The Biological Standard of Living and Body Height in Colonial and Post-Colonial Indonesia, 1770-2000

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Abstract

How did the Biological Standard of Living develop in Indonesia during colonial times? Did it increase substantially after decolonisation? In our study, we use four sets of anthropometric data to construct time series of average human height since the 1770s. The paper observes a significant decline of heights in the 1870s, followed by only modest recovery during the next three decades. Both are related to a sequence of disasters. Average heights increased from the 1900s, accelerating after World War II. The World Economic Crisis, the Japanese occupation and war of independence in the 1930s and 1940s were a set-back. Average height growth is related to improvements in food supply and the disease environment, particularly hygiene and medical care.

Key words: human heights, Indonesia, welfare, economic development
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1. Introduction

How did the Biological Standard of Living develop in Indonesia during colonial times? Did it increase substantially after decolonisation? Over the past decade, the colonial legacy debate has stimulated historical research about the ardent question of long-run effects of colonial expansion (Acemoglu *et al.* 2001, 2002). It followed a much older literature, but developed a particular comprehensive demand for quantitative data. One core data source with great potential is anthropometric evidence on human stature, as it has been developed into a widely accepted indicator of the 'Biological Standard of Living'.[1] Indonesia is a particularly important case for this line of research, because its colonial history can be divided into three different phases: During the early history, the Dutch colonial power was mainly interested in trading spices, interfering only modestly with the life of the population of the Indonesian islands. During a second phase, the Dutch colonial government implemented the so-called Cultivation System in much of Java after the 1830s. The system enhanced the cultivation of major export crops, such as coffee, sugar cane and indigo in Java. Farmers were compelled to produce such crops on farm land, or to contribute their labour to the growing of crops on newly opened plantations (Van der Eng 2004). Thirdly, the Dutch colonial government implemented a number of so-called 'ethnical' welfare policies since the 1890s, which involved agencies for hygiene and health care, agricultural extension, veterinary services, small-scale credit facilities and similar institutions (Boomgaard 1986; Cribb 1993). While some scholars argued that such policies had positive consequences for the standard of living, others maintained that these policies were mere window dressing and that the *raison d'être* of Dutch colonial rule continued to be exploitation of Indonesian resources, until Indonesia became finally independent in the 1940s. In this study, we will assess whether especially the second phase, the Cultivation System might have had a detrimental impact on the nutritional

[1] A term first coined by Komlos (1985).

status of Indonesians. One could hypothesise that the expansion of the plantation system might have put pressure on the subsistence production of food. As the population was also substantially growing, those factors taken together might have worsened the nutritional status of Indonesians. A second hypothesis would be that the increased international interaction during the 'First Era of Globalisation' of the late 19th century could have contributed to a deterioration of the disease environment in Indonesia. The measures of the third phase, the 'ethnical' welfare policy phase, could have been a reaction to health issues during the previous phase. We will assess the impact of these different phases on the Biological Standard of Living.

Two major studies found it difficult to strike a balance between contrary views on the long-term development of living standards in Indonesia (Booth 1998: 89-134; Dick *et al.* 2002: 133-35, 157-58).[2] Nevertheless, they echoed the very common argument that Indonesia since the 1970s experienced 'growth with equity' as a consequence of the 'pro-poor growth' policies pursued by its government that yielded low rates of income inequality (*e.g.* World Bank 2005: 126-127). This argument that economic growth in recent decades improved living standards equally across the board does not sit easily with recent evidence of significant income inequality (Leigh and Van der Eng 2009). The purpose of this paper is to contribute to these discussions in the literature on the basis of an analysis of long-term changes in average heights of men and women in Indonesia.

While the more recent anthropometric situation in Indonesia has been studied, it has not yet been featured in studies for the colonial period that used anthropometrics to assess changes in the biological standard of living in less-developed countries, such as in Africa (*e.g.*

[2] Indonesia's national accounts data are now of reasonable quality, but at least until the methodological revisions of 1993, Indonesia's official national accounts data are of questionable reliability (Van der Eng 2002a). Hence, for the analysis of long-term changes, alternative indicators of economic growth and changes in the standard of living are required. A few other indicators of living standards, such as life expectancy, infant mortality, educational attainment or per capita food supply are available (Van der Eng 2002b), but their reliability is questionable going back in time.

Moradi 2009; Austin *et al.* 2012) and Asia (*e.g.* Baten *et al.* 2010).[3] The lack of anthropometric studies is all the more astonishing since Indonesia is the fourth largest country in the world with a population of 238 million in 2010. The lack of readily available data prevented the analysis of anthropometric data for Indonesia for the period before 1900.[4] This paper analyses for the first time data based on several sources for this purpose. To analyse long-run changes in average heights, a number of determinants of height have to be taken into account. In particular, changes in nutritional status, as well as the disease environment and hygiene and health care, are relevant.

Multiple data sets are required to examine height development in Indonesia. These are presented in the following subsections A-D. Nonetheless, combining such diverse data sets creates their own identification problems inherent in coupling diverse data sets, because we are not fully able to isolate general patterns from selection biases, especially in the case of the early slave data set. Therefore, the causal interpretation in section 3 and the tentative conclusion (section 4) have to be drawn using some caution.[5]

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[3] One exception is Földvari *et al.* (2012) for the 20th century. This study finds that regional differences between Java and the Outer Islands changed towards the end of the period: while the Outer Islands had a nutritional advantage early-on, the 1960s saw an overtaking of the capital region – Javanese were now taller than those born on Sumatra and the other islands. Unfortunately, the trend estimate in this study for the period before the 1930s is difficult to interpret, because the authors did not include military category dummies and age dummies in their regressions: The first three birth decades consisted of older soldiers mainly in their 30s and 40s of age. In most armies of the period, those age groups represented elite groups such as specially trained soldiers, grenadiers, guardsmen, and officers. In other army samples, those groups were always taller than the normal (and young) recruits. The first two birth decades represented less than 1 percent of the total data set in the 1890s and 1900s, respectively, and the 1910s cohort is also much smaller than the young recruits in their early 20s. Hence their trend estimates are difficult to interpret. However, their regional findings seem reliable. In contrast to the dearth of studies of heights during the colonial era, there is a number of studies on the recent period. Research based on household surveys in Indonesia since the 1990s has pointed out the short run effect of crisis on the nutritional status for the fourth largest country in the world, as well as the negative effect of child labour on anthropometric values (Block *et al.* 2004; Wolff *et al.* 2008).

[4] Van der Eng (1995) focused for that reason on the 20th century.

[5] For 1770-1790 and 1810, we construct two benchmarks. From 1850 onwards, there are continuous time series until 2000.

2. Data section

A. Slaves in Batavia, 1770s-1810s

The first dataset we used consists of a list of slaves in the city of Batavia (now Indonesia's capital Jakarta), compiled in 1816 for the purpose of collecting tax from slaveholders. Slavery was a common institution in Southeast Asia and also in Batavia under Dutch colonial rule. During a brief English interregnum of 1811-16, the new government sought to undermine the institution with the purpose of abolishing it. In 1812 it proclaimed an annual tax on the owners of slaves in Java, for which purpose slave registers were created (Paulus *et al.* 1917-21, vol.3: 803-4). It is not clear what purpose the inclusion of heights in the slave register served. The government proclamation required owners to give a description of the slaves, possibly for the purpose of identification of slaves during checks by tax officials at the owner's household. Many owners recorded the height of their slaves as well as other physical features, while others only recorded identification marks such as facial scars.

