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Short Lives: The Impact of Parental Death on Early-Life Mortality and Height in the Netherlands, 1850–1940

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ABSTRACT We investigate how experiencing parental death in infancy, childhood, or adolescence affected individuals' health using two distinct measures: mortality before age 20 and young adult height. Using two complementary indicators of health enables us to gain more insights into processes of selection and the scarring of health. Employing nationally representative data for the Netherlands for the 1850–1940 period, we analyze the survival of roughly 36,000 boys and girls using Cox proportional hazard models, and the stature of more than 4,000 young adult men using linear regression models. Results show that losing a parent—particularly a mother—at an early age (0–1 or 1–5) was related to a strongly increased risk of mortality. We find no evidence that losing a parent at these ages affected stature in young adulthood. For boys, experiencing maternal death between ages five and 12 was strongly associated with a shorter young adult height; however, we did not find evidence for an association between experiencing paternal death and shorter stature. We conclude that stature may not be a particularly good measure of the effects of early-life adversity if the health shock greatly increases mortality, as these effects create potential issues of health selection.

KEYWORDS Height • Mortality • Parental death • Early-life conditions • Health outcomes

Introduction

Losing a parent in childhood is a dramatic event that affects children's health in both the short and the long terms. Research on historical populations has shown unequivocally that experiencing parental death increased the short-term mortality risk of infants and children (e.g., Beekink et al. 1999; Jaadla and Lust 2021; Kok et al. 2011; van Poppel and Van Gaalen 2008; Willführ 2009). Among historical populations, experiencing parental death early in life was associated with a reduction in stature (Horrell et al. 1998; Quanjer and Kok 2019; Reher and González-Quiñones 2003) and increased mortality later in life (Campbell and Lee 2009; Debiasi et al. 2021; Smith et al. 2014).

The present study aims to generate further insights into the short-term and long-term health consequences of experiencing parental death in childhood. We explore

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two distinct measures of well-being for the same birth cohorts of a large historical population: mortality before age 20 (for males and females) and height at age 20 (for males only). This approach allows us to compare the mortality and height effects of experiencing parental death and to address the advantages and disadvantages of those measures as proxies for health and living standards in historical populations.

Our historical data cover a period of nearly 100 years (1850–1922) during which important societal and economic transformations took place; significant reductions in infant, child, and adult mortality were achieved; and increases in adult height occurred. Therefore, we can examine potential changes in the association between parental death and child health over a long time. Because parental mortality was significantly higher in the past (van Poppel et al. 2013), our historical focus allows us to examine potentially critical age periods in more detail than studies of contemporary Western populations with low levels of parental mortality can (Rosenbaum-Feldbrügge 2019). Thus, this work is pertinent to the ongoing discussion in life course epidemiology about sensitive periods in childhood that may affect health and development over the life course (Hallqvist et al. 2004; Kuh and Ben-Shlomo 2004; Serratos-Sotelo and Eibich 2021). By looking in detail at the effects of experiencing parental loss across childhood, we are able to address issues of scarring and selection in relation to health.

Our findings show that young children were particularly vulnerable to the negative effects of losing a parent, and that boys and girls who experienced parental death in infancy had an especially high mortality risk. However, we find no evidence that losing a parent at an early age (0–5) affected male stature. These results suggest that the selection and the scarring effects of experiencing parental loss may have counteracted each other. In particular, we show that children who were living in unhealthy conditions—who thus likely may have remained shorter in early adulthood regardless of their parental survival—were less likely to have survived the death of a parent. We thus observe that the overall stature of individuals who were orphaned in early childhood did not differ significantly from that of nonorphans, although their mortality was higher. However, we also find that boys who experienced maternal death between ages five and 12 were significantly shorter in young adulthood. We conclude that stature may not be a particularly good measure of the effects of early-life adversity if the health shock greatly increases mortality, as these effects create potential issues of health selection.

Theoretical Background and Historical Context

Life course research has demonstrated that the social and economic conditions experienced in childhood have a long-lasting impact on their health and survival in adulthood (Bengtsson and Lindström 2000; Hallqvist et al. 2004; Hayward and Gorman 2004; Kuh and Ben-Shlomo 2004; Quaranta 2013). In the historical literature, two approaches are frequently used to measure the health impact of experiencing a sudden deterioration of living standards. At the contextual level, past living standards are measured by studying the consequences of sudden peaks in mortality and food prices, which usually have occurred during epidemics and subsistence crises related to failed harvests and famines (Bengtsson et al. 2004; Depauw and Oxley 2019).

