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Casting shadows: later-life outcomes of stature

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ABSTRACT

The central question in this special issue is a relatively new one in anthropometric history: how did body height affect the life course? This raises the issue of whether such an effect merely captures the underlying early-life conditions that impact growth, or whether some independent effect of stature can be discerned. Further, the effects of height on later-life outcomes need not be linear. These effects may also differ by gender, by context (time and place), and among life course domains such as occupational success, family formation or health in later life. The ten research articles in this issue use a plethora of historical sources on individuals, such as prison and hospital records, conscript records, genealogies and health surveys. These articles employ a variety of methods to distinguish between early-life and later-life effects, between intra- and intergenerational processes and between biological and socio-economic factors. Importantly, all articles discuss the impact of the specific context on their results to understand these effects. The overall conclusion is that independent later-life outcomes of height are rather ambiguous, and seem to stem more from the perception of physical strength, health and intelligence associated with height than from height itself. This special issue also reflects on intergenerational effects of the later-life outcomes of height. As populations have grown taller, it is possible that height and later-life outcomes have formed a 'virtuous cycle', resulting in taller, healthier and wealthier populations. So far, however, our research offers little support for this hypothesis.

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1. Introduction

Human height continues to fascinate scholars from disciplines as wide ranging as medicine, genetics, archeology, history and economics. Variations in average heights – social, regional and temporal – reveal the changing impacts of childhood experiences, in particular access to nutrition and (health) care. As such, height is a crucial indicator of the 'biological standard of living', which has come to be seen as an indispensable addition to traditional measures of inequality and progress (Steckel, 2009). However, adult height cumulatively results from complex interactions of genetic endowment and environmental effects on energy needed for growth in development. Further, height itself can lead to specific later-life trajectories, marked for instance by positive chances on the marriage market or adverse health in old age.

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In turn, these effects may be transmitted to subsequent generations, through selection to procreation and other social processes.

In this special issue, we adopt a life course approach in order to explore the complex mechanisms both leading to and resulting from stature. Thus, the 'shadows cast' by human bodies (Figure 1) allude to lasting effects of early-life conditions on the one hand, and effects of height on later-life outcomes such as health and social mobility on the other. This longitudinal approach to height serves four purposes. First, we aim to enrich knowledge of human growth by making full use of sources, such as genealogies, population registers and panel studies, that allow for the incorporation of determinants and outcomes across the life course, and even to subsequent generations (Inwood & Roberts, 2010). Second, we aim to contribute to family and social history by illuminating the interconnections between family settings, environmental conditions, stature, health, and the life course. Our collection brings together historical and more contemporary research, as the human growth patterns often used as standards in health research turn out to be dependent on specific environmental conditions. Research taking those conditions into account are therefore highly relevant. Third, we explore gender differences in the relationships of height to later-life outcomes. In anthropometric history this is not self-evident, as the field still heavily depends on adult male sources, particularly conscription records. Because of physiological reasons, men and women respond differently to improvements in nutrition, which can mean that secular trends differ by gender (Harris, 2021). Also, gender discrimination can lead to differences in the allocation of care and food within families (Meredith & Oxley, 2015; Quanjer & Kok, 2019). Finally, we include studies on children's height alongside the more 'traditional' focus on young adults drawn from conscription and prison records. Anthropometric history has much to learn from the study of children: if height at conscription is used, 20% to 40% of a birth cohort has likely already died, leading to biased conclusions. Also, when mortality rates drop, the selection effects recede, leading to changes over time in the composition of research populations.

Figure 1. Shadows of a family. *Note:*
Source: https://pixabay.com/en/family-together-parenting-lifestyle-492891/, archived at Wikimedia Commons.

In the next section, we briefly review the literature on how height is a marker, and can even serve as a proxy, for early life conditions. In other words, height may mediate the relationship between early-life conditions and later-life outcomes. Then, we explore the question of how height may play an independent role in determining later-life outcomes. Over and above early-life conditions, is height related to later-life outcomes? To ascertain this will be a challenge, as it requires sufficiently controlling for early life conditions. In section four, we introduce the ten articles of this special issue and highlight their main results. In the final section, we discuss the most promising avenues for future research in this field.