The register recorded name, age, height and region of origin of each slave. The original height evidence was reported in Rhenish foot; in our analysis, we use metric measures. Information about the slaves was provided by the owners. The place of origin was in most cases the port from where a slave had been transported to Java. Slaves may sometimes have been unaware of their age, in which case the owner had to estimate it. The penalty for false registration was the emancipation of the slaves, which suggests that owners had an incentive to register their slaves with accurate data.

The register allows us to create (1) a subset of 600 slaves which is characterised by modest rounding, and (2) a full data set of 1,537 observations. The datasets are drawn from some pages in the source on which substantial rounding occurred, and from other pages in which rounding was more modest.[6] We ran regressions both with the full data set, which is characterised by the strong rounding pattern, and the limited sample for which rounding was less severe. For the full data set, the rounding on 4 feet was actually much more common than rounding on 5 feet, hence the full data set yields estimates which are lower. We would argue that the limited data set yields more reliable estimates.

Where did the slaves originate from? The numbers of slaves from outside the Indonesian archipelago was negligible, but we omitted those singular cases. However, even within Indonesia we could imagine large ethnic differences. Fortunately, the regions of origin were relatively widespread; from Aceh in the Northwest to Nusa Tenggara in the Southeast of modern Indonesia. Many of the Indonesian slaves were Buginese from Sulawesi in the Northeast. Other well-represented areas were Bali and Timor (classified under Nusa Tenggara in Table 1), while a sizeable portion was born in Batavia as descendants of slaves. East Indonesia was well-represented in the data, because it was customary for people in this part of the country to enter slavery through sale by local rulers, debt, punishment, capture during war, or through piracy and raiding (Abeyasekere 1983: 291-3). Many slaves were born in Java, but they may have been descendants of slaves transported from elsewhere in the archipelago as an early ruling of the Dutch East India Company – the Dutch authority before the establishment of colonial rule in 1796 – prohibited the enslavement of Javanese.

In Table 1, we show the results of an OLS regression analysis of height.[7] The table does not distinguish between the three birth decades, as the number of observations is too small. Among the females, Balinese slaves and those from Nusa Tenggara were the tallest,

[6] The original data set contained 2,479 observations with height, age and gender statement (Abeyasekere 1983: 289). Reducing the data set to those aged 20-55 and limiting height to typical intervals (110 cm –200 cm), reduces the sample to 1,537 observations. The rounding issue is explained in detail in an Appendix, which will be made available on the internet. The register itself does not identify gender, which was established on the basis of the names of the slaves (Abeyasekere 1983: 289, 294).

[7] The age dummies of adolescents are heavily correlated with the birth decade dummies, and therefore do not yield robust results. They are therefore excluded. A joint dummy variable is used as a control for the 20-22 age groups as there are insufficient observations for the individual ages. The results are almost identical if this age group is excluded.

while among the males only those from Sumatra (including Aceh) were significantly shorter than those from Jakarta. We also report an estimate of overall population share of the different regions in Table 1 and compare this with the sample share of slaves. It is clear that slaves from Jakarta and Bali were oversampled, whereas the remaining part of Java and Sumatra were underrepresented. In order to make our estimates representative for Indonesia, we calculate weighted averages of the various regions. The weighted height average of male adults born during the 1770s-1790s is 156.3 cm, for females 146.0 cm. The height of slaves is close to the lowest level ever observed in the whole world of the 18th and 19th century.

In terms of social height selectivity, we cannot make definite statements. The slave sample may have an upward bias, if especially tall and strong persons were enslaved through war or raiding. On the other hand, a negative social height bias can be expected if poorer people were more likely to experience debt slavery. We cannot judge whether those potential biases might have balanced each other.[8] Eltis (1982) argued for African slaves that they were probably relatively unbiased, compared to the overall population. However, he did not have direct height evidence of other groups to compare. Instead, his arguments relied on the fact that samples of slaves were normally distributed, both slaves from regions in which slaves were short and those in which they were tall. If tall slaves would be been preferred, Eltis argued that there should be some shortfall in the lower half of the slave height distribution in ‘short’ regions. Eltis also argued that price differentials between regions of short and of tall slaves were not observable. Hence, his impression was that height did not play a role in the enslavement process. Whether those arguments refer to Indonesian enslavement processes as well cannot be ascertained.

[8] On the other hand, around 1800 most of the Indonesian archipelago was still relatively sparsely populated and – with the possible exception of occasional famines caused by crop failure and epidemics – the average diet may have been sufficient for subsistence. But this assumes that the diet of slaves was sufficient as well and therefore that the cost to owners of feeding slaves was sufficiently low.

The adolescents in the sample were all born in the 1800s and 1810s. Previous studies have found that the years before measurement have a substantial impact on the heights of adolescents than later years preceding adulthood (*e.g.* Baten 2000). Many of the adolescent slaves may have grown up in relatively affluent households.[9] We therefore test whether these adolescent slaves benefited from being in such households compared to the adult slaves in the sample. For this purpose, we estimate the adult height of the adolescents in the 1816 slave dataset.[10] For each child, the height-for-age z-score (HAZ value) was calculated, which is a device to express height independent of the age of measurement. A HAZ value of 0 corresponds to an average child stature of well-nourished populations in the late-20th century. HAZ = -1 means that the child has a growth path one standard deviation below this modern average.[11] In this case, final height is expected to be 6.6 cm – or one standard deviation – shorter than 176 cm, the average US height. A child with HAZ = 0 would achieve an adult height of 176 cm, if the environment would not change, and a HAZ = -1 child would be correspondingly shorter. We find HAZ values of -2.36 standard deviations for male children (N = 69), after discarding extreme outliers of ± 9 standard deviations), and -2.93 for female children (N = 72). Transformed into adult height, the male children would be expected to become on average 161.3 cm later in life and the females 146.1 cm, if the nutrition remained as it was in the household of the slave owner. In both cases the adult adolescents would be taller than their adult peers in 1816. Their heights are close to the highest level observed later in the 19th century (see below). In other words, adolescents may have benefited from growing

[9] Abeyasekere's (1983: 296) 10% sample suggests that about one-third of the slaves were in respectively European, Chinese and other (*i.e.* Arab, Moor, indigenous) households.
[10] For the purpose of converting HAZ values into adults height equivalents, the HAZ-values are expressed relative to mean heights in the US (in this case 176.8288 cm), and their standard deviation (6.576107 cm). It is then possible to convert for males using the equation height = 176.8288 + 6.576107 × HAZ and for females height = 163.66 + 5.989 × HAZ
[11] The reason to use a US standard, rather than standards for developing countries is that the US standard is the measure used in the overwhelming majority of relevant studies. The aim is to make this calculation not for a subgroup of countries (such as developing nations), but to make it comparable for the whole world.

up in slave households, possibly because their diet was better than in the villages where their parents grew up, or the biological standard of living in Java as a whole improved.