Variation across social groups, such as socioeconomic classes, is used to identify groups with a particular vulnerability to decreasing standards of living. The second approach—which we apply here—examines the consequences of experiencing a sudden decline in living standards by studying events occurring on the family level, such as the health effects of losing a sibling (Marco-Gracia and González-Esteban 2021; van Dijk et al. 2019) or a parent (Reher and González-Quiñones 2003; Sear and Mace 2008). We focus on the health consequences for children of experiencing parental death, which we believe is a better proxy for (the absence and quality of) parental care and resources than sibling mortality would be. Across historical populations, parental death has generally been associated with declining living standards and an elevated poverty risk for the entire family unit (Humphries 2010:63–83; Oris and Ochiai 2002; van Poppel 1995). Thus, bereaved children were at higher risk of growing up under crowded and unhygienic housing conditions (Horrell et al. 1998), which would, in turn, have negatively affected their health.

Our focus on parental death also enables us to make use of the historical family context and the distinct mechanisms operating through paternal and maternal death. In the Netherlands during the study period, fathers were largely responsible for their family's financial well-being. Mothers, by contrast, typically left the labor market upon marriage or upon their first birth (van Poppel and Walhout 2003) and were predominantly in charge of domestic work and childcare (de Regt 1984:60–61; Pott-Buter 1993:189–190). This division of labor was less strict in rural areas, where married women played an important role in the household economy (Schmidt and van Nederveen Meerkerk 2012) and, depending on the structure of the local labor market, engaged in different types of work to provide additional household income (Boter 2017). Nevertheless, growth in real wages combined with structural economic changes during the second half of the nineteenth century (van Zanden and van Riel 2000) led to an expansion of the wage gap between men and women in the Netherlands, which, in turn, greatly increased the gendered division of household tasks. Accordingly, the different effects of experiencing either maternal or paternal death on the health of a child may be partially attributed to this strict gendered division of labor, which has been referred to as the breadwinner–homemaker model (de Vries 2008). In line with this model, it has been proposed that losing a mother or a father affected a child's life course through distinct mechanisms: whereas the impact of losing a father mainly operated through a decrease in the economic resources of the household, the impact of losing a mother operated largely through a loss of access to nonmarket labor (i.e., a decline in housekeeping, childcare, and access to breastfeeding) (Dribe et al. 2007; Rosenbaum-Feldbrügge 2020; van Poppel 1995). As previous research has additionally indicated that experiencing the death of a mother is more harmful for children than experiencing the death of a father over both the short term (see Sear and Mace 2008 for a review) and the long term (Quanjer and Kok 2019; Rosenbaum-Feldbrügge 2019), in this article, we study in detail the different effects on children of losing either a mother or a father.

To capture health effects, historical demographers typically refer to the most extreme form of health inequality: mortality. Mortality levels—and particularly infant and child mortality levels—were much higher in the past than in today's Western populations. Therefore, studying infant and child mortality enables researchers to investigate the effectiveness of public health measures (Jaadla and Puur 2016), the

consequences of rising food prices (Bengtsson et al. 2004), and the effects of losing a parent. However, using child mortality as a proxy for child health has two major limitations. First, mortality research does not take the state of health of the survivors into account, as it is impossible to differentiate between survivors with good health and those with bad health. Second, the analysis of mortality at ages at which extremely small shares of the population perish is of limited value; this particularly applies to children above age five, adolescents, and young adults. Thus, examining mortality is less suitable among children who may have survived the period after they lost a parent, but who were scarred for the rest of their childhood.