2. The long reach of childhood

Adult height is itself a later-life outcome, determined by experiences and exposures during development. In historical and contemporary, low-income contexts, more detailed information on early-life conditions may be lacking. Here, height can be a very useful proxy of early-life conditions, or of the biological standard of living. While this term is useful, it may obscure the numerous mechanisms that link early-life circumstances to later-life outcomes through heights (Kelly-Irving & Delpierre, 2019). Therefore, this section will attempt to illuminate the 'black box' of the biological standard of living. First, several key early-life determinants of height will be discussed. Second, we will explore different facets of the growth trajectory that may complicate the interpretation of height as an indicator of the biological standard of living.

There are a number of early-life determinants that affect adult body height. One of the most important ones is nutrition. Studies have shown that diets, influenced by cultural, geographical, and climatic conditions, impact height, e.g. through the consumption of protein and iodine (Baten & Murray, 2000; Staub & Rühli, 2013). Dietary practices also influence morbidity and mortality outcomes such as diabetes and cancers (Osler & Schroll, 1997; Schwedhelm et al., 2016). Malnutrition can result in stunting, but also in reduced cognitive development and, ultimately, in worse occupational outcomes (Kossmann et al., 2000).

Health in childhood is also a crucial determinant of adult height. Illnesses in childhood can claim energy that would have otherwise been used for growth, leading to stunting. The same illnesses may also impair brain development, which may then decrease earning potential, the likelihood of finding a partner, and health-related behaviors, all which may lead to higher mortality risks in adulthood (Guven & Lee, 2015). Further, infections and inflammations that retard early growth have also been shown to be related to cardiovascular diseases, respiratory diseases and stomach cancers in old age (Crimmins & Finch, 2006). Childhood diseases appear to lead to both shorter stature and specific diseases (Inwood & Roberts, 2010).

More generally, the exposure to childhood diseases can affect both height and later-life mortality via two mechanisms. First, it can selectively cull the weakest of a population, resulting in taller survivors (Bozzoli et al., 2009), who also have been found to have lower mortality risks in early adulthood (Quaranta, 2013). Second, exposure to childhood diseases can scar survivors (Checkley et al., 2003; Schmidt et al., 1995), resulting in shorter stature and higher mortality risk later in life (Van Dijk et al., 2019). Whether scarring or selection dominates in a particular population should be carefully considered when using height as a proxy for the 'long harm' of disease in childhood.

Additionally, context appears to determine the extent to which environmental exposures, such as nutrition and disease, impact height. In contemporary, high-income societies, it is estimated that about one fifth of the variance in adult height can be attributed to early life conditions (Silventoinen et al., 2000). In lower income and historical contexts, studies have shown that early life conditions claim a more dominant role (Alter & Oris, 2008). It is useful to identify the relative contributions of genes and environment to height, because height's relationship to mortality may result from genes conducive to both tallness and longevity (Harris, 1997; Riley, 1994). Epigenetic effects may also hamper height's usefulness as a proxy of early-life conditions during development. This is because the expression of genes inherited from previous generations can be affected by the early-life conditions of those earlier ancestors (Kok, 2023 - this issue).

The growth trajectory, and the adult height an individual ultimately reaches, is based on a genetic target. Various negative environmental factors may arise that cause someone to miss their genetic target, resulting in shorter-than-expected, or even stunted height (Cole, 2003). These external factors are seldom constant in historical settings. Experiencing famines, parental loss, and epidemics during development have all been shown to hinder growth (Chen & Zhou, 2007; Sheppard et al., 2015).