B. Data on migrants from Indonesia to Surinam, 1850s-1910s

Our second data set refers to contract labourers who migrated from Indonesia to the Dutch colony of Surinam in South America.[12] The institution of contract labour has a long history in the Indonesian archipelago. For example, the first attempt by the Dutch colonial government to regulate the practice dates back to 1819. After slavery was abolished in Surinam in 1863, plantation owners started to recruit contract workers in India and Indonesia. The Indonesian contract labourers were almost exclusively recruited in Java during 1888-1939 to work on plantations in Surinam. Their details, including age and height, were recorded upon arrival in Surinam. Java was a preferred area for recruitment, because increasing population growth and density implied that Javanese wage rates were relatively low.

Two potential biases in the migrant sample may have affected the oldest cohorts, since those aged over 45 may have started to shrink already, although modern longitudinal studies find this effect to be relatively modest, *i.e.* less than half a centimetre up to the age of 50, less than 1 cm until age 55.[13] Still, this could produce a downward bias among the earliest cohorts. On the other hand, those who survived to ages 50 or 55 may have been better-nourished individuals. Moreover, a small upward bias might have been generated by recruitment, if the recruiting agents of the plantations were more selective in their choice of older recruits than younger ones. Although detailed studies found that this recruitment bias mainly concerned

[12] Sources: Historical Database of Suriname, assembled by Maurits Hassankhan (University of Suriname) and Sandew Hira (Amrit Consultancy), based on the following orignial sources: National Archives of Suriname, immigration registers: 1.China 1864/1871 no. C1- C966; 2. China 1864/1871 no. C967- C1080; 3. Register China 1880 4. Register Barbados and China 1879 no 386D.
[13] Guntupalli and Baten (2006) also arrived at low degrees of shrinkage in cross-sectional data in their study of heights in prewar India.

chest circumference (Brennan *et al.* 1994a, 1994b), the possibility that this also applied to height cannot be excluded.

All male observations were first included in a joint regression, using age dummies for those aged 18-22. The age dummies were correlated with some of the birth decades and the results were therefore implausible. Table 2 therefore distinguishes between mature adults aged 23-55 and young adults aged 18-22, which were analysed separately as a cross-check for the trends in the 23-55 age groups. Migrants from West Java were used as the reference group in the constant, and the 1900s birth decade. Regression analysis in Table 2 indicates that regional differences within Java, where most contract workers were recruited, did not matter much. Those born in Jakarta were consistently taller, whereas males from Yogyakarta were sometimes shorter, although not always significantly so. Heights in the three regions of rural Java appear relatively homogenous for this group. Table 2 shows that the young adults (aged 18-22) were much shorter than the mature adults. A possible reason is that in periods of poor nutrition, young males grew astonishingly long, sometimes even until their mid-20s.

Compared to the male birth decade constant of the 1900s, people born in the 1850s and 1860s were significantly taller. The lowest values were reached in the 1910s and the 1870s/1880s. Male and female height development reveals some similarities, such as the low levels in the 1870-1880 period, but also some differences.[14] In Figure 1, we see that the height development of the series ‘Migrants, adults’ and ‘Migrants, 18-22’ is almost identical. However, the levels are quite different, as growth until age 22 (which is the constant for the young males) is still substantial.

[14] Figure 2 reveals the differences. A Figure will be made available in an internet appendix.

C. Anthropological and Medical Surveys Dataset, 1850s-1930s

For a similar period as in the previous sub-section, a dataset was constructed on the basis of height data for males reported in a range of anthropological and medical studies of people in Indonesia.[15] Despite some shortcomings, as will be discussed below, this dataset is a valuable resource for the purpose of cross-checking possible biases in the migrant data. It also allows this study to extend the analysis of trends until the 1930s.

The main challenge of this dataset was that some observations are grouped data. When studying height trends, a frequent problem regarding anthropological surveys is the paucity of the information given on birth cohorts, as many anthropologists of the late-19th and early-20th century assumed that anthropometrics did not change over time. Hence, the decades of birth of the measured individuals had to be approximated, and it had to be accepted that a smaller proportion of the measured individuals was born before or after the most prominently represented birth decade. In a way, the time trend which results from these estimated birth cohorts resembles moving averages insofar as it smoothes the height development. Koepke and Baten (2005, 2008) and Stegl and Baten (2008) estimated these grouped and individual data jointly with Weighted Least Square Regressions (WLS) in order to estimate average heights for populations for which otherwise study of anthropometric development would not be possible. This part of the paper uses the same methodology and follows Dickens (1990) by weighting each observation by the square root of its group size.

Table 3 shows the results of two regression models to capture trends in heights. The data yield a low point for the birth decade of the 1870s, relative to the constant which refers to the 1900s, and also low heights for the 1880s and 1890s (although the 1880s coefficient is not statistically significant). Table 3 confirms the taller birth cohorts of the 1850s and 1860s found for the migrant evidence, as well as the recovery of average height after the 1890s. The

[15] Data from across the Indonesian archipelago were used for this purpose, with the exception of New Guinea or West Papua. A list of the publications from which these data were obtained is available from the authors.

low values of the 1870s and 1880s in both the migrant and the anthropological data sets might give a first hint that the Cultivation System of this period may have had adverse effects on human stature, if we assume some lags.

For the 1920s and 1930s, some height data are available for young Indonesian male adults. In this case the underlying sample size is large (N = 2,020), but most of this data is grouped.[16] The coefficient of the 1930s is not statistically different from the constant which represents the 1920s.

D. Indonesian Family Life Survey Datasets, 1940s-2000s

We used data from three rounds of the representative Indonesian Family Life Survey (IFLS), which comprises large-scale socio-economic and health surveys conducted throughout Indonesia in 1993, 2000 and 2007. Although not all regions were covered, IFLS was organised with great care to make it is as representative as possible. In Table 4, we find a more substantial increase in average heights between the 1940s and the 1980s.

Finally, we estimated adult heights for the 1990s and 2000s on the basis of the heights of children from IFLS. We apply the method to estimate adult height from child-related evidence. Hence we use the heights of 3,031 female and 2,893 male children aged 8 to 17 born during the 1990s, as well as 3,324 female and 3,416 male children aged 4 to 7 born during the 2000s, to project adult height. The average adult heights of males born in the 1990s and 2000s were estimated at 165.9 and 167.7 cm, and females 153.8 and 156.0 cm. In other words, economic development in Indonesia during 1990-2007 had very positive effects on the stature of children born during these years, despite the 1997-98 economic crisis. If those relatively favourable circumstances continue, the children are likely to acquire a higher adult stature than their parents.

[16] The dummy variable for age group 20-21 yielded implausible values, partly because age rounding interacts here with age structure, as the observations include individuals whose age was rounded to 20. In Figures 1 and 2 we therefore use the average height, not the constant.

3. Long-Term Trends in Heights in Indonesia

Figures 1 and 2 draw the evidence from Section 2 together and present long-term trends in average heights of adult males and females in Indonesia during more than two centuries. These are trend estimates after controlling for differences in the four samples in terms of age and region of origin. For the 1810s, 1990s and 2000s, the data are estimated on the basis of the heights of children.[17]

In Figure 2, we reveal broadly similar trends of average heights of males and females. The gap between the two sexes did not increase, because there were no substantial changes in the status of women in Indonesia.[18] Male slave children in the 1810s were projected to be taller than adults later in the 19th century. This may suggest that male heights in especially the 1810s were overestimated. As we possess very little continuous information about the height before the second half of the 1850s, the trend in that period is ambiguous. Another key feature in Figures 1 and 2 is the decrease in average heights of especially adult males in the birth cohorts of the 1870s and the slow recovery during 1880s-1900s, and the decrease of the heights of females in birth cohorts of the 1870s and 1880s. The decrease of female heights in the 1910s birth cohort may be related to a low number of observations. But how can the decline during the 1850s-1880s be explained?

