Long-term changes in socioeconomic differences in height among young men in southern Sweden, 1818-1968

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Abstract

Socioeconomic differences in heights have been found in a large number of studies covering different populations and historical periods and indicate the influence from environmental factors on growth. Despite the large number of studies, few explore the long-term changes in socioeconomic height differences, with most previous studies investigating only parts of the 19th or the 20th century, or inferring the long-term changes from different samples. The aim of this study is to present the long-term development of socioeconomic differences in heights among young adult men in southern Sweden. I have linked information from conscript inspections to the Scanian Economic Demographic Database; a longitudinal demographic database covering the population in five parishes in southern Sweden. Detailed information on the occupational status and landholding of the family is used to investigate the differences in standards of living in different social group. I find no dramatic change over time in either the magnitude of the socioeconomic differences in heights or in the predictive power of the socioeconomic measures for the heights of the men. The difference in heights between sons of fathers with non-manual as compared to manual occupations is the most consistent and important divide, similar to what is found for many 20th century populations. The conditions for skilled manual workers improved and the influence from landholding on the height of the sons changed over time indicating the importance for changing social structure and resource distribution for explaining the patterns of socioeconomic differences in heights. The impression of dramatically different socioeconomic differences in heights historically as compared to the 20th century might need to be somewhat revised.

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1. Introduction

Socioeconomic differences in heights have been found in a large number of studies covering different populations and historical periods (Compilations of results regarding children can be found in (Meredith 1984) and (Gwatkin et al. 2007), See also reviews by f. ex. (Bielicki 1986) and (C.G. Nicholas Mascie-Taylor 1991)). Socioeconomic differences in heights is an indicator of the influence from environmental factors on growth (f. ex. Eveleth 1986 or)(Bogin 1999). It is, in most situations, unethical to consciously vary the standards of living of different groups of people in order to study such influences, but human society still creates situations where it can be studied through inequalities in access to resources. Heights also provide a way to study the structure and development of environmental inequalities in situations where other sources are scarce, for example for historical populations (f. ex. Steckel & Floud 1997).

Despite the large number of studies, few explore the long-term changes in socioeconomic height differences. Most previous studies investigate only parts of the 19th or the 20th century, and generally the long-term changes have to be inferred from different samples (Costa & Steckel 1997)(Floud et al. 2006) or age groups within cross-sections (Peck & Vågerö 1987)(D. L. Kuh et al. 1991). Since adult heights don't change much once adult height is reached they are one of few measures where long-term changes can be inferred from cross-sections. But there can still be problems related to recall of childhood social status or different mortality rates that might bias the results (Carr-Hill 1988)(Guntupalli & Jörg Baten 2006). A recent collection of results on social differences in mortality indicates that conclusions on long-term trends based on studies of different samples and populations are not always upheld when tested longitudinally within populations (Bengtsson & van Poppel 2011).

It is well established that elite groups in Europe and North America in the 18th and 19th centuries were quite a lot taller than disadvantaged groups (Komlos 2008). These height differences are much larger than what is usually found in 20th century populations (Peck & Vågerö 1987)(D. L. Kuh et al. 1991)(Bielicki & Szklarska 1999)(C. G. N. Mascie-Taylor & Lasker 2005)(Webb et al. 2008). But the elite and destitute groups in the historical populations constituted only minorities within the populations (Eveleth & Tanner 1990, p. 199). Differences found within full cross-sections of historical populations are sometimes still larger than those found in the 20th century but much smaller than between the elites and destitute groups (Twarog 1997)(Haines et al. 2003)(Lantzsch & Schuster 2009). Large absolute differences of course indicate large inequalities in standards of living, but smaller differences in standards of living concerning larger segments of the population may also indicate influential inequalities, though of a different kind. Since most of what is known about the long-term development of socioeconomic differences in heights is based on different samples it has previously been difficult to evaluate the relative importance of social differences in heights at different points in time.

The impression from previous studies on the long-term development of socioeconomic differences in heights is of declining differences from the 19th to the 20th century (Floud et al. 2006)(Costa & Steckel 1997). Height differences have been shown to be declining over the 20th century in some present-day high-income countries (Britain: (D. L. Kuh et al. 1991), (Leah Li et al. 2004), Sweden: (Peck & Vågerö 1987), (Lars Cernerud 1993) see also (Rona 2000)). But socioeconomic differences in heights are highly persistent, change only slowly over time, and reduced differences in heights can increase again. A study on Swedish urban schoolchildren born in 1955 is one of a few examples where no socioeconomic differences in height were found (G. Lindgren 1976), see also (Brundtland et al. 1980, p. 317f). A later study confirmed that there seem to have been no differences in heights between children born in 1953 in Stockholm, Sweden, with fathers with different occupational classes (G. W. Lindgren & L. Cernerud 1992). But Lindgren and Cernerud (1992) also showed that the lack of (occupational) socioeconomic differences in heights might have been valid only among children born in 1953. Differences in heights reemerged again among boys in cohorts born in 1963 and 1981 (G. W. Lindgren & L. Cernerud 1992)(D. L. Cernerud 1994). And others have shown that the lack of socioeconomic differences in heights among cohorts born in the early-1950s probably also was limited to urban populations. When covering full cohorts of Swedish conscripts there were differences in heights between individuals with different family backgrounds, also among men born 1949-1951 and 1953 (Kihlbom & Johansson 2004) and (Otto 1976, p. 51)(see also Halldórsson et al. 2000). It is clear from previous research that the extent of socioeconomic differences in heights can change over time and that the differences can be reduced and maybe even fully removed.