Considering the impact of shocks on height, timing may be important. Are there critical periods in development during which a shock might affect growth the most? This is probably the case when growth velocity is at its peak. Researchers accordingly have investigated how adverse environmental factors affect growth during the first year of life, when the body develops the fastest (Öberg, 2015). For instance, the negative effect of parental loss on heights is strongest for young children (Quanjer et al., 2023). However, shocks at other ages may also be important. The disease environment has been found to also impact growth between age two and six (Hatton, 2011), six and eleven (Schneider & Ogasawara, 2018), and in adolescence (De Beer, 2001; Depauw & Oxley, 2019). When heights are used as a proxy to study the long reach of childhood, these critical age windows of growth, and whether or not a shock was experienced during them, should be considered. This is because adult height may better-reflect conditions at some moments in development than at others.

However, the growth trajectory is also flexible. After a shock in early-life, the body can recover and catch up with the initial growth trajectory (Boersma & Wit, 1997). Catch-up growth might therefore mask brief shocks early in life. It is also possible that growth velocity may slow down due to adverse environmental conditions. Further, there is evidence that the growth trajectory of populations in the past differs from today, in the sense that people had a more prolonged and slower growth trajectory. Particularly, growth velocity during adolescence was lower, and the adolescent 'growth spurt' came at later ages, or not at all (Gao & Schneider, 2021 also Quanjer & Kok, 2021).

Might rapid, brief periods of catch-up growth or slow growth bring health risks of their own? There is evidence that experiencing catch-up growth may strain bodies, and has been associated with increased risks of high cholesterol, diabetes, obesity and coronary diseases (Harris, 2021; Metcalfe & Monaghan, 2001; Singhal, 2017). Growing slowly may also be associated with a health penalty. By combining conscription heights at age 20, height information from a re-examination at age 25, and individual cause-of-death data, Thompson, Quanjer & Murkens (2020) were able to evaluate the mortality risk of a very slow growing sample from the nineteenth-century Netherlands. The authors found that, surprisingly, men who were tall and had reached their final stature relatively early had higher mortality risks than those who grew slower. This may indicate that slow growth is favorable in historical settings.

3. Independent effects of height

Stature reflects early life conditions, but can have effects of its own on later-life outcomes. Figure 2 shows these intricate connections. Social and economic outcomes in adulthood can be strongly influenced by early life conditions, which also influence height. But these outcomes can also be impacted by the independent effects of height. This is because height may be associated with a number of positive attributes, such as intelligence, strength, health and/or dominance. Not only might taller people be more likely to possess these characteristics, they are also more likely to be perceived as having them. These attributes can contribute to people being selected into education, employment, or marriage. This is because height may function as a *signal* of a number of positive attributes, including intelligence, strength, health or dominance. This can imply that, all else being equal, twins might have different later-life outcomes determined only by their height, which always has some random variation.

Finding the independent effect of height on later-life outcomes – education, career, migration, marriage and fertility – is complicated by physical growth's association with these positive attributes. The question what positive attributes are important in explaining height's relationship to later-life outcomes is debated in the literature. Case and Paxson (2008) found that height's relationship to occupational status could be explained by both height and occupational status being related to cognitive ability. Cinnirella et al. (2011) showed that taller German children had a higher chance of entering pre-university education. However, in contrast to Case and Paxson (2008), the authors argued that this was not because of higher IQ scores. Rather, tall schoolchildren possess more social skills and locomotion than short ones. This translates into teachers advising more advanced study tracks (Cernerud, 1995). This argument is echoed by Persico et al. (2004), who

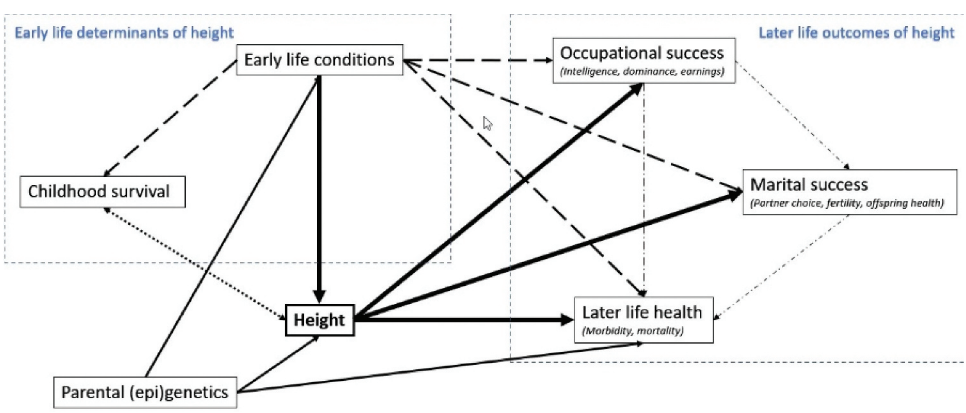

Figure 2. Diagram of later-life effects of heights.