Most anthropologists agree that modest or severe malnutrition – particularly in infancy and childhood – in interaction with a disadvantageous disease environment is a major cause of stunted growth in developing countries today (Bogin 1988). It is difficult to be specific about the impact of individual events, but Indonesia did suffer the consequences of four disasters

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[17] There is also evidence on 54-55-year adults born in the 1930s, but their height is probably affected by old-age shrinking, which has been estimated to be around 1 cm at this age. Adding 1 cm to their age, actually fits the estimate based on the 18-22 year-olds quite well (the height of those aged 54-55 is still one centimetre lower, but the gap to those aged 18-22 is smaller). Hence we added this adjustment for old-age shrinking in Figure 1.

[18] Block *et al.* (2004) identified that reduction of micronutrient food intake during the crisis of 1997-1998 essentially affected the nutritional status of women and mothers. These findings are consistent with the hypothesis that mothers buffer children's caloric intake.

during these decades, particularly the core island of Java. Firstly, a series of droughts during the 1870s-1900s, particularly 1875, 1877-78, 1885-86, 1888-89, 1891, 1896-97 and 1902-03 (Van Bemmelen 1916; Paulus *et al.* 1918-21, vol.2: 339), which had a negative effect on the production of rice, the main staple crop in the core island of Java at a time when new technologies to advance rice production were still at least 20 years away (Van der Eng 1996).

Secondly, the 1883 eruption of the Krakatau volcano off the coast of West Java was one of the biggest volcanic disasters in human history. The eruption and the subsequent tsunami claimed an estimated 36,147 deaths (Tanguy *et al.* 1998: 139) and affected rice production in Java's coastal regions. The enormous quantities of ash released by the eruption and the subsequent showers of ash pouring down also affected crop production across the Indonesian archipelago.

Thirdly, the 4th (1864-75) and 5th (1883-96) global cholera pandemics were brought to Indonesia by Muslim pilgrims returning from the annual Hajj to Mecca. Cholera was at that time endemic in Indonesia, and contributed to significant spikes in mortality rates, such as during 1874-75 and 1881-84 (Boomgaard 1987: 50; Gardiner and Oei 1987: 71), although other diseases such as dysentery, malaria, smallpox and measles contributed as well.

Fourthly, a massive outbreak of cattle plague took place during 1879-1883 for which the only solution at the time was the wholesale slaughter of infected and suspected animals (Spinage 2003: 487). In all, the stock of buffaloes in Java declined by 17% relative to 1878, particularly in West Java. This is likely to have had a negative effect on food supply, because buffaloes were crucial to the preparation of fields for rice production and as a source of protein. The cattle plague problem flared up in 1889-93 and 1897-99 (Paulus *et al.* 1917-21, vol. 4: 522) until it was finally eradicated in 1911.[19]

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[19] Was animal protein consumption influenced by religious taboos? Early 20th century assessments of food consumption practices across Indonesia suggest that religious or cultural customs did not impose major

During this period per capita food supply was only 1,600 to 1,750 Kcal per day in Java, just enough for subsistence and physical labour on small farms (Van der Eng 2000: 596-7). But such disasters occasionally obstructed the production of the main staple crop, rice, and affected the delicate balance between population growth and the growth of food production in Java. Markets for food products in Java were still poorly integrated by 1880 (Van Zanden 2004: 1040), which meant that insufficient food from surplus areas reached deficit areas in Java. This contributed to food shortages and malnutrition, particularly during the months just before the next rice harvest. In turn, malnutrition enhanced stunted human growth.[20]

The Cultivation System promoted by the colonial government may have put additional pressure on nutritional status, but the factors mentioned above were mostly exogenous to this system. Nevertheless, the spread of human and cattle disease probably was probably promoted by the intensified global integration of Indonesia.

Such occurrences help to understand the reduction in average height during the 1870s and the absence of recovery during the 1880s, but endemic malnutrition and diseases also help to account for the fact that average human heights in Indonesia were quite low by modern standards over a long period. It should be noted that today's developed countries were in the past also affected by a combination of malnutrition and a disease environment that stunted human growth. For example, the Dutch were among the shorter populations in mid-19th century Europe, because rapid urbanisation had made the provision of food and particularly fresh milk costly (Drukker and Tassenaar 1997). At that time, regional populations that had easy access to substantial amounts of animal protein (such as the American Indians, or some of the white American farmer populations) were particularly tall, while a low population

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restrictions on the use of animal proteins. Paulus *et al.* (1917-21, vol.4: 597-604) notes that most Muslims would not strictly observe the religious bans on the consumption of pork or meat that was not *halal*. Unlike India, the Hindu faith in some regions of Indonesia, particularly in Bali, did not inhibit the consumption of beef, which is still the case today.

[20] With the exception of the 1940s (see below), comparable episodes of reduced food supply and malnutrition did not re-occur in Indonesia during the 20th century, despite occasional massive volcano eruptions and droughts. Effectively, the increasingly advanced integration of markets for food crops allowed the Indonesian economy to absorb the consequences of such events.

density created a beneficial disease environment (Steckel and Prince 2001; Komlos 2003). By the late-19th century, they were closely followed by Australians of European origin, who had similarly protein-rich diets. Improvements in the protein and calcium content of the average diet are likely to be an important factor in explaining average height gains, and *vice versa* (Baten 2009). As the final stature of humans is largely determined during the first years of life, the availability of those nutrients to children was crucial for the purpose of maximising adult stature (Bogin 1988).

While not conclusive, Figure 3 suggests a close correlation between per capita protein supply and average male heights, particularly during the colonial years until the 1940s. However, the main part of the consumed protein was of vegetable origin, despite the growth of the consumption of animal products particularly in recent decades. Indonesia does not have a tradition of dairy farming. Until recently, the production of milk and dairy products for human consumption was marginal and provided mostly to the non-indigenous population in the country (Den Hartog 1986: 64-102). Buffaloes and cows were kept as domestic animals, but largely as draught animals for agricultural or transport purposes, and for fertilizer. Around 10% of these animals was slaughtered every year, and per capita beef consumption was only 2 to 2.5 kilogram per person and year, or 6 to 6.5 grams per day in the late-19th century (Van der Eng 2000: 596-7). The consumption of eggs, poultry, goat meat and mutton may have been more relevant at the time, but there are no data to confirm this. The consumption of dairy products only increased significantly since the 1970s, mainly in urban areas. Until then, the main sources of protein in the average diet in Indonesia were rice, maize and soybeans; fish and meat were luxuries. While the consumption of proteins was quantitatively sufficient, the fact that it was mainly of vegetable origin may have caused the Indonesian population to miss out on important calcium and vitamins in dairy products (Baten 1999), as well as antibodies that allowed dairy-consuming populations to withstand the impact of an adverse disease environment (Bogin 1988: 132-33). Still, the correlation in Figure 3 is imperfect, which suggests that other factors must have been relevant.