Heights are influenced by the nutritional status of the mother and by living conditions during childhood and adolescence (Silventoinen 2003)(Ulijaszek 2006)(Özaltin et al. 2010). To study differences in standards of living, as reflected in heights, it is therefore preferable to use information on the socioeconomic status of the family where the person grew up. In most historical studies the measured individuals own occupational status is used to divide the men into social classes (Åkerman et al. 1988)(Alter et al. 2004)(Schoch et al. 2012)(Exceptions including full cross-sections of populations and using family background are Twarog 1997 and)(Lantzsch & Schuster 2009.). The differences found are then not only a result of differences in standards of living during childhood and adolescence but include also a selection effects. Firstly, it is possible there is self-selection into different occupations related to physical fitness and height. A second, but related, selection effect is created since healthier, taller (unhealthy, shorter) individuals are upwardly (downwardly) socially mobile to a higher degree than others. Evidence of this effect have been found in both 19th and 20th century populations (Twarog 1997)(Lantzsch & Schuster 2009)(Peck 1992). It is not self-evident if this selection effect would tend to increase or decrease estimated socioeconomic differences in heights (Chris Power et al. 2002). It is also plausible that the size of the bias changes over time making it even more difficult to evaluate. Socioeconomic differences in heights estimated using the measured persons' own status will in any case not only reflect differences in standards of living during upbringing.

The variability of heights can also be used to study inequality in the distribution of resources (Steckel 1995)(Quiroga & Coll 2000)(Moradi & J. Baten 2005). A higher degree of inequality in the distribution of resources in a society will tend to increase the coefficient of variation of the heights. In this way it is therefore possible to examine inequality without having information on heights within sub-groups of the population. But the coefficient of variation can also be affected by for example the degree of measurement error and the rate of maturation (Moradi 2006). Since both the accuracy of the height measurements and the physical maturity of the conscripts changed during the 150 years studied here it is not a good idea to use the coefficient of variation to study inequality in this population (Öberg 2012).

The aim of this study is to present the long-term development of socioeconomic differences in heights among young adult men in southern Sweden. The focus here is on differences in standards of living between families of different socioeconomic status as reflected in the heights of the sons in the families. Socioeconomic status is measured here by the occupation and landholding of the father at the birth of the studied men. The sample size is quite small but I can carry out the analyses within an ethnically homogenous and geographically concentrated population over time using the same data source. A very long period of time is covered making it possible to trace the socioeconomic differences in heights from the early 19th century, pre-industrial setting into a mature industrialized society with expanding social security systems in mid-20th century. The full cross-section of the population is included and the social structure of the studied population is known. Since the same data source is used throughout I can examine the relative importance of the height differences between groups and across time. Detailed information on occupations and landholding can be used to divide the men based on their family background. And since family relations are known I can also adjust the estimates to better compare the differences between families.

2. The Scanian Economic Demographic Database

The data used in the study come from the Scanian Economic Demographic Database (SEDD) (Bengtsson et al. 2012).[1] The database is a project that has been underway since 1983 and is now administered by the Centre for Economic Demography at Lund University (Reuterswärd & F. Olsson 1993). The SEDD is a longitudinal demographic database covering the population in five rural parishes in southern Sweden from the 17th to the 20th century. It includes all demographic events as well as information on for example landholding and occupations. I have now linked information from conscript inspection lists to the SEDD for men born between 1797 and 1950 (Öberg 2012). The men included in the sample lived some part of their life in any of the five parishes, Kävlinge, Hög, Kågeröd, Sireköpinge, or Halmstad(M). The populations in Kävlinge, Hög, Kågeröd are included for the full time period. The populations in Sireköpinge or Halmstad(M) after 1895 were not included in the SEDD at the time of the data collection.

Scania, where these parishes are located, is the southernmost part of Sweden. It is dominated by fertile agricultural land, though some parts are more hilly and wooded. This description fits well with the five studied parishes as well. These are all situated some 10 kilometers from the western coast and 10-30 kilometers from Landskrona, Lund and Helsingborg which are the closest towns. The parishes were all dominated by agriculture during most of the 19th century. Starting from c.1865 Kävlinge and Hög transformed into a small town with some industries and a railway station (Svensson 2006)(Bengtsson & Dribe 2011). The men measured at the conscript inspections were born between 1797 and 1950 and were inspected between 1818 and 1968. The sample is here divided into four periods based on the years of birth to investigate the changes over time. The periods are based on characteristics of the data and on the economic development in the area. The periodization also follows the one used in a recent study on socioeconomic differences in mortality using the same data source (Bengtsson & Dribe 2011). The men born in the first period, born 1797-1865, grew up during the

[1] A description of the SEDD can be found at http://www.ed.lu.se/EN/databases/sdd.asp (Anon 2012).

transformation of the agricultural economy and early industrialization. The cohorts born 1866-1914 and 1915-1935 experienced the industrial expansion and early welfare reforms. Men born in the last period, 1936-1950, grew up in a time of rapid economic growth in Sweden and the gradual emergence of a modern welfare society.

The economic growth and transformation resulted in generally improving conditions in the studied population. Real wages in southern Sweden were relatively stable up until c.1860 and then increased throughout the rest of the 19th century and first decades of the 20th century (Bengtsson & Dribe 1997)(Lundh 2008). The generally improving conditions in the studied population are also mirrored in a nearly linear increase in the average heights of conscripts (*Figure 1*). The average height in the studied population closely follows the national trend but shows no clear trend for cohorts born before c.1820.

[*Figure 1* about here.]

The conscript inspections were organized in a similar way throughout the studied period (Öberg 2012). It always included a physical inspection and the measuring of height. The men were then either accepted for conscript training or freed from duty if they were deemed unfit to benefit from the training. Up until 1860 there was a minimum height requirement for being accepted. From 1821 until 1860 the men who were too short but otherwise healthy were temporarily rejected and inspected again in the following year. The data therefore include also some of the heights below the minimum height requirement. All available heights are used in the analyses here regardless of the inspection outcome. The age of conscription was 21 years from 1818 up until 1914 (birth cohort 1893). It was lowered in 1914 (birth cohort 1894) to 20 years, in 1949 (birth cohort 1930) to 19, and in 1954 (birth cohort 1936) to 18 years. Controlling for the age at inspection, as expected, only changed the other estimates marginally and I have therefore not included any controls for age in the models below. I have excluded two height measures below 140 centimeters as potential outliers. A final sample of 2917 men had all the necessary information and is used in the analyses.