argued that the relationship between height and occupational attainment could be explained by participation in secondary school-level sports and clubs, which they used as a proxy for 'non-cognitive skills', or social skills.

In many studies, especially historical ones, it is not possible to adequately control for intelligence. Ideally, one would compare identical twins, control for IQ score, and then see whether differences in height has a significant effect on their later-life outcomes. In some studies (see also Thompson & Portrait, 2023 -this issue; Roberts et al., 2023-this issue), a sibling design is chosen to control as much as possible for shared environment.

There are also important gender differences in height's relationship to educational attainment. For boys, this (potentially discriminatory) practice is more evident than for girls (Cinnirella et al., 2011). A Swedish study found that men taller than 194 cm were two to three times more likely to obtain a higher education than men shorter than 165 cm, even after controlling for parental socioeconomic position, other shared family factors, and cognitive ability (Magnusson et al., 2006). In a Polish comparison of the educational attainment of siblings pairs, the taller siblings did significantly better. For girls, the same tendency was found, but was not statistically significant (Bielicki & Charzewski, 1983). This seemed to suggest an effect of discrimination against shorter men, or a preference for taller men.

Similarly, height and occupational status are generally found to be positively associated with one another, particularly for men. Taller men on average have higher incomes or attain higher social statuses, even in societies and periods in which education was not the main route to the labor market. For men engaged in manual labor, their size and strength are thought to enhance their labor productivity and their incomes (Floud et al., 2011, p. 20; Judge & Cable, 2004; Thomas & Strauss, 1997). In selection to jobs or specific (managerial) functions, the association with health and intelligence may play a role (Jaeger, 2011). Taller men may also be more dominant, and therefore able to negotiate or secure better positions (Stulp et al., 2015). It is also worth emphasizing that taller men may both be stronger and more dominant, and more likely to be perceived as such.

Higher occupational status also implies that taller men have more chances to achieve upward intergenerational mobility than shorter men. For instance, a UK-based study showed that downwardly mobile sons were shorter by about 0.9 cm and the upwardly taller by between 0.6 cm and 1.2 cm (Krzyzanowska & Mascie-Taylor, 2011). Sons with higher BMI were also more likely to be intergenerationally downwardly mobile (Krzyzanowska & Mascie-Taylor, 2011 see also on Sweden in the 1980s Nyström, 1992).

Height's relationship to labor market outcomes is also less straightforward for women. In a meta-analysis, Thompson et al. (2021) found that, in European, American and Australian studies, there was not a significant height premium for women. However, there was for women in studies set in Asia. For men, while the height premium varied in size, it was significant across all geographies.

Further, taller stature, again particularly for men, often translates in better chances on the marriage market (Harris, 2021). Women prefer men who are taller than themselves – but not extremely so. This may be because taller men tend to be higher earners (Sohn, 2015), or because taller men are perceived to be more physically protective (Yancey & Emerson, 2014). Finding partners is more difficult for short men. Several studies, including historical ones, have shown that indeed taller men are more likely to marry or be in a relationship than shorter men (Hacker, 2008; Herpin, 2006). To control for the early life determinants of both height and chances on the marriage market, Thompson et al. (2021) used a sibling design to study the association between height and marriage of Dutch men born between 1841 and 1900. They did not find a specific bonus to tallness, but instead found a penalty for shortness. The bottom 20% of heights had a lower odds of being married. There were no effects found on the timing of marriage.