One relevant factor is that Indonesia's economy experienced gradual growth of GDP per capita after 1900, which can be taken as an indicator of a broader array of gradual changes that affected the biological standard of living, both directly and indirectly (Van der Eng 2002a). An example is a gradual increase in public spending on the services of government agencies that fostered welfare (Boomgaard 1986; Cribb 1993). In addition, physical infrastructure improved and the economy diversified, creating a growing range of new income opportunities across the country. Public facilities for health care and hygiene gradually improved, and the negative impact of common diseases and pests on popular health gradually decreased, as for example the successful case of plague eradication demonstrates (Hull 1987; Hugo *et al.* 1987: 108-9). Nevertheless, infant mortality in urban areas was still high in the 1930s (Van der Eng 2002b), which implies that the impact of improved health care and hygiene facilities was gradual.

The opening of new land for farming and new food production technologies also contributed to significant improvements in the average diet, particularly during 1905-1920 and later since the 1960s (Van der Eng 2000). There were occasional setbacks in terms of regional food shortages that caused local famines, such as in Semarang in 1900-02 (Van der Eng 2004b), as well as epidemics, particularly the Spanish flu epidemic that struck Indonesia in 1918 (Brown 1987). The economic crisis of the early-1930s reduced income opportunities and may have been a set-back for human growth (Van der Eng 2000; Boomgaard 2000: 44-45). Figures 1 and 2 show that the 1930s and 1940s birth cohort experienced a set-back in human growth. During these decades Indonesia experienced not only the World Economic Crisis, but also the Japanese occupation and the war of Independence. This was a difficult period of economic contraction and a major famine that caused the death of an estimated 2.4

million people in Java during 1944-45 (Van der Eng 2000: 605-7). After the 1940s, sustained improvements in health care and hygiene caused mortality rates to fall and population growth to accelerate (Hugo *et al.* 1987: 107-35). These changes are likely to have reduced the incidence of infectious diseases in infancy, and therefore may have benefited human growth.

Another important change was the improvement of per capita food supply since the late-1960s. Until then, population growth and the growth of domestic food production had been delicately balanced, particularly in densely populated Java, with some improvements in per capita food supply during the 1920s and 1940-41, but lower levels in the 1950s and 1960s. Underlying the growth of food production after the 1960s was the so-called 'Green Revolution' in rice agriculture, but also the development and integration of domestic markets for food products that enhanced the growth of the marketable surplus and the diversification of food production, as well as greater flows of food products from surplus to deficit areas (Van der Eng 2000: 605-7). Assisting these improvements was accelerating economic growth since the 1970s, which facilitated a significant increase in public and private investment in physical and health-related infrastructure. Infant mortality rates decreased further (Van der Eng 2002a), which indicates further improvements in health care and hygiene, which in turn encouraged human growth in Indonesia. According to Frankenberg *et al.* (2005: 6) the midwife activity was particularly noticeable in Indonesia. The impact of improvements in health care and hygiene was provided by the introduction of village-midwife-programme in 1989, which had large positive effects on the height-for-age values. [21]

Having outlined the main underlying factors that help to explain long-term trends in average height in Indonesia, it is now relevant to discuss how these trends relate to long-term

[21] Maccini and Yang (2009) studied weather variation and documented that higher early-life precipitation has large positive effects on the adult heights, health and a household asset index for women, but not for men. The positive impacts are the results of the effect of rainfall on crop output, impacting especially on the nutrition of infant girls (Maccini and Yang 2009: 11).

economic growth in Indonesia, given the fact that until 1993 Indonesia's national accounts data are tentative at best. When we compare the level of average male heights in Indonesia with a selection of other Southeast Asian countries, there is a substantial correlation in both, Indonesian values over time, and Southeast Asian levels in a panel (Figure 4).[22] It may be argued that height differences across countries are related to differences in genetic potential for height growth. However, contemporary understanding of human growth is that there is only a very limited role for genetically predetermined maximum human height potentials, and therefore that human heights are in principle comparable across continents (Baten 2009).

Several issues prevent a straight comparison of average height in countries at similar stages of economic development, as indicated by GDP per capita. One issue is that changes in nutrition and the disease environment may occur independent of changes in GDP per capita, and that discrepancies between countries in these nutrition and disease environment may persist, even if levels of GDP per capita are the same. In other words, it needs to be kept in mind that at any time the relationship between GDP per capita and average height depends on historical context.

Were Indonesian heights in the long run influenced by the productive capacity that we usually measure with Gross Domestic Product per capita? And if we plot height and GDP estimates for other Southeast Asian countries and Indonesia, were they on a similar gradient? Indonesian heights actually followed the GDP development (in logs) quite closely. The lowest GDP has the lowest height level, and the 1980s have the highest values of both variables. The most notable deviation to the lower right occurred during the 1940s, when the Japanese occupation caused a substantial reduction in the biological standard of living. Given that by all accounts the welfare of Indonesian population was quite low during Japanese occupation we maintain that the anthropometric indicator is quite informative. Slightly better

[22] Data and charts are available from the authors.

anthropometric values than expected by an imaginary regression line based on GDP can be observed for the 1950s and 1960s. The other Southeast Asian nations followed in general a similar log GDP-height relationship. However, except for Malaysia and Vietnam, the Southeast Asian nations reached slightly higher anthropometric levels, relative to log GDP per capita: Already on a log GDP level of around 6.5, heights of around 162-163 cm were reached in Burma/Myanmar and Cambodia, and heights in The Phillippines and Thailand were not much lower. This might be explained by the slightly higher level of animal protein consumption in the latter four nations. [23] In contrast, the disease environment was probably not much more favourable in some of the other Southeast Asian countries. For example, Cambodia and the South of Vietnam also have a difficult disease environment. However, apart from this deviation, all nations displayed a positive log GDP – height relationship.

Differences may also appear, because equating GDP per capita with average income neglects two other factors. Firstly, apart from the poor quality of national accounts data in less-developed countries, there may be a significant difference between GDP and total income (or Net National Product). For example, Indonesia has had a trade surplus to finance its foreign payments over a long period. Hence, during 1960-2008 its NNP at factor costs was on average 13% lower than its GDP at market prices, according to Indonesia's national accounts data.

Secondly, high levels of income inequality may increase the discrepancy between median and mean incomes. For example, prewar Indonesia had relatively high levels of income inequality (Leigh and Van der Eng 2009), which meant that the growth of GDP per capita did not necessarily generate a corresponding growth in median income and therefore a matching improvement in the standard of living as indicated by average height. Income inequality in Indonesia since 1982 has generally been significantly lower than in prewar years,

[23] For example, the ratio of cattle and population was four higher in Thailand than in Indonesia during the 1980s, see FAO (2005).

which helps to explain that the increase in the average height of males in Indonesia since the 1950s is close to the average. For example, Moradi and Baten (2005: 1234) listed several studies of heights in less-developed countries that showed that the height differences between rich and poor can be extraordinarily large, and Deaton (2008) analysed the same phenomenon for India.

