



# Differences in height by education among 371,105 Dutch military conscripts



Ying Huang<sup>a</sup>, Frans van Poppel<sup>b,c</sup>, L.H. Lumey<sup>a,d,\*</sup>

<sup>a</sup> *Epidemiology Department, Mailman School of Public Health, Columbia University, New York, USA*

<sup>b</sup> *Netherlands Interdisciplinary Demographic Institute (NIDI/KNAW)/University of Groningen, The Hague, The Netherlands*

<sup>c</sup> *Department of Sociology, Utrecht University, The Netherlands*

<sup>d</sup> *Department of Molecular Epidemiology, Leiden University Medical Center, The Netherlands*

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## ABSTRACT

Adult height is associated with a variety of familial and socio-economic factors and large, well-defined populations are needed for a reliable assessment of their relative contributions. We therefore analyzed recorded heights from the military health examinations of 18-year conscripts in the Netherlands born between 1944 and 1947 and observed large differences by their attained education and by their father's occupation. The 5.1 cm height gradient from lowest to highest education level was more than twice as large as the gradient between father's occupation levels. The education gradient was not explained by common determinants of height including paternal occupation as a measure of familial background, region of birth, family size, or religion.

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## 1. Introduction

The association between body height and socio-economic factors including parental occupation and a subject's education is a well-recognized phenomenon (Peck and Lundberg, 1995; Meyer and Selmer, 1999; Silventoinen et al., 2001, 2003; Komlos and Kriwy, 2002; Gyenis and Joubert, 2004; Heineck, 2006; Krzyzanowska and Umlawska, 2010; Jordan et al., 2012). These same factors often underlie regional gradients and urban vs. rural gradients in height which have been observed in

several countries including the Netherlands (Fredriks et al., 2000; Hiermeyer, 2009; Schonbeck et al., 2012). Heights are now widely seen as a useful measure of human welfare (Steckel, 2009).

Family studies suggest that most of the variation in height is under genetic control (McEvoy and Visscher, 2009) but environmental factors must also be important as suggested by the continuing secular increase in heights. In the Netherlands, this increase has been especially well documented. The increase began in the second half of the 19th century and accelerated in the second half of the 20th century (de Beer, 2004). By the end of the 20th century, the Dutch had become the tallest in the world (Fredriks et al., 2000; Komlos and Breitfelder, 2007; Schonbeck et al., 2012). Among Dutch military conscripts, the mean height

\* Corresponding author at: Epidemiology Department, Mailman School of Public Health, Columbia University, 722 West 168 Street, Rm 1617a, New York, NY 10032, USA. Tel.: +1 212 305 9222; fax: +1 212 342 0168.  
E-mail address: [lumey@columbia.edu](mailto:lumey@columbia.edu) (L.H. Lumey).

increase since 1865 has been 21 cm (van Wieringen, 1986) and of this increase 9 cm was already achieved by 1940 (Brinkman et al., 1988). The most important environmental improvements are likely to be from better childhood living conditions in nutrition, health practices, and control of diseases, but these factors are hard to disentangle (Silventoinen, 2003). Family size is a factor (Fredriks et al., 2000), and psychosocial stress and adverse social conditions may also play a role (Batty et al., 2009).

As familial conditions are closely related to occupation and education, well defined populations are needed to reliably assess the relative impact of both on adult height. In addition, regional differences in socio-economic conditions and education need to be taken into account (Vliegen et al., 1981).

We therefore examined in a Dutch national conscript population the relation of conscript's education and father's socio-economic position to height at age 18 and the effects of region of birth, family size, and religion.

## 2. Methods

### 2.1. Study population

We studied anonymized military records provided by the Dutch Ministry of Defense in 1969 for a study of the relation between early nutrition and mental performance at Columbia University (Stein et al., 1972). The records include all men of Dutch nationality born between January 1, 1944 and December 31, 1947 examined for military service in the Netherlands ( $n = 408,015$ ). Military examinations were based on yearly listings of all Dutch male citizens in the national population registers. All men were called to the military service induction exam at age 18, except those living in psychiatric institutions or in nursing institutes for the blind or for the deaf–mute (0.6%). Foreign births (2.5%) were excluded.

### 2.2. Available measures

Standing heights were measured for all men using the same military protocol with wall-mounted stadiometers. Measurements were taken without socks or shoes with the individuals' head positioned in the Frankfort plane.

From the military examination record we selected for further analysis subject's education and paternal occupation as the variables of primary interest for this study. In addition, we selected other relevant variables for which associations with adult height have been reported (Fredriks et al., 2000), including place of birth in view of the North–South gradient in height in the Netherlands and religion and family size as closely related variables. In the Netherlands, the Catholic religion is predominant in the South and family size at the time was largest in this group (van Poppel, 1985).

To evaluate the role of education, we defined six education categories, ordered by years of formal education in relation to primary school education from age 6 to 12. In the category 'less than primary school', we included individuals with special education for the handicapped. We then distinguished men who had received 2, 4, 6, or

more than 6 years of formal education beyond primary school corresponding to 8–9, 10–11, 12, or 12+ years of education.

Paternal occupation was ordered into five SES based categories ranging from laborers and miners, service employees (including shop assistants), farmers and farm workers, to clerical workers and self-employed individuals and managerial and professional occupations.

Place of birth was classified by geographic region and urbanization to include selected cities in the North/East vs. remaining municipalities, selected cities in the West vs. remaining municipalities (including the province of Zeeland), and selected cities in the South vs. remaining municipalities. Religion was defined as Roman Catholic, Protestant (Dutch reformed or Calvinist), no religion, and other religions, including unknown. Family size was ranked by number.

All remaining study subjects were included for analysis unless information was missing on height (1.8%), education (1.5%), or paternal occupation (6.8%). Because of partial overlaps of missing variables, 91.0% ( $n = 371,105$ ) of the study population remained for analysis.

### 2.3. Statistical analysis

We evaluated differences in height by education, paternal occupation, and other selected variables and carried out multiple linear regression models to evaluate the independent contribution of education, paternal occupation, and the other covariates to height at age 18.

## 3. Results

Social and demographic characteristics of the study population are listed in Table 1 together with the range of heights of 18-year old conscripts within each of the variable categories not adjusting for other variables. There is a monotone height increase with a gradient of 5.1 cm comparing conscripts with the lowest and highest education level (range from 174.8 cm to 179.9 cm) and a 2.4 cm gradient comparing conscripts with fathers of the lowest and highest occupation status (range from 176.1 cm to 178.5 cm). In addition, there is a height difference by region of birth (range from 175.2 cm in the rural South to 178.7 cm in the urban North) and by religion (176.4 cm among Roman Catholics vs. 178.2 cm among Protestants). Starting at family size 2 (average height 178.2 cm), average heights tend to be lower among larger families (Table 1).

The height increase with increasing conscript education is seen within all paternal occupation groups. It ranges from 4.3 cm comparing sons of miners and laborers to 5.4 cm comparing sons of fathers with professional or managerial positions. (Table 2 and Fig. 1) A monotone height increase by paternal occupation is seen within all conscript education levels (Table 2).

These patterns are reflected in linear regression models with explanatory variable either subject's education alone or paternal occupation alone (Table 3, Model A, upper and lower panels). With additional adjustment of subject's education for paternal occupation (Model B, upper panel), the education gradient narrows from 5.1 cm to 4.4 cm, and

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