Similarly, height's relationship to marital outcomes is weaker for women than for men. When a significant relationship between height and marriage is sometimes found for women, it is generally non-linear. Baten & Murray (1998) found that the shortest women were disadvantaged on marriage markets, but that height was not a significant factor for other women. Several studies also find a curvilinear relationship between women's heights and marital outcomes, whereby extreme tallness is associated with the decreased probability of marriage (e.Nettle, 2002; Stulp et al., 2015). This means very tall and very short women generally have the lowest probabilities of marriage. However, several other studies find no relationship between height and marriage for women (e.g. Sear et al., 2004; Yamamura & Tsutsui, 2017). In these contexts, other (physical) attributes may be more important for women on marriage markets.

When healthier and taller individuals – particularly men – have more income and are more likely to marry, does this set into motion a 'virtuous cycle' in which constantly wealthier, healthier and perhaps taller generations are produced? This is suggested by a Dutch study based on the Lifelines panel, which includes health and life courses of 167,000 individuals. Relatively tall men and women of average height had more children than other combinations. As this coupling is favored in the Netherlands, this might have contributed to the remarkable secular trend of increasing heights (Stulp et al., 2015). Supporting the notion of a 'virtuous cycle', Thompson et al. (2021) found that somewhat tall men (0.5 standard deviations above the mean) were more likely to have children surviving infancy. However, in this issue (Stulp et al., 2023) this hypothesis was tested with the use of simulation, and the authors found that fertility was unlikely to have contributed to the secular trend.

The evidence for women is equally mixed. On the one hand, evolutionary biologists postulate a trade-off between energy invested in growth and in reproduction, particularly for women. Therefore, an earlier age at menarche should be related to short stature, and would enable women to have longer reproductive careers. Indeed, some studies find an association between early childbirth and short stature among women (Rivara & Madrigal, 2019; Sear, 2010). On the other hand, taller women also have been found to have easier births, higher birthweight babies, fewer stillbirths and higher survival chances among their children (ibid). For both men and women, the relationship between height and fertility outcomes is still largely unknown.

To summarize, height may indeed have a relationship to later-life outcomes independent of early-life conditions, but this is complicated by who is being studied, where they live, and what outcome is analyzed. In general, it appears that these relationships are stronger for men than for women. It also appears that for some outcomes, tallness is not rewarded unequivocally: men around average height, or just above the mean height, seem to have the most positive later-life outcomes.

4. The articles in this issue

Using a variety of sources and methods, the articles in this special issue offer a good overview of the state-of-the art research into the long-term effects of stature. The papers can be roughly divided into three topics: 1) the interplay between nutrition, disease and height in early life; 2) later-life effects of height and, finally, 3) effects of height – and associated life course experiences – on next generations.

4.1. Adversity and height in early life

A number of articles in this issue focus on the outcomes of height, or nutritional status, in childhood and adolescence. In his contribution, Schneider (2023 - this issue) examines the effect of nutritional status of young orphans, which he proxies by weight- and height-for-age z-scores, on the odds of contracting infectious diseases during their stay in the London Foundling Hospital. He finds no relationship between nutritional status and contracting measles, mumps, rubella, chickenpox, or whooping cough. Thus, there appears to be no clear link between nutritional status (proxied by height) in early life, contracting diseases, and, through scarring, health in later life. However, Schneider does find that nutritional status is related to the *duration* of measles and mumps. Thus, both scarring (through the duration) and selection (through the severity) can occur, which might affect mortality in later life in both directions. The novel approach of Schneider can help us to unravel the independent effects of diet and disease on height, which, so far, have only been approached theoretically (Alter, 2004).

After the First World War, the health of American children below age 6 was checked, following welfare initiatives in other countries. For the city of Saint Paul (Minnesota), more than 14,000 of the original cards with names, ages, height and weight measurements were preserved. Roberts et al. (2023 - this issue) managed to link 2499 of these cards to the censuses of 1920, 1930 and 1940. For 1940, only boys could be linked. This research design allows them to trace the effects of childhood deprivation to school attendance at ages 12–18 (1930), educational attainment, years of schooling and employment status at ages 22–28 (1940).They show that, for early twentieth century American children, height and weight were clearly, and positively, associated with these outcomes. These findings are concomitant with studies for contemporary low income countries.