Another factor that needs to be kept in mind is the persistence of dietary customs. While the consumption of animal protein and calcium enhances human growth, the role of animal protein in Indonesian diet in the past was often even more marginal than in other Southeast Asian countries. In addition to nutrition, the disease environment and the economic situation more generally, intergenerational effects of height might also play a role (Baten and Hira 2008: 221-223). In other words, a biological mechanism may prevent short mothers to give birth to very large children, for example the restricted size of the birth canal. Hence, East Asian people may still remain relatively short for another generation or two, in spite of their relatively high income and dietary changes. This might be caused by the protein-scarce nutrition of the 19th and early 20th century, but has effects until today.

4. Conclusion

In this paper we presented for the first time data on long-term trends in average heights of adults in Indonesia since the birth decade of the 1770s. The data were obtained from four different sources, and they were closely scrutinised for the purpose of making them comparable. These height data were then taken as indicators of changes in the Biological Standard of Living in Indonesia, and compared with available evidence on long-term economic growth in order to assess the relationship between economic growth and living standards.

We were primarily interested in the question: how did the Biological Standard of Living develop during colonial times? Did it increase substantially after decolonisation? We established that during the second phase of the colonial period, when the Dutch colonial government implemented the so-called Cultivation System in much of Java after the 1830s, human stature declined. It is possible that this system enhanced the cultivation of major export crops, such as coffee, sugar cane and indigo in Java, at the expense of food production for local subsistence. If so, the Cultivation System may have had a detrimental impact on the nutritional status of Indonesians, given that markets were imperfect

A second hypothesis was that the increased international interaction during the 'First Era of Globalisation' of the late 19th century could have contributed to a deterioration of the disease environment in Indonesia. We demonstrated that the 1870s and 1880s constituted a difficult period for Indonesia. In particular, we attribute the height decline to four disasters: a sequence of droughts, the massive eruption of the Krakatau volcano in 1883, cholera epidemics and cattle plague. The impact of the latter two on heights may have been compounded by a situation of weakened antibodies due to less protein-rich nutrition of both human beings and cattle.

Since the 1890s, the Dutch colonial government implemented a number of welfare policies, which involved agencies for hygiene and health care, agricultural extension, veterinary services, small-scale credit facilities and similar institutions. Nevertheless, recovery of average heights during this period was slow – especially in international comparison (Baten and Blum 2012).

After decolonisation, there was a gradual increase of average heights, which was related to a gradual improvement in the general economic situation, and more specifically to improvements in nutrition and the disease environment. Both enhanced human growth, particularly during the crucial period of infancy. While these explanations are plausible, it is not possible to be certain about the relative importance of each of these factors, which should be the subject of further research.

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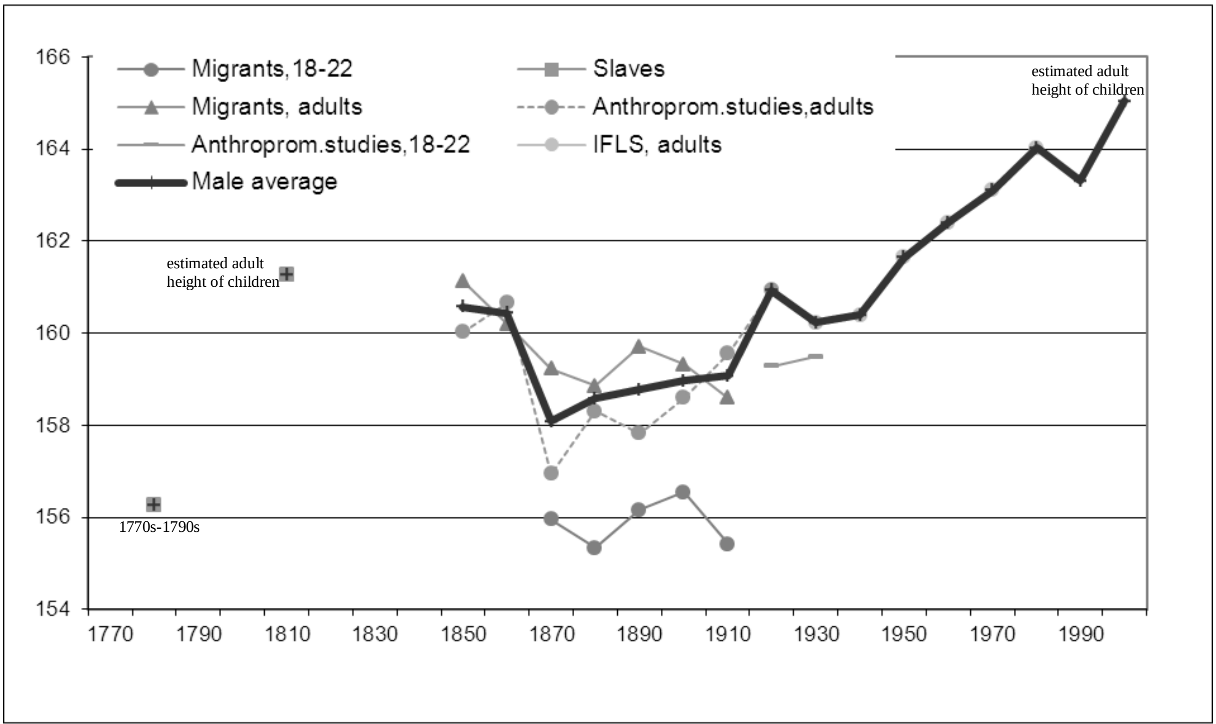
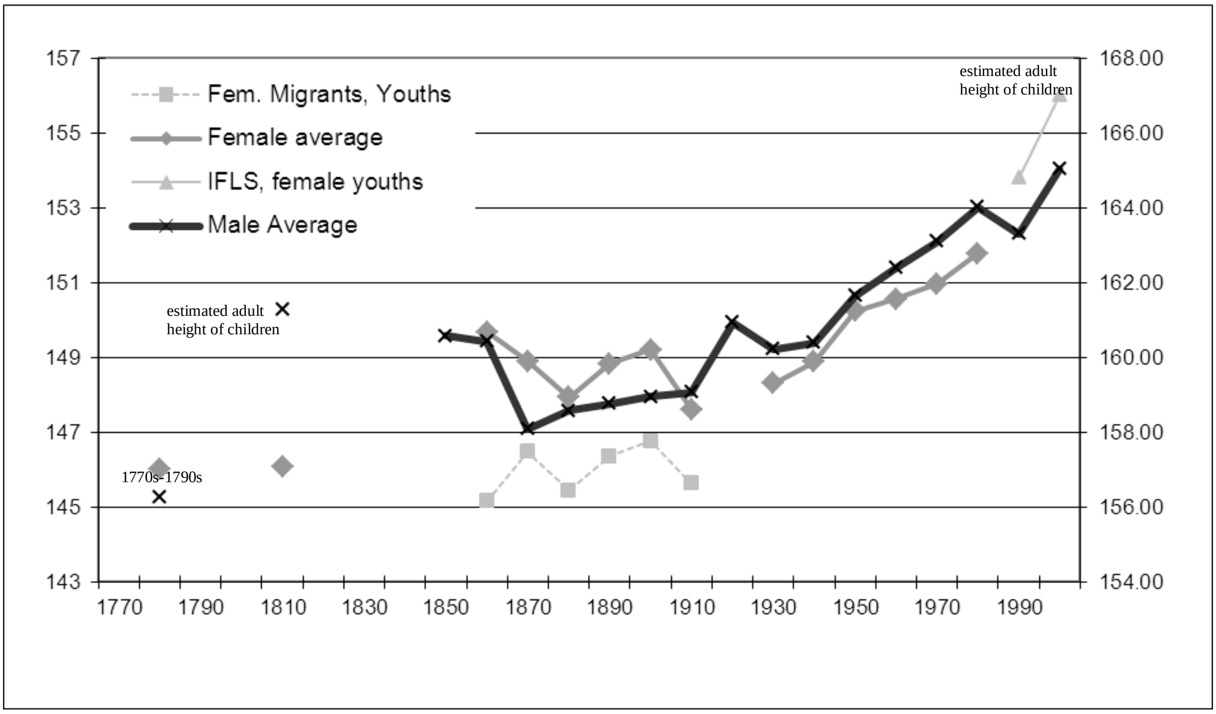
Figure 1: Average Male Height in Indonesia by Birth and Measurement Decade, 1770s-2000s (centimetres)*