To deal with these limitations, we also examine how losing a parent affected children's stature. Studying the young adult height of surviving orphans enables us to estimate their average health and, thus, to address the more subtle effects of experiencing parental loss on children's health. As stature is determined by a growth process that occurs throughout infancy, childhood, and adolescence, the study of height better reflects cumulative childhood living standards than the study of mortality. Stature is a measure that is commonly used to capture health developments across populations (e.g., Floud et al. 2011; Steckel 2009). In addition, stature can be seen as a proxy for individual health (Costa and Steckel 1997; Oddy 1982) because experiencing adverse conditions in childhood can divert energy away from growth through a variety of mechanisms, such as through lower nutritional intake, a higher risk of contracting infectious diseases, and stress. Accordingly, empirical research on a modern, high-income population found that experiencing parental death in early childhood is negatively associated with height (Sheppard et al. 2015); similar findings have been reported for historical populations (Horrell et al. 1998; Reher and González-Quiñones 2003). However, the downside of using stature in this context is that the research population suffers from selection bias because those individuals who died during childhood are not analyzed in the height sample. Thus, by combining mortality and height outcomes, we are able to address scarring and selection mechanisms that would otherwise remain undetected.

One previous study compared the effects of losing a parent on the mortality and stature of a historical population by the age at parental death. Using data on a Spanish town for the period 1870–1950, Reher and González-Quiñones (2003) showed that child mortality in the first two years of life was particularly high after the death of the mother but was not as high after the death of the father. In addition, they found that losing a mother in infancy or up to age six was associated with having shorter stature later in life. Whereas this study mainly focused on the effects of experiencing maternal death, in the present article, we consider in detail the health consequences of experiencing either paternal or maternal death, as they are expected to operate through different mechanisms in the historical context that we study. Moreover, we use a large historical data set representative of an entire country to examine in more detail the effects of the timing of the parental death.

We are also interested in the question of at which childhood ages losing a parent was most harmful to individual well-being. Previous research on child mortality and young adult height has indicated that the timing of childhood adversity greatly affects health outcomes (Depauw and Oxley 2019; Reher and González-Quiñones 2003; van Dijk 2019). While losing a parent might increase a child's mortality risk over the short term, it might also reduce survival chances over the longer term. However,

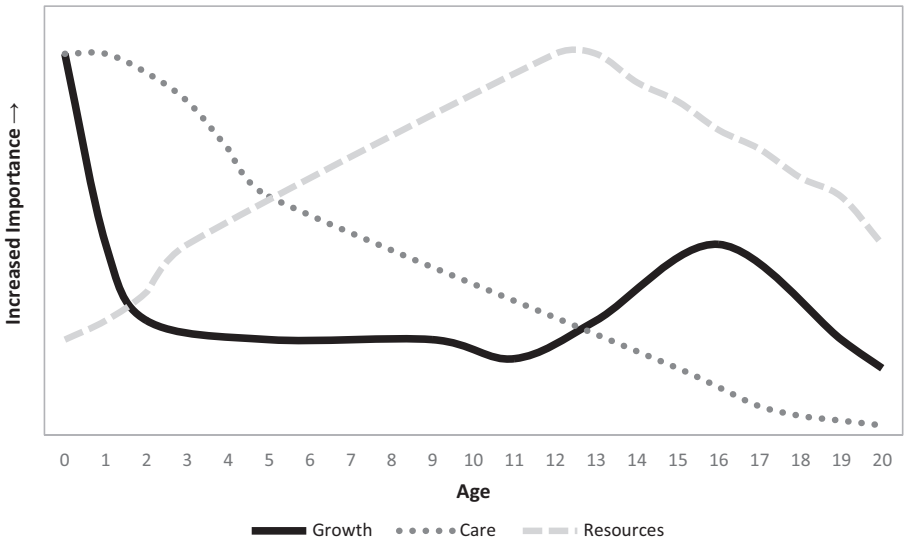

Fig. 1 Dependency on care and resources and growth velocity by age. The schematic lines on care and resources are based on the consumer–producer literature (see the appendix of Quanjer and Kok 2019). The growth trajectory comes from Tanner (1978).

when addressing the effects of losing a parent on a child's height, we need to account for two critical periods in which growth velocity is high and height is expected to be strongly influenced by external circumstances: during the first two years of life and in adolescence (Tanner 1978). Still, it remains unclear whether exposure to childhood adversity has a persisting effect that influences an individual's final height (Öberg 2015) or whether a child who undergoes adversity experiences catch-up growth before reaching adult stature (Boersma and Wit 1997). If the disruptive events take place close to the point of height measurement, the potential catch-up period will be limited and the events may, therefore, have a more pronounced effect on height. The empirical evidence that this is the case is, however, scarce.