The men born during the 19th century could only be found if they lived in any of the SEDD parishes around the age of conscription (Öberg 2012). Geographically mobile men were also harder to find in the inspection lists than others and there were socioeconomic differences in the propensity to move, with (freeholder) farmers being less likely to move than others (Dribe 2000)(Dribe & Stanfors 2005). This could create a selection problem in the data if for example the healthier, taller landless groups are lost because of migration. An attempt is made to control for this by analyzing also only the men who were accepted for military training and judged to be healthy. I exclude the men who were freed from duty at the inspection as well as those temporarily rejected. In the 20th century fewer men were freed from duty but instead more detailed physical evaluations are available from 1929 onwards (Öberg 2012). For this period I exclude all men indicated as having relatively severe physical limitations. The sample of accepted, healthy men consists of 2433 men, excluding 13.6, 20.4, 17.7 and 14.8 percent of the men in each period respectively.

3. Measures of socioeconomic status

Measuring socioeconomic status in a comparable way over long periods of time is very difficult. Historical studies have also shown that socioeconomic differences in heights have changed as economies have developed and the social structure of the populations changed. Economic development and change have shifted the distribution of resources within populations and have also changed the relative importance of different factors influencing growth. This has resulted in that the group being taller than others has changed over time. In the 19th century Bavaria sons of farmers were sometimes at least as tall as sons of high ranking fathers with non-manual occupations (Lantzsch & Schuster 2009). Farmers were the tallest group also in the US during the 19th century (Costa & Steckel 1997). But the group being the tallest on average changed over time and in the US the farmers were joined and superseded in height by professionals and proprietors from the end of the 19th century.

It is likely that the taller stature of children of farmers in the 19th century is a result of these families having better or more stable access to food. Previous research on the SEDD have shown that the families' access to land was important for their standard of living, not the least in the 19th century (Bengtsson 2009b)(Bengtsson & Dribe 2010). Aravinda Meera Guntupalli and Jörg Baten (2006) find differences in heights between occupational groups in India that point to an influence from both occupational status and access to nutrition.[2] Men with non-manual occupations and men from groups with agricultural occupations were taller than the other groups. Guntupalli and Baten (2006) also find that the position of the family in the agricultural economy was important for the outcome, with landholders being taller than the other groups (see also f.ex. Bengtsson 2009a).

[2] Guntupalli and Baten (2006) estimate the socioeconomic difference in heights using the measured individuals own occupation. This is, as discussed above, not a good way of estimating socioeconomic differences in the standards of living but could be defended in the Indian case based on the low rates of social mobility.

To trace the socioeconomic differences in heights over the long time period covered here, with changing economic and social structure, I include measures of both occupational status and landownership of the families in the analyses. The occupational measure implies that different occupations were associated with different levels of income and thus living conditions of the family. The measures of occupational status used here are based on the historical class scheme HISCLASS (van Leeuwen & Maas 2011). HISCLASS allocates occupations to twelve different levels according to the economic sector, level of skill and supervision, and whether it is a manual or non-manual occupation. It has been created to do this in a way that is comparable over time making it useful for historical analyses. HISCLASS is based on the 1965 *Dictionary of Occupational Titles* (DOT) which includes evaluations of the skills and training required, as well as the tasks usually performed when working in different occupations and is based on extensive surveys and observational studies in the US. The classification in HISCLASS is used here to create the four occupational groups analyzed here; non-manual workers, professionals and managers (HISCLASS 1-5), farmers (HISCLASS 8), skilled manual workers (HISCLASS 6-7) and less skilled manual workers (HISCLASS 9-12).

I divide the families into three categories of landholders inspired by work by Martin Dribe (2000) and Tommy Bengtsson ((2009b)(2009a) and (Bengtsson & Dribe 2005)) and Bart Van de Putte and Patrick Svensson (2010); landless, small-scale and large-scale landholders. The "large-scale landholders" include landholders that are likely to have been able to produce a stable income from the farming and being able to market the surplus production. The group includes freeholders with enough land to be self-subsistent, some nobility, and tenants with large amounts of land (≥0.5 *mantal*). The freeholder category also includes crown tenants (sv. *kronobönder*) and tenants on church land because their conditions were more similar to the freeholders than the manorial tenants. The tenant category consists of tenants on manorial land and a small uncertain category of "church-manorial tenants". Freeholders with only small plots of land, tenant farmers without large amounts of land, and crofters (families living on crofts, sv. *torp* or *gatehus*) are classified as "small-scale landholders". This group had to complement the farming income with other incomes and is likely to not have produced much surplus. Landholding was measured in a taxation unit called *mantal* based on acreage and productive potential of the land (Svensson 2006). The amount of land needed to be classified as a farmer is 1/16 of a *mantal* for observations up until 1840. The amount is then lowered twice (1/32, 1840-1870 and 1/64, 1870 onwards) to account for the raised agricultural productivity. Here I follow Luciana Quaranta's ongoing work analyzing data from the SEDD (personal correspondence).

Information on landholding of the father at the birth of the men is sometimes missing. The families are considered as landless if information on landholding is missing. The sons from families missing information on landholding were never different from the certain landless group in preliminary analyses so both groups are included in the landless, reference category. The sample only includes men with information on the occupational status of the father thereby excluding the families with information on landholding but not occupation.

The socioeconomic status of the father at the birth of the men is used in the analyses. Men and families moving into the parishes have been traced to their parish of origin to collect information on the socioeconomic status of the father at the birth of the children. This reduces any potential bias from differences in migration patterns between socioeconomic groups. If the father's status at the birth is missing the first available observation before the inspected man turned age five years is used where available. Oftentimes more than one observation on occupation is available from the same point in time. The highest ranking observation is then used in the analyses. Each son is assigned the status his father had at his birth. The socioeconomic status of the father is in most cases the same for all sons but varies for about ten percent of the families.