Notes: *Measurement decade is used for children measured in the 1810s, 1990s and 2000s. Birth decade 1780s refers to 1770s-1790s. For males aged 54-55 (birth decade 1930s) in the IFLS dataset, 1 cm was added to account for old-age shrinking. For the adolescents in anthropological surveys (anth_age18-22), we included their average instead the regression results.

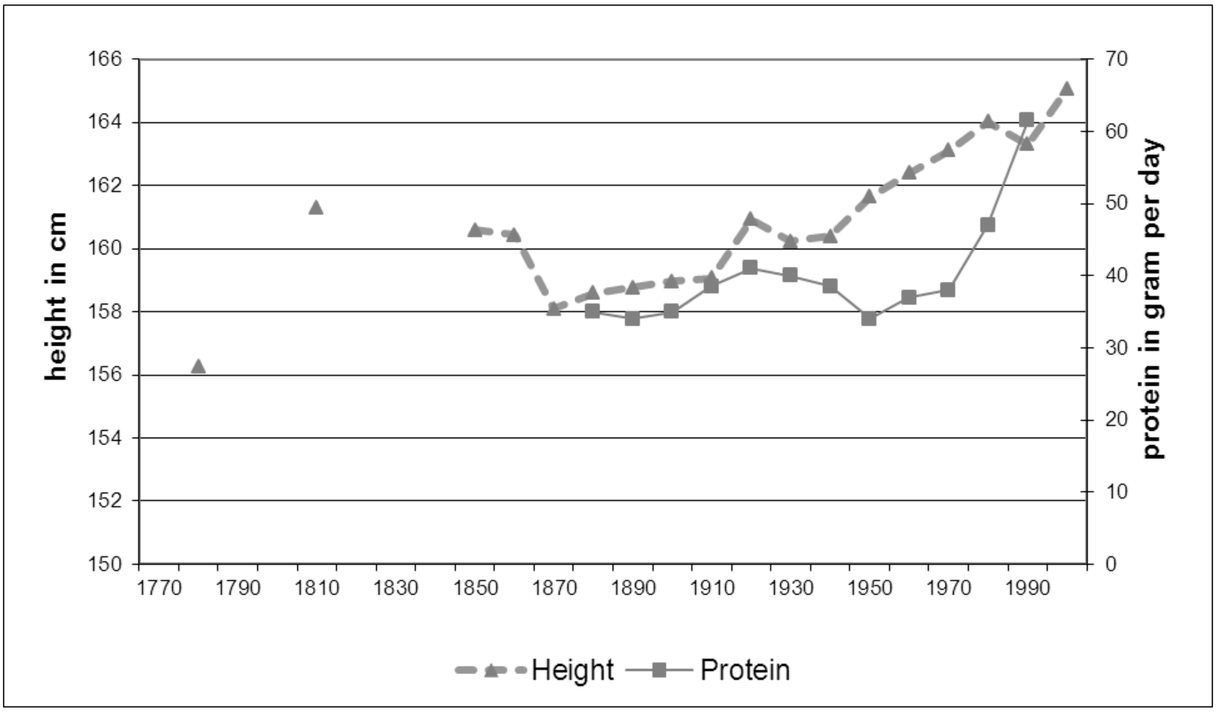
Sources: On the slave data set, see Abeyasekere (1983). Sources for migrant heights: Historical Database of Suriname, assembled by Maurits Hassankhan (University of Suriname) and Sandew Hira (Amrit Consultancy), based on the following original source: National Archives of Suriname, immigration registers. On the anthropological and medical studies in Indonesia, see a list of references available from the authors. On the post-war period: Indonesian Family Life Survey 1993, 2000 and 2007.

Figure 2: Female and Male Height in Indonesia by Birth and Measurement Decade, 1770s-2000s (centimetres)*



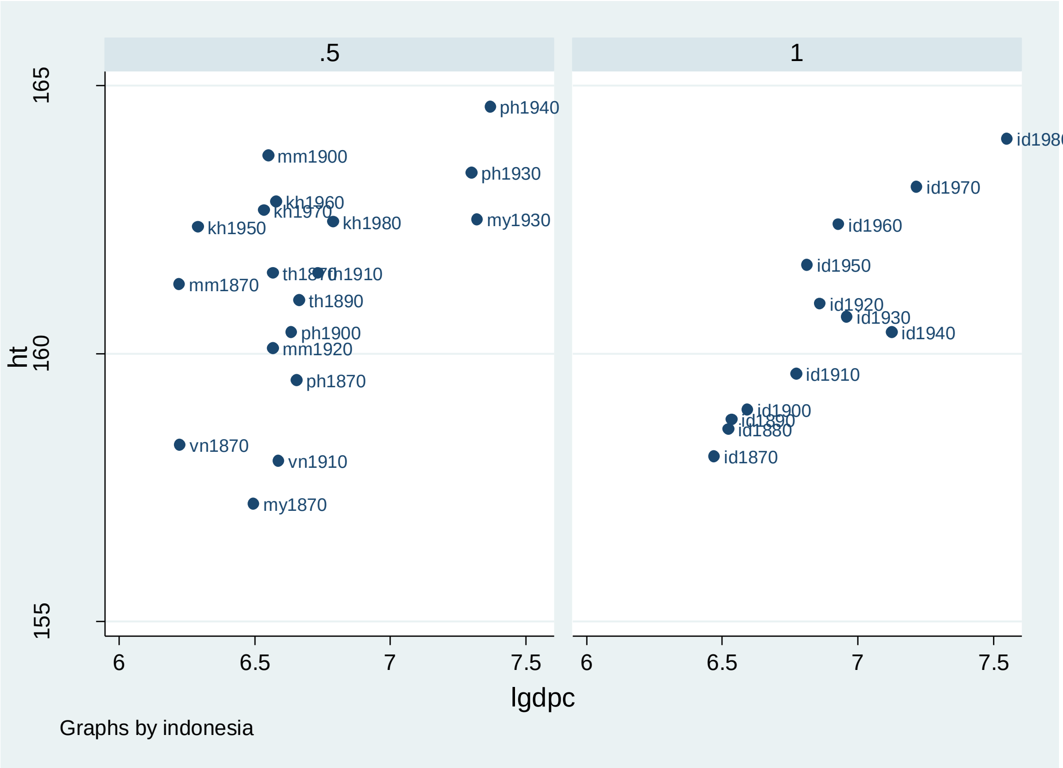
Note: *Measurement decade is used for children measured in the 1810s, 1990s and 2000s. Birth decade 1780s refers to 1770s-1790s. "Female average" refers to the following series: between 1780 and 1810 female slaves, between 1860 and 1910 to female migrants (adults) and between 1930 and 1980 to IFLS female adults.
Sources: See Figure 1.