We study the association between experiencing parental death and the health of orphaned infants, children, and adolescents aged 0–1, 1–5, 5–12, and 12–20 years. The upper age limit of 20 is applied in both the height and the mortality analyses because the young adult height of each individual was measured at around age 20 (19.7 years on average). The use of these four age groups enables us to distinguish between different stages of infancy, childhood, and adolescence that were associated with different levels of care, resources, and growth. Figure 1 provides a schematic overview of study subjects' levels of resource and care dependency throughout their early life, and of their average growth rates by age. In infancy (age 0–1), children have high growth rates and are highly dependent on parental care (in this historical context commonly provided by mothers) but are less dependent on household economic resources (in this historical context commonly provided by fathers) because they are often breastfed and have lower nutritional requirements. It should be noted that the nutritional value of breast milk is known to be relatively independent of the mother's nutritional status, unless the mother is in extremely deprived conditions (see, e.g., Prentice 1998). At age 1–5, children are increasingly dependent on household

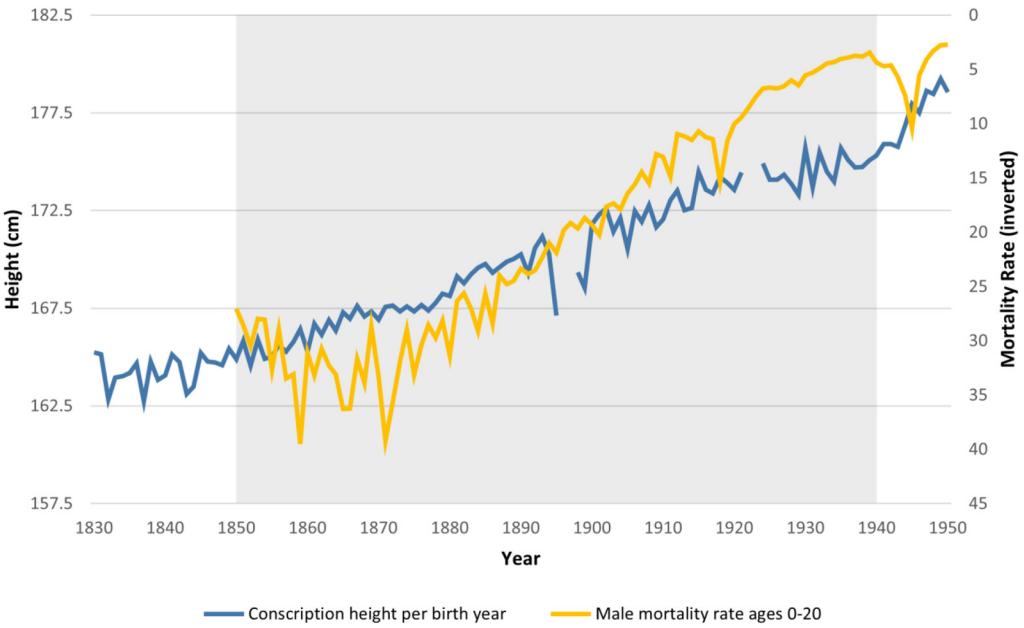

Fig. 2 Trends in conscription height at about age 20 and male mortality rates at ages 0–20 in the Netherlands, 1830–1950. The gray shading indicates the research period. *Sources:* Historical Sample of the Netherlands (HSN 2018) and the Human Mortality Database (2020).

resources and remain highly dependent on parental care but have decreasing growth rates over time. At age 5–12, children's growth rates are comparatively low and their care dependency declines, but they remain highly dependent on household resources. Finally, during adolescence (age 12–20), individuals become more self-reliant and less dependent on parental care and on household resources, to which they could start to contribute themselves. As puberty takes place during adolescence, individuals' growth rates generally increase for several of these years (Tanner 1978).

During our study period (1850–1940), there were important societal, cultural, and economic developments in the Netherlands (de Vries 2008; van Zanden and van Riel 2000) that resulted in higher living standards across the entire population. Sanitation reforms, improved medical knowledge and hygienic awareness, and increased breastfeeding rates all helped to improve the health of the Dutch population (Hofstee 1981; Tassenaar 2014; Walhout 2010, 2019). From the end of the nineteenth century onward, adulthood mortality was declining in the Netherlands (Wolleswinkel-van den Bosch et al. 1998) and the parental mortality risk decreased. In our research sample, the total share of children who experienced the death of a parent before age 20 dropped from 29% for the 1850–1879 birth cohort to 18% for the 1900–1922 birth cohort (see also van Poppel et al. 2013).