The social structure of the population, as measured by the four occupational groups included in the analyses here, changed with the industrialization and modernization (*Table 1*). About half of the fathers have manual occupations and requiring low levels of skill throughout all periods. But skilled manual workers increase in size as a group from 7 percent in the first period to 21 in the last. The fathers with a non-manual occupation were also always a minority but also increase in size in a very similar fashion. The most dramatic changes can be seen for the farmer category and in the landholding. 40 percent of the fathers were farmers in the early and mid-19th century. The size of this group declines drastically already in the second period and declines further with each period. Parts of this decline can be explained by the change in the sample frame after 1895. Sireköpinge or Halmstad(M) remained a largely agricultural area also in the 20th century but are then not included in the sample here. The landholding also changes a lot over time. Some of this change is also due to the changing sample frame mentioned, but some of it is also due to changes in the social structure. A majority of the households had access to some land in the early and mid-19th century, with only about a third of the families being landless. Most families only had access to very small amounts of land. Landownership was highly unequally distributed in the studied area (Lee et al. 2009). The landless category increased to about two-thirds of the fathers already in the second period because of a large decline in the small-scale landholding (compare Bengtsson & Dribe 2005). The large-scale landholders in contrast increased a bit between the first and second period but then starts declining. Only a very small fraction of the families had any land in the mid-20th century.

[*Table 1* about here.]

4. Methods

The interest here is in the socioeconomic differences in heights as reflecting differences in standards of living. The differences between families are investigated by ordinary least squares (OLS) regressions. The observations are weighted in the regression by the inverse of the number of measured brothers in the family. Families are defined here as brothers born to the same two parents. All families therefore provide the same weight to the regression results regardless of the number of brothers included in the data. The estimated effects should consequently be less affected by systematic differences in fertility behavior or time observed in the database. All models include the year of birth of the men to capture the, close to linear, secular trend in heights. The trends for each period are centered so the constant refers to the average height in the reference category for men born in 1860, 1890, 1920 and 1950 respectively. The regressions were estimated using Stata 12.1®. The standard errors are adjusted for heteroskedasticity and clustered at the family level. The shares of variance explained as presented in *Table 3* are the values of the R-squares from unweighted OLS regressions including only the relevant socioeconomic indicators.

Information on height is sometimes missing for men rejected at the inspections during the first time period. The distribution of the heights data show that heights are missing more often from the lower end tail of the distributions (Öberg 2012). An unrestricted maximum likelihood estimator for truncated samples was therefore also tried to account for this partial truncation (Komlos 2004). The truncation points were inferred from analyzing the distributions graphically. The estimated coefficients were all similar so the partial truncation doesn't seem to influence the results in any important way. I could also not use a preferred restricted estimator while also weighting the observations (A'Hearn 2004)(Jacobs et al. 2008). Therefore I decided to use OLS regressions also for the first period.

5. Results

5.1 The socioeconomic differences in heights in the population

There were socioeconomic differences in heights in the studied population at all times (*Table 2*). But not all dimensions of social stratification were associated with differences in height at all times. In general the occupational status of the father had a larger impact on the height of the sons than the landownership status, also in the early and mid-19th century. The occupational measures have higher explanatory power and result in larger and more significant coefficients. The effect from the occupational status on the standards of living was also largely independent from the families' access to land. Most coefficients change only slightly when controlling also for the landholding status, as can be seen comparing panels 1 and 3 in *Table 2*.

[*Table 2* about here.]

Landholding was important for the standards of living in the families, but as expected especially so in the 19th century. Sons of large-scale landholders were always taller than others in all periods but only significantly so the first period. The effect from large-scale landholding (*Table 2*, panel 2a) is attenuated when including also the occupational status in the model (*Table 2*, panel 3a). Many of the large-scale landholders apparently also had occupations or titles that were more systematically associated with taller stature of the sons. Having access to only small amounts of land did not have any positive impact on the heights of the sons. The coefficients are negative in three out of four periods but are never statistically significant. I anticipated that the ability of the small-scale landholders to complement other incomes with the produce from the land would increase or secure the access to foodstuffs also in these families, but that does not seem to generally have been the case.

Sons of farmers were taller than sons of lower skilled manual workers until the mid-20th century when the small remaining group of sons of farmers was somewhat shorter. The difference is significant in the first and third period (*Table 2*, panel 1). The coefficients for sons of farmers are all reduced and lose their statistical significance when including also the landholding (*Table 2*, panel 3). Some, but not all, of the benefits from being born to a farmer was connected to their landholding. The sons of the farmers have their largest height premium (+1.6 cm) in the third period. The positive effect from being born to a large-scale landholders is at its lowest in the period when the sons of farmers are tallest. A little more than half of the farmers were large-scale landholders in the third period. A cautious conclusion is that not too much should be made from the larger coefficient for farmers in the third period.

The influence from the landholding on the heights declines over time, as could be expected with increasing agricultural productivity, rising real wages and improved markets for foods. The coefficients increase in size again in the last period (*Table 2*, panel 3d) but the affected groups are by then very small and the standard errors are large. Bengtsson and Dribe (2010) study infant and child mortality in the same population as studied here. In contrast to the results here they find that the influence from the families' access to land differences on the risk of child mortality increased over the 19th century. The landless and, here, small-scale landholders had significantly higher risk of losing a child than large-scale landholders in the second half of the 19th century. The sons of large-scale landholders are taller also in the second period covering this period but not significantly so. It is possible that mortality selection in the landless and small-scale landholding groups decrease the differences between the groups in my analyses. Another explanation could also be that heights and mortality reflect somewhat different aspects of health status (compare Haines & Steckel 2000). Another sign of this is that despite the socioeconomic differences in heights found here, there were no socioeconomic differences in adult mortality in the population until the last period (Bengtsson & Dribe 2011).[3]

Sons of fathers with a non-manual occupation (or being a professional or manager) is the only group significantly taller than the others in both the 19th and 20th century. This supports the view that the manual/non-manual divide of occupations was as important in the 19th as in the 20th century (compare van Leeuwen & Maas 2010, p. 434). The size of the coefficient is largest in the first period, early and mid-19th century, and smallest in the last, mid-20th century. It is reduced in size in the second but increase again in the third. The coefficient is still substantial also in the mid-20th century, amounting to c.+1.7 centimeters. This is comparable in size to the height difference found among the older groups in the Swedish 1981 cross-section analyzed by Peck and Vågerö (1987). The group non-manual workers,

[3] The height differences found here are too small to have contributed in any measureable way to the socioeconomic differences in mortality through the correlation between height and mortality (f.ex. Floud et al. 2011).

professionals and managers had increased to include almost twenty percent of the measured men in the mid-20th century. The increase in the size of the group leads to that the influence on the population average height is increasing rather than decreasing despite the smaller magnitude of the coefficient in the last as compared to the first period.