Figure 3: Average Male Heights and Per Capita Supply of Protein, 1880s-2000s



Note: Heights by birth decade, except: measurement decade is used for children measured in the 1810s, 1990s and 2000s. Measurement decade is used for children measured in the 1810s, 1990s and 2000s. Per capita protein supply averaged by decade.
Sources: Figure 1 and Van der Eng 2000.

Figure 4: Heights of Adult Males and GDP per Capita in Indonesia (right panel) and other Southeast Asian countries (left panel)



Notes: Heights by birth decade.
Abbreviations: left panel -- mm-Burma/Myanmar, kh-Kambodha, th-Thailand, ph-Phillippines, vn-Vietnam, my-Malaysia. Right panel: id-Indonesia.
Source: Compilation of global height by Baten and Blum (2012), thanks to Matthias Blum and Jörg Baten for providing the data. Decade averages of male heights calculated from Figure 1 (Indonesia); Decade averages of GDP per capita from Maddison (2001), extended for Indonesia to 2008 based on Van der Eng (2010).

Table 1: Regressions of Heights of Indonesian Slaves Aged 20-55 by Region of Origin, Reported in Batavia (Jakarta) 1816

	(1)	(2)	(3)	(4)
Rounding	Only modest	Only modest	All	All
Gender	Males	Females	Males	Females
Bali	-0.56	5.04**	-1.49	1.15
Java (excl.)	0.58	4.13	-3.91	1.11
Nusa Tenggara	0.96	5.26*	-2.67	2.47
Sulawesi	0.68	1.31	-0.93	-2.36
Sumatra	-6.10**	-1.75	-6.58***	-3.51*
Age 20-22	-0.76	-1.63	-0.56	-2.14
Constant	157.39***	144.11***	157.53***	145.32***
Observations	292	308	758	779
R-squared	0.02	0.03	0.01	0.02
Weighted average	156.3	146.0	153.9	144.5

	Pop share (=weight)	Sample share
Bali	0.002	0.140
Jakarta	0.032	0.192
Java (excl.)	0.343	0.067
Nusatenggara	0.120	0.116
Sulawesi, Kalimantan, Maluku	0.240	0.400
Sumatra	0.263	0.087

Notes: All explanatory variables are included in the regression as dummy variables. The constant refers to slaves born in Batavia (Jakarta).
*** p<0.01, ** p<0.05, * p<0.1
Sources: On the slave data set, see Abeyasekere (1983). Population figures are mainly from Reid (1987), here pp.46 and 47.

Table 2: Regressions of Heights of Migrants to Surinam

	(1)	(2)	(3)	(4)
	Adult males (23-55)	Males, aged 18-22	Adult females (23-55)	Females, aged 18-22
Bdec1850	1.82**			
Bdec1860	0.88***		0.47	-1.6
Bdec1870	-0.1	-0.58*	-0.31	-0.28
Bdec1880	-0.47**	-1.20***	-1.27***	-1.31***
Bdec1890	0.39**	-0.38	0.16	-0.41*
Bdec1910	-0.73	-1.12***	-1.60***	-1.13***
Jakarta	1.08***	1.14	1.33**	1.79**
Central Java	-0.29	-0.51	-0.16	0.4
East Java	0.17	0.52	0.1	0.87*
Yogyakarta	-1.10***	-0.56	-0.42	0.21
age51+	-1.35		1.19	
age18		-2.77***		-2.80***
age19		-2.03***		-1.79***
age20		-1.55***		-1.14***
age21		-0.35		-1.01***
Constant	159.32***	158.10***	149.21***	147.90***
Observations	11,650	3776	6349	3501
R-squared	0.01	0.05	0.01	0.04

Notes: All explanatory variables were included in the regression as dummy variables. The constant refers in all models to a person born in West Java during the 1900 birth decade. *** p<0.01, ** p<0.05, * p<0.1
Source: See Figure 1.

Table 3: Regressions of Heights of Males from Anthropological and Medical Surveys

	(1) Male adult	(2) Male age 18-22
bdec1850	1.42*	
bdec1860	2.06***	
bdec1870	-1.65***	
bdec1880	-0.29	
bdec1890	-0.77***	
bdec1910	0.95***	
bdec1920	2.33***	
bdec1930		0.21
Central Java	-0.22	4.40**
Bali	2.29***	
Central Kalimantan	-0.34	
Nusa Tenggara	-1.78***	
North Sulawesi	-0.55	
North Sumatra	2.69***	3.49
West Nusa Tenggara	1.39***	
West Sumatra	-0.42	
Yogyakarta	2.81***	
age1819		-2.38*
age2021		-4.24**
Constant	158.60***	159.10***
N(underlying)	12,195	2,020

Notes: All explanatory variables are included in the regression as dummy variables. The constant of the regression of adult height refers those born in 1900s in West Java. The constant of the regression of adults aged 18-22 refers those born in the 1920s in West Java, aged 22. N(underlying) refers to the underlying, originally measured persons. For example, due to the nature of grouped data, the underlying number of measurements are 12,195 in the first column, but there are grouped into 2,155 groups for the adults. The 2,020 underlying height measurements for the young group (age 18-22) are grouped data into only ten different groups. The R-squares would be misleading here and are hence not reported.

Sources: On the anthropological and medical studies in Indonesia, see a list of references available from the authors.

Table 4: Regressions of Heights from the IFLS Datasets for 1993, 2000 and 2007

	(1) Male Adults	(2) Female Adults
Bdec1930	-3.87***	-2.66***
Bdec1940	-2.70***	-2.09***
Bdec1950	-1.46***	-0.73***
Bdec1960	-0.70***	-0.40**
Bdec1980	0.92**	0.81**
North Sumatra	0.18	-0.11
West Sumatra	-0.83**	-0.66**
Bali	1.03***	2.25***
Central Java	-1.33***	-0.50**
East Timor	-0.46*	-0.35
Jakarta	0.33	0.27
Lampung	-1.21***	-0.79**
Riau	4.27**	0.73
South Kalimantan	-1.72***	-1.40***
South Sulawesi	0.05	0.56*
South Sumatra	-1.03**	-0.15
West Nusa Tenggara	-1.21***	-0.62*
Yogyakarta	-0.17	0.63*
Constant	163.10***	150.97***
Observations	6,359	7,191
R-squared	0.04	0.03

Notes: The explanatory variables were included in the regression as dummy variables. The constant of the regression of adult height refers those born in 1970 in West Java. *** p<0.01, ** p<0.05, * p<0.1. We also estimated using the sample weight variable. The differences were very small. But as we control for regional composition effects anyway in Table 4, we only report the unweighted estimates here.
Sources: Indonesian Family Life Survey 1993, 2000 and 2007.