During the study period, child health also improved substantially. Figure 2 shows the decline of the below-20 mortality rate in the Netherlands (inverted rates, yellow line) from the middle of the nineteenth century to the late twentieth century. In the same period, the average stature increased (blue line by birth year). The figure shows that to some extent, height and mortality captured similar underlying health and living

conditions. The decline in the mortality rate—initially strongly driven by a decline in infant mortality—started around 1875, which marked the beginning of the epidemiological transition in the Netherlands (Wolleswinkel-van den Bosch et al. 1998). Given these substantial positive health developments during our research period, we examine whether the strength of the relationship between experiencing parental death and our health indicators changed over time. Thus, we assume that the strength of the relationship between experiencing parental death and health generally became weaker over time because even the most vulnerable members of society benefited from the improved living conditions and were, therefore, better able to compensate for the loss of a parent.

Data

In this article, we use the Historical Sample of the Netherlands (HSN) life courses and civil certificates releases (HSN 2010a, 2010b; see also van den Berg et al. 2021), which cover the 1850–1940 period. The HSN is based on a stratified 0.5% random sample of all Dutch birth certificates issued between 1850 and 1922. Stratification guarantees that the HSN sample is representative over time and space (Mandemakers and Kok 2020). As only one person per household is randomly selected, the sampled individuals are not clustered within households.

The life courses of study subjects were reconstructed with the help of the individuals' birth, marriage, and death certificates, as well as the population registers. Deaths of sampled individuals are almost completely covered in the HSN, and for those who were lost from observation (e.g., because they moved abroad), a date of last observation is available. The population register is a rich historical data source that provides information on changes in the composition of each household (through births, deaths, marriages, arrivals, and departures) together with the dates of these changes, as well as information on each household member's religion, occupation, and relationship to the household head (Mandemakers and Kok 2020). Accordingly, the population registers allow us to track all household members who shared a household with the study subject. This means that information on a parent's death is available for the period when the study subject was present in the parental household. In many cases, the date of a parent's death is available even after children had left the parental home because this information was noted on the same record within the digitized population registers. We focus on individuals who experienced parental death in infancy, childhood, or adolescence. At those ages, it was unlikely that study subjects were not residing in their parental home, and if they were not, the care and resources provided by the parents probably had a relatively minor influence on health and survival (Rosenbaum-Feldbrügge 2018). Thus, we expect that there are only a few overlooked cases in which the study subject experienced parental death before age 20, and these cases are not expected to affect our results. Our sample contains 18,845 fully reconstructed male and 17,866 fully reconstructed female life courses, which are used in the mortality analysis.

Recently, through archival research, the HSN life course release has been extended to include the conscription heights of 4,166 male subjects, who represent a subset of the sampled males who survived to age 20 (Heights and Life Courses release 2018.02;

HSN 2018). At conscription, heights were systematically measured in millimeters by military officers, and the yearly cohorts of conscripts were based on birth years, which limits the maximum age difference among yearly recruits to one year and reduces the possible variation in growth patterns. On average, the conscripts in our sample were 19.7 years old. By this age, many young adults in the nineteenth century would not have reached their final height (Beekink and Kok 2017; Thompson et al. 2020). However, this is not necessarily a disadvantage, as the heights of still-growing individuals are more likely to capture the impact of harmful early-life conditions (Schneider 2020). Even though not all of the heights of the study subjects can be found in the archives (in particular, the heights for boys born after 1900 are missing), and no height data are available for the provinces of Groningen, Gelderland, Zeeland, and parts of South-Holland, we find no evidence of systematic biases in other background characteristics, such as socioeconomic status (Quanjer and Kok 2020).

To reduce the influence of certain unobservable family characteristics, we conduct family fixed-effect analyses. A second height sample was collected within the HSN that contains information on the conscription heights of the brothers of the conscripted study subjects. As this brother sample includes the conscription heights of 1,898 younger and older brothers of sampled individuals, it allows us to conduct within-family comparisons with sibling fixed effects. Half- and stepbrothers—who might have grown up under very different circumstances and share less of their genetic material than full siblings—were excluded from the sample. It should be noted that the brother sample is based on the original HSN sample of individuals with a brother and is therefore biased toward larger households.