Most of the fathers in the non-manual, professionals and managers group had manual occupations as well or were farmers with an additional occupational title. The most common occupations placing the fathers in this category are parish clerk (sv. f.ex. *klockare*), farm supervisor (sv. *fogde, rättare*), sheriff (sv. *länsman*), or merchant (sv. *köpman*). About half of the fathers in this category had access to land in the first period and about one third in the second. Panel 3 in *Table 2* show the height differences adjusted for landholding of the families. The coefficient for sons of fathers with non-manual occupations is attenuated by 14 percent in the first time period (panel 1a) but otherwise the coefficients in panel 3 are very similar to those in panel 1. The difference in height between men with manual/non-manual family backgrounds seems to have been largely independent from landholding.

The lowest status group, sons of fathers with manual occupations requiring low levels of skill, is not the shortest in the 19th and early-20th century. The sons of the skilled manual workers are actually shorter, and significantly so in the first period. The skilled fathers worked for example as tailors, blacksmiths, millers, or carpenters. In the 20th century they were also for example butchers and shoemakers. The lower skilled group consisted of farmhands and laborers in the 19th century. With the industrialization in the area several of these fathers also worked in the leather and sugar factories. The income premium for the skilled workers was apparently not large enough in the 19th century to make the standards of living in these families better than among those with lower skilled fathers (compare Guntupalli & Jörg Baten 2006). The closer relation to the agricultural sector in the lower skilled group in the 19th century is a possible explanation for the higher standards of living in this group. The significant negative coefficient for the sons of the skilled manual workers gradually changes to a positive over time. The industrialization does not seem to have brought any devaluation of the artisans' position but rather the opposite (compare van Leeuwen & Maas 2010, p. 434).

A majority of the fathers with skilled manual occupations are also included in the small-scale landholders' category in the first period. About one-third in the category had access to small or large amounts of land also in the second period. But the height difference of the sons of the skilled manual workers is unrelated to the landownership status of the families, as can be seen comparing the coefficients in panels 1 and 3 in *Table 2*.

5.2 Robustness check

The estimated effects when including only the healthy men are very similar to the ones from the full sample (*Table 3*). Some of the coefficients change in the first period. The sons of farmers and non-manual workers in the first period and large-scale landholders in the second period are not as much taller than the others in the healthy sample as in the full sample. The largest change is that the coefficient for the sons of non-manual workers is reduced by 44 percent and loses its statistical significance. The average height in the reference category is the same in both samples so the different estimates are likely to be a result of some of the taller men being excluded in the healthy sample. The military doctor Carl Arbo writes about the outcomes from conscript inspections in Norway in the mid-19th century (Arbo 1875). The rejection rates were then higher among the shortest and tallest men than among those of average height. Lantzsch and Schuster (2009) also find that some diagnoses and causes for rejection were associated with taller stature among early 19th century Bavarian conscript. This could be one explanation for the attenuated positive coefficients. Sons of large-scale landholders are in contrast taller in the healthy sample than in the full sample in the first and last period, thus excluding shorter peers in the healthy sample. Other than this the differences are reassuringly small (difference < one standard error) between the estimates in *Table 3* and *Table 2*, panel 3. This is of course an insufficient test of any selection effects but indicates that it might not be a big problem.

[*Table 3* about here.]

5.3 Interpreting the socioeconomic differences in heights

It can be hard to interpret what the difference in standards of living is that is underling a height difference of one to three centimeters between the socioeconomic groups. As an attempt to substantiate the findings the sizes of the socioeconomic differences can be compared to the secular trend in the population. As can be seen in *Table 2* the population's average height increased by about one centimeter per decade. The differences found here amount to about one to three centimeters. This suggests that the difference in standards of living between the families amounted to about as much as the difference in standards of living created by ten to thirty years of economic growth and improving conditions.

Income is a powerful determinant of heights since it can affect nutrition, living conditions and possibilities of trying to prevent, cure and counteract diseases (Steckel 2008)(Baten 2000) (for a good example see Cernerud & Elfving 1995). Applying the log-linear relationship between average heights and gross domestic product proposed by Baten and Blum (2012) implies that a height difference between groups of one centimeter roughly corresponds to a 11 percent difference in average income level. A height difference of three centimeters corresponds to a 37 percent higher income in the taller group. The sons of non-manual workers, professionals and managers were about three centimeters taller than sons of lower skilled manual workers in the first decades of the 20th century (*Table 2*, panel 3). Interestingly Christer Lundh (2012) finds that the real wages of urban non-manual workers were 27-46 percent higher than the real wages of rural, lower skilled manual workers, depending on the comparison group. It is not certain that the rural non-manual workers had the same income levels but the similarity of the estimates of group differences in income levels is thought-provoking.

Lundh (2008)(2012) also analyzes the differences in diets between groups of workers in Scania between 1913-1920. He finds only small differences in calories consumed per consumption unit and in shares of calories coming from protein, fats, and carbohydrates. The higher incomes were not used so much to buy more food but a more varied diet and more refined and higher quality foodstuffs. The small socioeconomic differences in intake of macro nutrients in Scania in the early 20th century are probably not large enough to create height differences of up to three centimeters. But the improved quality and diversity of the diets in the high income groups might have contributed to their taller stature (Arimond & Ruel 2004).

Heights are influenced by the cumulative net nutritional status of the mother and of the individual during infancy and childhood (Silventoinen 2003)(Ulijaszek 2006)(Özaltin et al. 2010). *Net* nutritional status means that both the amount and quality of the food intake and the energy and nutrients needed for example for work, heat and fighting diseases are important as influences on heights (Hansen & Grubb 2002)(Steckel 2009). If the balance between inputs and requirements is not sufficiently positive the bodily growth slows down and if the insults are severe or prolonged they will result in a shorter adult stature. If conditions improve the body will start growing again and can overcome some, or all, of the growth lost by faster, catch-up growth (Eveleth & Tanner 1990). For this to be possible the body requires more energy and nutrients than usual. A more secure access to foodstuffs, more diversity, and higher quality should have improved the ability of the higher status families to supplement the diets of the children after infections or times of food scarcity. The socioeconomic differences in heights might therefore reflect differences in the ability to overcome temporary shocks, such as disease or food scarcity (compare Bengtsson 2009a)(Bengtsson & Dribe 2005).

