the tails. The 24–40-year-old adult female height distribution (4,463 observations) exhibits similar characteristics. The mean is 59.43 inches.

The female height regressions (see Table 3) display parallels with the male regressions. As for males, in the specification A regression, the intercept estimates the average height of a 16–17-year-old from the 1840–49 birth cohort who was Tribal, from the Bengal, Bihar, and Orissa region, recruited during 1879–84. The age factor is highly significant. Eighteen- to nineteen-year-old women were, on average, about an inch taller than those 16–17 years old, and 24–40-year-olds were more than two inches taller.

The birth cohort effect is (just) significant at the 1% significance level. For the 1840–49 and 1855–94 cohorts the average height varies little and is about half an inch greater for the 1850–54 cohort, and one-third of an inch greater for the 1895–99 cohort. The social group effect is also (just) significant at the 1% level. The height differences are smaller than for men, High Caste Hindus being, on average, less than half an inch taller than the shortest group (Tribals). The height ordering of the social groups is similar to that for men (although Muslim females are relatively shorter and those in the “other” group are relatively taller than males).

The region factor is also less significant than in the males regression, the differences in height being reduced, but the basic pattern is the same. The recruitment year factor is significant with a pattern similar to that of males, heights being on average between an inch and one and a half inches taller during the 1890–1904 recruitment years than 1879–84.

In the specification B regression, both the demand and supply variables are highly significant, with expected signs, and age, social group, and region effects are similar to those in specification A. The birth cohort factor now appears more significant with estimated average height about three-quarters of an inch greater for the 1865–89 birth cohorts than the earliest.

Height measurements are usually normally distributed, but the evidence reported earlier indicates that the distributions have tails unlike the normal. This could be due to a bias against selecting very short people, the heights of some taller people being exaggerated, and other minor measurement errors. One way of allowing for these features is to estimate the regressions by reduced sample truncated regression (see Brennan et al. 1992a). The estimates obtained with this method (truncating male heights at 58.50 and 70.25 inches and female heights at 53.50 and 65.25 inches) were, however, similar to the least squares results (and hence are not reported). The similarity of the estimates suggests that the least
squares height estimates reported here are largely unaffected by such selection biases and measurement errors.

A main focus of interest is the birth cohort effects. These are significant in all the regressions but relatively small in magnitude, particularly in the specification A regressions. Also, the pattern of cohort effects differs, depending on whether recruitment year variables are entered as explanatory variables in the regression.

Interpretation of birth cohort and recruitment year effects is difficult. Recruitment year variable effects may reflect the changing height of the Indian population or changes in recruiting standards. Moreover, there is multicollinearity between the cohort and recruitment year effects. This is because the recruits tend to have similar ages (males were predominantly between 20 and 25 years), so a large portion of a given cohort was recruited in a single or adjacent recruitment year group. This tends to dilute the cohort effect. (Notice how the relatively greater heights for the 1890–1904 recruitment years in specification A are reflected in the 1865–84 cohort effects in the specification B regressions.)

Focusing on specification A, if the recruitment year variables mainly measure changes in the height of the underlying Indian working population, then both birth cohort and recruitment year effects reflect changes in the average height of that population, and on this interpretation, average height increased by well over an inch from the earliest cohort group, 1840–49. On the other hand, if the recruitment year variable mainly measures changes in recruiting standards, then their effects should not be interpreted in this way. Moreover, because of intercorrelation with the birth cohort variables, the birth cohort effect is diminished.

Introducing the demand and supply variables in place of recruitment year (specification B) has the advantage that these variables are more orthogonal to the birth cohort variables. (This should result in more precise estimates of the separate effects on height.) They also measure more directly (if roughly) factors that may have affected recruiting standards. Despite the fact that the fit from these regressions is slightly inferior, and the demand and supply variables are only a rough proxy for factors affecting recruiting standards, on balance, we have more confidence in these estimates.

An indication of how successful the total migration from Calcutta variable and the famine dummy variables were in proxying demand and supply factors affecting the average height of migrants can be obtained by regressing average height each recruitment year on these variables. In the regressions we controlled for variations in age by measuring the average height of 24–40-year-olds only. For males, the estimated coefficients on the total migration and the famine variables were significantly negative and positive, respectively (thus conforming to expectations), but the value for $R^2$ was only 0.262. (To allow for autocorrelation in the
disturbances, a first-order disturbance autoregressive process was estimated.) A similar result was obtained for the females regression, the $R^2$ value being 0.247.12

These regressions do not control for variations in migrant caste and region of origin across recruitment years. To an extent, these variations account for the poor fit of the regressions. A cross-tabulation of region by the three recruitment periods 1879–89, 1890–1904, and 1905–16 indicates major changes in the percentage of migrants from the different regions (for example, during 1879–89, 32% of migrants came from the Bengal, Bihar, and Orissa region, but only about 8% during 1890–1904 and 1905–16). The caste proportions are more stable across the recruitment periods. Even allowing for variations in caste and region, the fits are rather poor.