Methods

We study mortality and height separately. In the mortality analyses, we employ Cox proportional hazard models for the entire sample (ages 0–20) and for each age group (ages 0–1, 1–5, 5–12, and 12–20) for boys and girls separately.[1] In each model, the children who were alive at the start of the respective interval (at birth and at ages one, five, and 12) are defined as the population at risk and are correspondingly censored at ages one, five, 12, and 20 (or at the date of the last observation). Parental death occurring within the specific age interval is introduced as a time-varying variable, and parental death before a specific age interval is included as a dummy variable. To give an example, in the model studying mortality in the 5–12 age group, we introduce a dynamic variable indicating whether a parent died within the analyzed age range of 5–12. In addition, we add two dummy variables that indicate whether a mother or a father had died while the child was in infancy (ages 0–1) or in young childhood (ages 1–5). Data are analyzed in R using the package *eha* (Broström 2014).

In the height analysis, we apply linear regression models with male height in centimeters as the dependent variable. In the first model, we differentiate between the loss of a mother and the loss of a father, with nonbereaved children as the reference category. In the second model, we additionally differentiate the timing of parental death by the four

[1] Age groups do not overlap; they range up to but not including the end of the specific interval.

age groups discussed earlier. Moreover, we use the brother sample to run family fixed-effects models and to compare individuals who experienced parental death within a given age range with their brothers who experienced parental death within another age range. We do so to reduce the influence of unobservable time-invariant family factors. Applying sibling fixed-effects models is not meaningful in the mortality analysis, as the HSN does not provide complete mortality information about sampled individuals' siblings.

In both the mortality and height analyses, we run separate models in which we account for the entry of a stepfather and/or a stepmother into the family. Because the number of remarriages was rather small, especially among mothers with young children (Rosenbaum-Feldbrügge 2018), we do not differentiate by age groups in the stepparent analyses. We also do not control for the presence of other supporting family members, such as uncles and aunts, as the nuclear family was the common household form in the Netherlands over the study period (Kok et al. 2011). Although other kin living nearby might have provided support, this support would not have been captured by the HSN database, as only information on the household members was recorded. To analyze the relationship between experiencing parental death and our child health indicators over time, we run separate models for three birth cohort groups (1850–1879, 1880–1899, 1900–1922) (see Tables S2–S10 in the online supplement). The members of the first birth cohort were largely born before the start of the demographic transition, the members of the second cohort experienced initial declines in infant and child mortality, and the members of the last cohort grew up in a period characterized by sharp reductions in adult and child mortality.

We control for study subjects' birth order to capture possible sibling effects (Riswick 2018; Stradford et al. 2017). Information on the sampled individuals' place of birth is drawn from the birth certificates and grouped into four regions: North-West, South-West, East, and South. Information on the father's occupation is also drawn from the birth certificates and is standardized according to HISCLASS 5 (Mandemakers et al. 2018; van Leeuwen and Maas 2011). The father's occupation at the time of the child's birth is a more reliable indicator of the socioeconomic background of the household during the child's early life than the highest paternal occupation ever recorded (Rosenbaum-Feldbrügge 2019). Finally, in line with previous research (van Poppel et al. 2013), we control for the study subjects' birth cohort to capture the economic and health-related improvements over time, as described earlier (1850–1879, 1880–1899, 1900–1922).

Table 1 displays the summary statistics of the mortality and height samples. It indicates that there were no substantial differences between the boys and the girls in the mortality sample, with the exception that a slightly larger share of the boys died before reaching age 20. The mortality sample and the height sample do not differ considerably with regard to birth order or socioeconomic status at birth. Only limited height information is available for the southwestern provinces of Zeeland and South-Holland, as mentioned, and for the 1900–1922 birth cohort, as fewer conscription records are available in the archives after 1918. Finally, boys in the height sample were more likely than the boys in the mortality sample to experience the death of a parent. Many of the infants and young children in the mortality sample died before they could experience parental death. By contrast, the height sample consists of boys who survived to age 20 and therefore had a higher risk of experiencing parental death. Additional summary statistics differentiating the control variables for orphaned and nonorphaned boys can be found in Table S1 in the online supplement. Orphanhood