Other differences in standards of living might also have influenced the heights, such as systematic differences in the place of residence, access to clean water, the quality of housing, or differences in child care practices (compare f.ex. (Bengtsson & Dribe 2010)). There were differences in the quality of housing among rural groups in Scania in the first decades of the 20th century (Lundh & M. Olsson 2011). The differences in housing standards corresponded to differences in the income levels. Artisans, farmers and industrial workers had better housing than agricultural workers and smallholders. Differences in housing standards might have contributed to the disadvantaged situation of the small-scale farmers found here.

The heights of the parents might also have contributed to the socioeconomic differences found. A contribution from genetic differences cannot be ruled out but large and systematic genetic differences are highly unlikely. But the heights of the parents could influence the heights of the children in other, biological, but non-genetic, ways. The achieved height, and current weight, of the mother influence the health and height of her children (Baird 1965)(Özaltin et al. 2010). And since the heights of the parents are themselves also the results of both genetic and environmental influences this could contribute to preserving socioeconomic differences in heights (Spencer & Logan 2002).

6. Discussion

The Swedish society underwent dramatic changes during the 150 years studied here. Parts of the studied area, Hög and Kävlinge, also experienced some industrialization but the town remained small and the results in this study reflect the socioeconomic differences in a, in international perspective, largely rural population. This could of course affect generalizability of the results, but the results are very similar to what has been found in other studies. The magnitude of the socioeconomic differences in heights found here for the 19th and early-20th centuries amount to approximately 1-3 centimeters depending on the group examined. This is comparable to what has been found in other similar historical studies (Twarog 1997)(Haines et al. 2003)(Alter & Oris 2008)(Lantzsch & Schuster 2009). The differences found for the mid-20th century are also comparable to those found in studies on other countries and point to the persistence and international similarities of socioeconomic height differences (Peck &

Vågerö 1987)(D. L. Kuh et al. 1991)(Bielicki & Szklarska 1999)(C. G. N. Mascie-Taylor & Lasker 2005)(Webb et al. 2008).

The pattern of the socioeconomic height differences is also very similar to 20th century patterns in that the manual/non-manual divide, which has been found to be associated with differences in heights among the children in the 20th century, were so also in the 19th century. The two most important changes of the socioeconomic differences in heights over time are that the development for the sons of skilled manual worker and the changing influence from landholding. Sons of skilled manual workers went from being a deprived to being an advantaged group. The positive influence from landholding on the standards of living in the family was strong in the early and mid-19th century but later quickly lost its importance. Both changes testify of the significance of societal changes for the socioeconomic differences in heights. The position of the skilled manual workers changed with industrialization which seems to have brought improved possibilities for specialization and/or rising rewards for their skills. Owning your own land was no longer important when the economy diversified, increasing the real wages and employment opportunities outside agriculture increased, and markets for foods improved.

Other than the developments just described there was no dramatic change in the magnitude or importance of the socioeconomic differences in heights over time in the studied population. The estimated absolute height differences change over time but show no general trend. The estimated socioeconomic differences in heights for the 19th and early 20th centuries don't reflect differences in adult heights. Many of the men were still growing at the time of measurement. Some negative environmental influences can, as mentioned, be overcome by later catch-up growth. The same factors that influence growth also affects the rate of physical maturation (Eveleth & Tanner 1990). Growth can therefore continue for a longer time for disadvantaged, shorter individuals. The measureable impact from environmental factors, and socioeconomic status, on heights are therefore often found to be stronger among children than among adults (L. Li et al. 2004)(Leah Li et al. 2007)(A. Barros et al. 2006). Some of the socioeconomic difference in heights found in the early time periods is therefore likely to be a growth tempo effect. The shorter, low status groups probably continued growing for a longer period making up for some of the differences observed here. These growth tempo effects can be expected to be smaller in the later periods and we should therefore expect smaller differences in the 20th than in the 19th century. This further enhances the conclusion of no clear general trend in the magnitude of the socioeconomic differences in height in the studied population.

The shares of variance explained, as expected, confirm several of the findings discussed above (*Table 4*). The occupational status of the father was more important than the landholding status for determining the heights of the sons. The influences from the occupational and landholding statuses of the father also had largely independent influences on the heights of the sons. The sum of the shares explained by occupational and landholding status separately is not much larger than their joint explanatory power. The declining importance of landholding after the 19th century can be seen also in the explanatory power of these measures.

[*Table 4* about here.]

No tendency for a declining importance of the socioeconomic differences in heights can be seen in the shares of variance explained. The shares are smaller in the first than in the last period, but are smallest in the second and largest in the third period. The share of variance in heights explained by the socioeconomic indicators can also be influenced by the share of the men having reached their adult heights. Because of the possibility of catch-up growth and prolonged growth period from negative environmental influences socioeconomic indicators are stronger predictors of heights during growth than after final adult height is reached. Most of the men who were measured in the 19th and early 20th centuries had not reached their final adult heights while most men had by the mid-20th century. We should therefore expect stronger explanatory power in the early periods than in the last. This further enhances the impression of no trend in the predictive power of the socioeconomic indicators on the heights of the conscripted men.

The socioeconomic measures explain only small amounts of the variation of heights in the population (*Table 4*). The small overall shares of the variance explained indicate relatively small systematic socioeconomic differences in heights in the studied population. But they should also be expected given that environmental factors can explain only small shares of the variation in heights and the status indicators used most likely only capture parts even of these (see f.ex. Silventoinen 2003). And the small shares of variance explained should not necessarily be taken as indicating that social differences were unimportant in the population. Socioeconomic status has for example been shown to explain only about two percent of the variation in heights in 20th century developing countries (Boyle et al. 2006). But these within-population differences in socioeconomic status explained as much of the overall variation in heights as the differences between the populations in national income levels.