It is hard to imagine the tribulations endured by young British convicts who, in the first half of the nineteenth century, were sent to the penal colony of Tasmania. Donald et al. (2023 - this issue) discover that male convicts deported as adolescents did not reach the same heights as adult convicts, despite the fact that, by and large, the available nutrition was adequate. For deported girls, no differences in height were found. Possibly, individuals being convicted so early in life had experienced even worse conditions in early childhood than older 'criminals', but the authors discard this and other selection effects. They conclude that employers in Tasmania had no incentive to invest in young and unskilled convicts, who were subsequently treated worse than others. Girls at least had the benefit of not having to do gang labour. The stagnating growth of young convicts stands in contrast to the catch-up growth experienced by adolescent slaves in Antebellum American South (Steckel, 1986). Clearly, American slave owners expected more (labour) return than the Tasmanian settlers to whom young convicts were assigned.

4.2. Later-life effects of height

Stature captures early life experiences, which impact later life outcomes. But height can also have effects of its own, although they are difficult to identify. For instance, is taller height itself rewarded on job markets, or is another factor correlated with height, such as intelligence, being rewarded? Thompson and Portrait (2023 - this issue) add to the debate on this issue, by employing instrumental variable analysis, a causal inference method, among a sample of Dutch men born in the late nineteenth century. While other studies have used instrumental variable analyses when studying contemporary populations, Thompson and Portrait (2023 - this issue) are the first to use this method to examine height's relationship to job market outcomes among a historical sample. The authors find that body height was both related to occupational status, and to intergenerational mobility between fathers and sons. This study provides evidence that taller height, in and of itself, increased men's chances of labor market success.

Several articles in this special issue examine whether height might be related to mortality in later-life. Thompson et al. (2023 - this issue) explore this topic using a sample of Dutch women. The women included in this study's sample were notably deprived: these women had all been convicted of vagrancy, and received custodial sentences at the colonies of Veenhuizen and de Ommerschans as punishment. Although women convicted to beggar colonies are unlikely to be representative of Dutch women overall, they were some of the only Dutch women whose heights were recorded in a systematic way prior to the twentieth century. This unusual population thus offers an important window into the past. Curiously, Thompson et al. (2023 - this issue) find that taller vagrant women had higher risks of death. Perhaps among this very deprived, likely food-insecure population, taller bodies, with their greater caloric demands, presented more of a liability: taller women were likely more at risk of becoming malnourished, and therefore perhaps more at risk of earlier deaths.

Ziegler et al. (2023 - this issue) present a different perspective on height's relationship to mortality, and underscore that this relationship may vary by context. The authors use a sample of men conscripted from 1925 to 1927, from Glarus, a canton in the Swiss Alpine region. Men included in this sample, in contrast to the female beggars studied in Thompson et al. (2023 - this issue), were on average very prosperous: Glarus was highly industrialized, and benefitted from the economic hub of neighboring Zurich. The authors find that height was positively related to lifespan, and that the very short had higher risks of an earlier death. Substantively, however, these differences in lifespan were rather small, a finding in line with those in several other studies of height's relationship to mortality (Alter et al., 2005; Marco-Gracia & Puche, 2021). Although height may be a good indicator of health in early-life, this study helps to show that height's relationship to mortality in adulthood is less straightforward.

The latter finding is confirmed by Sear et al. (2023 - this issue). They analyze data from an extensive survey in four villages in Gambia. Between 1950 and 1974, more than two thousand adult villagers were examined and their height, weight and haemoglobin levels were recorded repeatedly. The authors include these as variables in an event history regression on the risk of dying (in the same period). In their study, they use the interesting concept of 'embodied capital' (also Kaplan et al., 2003; Wells, 2010), which in different ways reflect current and past nutrition and health exposures. Haemoglobin levels, as the most dynamic or 'liquid' form of physical capital had the clearest relationship to mortality. In this low-income country, BMI had a negative association with mortality risk. Height as the most 'illiquid' form had no effect on mortality of men, whereas women of average stature had relatively the best chances of survival.