Table 1 Summary statistics

	Mortality Sample		Height Sample
Variable	Boys	Girls	Boys
Deceased Before Age 20 (%)	29.2 (5,510)	26.7 (4,772)	—
Stature at Draft (cm; SD)	—	—	168.8 (7.1)
Independent Variables			
Both parents alive (%)	81.5 (15,364)	81.2 (14,511)	73.0 (3,041)
Paternal death at <20 (%)	8.6 (1,628)	9.0 (1,607)	12.9 (537)
Maternal death at <20 (%)	8.2 (1,549)	8.2 (1,469)	11.7 (487)
Both parents died (%)	1.6 (304)	1.6 (279)	2.4 (101)
Age at maternal death (SD)	9.6 (6.0)	9.7 (6.0)	10.4 (5.8)
Age at paternal death (SD)	10.3 (5.8)	10.8 (5.8)	10.8 (5.7)
Control Variables (at birth)			
Birth order (SD)	3.4 (2.3)	3.5 (2.3)	3.3 (2.2)
Socioeconomic status (%)			
Unskilled workers	34.9 (6,584)	34.5 (6,170)	34.5 (1,437)
Elite	2.3 (426)	2.3 (413)	1.7 (70)
Middle class	14.8 (2,785)	14.5 (2,591)	14.2 (593)
Skilled workers	30.6 (5,767)	31.8 (5,679)	31.1 (1,295)
Farmers	13.4 (2,518)	12.9 (2,304)	15.6 (648)
None/unknown	4.1 (765)	4.0 (709)	3.0 (123)
Province (%)			
Friesland/Groningen/Noord Holland (NW)	30.7 (5,785)	30.6 (5,461)	47.8 (1,990)
Drenthe/Overijssel/Gelderland (E)	17.4 (3,288)	17.1 (3,053)	15.9 (664)
Utrecht/Zuid Holland/Zeeland (SW)	35.9 (6,767)	36.4 (6,512)	19.0 (793)
Noord-Brabant/Limburg (S)	15.9 (3,005)	15.9 (2,840)	17.2 (718)
Birth cohort			
1850–1879	32.4 (6,107)	32.1 (5,730)	44.2 (1,843)
1880–1899	36.3 (6,842)	36.8 (6,578)	39.7 (1,655)
1900–1922	32.3 (5,896)	31.1 (5,558)	16.0 (668)
Number of Observations	18,845	17,866	4,166

Notes: Numbers in parentheses refer to the total number of individuals in the specific group, except for variables that include a standard deviation. Summary statistics of control variables for both samples are generated at birth. Stature is known and linked for a subset of the study subjects who survived to age 20. The 4,166 height observations are a representative sample of the survivors of the 18,845 male births (see Data subsection).

Sources: HSN (2010a, 2010b, 2018).

was more common among the boys born at the beginning of the study period (when adult mortality was higher) and among the boys born later than most of their siblings (and thus to older parents). Otherwise, however, there were no substantial differences in height or in mortality between orphaned and nonorphaned boys in the sample.

Results

Parental Death and Mortality Between Birth and Age 20

To gain a better understanding of the importance of timing in the association between experiencing parental death and early-life mortality, Figure 3 plots Kaplan–Meier

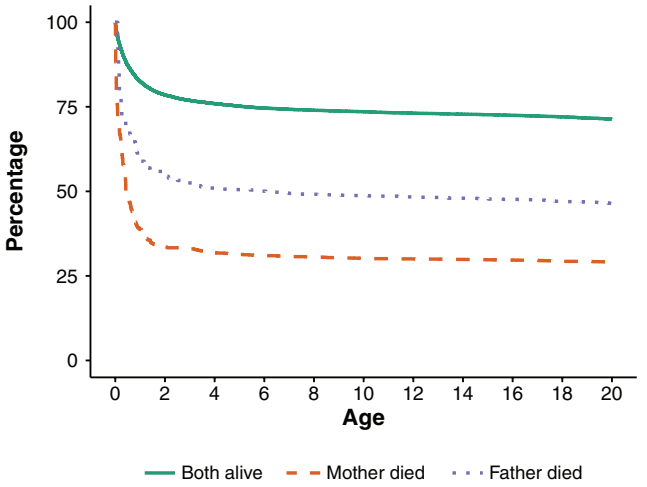

Fig. 3 Kaplan–Meier survival curve of boys' survival after parental loss at various ages. *N*=17,866. *Sources:* HSN (2010a, 2010b).

survival curves for boys by parental survival and death. The children with two surviving parents were most likely to survive to age 20. Experiencing maternal death was strongly associated with high mortality among infants and young children, but experiencing paternal death was also associated with elevated mortality in the first two years of life. From around age two onward, the survival curves run more or less parallel to each other, which indicates that differences in survival by parental death were less pronounced at higher ages, most likely because of a reduction in mortality later in childhood.