Not much is known about why socioeconomic differences in heights change over time and few hypotheses have been proposed about what the causes for any changes might be. The expectation in some of the previous writings on socioeconomic differences in heights is that the extent of the differences will decline with rising income levels (see f.ex. Martorell & Habicht 1986)(Eveleth & Tanner 1990)(Moradi 2006). The lack of long-term longitudinal studies of socioeconomic differences in heights has resulted in that hypotheses must be based on indirect empirical evidence (Lindgren 1976)(Peck & Vågerö 1987)(Li et al. 2004)(Bielicki 1986), comparisons within cross-sections of countries (Eveleth & Tanner 1990)(Moradi 2006), and on what is known about the determinants of heights (Martorell & Habicht 1986)(Steckel 2008). The sometimes large differences in heights between elite and destitute groups historically have also been seen as an important indicator of the relationship between the general income level and the extent of socioeconomic differences in heights. But a direct effect from the general income level on the extent of socioeconomic differences in heights have been questioned on both theoretical grounds (Quiroga & Coll 2000) and gains no support in some empirical tests (Schmitt & Harrison 1988)(Van de Poel et al. 2008)(see also Costa & Steckel 1997). The declining absolute socioeconomic height differences over the 20th century in present-day, high-income countries could indicate that the hypothesis of a direct effect from the general income level of the extent of socioeconomic differences in heights needs a qualification. It could be that there is a threshold income level that needs to be reached before rising incomes can have the expected effect on the socioeconomic differences in heights.

The societal distribution of nominal incomes and purchasing power is quite naturally important for the socioeconomic differences in heights (Quiroga & Coll 2000). Sweden is one of few examples of a country where it has been possible to find support for a development of inequality following the pattern of increase and decline as predicted by Kuznets (1955) (Waldenström 2009). Wage inequalities increased in Sweden from 1870 up until c.1930 after which a drastic leveling sets in (Söderberg 1991). There are indications of a Kuznetsian pattern of temporarily increasing inequality in the results here, with the height differences being larger in the third period than before or after. But not enough is known about the long-term development of income differences in Sweden to make any further comparisons with the height differences fond here. The lack of dramatic changes in the magnitude and importance of the socioeconomic differences in heights indicate a stable and similar level of inequality in the area from the early 19th century to the mid-20th century. This is surprising and warrants further investigation.

7. Conclusions

There was no dramatic change over time in the magnitude or pattern of the socioeconomic differences in heights in the studied population. The most consistent and important divide found is the difference in heights between sons of fathers with non-manual occupations as compared to the others. This is also what is found in most studies of 20th century populations. There is no uniform trend in the magnitude of the differences. The sizes of the height differences found here are quite similar in the 19th and 20th centuries. Historical studies on full cross-sections of populations using family backgrounds to investigate socioeconomic differences in heights in general find differences in heights that are quite similar to what is found in 20th century populations when using similar methods (Compare (Twarog 1997)(Haines et al. 2003)(Lantzsch & Schuster 2009) with f.ex. (Peck & Vågerö 1987)(D. L. Kuh et al. 1991)(Bielicki & Szklarska 1999)(C. G. N. Mascie-Taylor & Lasker 2005)(Webb et al. 2008)). The predictive power of the socioeconomic measures on the heights of the sons is also largely unchanged across time further confirming the lack of dramatic changes in the importance of the socioeconomic differences in heights.

The lack of drastic changes in the socioeconomic differences in heights found here does not lend any support to a direct effect from the general level of income or living conditions on the extent of socioeconomic differences in heights. The distribution of incomes and the differences in standards of living changed with the economic development improving the conditions for skilled manual workers and removing the importance of landownership for heights. The changing social structure and resource distribution is important for explaining the development of socioeconomic differences in heights in the studied population.

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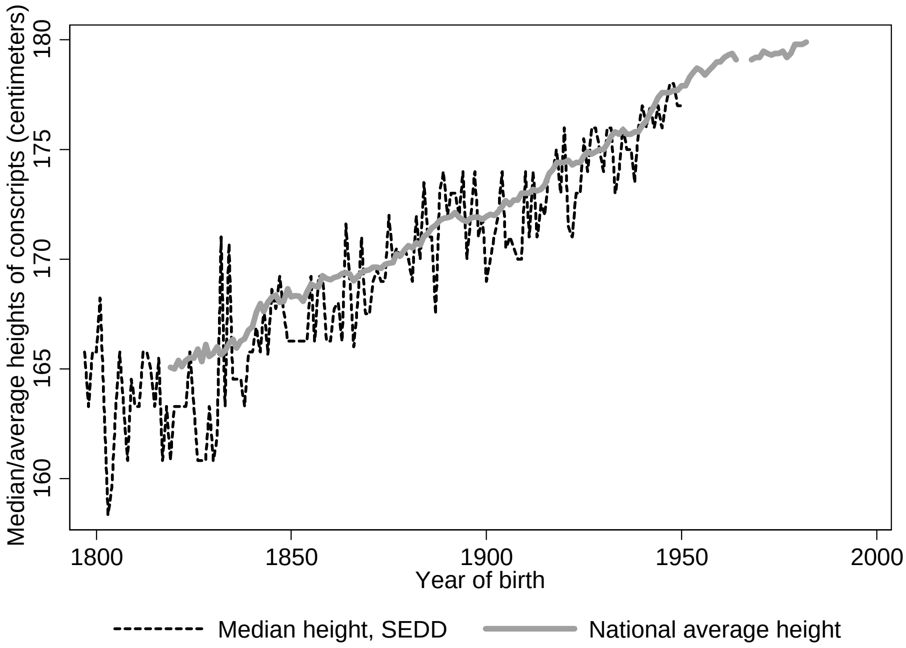
Tables and figures.

Figure 1. Conscript heights in SEDD and Sweden, 1797-1982



Sources: Median heights in the SEDD data; own calculations. Median and average heights of Swedish conscripts, various sources.