4.3. Intergenerational effects of height

To what extent does height also cast a shadow on the lives – height, health, socio-economic success – of the next generation? Quanjer (2023 - this issue) examines if the paternal life course affected the height of his sons. He finds that if the father achieved upward social mobility, his sons were able to outgrow him to a greater extent than the sons of fathers who did not experience social mobility. Nevertheless, in terms of absolute heights, the second generation was not able to reach the heights of their higher socio-economic peers after the upward mobility of the father. The study also finds that maternal early life conditions played a crucial role in outgrowing one's father, especially if those conditions were favourable and the father married into a higher class. Further, and in line with other studies on height correlations (Alter & Oris, 2008), he notes that the correlation between heights of fathers and sons was lower in earlier periods and in lower classes due to the stronger variation in external factors. The study made use of a new growth estimation method at the individual level, which corrects for the fact that much of the lower correlation could have been ascribed to shifting growth patterns between the generations.

Going beyond intergenerational effects, Kok (2023 - this issue) explores whether the impact of negative shocks can extend to the grandchildren. Using descendant family trees of a Dutch island population, including branches living on the mainland, he studies whether food crises or the loss of a parent experienced in early life had an impact of the height and lifespan of children and grandchildren. The mechanism suggested in the literature is a changed expression of genes, which might last for several generations. The author concludes that such 'epigenetic' mechanisms played no important role in the Dutch secular increases in stature and longevity, but he readily concedes that replication studies on more deprived populations are needed.

Finally, Stulp et al. (2023 - this issue) set out to place the rewards of tallness in the context of evolutionary biology. They investigate the potential role of natural selection in explaining the increasing tallness of the Dutch, under the hypothesis that taller men are more successful in reproduction. Using simulation, Stulp et al. (2023 - this issue) find that the selection pressure would simple be too high, with only the tallest third reproducing, to have contributed to the secular increase in heights. In their study they estimate that the potential contribution to the upward trend in heights is very limited and ranges from 0.07 to 0.36 centimetres.

5. Conclusion: pathways to explore

With this special issue, we hope to better understand height's relationships to later-life outcomes, and to suggest best practices for its study. Our selection of papers is not comprehensive; there are still topics untouched and research angles unexplored. In the next section, we will go into the possibilities for future research.

This special issue has raised the question: Is height simply a summary measure of early-life exposures, or is it something more? If height were a summary measure, this would imply that height's relationship to later-life outcomes could largely be explained by resources during development, such as socio-economic status or nutritional availability. Indeed, adequately controlling for environmental conditions in early-life does explain much of the relationships between height and later-life outcomes in a number of studies (e.g. Thompson et al., 2021). However, this does not tell the full story: height itself appears to signal positive qualities that are frequently associated with beneficial later-life outcomes. This explains why even in studies among siblings, whose early-life conditions are likely very similar to one another, taller height is nonetheless associated with more beneficial later-life outcomes (see in this issue, Thompson & Portrait, 2023).

Height's function as a signal of desirable qualities – rather than actually being associated with those qualities – may also help to explain why height's relationship to later-life outcomes is not consistent in all contexts (e.g. Sear, 2010; Thompson & Portrait, 2023-this issue). If height functions as a signal, some element of subjectivity is likely involved, with the value placed on height perhaps in part determined by cultural preferences and values. This may be why height is associated with greater economic advantages in lower-resource settings, even in non-manual occupations, relative to higher-resource settings (Vogl, 2014).

There is also evidence that height's value is not absolute, because height is often non-linearly related to later-life outcomes, with decreasing returns past a certain point of tallness. For instance, while tallness in men is generally associated with beneficial outcomes on dating and marriage markets, it appears that relative height is important. This means that men who are taller than women, but not too much taller, have been found to be successful on marriage and dating markets (Pawlowski, 2003; Sohn, 2015). The actual height that is preferred is also dependent on the height of women, so what is 'too short' in one context is not in another (Pawlowski et al., 2000). If height's value were strictly absolute, we would expect to see improved later-life outcomes with every additional centimeter of height, across all contexts. This is clearly not the case.