A further check on the finding that there was a cyclical pattern in average height by birth cohort is performed by running separate regressions for the three relatively homogeneous periods of recruitment (1879–89, 1890–1904, and 1905–16), relating height to age, social group, region, and birth cohort, taking care to define the birth cohorts so that there were at least 50 observations in each cohort (see Tables 4 and 5). For both males and females, for the recruitment periods 1879–89 and 1905–16, the birth cohort effect was significant at the 5% level and shows a cyclical pattern somewhat similar to that observed in specification B in Tables 2 and 3. The birth cohort effect was not significant at the 5% level for the 1890–1904 period.

Notes

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1 During the British raj, UP had a number of titles, including the North-Western Provinces and Oudh between 1877 and 1902 and then, until 1937, the United Provinces of Agra and Oudh. Bihar was a distinctive region of Bengal up to 1911, when, joined with Orissa, it was set up as a province. It became a separate province in 1935.

2 The landholding systems in the districts of eastern UP and Bihar varied from taluqdari to zamindari to mahalwari, and from permanent to 30-year settlements. The permanent settlement in the 1790s fixed for good the land tax demand on land in
Bengal, Bihar, and the Varanasi region of UP. From the 1820s and 1830s in the
remainder of the UP land tax was reassessed after village-level investigation every
30 years or so. By the last half of the nineteenth century, land taxes were usually
higher in UP than in Bihar. A taluqdari settlement was an engagement in Oudh be-
tween a superior landlord—in pre-British times often a local political figure—and
the government for the payment of the land tax from the rental and other income
from his estate. A zamindari settlement was similar, though few zamindars held as
many villages as the Oudh taluqdars. A mahalwari settlement was one between the
government and the zamindars who shared ownership of the estate (mahal) in which
they also usually lived.

3 This document can be found in Indian Immigration Trust Board Papers, 1909, II/1164, 29/09, Natal Archives. We are indebted to Joy Brain for a copy of these
instructions.

4 It is possible that the observed average height differentials may also be due to dif-
fferences in the proportion urbanized and to differences in feeding practices. These
possibilities require further research.

5 Eveleth and Tanner (1990: 309) also report other studies, but these relate to the
Punjab, Gujarat, and South India and so are not directly comparable to our results.

6 Data on the total number of labor emigrants departing from Calcutta each year were
reported in the annual reports on emigration to British and foreign colonies of the
Bengal Department of Emigration, Calcutta, published by the Government Press.

7 Although final adult height is a function of nutrition and disease conditions during
the entire period of growth, it appears that the first few years of life are the most
critical (Tanner 1982: 576). Therefore, it seems appropriate to compare trends in
height by year of birth with general economic trends in those years.

8 Parts of Bihar were affected by the famine of 1865–66 when food prices more than
doubled, work was unavailable, and relief was delayed until many people were too
weak to benefit from it. See Bhatia 1967: 69–73. Sheel (1992: 337–38) discusses the
impact of disease on Gaya and Shahabad districts.

9 For example, when the squared residuals were regressed on the predicted height,
the chi-square heteroskedasticity test statistic was 39.890, significant at the 1% level. Heteroskedasticity-consistent t test statistics and Wald chi-square statistics
(see White 1980) of total factor effects were calculated. Diagnostic tests revealed no
evidence of autocorrelation in the disturbances.

10 The individual birth-cohort effects are mostly insignificant from each other, so no
great confidence can be placed in these estimated individual birth-cohort effects.
Numbers and percentages (in parentheses) for each of the eleven birth cohorts
(starting with the earliest) were 405 (1), 1,215 (4), 2,502 (9), 2,750 (9), 3,670 (13),
4,313 (15), 5,018 (17), 4,937 (17), 3,316 (17), 789 (3), and 152 (1).

11 Numbers and percentages (in parentheses) for each of the birth cohorts (beginning
with the earliest) were 175 (1), 519 (4), 922 (8), 947 (8), 1,432 (12), 1,627 (14), 2,016
(17), 2,383 (20), 1,445 (12), 363 (3), and 67 (1).

12 For males, the estimated regression was $R_i = 64.70 - 0.000041D_i + 0.3935S_i$, where
R, is the average height of males aged 24–40 in the t-th recruitment year, D, is total migration from Calcutta in that year, and S, is the famine dummy variable. For the three coefficient estimates, t ratios were 275.2, 1.8, and 2.0, respectively, and the disturbance autoregressive parameter 0.31 with t ratio 2.4. The females equation was 

\[ R, = 59.63 - 0.000028D, + 0.4655S \] 

(t ratios 357.2, 1.7, and 3.2), and disturbance autoregressive parameter 0.17 (t ratio 1.0).

References


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