Table 1. Socioeconomic family background of the studied men

	Years of birth			
	1797-1866	1867-1914	1915-1935	1936-1950
	Shares of the fathers (percent)			
	Occupational status			
Manual workers, unskilled or low skill	49	54	54	55
Skilled manual workers	7	18	15	21
Farmers	40	18	16	8
Non-manual workers, professionals and managers	4	10	15	16
	100	100	100	100
	Landholding			
Landless	32	64	79	94
Small-scale landholding	58	21	7	2
Large-scale landholding	10	15	14	4
	100	100	100	100

Sources: own calculations.

Table 2. Socioeconomic differences in heights among conscripts in southern Sweden, 1818-1968

		Years of birth			
		1797-1866	1867-1914	1915-1935	1936-1950
Panel 1.		a.	b.	c.	d.
Manual workers, unskilled or low skill (ref.)	Coeff. (s.e.)	167.63 (0.44)***	171.05 (0.31)***	172.74 (0.50)***	177.39 (0.53)***
Skilled manual workers	Coeff. (s.e.)	-2.10 (0.84)*	-0.58 (0.62)	+0.80 (0.80)	+1.06 (0.62)’
Farmers	Coeff. (s.e.)	+1.05 (0.50)*	+0.25 (0.59)	+1.72 (0.80)*	-0.57 (1.11)
Non-manual workers, professionals and managers	Coeff. (s.e.)	+3.82 (1.39)**	+2.59 (0.83)**	3.37 (0.83)***	+1.73 (0.76)*
Linear trend	Coeff. (s.e.)	0.12 (0.01)***	0.07 (0.02)***	010 (0.05)’	0.15 (0.06)*
	R^2	0.1193	0.0507	0.0447	0.0258
	F	20.87	7.77	5.66	3.59
Panel 2.					
Landless (ref.)	Coeff. (s.e.)	167.98 (0.51)***	170.98 (0.31)***	173.57 (0.45)***	177.98 (0.48)***
Small-scale landholding	Coeff. (s.e.)	-0.60 (0.52)	+0.55 (0.60)	-0.74 (1.21)	-1.34 (2.53)
Large-scale landholding	Coeff. (s.e.)	+2.17 (0.95)*	+0.93 (0.58)	+0.90 (0.87)	+0.51 (1.52)
Linear trend	Coeff. (s.e.)	0.11 (0.01)***	0.08 (0.02)***	0.10 (0.05)*	0.17 (0.07)*
	R^2	0.1077	0.0340	0.0106	0.0133
	F	26.19	8.17	1.75	2.57
Panel 3.					
Landless manual workers, unskilled or low skill (ref.)	Coeff. (s.e.)	167.89 (0.54)***	170.84 (0.34)***	172.76 (0.51)***	177.40 (0.53)***
Skilled manual workers	Coeff. (s.e.)	-2.05 (0.84)*	-0.66 (0.63)	+0.80 (0.80)	+1.07 (0.62)’
Farmers	Coeff. (s.e.)	+0.80 (0.54)	-0.31 (0.71)	+1.63 (1.00)	-0.75 (1.23)
Non-manual workers, professionals and managers	Coeff. (s.e.)	+3.28 (1.30)*	+2.48 (0.83)**	+3.35 (0.83)***	+1.76 (0.76)*
Small-scale landholding	Coeff. (s.e.)	-0.59 (0.53)	+0.73 (0.65)	-0.88 (1.30)	-1.04 (2.54)
Large-scale landholding	Coeff. (s.e.)	+1.31 (0.97)	+1.01 (0.67)	+0.41 (1.05)	+1.26 (1.56)
Linear trend	Coeff. (s.e.)	0.12 (0.01)***	0.07 (0.02)***	0.10 (0.05)’	0.16 (0.07)*
	R^2	0.1256	0.0542	0.0465	0.0274
	F	15.19	5.50	3.91	2.49
Sample size		856	828	565	668

Notes: Statistical significance; ‘ - p < 0.10, * - p < 0.05, ** - p < 0.01, *** - p < 0.001. Own calculations.

Table 3. Socioeconomic differences in heights among healthy conscripts in southern Sweden, 1818-1968

		Years of birth			
		1797-1866	1867-1914	1915-1935	1936-1950
Landless manual workers, unskilled or low skill (ref.)	Coeff. (s.e.)	167.63 (0.53)***	171.27 (0.35)***	173.13 (0.58)***	177.65 (0.56)***
Manual workers, medium level of skill	Coeff. (s.e.)	-2.13 (0.88)*	+0.00 (0.61)	+0.68 (0.89)	+0.96 (0.65)
Farmers	Coeff. (s.e.)	-0.03 (0.50)	+0.12 (0.77)	+1.32 (1.14)	-1.46 (1.32)
Non-manual workers, professionals and managers	Coeff. (s.e.)	+1.84 (1.34)	+2.51 (0.91)**	3.09 (0.90)**	+1.83 (0.78)*
Small-scale landholding	Coeff. (s.e.)	-0.35 (0.51)	+0.17 (0.70)	-0.39 (1.37)	-1.49 (2.85)
Large-scale landholding	Coeff. (s.e.)	+2.36 (0.92)*	+0.15 (0.71)	+0.64 (1.22)	+1.83 (1.62)
Linear trend	Coeff. (s.e.)	0.04 (0.01)*	0.06 (0.02)***	0.10 (0.06)’	0.15 (0.07)*
	R^2	0.0482	0.0494	0.0428	0.0318
	F	4.43	3.58	2.83	2.33
	N	740	659	465	569

Notes: Statistical significance; ‘ - p < 0.10, * - p < 0.05, ** - p < 0.01, *** - p < 0.001. Own calculations.

Table 4. The share of the variance in heights explained by the socioeconomic status variables

	1797-1866	1867-1914	1915-1935	1936-1950
	Shares of the variance explained in percent (%)			
Occupational status	2.00	1.30	3.78	1.92
Landholding	1.60	0.27	0.62	0.18
Occupational status & landholding	2.96	1.48	4.20	2.15

Note: The shares of variance explained are the R-squares from un-weighted OLS regressions on the full sample including only the socioeconomic status variables without any trend variable (results not shown here). Own calculations.