It is also worth bearing in mind that height is one physical characteristic among many that may influence later-life outcomes. For instance, Devaraj et al. (2018) examined the interaction of height and race's relationship to earnings in a sample of men and women from the U.S. The authors found that, particularly for non-white men, tallness was negatively associated with earnings. This was not the case for white men. The authors hypothesized that, for taller non-white men, tallness was perceived as threatening, whereas white men were not subject to the same prejudices (ibid.). Perhaps bearing the different relationship of height and wages among people of different races, a number of studies examining height's relationship to wages in Europe only include white individuals (Oreffice & Quintana-Domeque, 2016; Persico et al., 2004). Particularly when examining more racially diverse populations, considering race as a moderator of later-life outcomes may be important.

Another important factor to consider may be weight. Body build may interact with height to determine the strength and direction of both socio-economic outcomes and health-related ones. Waaler (1984) found that, while there is a clear negative relationship between height and mortality, this is not the case for BMI, which has a pronounced curvilinear (or U) shape to mortality. When considering height's relationship to wages, several studies (Harper, 2000; Lee & Zhao, 2017; Tyrrell et al., 2016) have found that interacting weight with height changed the strength and direction of these relationships. In particular, Tyrrell et al. (2016) found a penalty of being overweight for both men and women, but this was less pronounced among taller men. However, in historical periods as well as in low income countries, height and weight appear to have a more uniform, positive, effects on employment and earning (Roberts et al., 2023 - this issue). In future, considering the body in three dimensions may nuance our understanding of height's relationships to later-life outcomes.

Gender differences in height's relationships to later life outcomes are also crucial to consider. Depending on the outcome, these relationships can vary markedly. Height and marital outcomes are often strongly, positively related for men, but are less strongly related for women. Several factors might explain this. First, it may be because the beneficial factors with which height is strongly correlated in men, such as intelligence or social skills, are less strongly correlated among women. There is evidence that, during development, females are more robust than males (Snell & Turner, 2018). Because their heights are less reflective of early-life exposures, they may be therefore less indicative of women's intelligence and capabilities. Consequently, height may be less strongly related to later-life outcomes. However, in anthropometry in general, women are understudied relative to men. This represents a serious knowledge gap: to understand secular trends in heights among any group, it appears fundamental to consider women's heights. Fogel and Costa (1997) argued that part of the reason that subsequent generations grew taller is because mothers were increasingly healthy, and passed down this health benefit to their children. This can be seen with the effects of maternal height on birthweights and infant survival (Cole, 2003; Monden & Smits, 2009).

As mentioned, height also functions as a signal that is likely dictated by cultural preferences. What tallness signals for women may be less widely and strongly valued than what is signaled for men. We see clear evidence of this with marriage and dating markets. Taller men (up until a certain point of tallness) are seemingly universally perceived as more attractive than their shorter peers, while this is not the case for taller women. Stulp and Barrett (2016) discussed that while Dutch men appeared to prefer taller wives, American men appeared to prefer shorter wives. Both American and Dutch women preferred taller husbands (ibid.). Because tallness in women may be less universally prized, it may be less rewarded with socio-economic later-life outcomes.

Finally, we pose some questions to researchers investigating height's relationship to later-life outcomes: what do the long shadows cast by human bodies tell us about historical and societal processes? Are mechanisms and relationships constant, or does the changing context impact the mechanisms linking height to later-life outcomes? And ultimately, what are the most promising avenues to explore in future research? Because heights result from a complex interplay of genes and environment, looking over time at family members is crucial to understanding how terminal height is reached. In particular, twin studies would capture all the shared inherited genes and environment and enable us to focus on the effect of height itself. Still, exploiting datasets containing the heights and life-course information of brothers or sisters would also improve our understanding of the underlying mechanisms of height's relationships to later-life outcomes, as is shown by Thompson and Portrait (2023 - this issue).

Thus, longitudinal and/or family information appears to be key in clarifying the different pathways in the triangle between early life conditions, height, and later life outcomes.

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