The results of the survival analyses with mortality as a dependent variable are displayed for the male sample in panel A of Table 2 and for the female sample in panel B. Model 1 presents the uncontrolled overall mortality risk between birth and age 20 by parental death, and shows that losing either a mother or a father before age 20 was related to an increased mortality risk. In Model 2, we add the covariates described above and obtain very similar results. Even though experiencing maternal death was associated with a higher point estimate than experiencing paternal death in both models, the differences between losing a mother and losing a father were not statistically significant (results not shown).

In Models 3–6, which control for the covariates, we show the results for the four age groups. Model 3 presents the results for infants aged 0–1 and shows that experiencing either maternal or paternal death was strongly related to an increased mortality risk relative to that among nonorphaned infants. In Model 4, we analyze the mortality hazards for young boys aged 1–5 and find that experiencing either maternal or paternal death in this phase of life was associated with significantly higher mortality risks, but also that the effects were weaker than in infancy and that the difference between losing a mother or a father was not statistically significant. However, experiencing parental death in infancy was not associated with increased mortality among boys aged 1–5. Between ages 5 and 12 (Model 5), experiencing maternal death was no longer associated with increased mortality risk. At the same time, experiencing paternal

Table 2 Effect of parental death in period of childhood on boys' and girls' likelihood of death, Cox proportional hazard survival analysis

	Model 1: Ages 0 to 20			Model 2: Ages 0 to 20, Controlled			Model 3: Ages 0 to 1			Model 4: Ages 1 to 5			Model 5: Ages 5 to 12			Model 6: Ages 12 to 20		
	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*
A. Boys																		
Parental Death																		
No death age 0–20	ref.																	
Father dies age 0–20	1.82	1.51–2.19	.000	1.66	1.38–1.99	.000												
Mother dies age 0–20	2.08	1.76–2.48	.000	1.95	1.65–2.30	.000												
No death between 0–1							ref.			ref.			ref.			ref.		
Father dies 0–1							2.67	1.63–4.37	.000	1.07	0.53–2.15	.842	0.50	0.07–3.57	.491	1.76	0.56–5.51	.332
Mother dies 0–1							4.59	3.47–6.07	.000	1.57	0.87–2.84	.137	0.00	—	.967	0.53	0.07–3.80	.530
No death between 1–5							—			ref.			ref.			ref.		
Father dies 1–5							—			1.59	1.02–2.48	.041	1.29	0.75–2.19	.359	0.84	0.42–1.70	.635
Mother dies 1–5							—			1.93	1.26–2.96	.002	1.57	0.96–2.55	.071	0.86	0.43–1.76	.682
No death between 5–12							—			—			ref.			ref.		
Father dies 5–12							—			—			1.81	1.05–3.10	.032	1.73	1.18–2.52	.005
Mother dies 5–12							—			—			1.25	0.66–2.36	.484	1.17	0.75–1.82	.489
No death between 12–20																ref.		
Father dies 12–20																1.36	0.87–2.38	.212
Mother dies 12–20																1.44	0.84–2.20	.161
Number of Events	5,510			5,510			3,335			1,410			409			356		
Number of Observations	18,845			18,845			18,845			15,510			14,100			13,691		

Table 2 (continued)

	Model 1: Ages 0 to 20			Model 2: Ages 0 to 20, Controlled			Model 3: Ages 0 to 1			Model 4: Ages 1 to 5			Model 5: Ages 5 to 12			Model 6: Ages 12 to 20		
	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*
B. Girls																		
Parental Death																		
No death age 0–20	ref.																	
Father dies age 0–20	1.83	1.53–2.20	.000	1.68	1.40–2.02	1.68												
Mother dies age 0–20	2.27	1.93–2.66	.000	2.15	1.83–2.52	2.15												
No death between 0–1							ref.			ref.			ref.			ref.		
Father dies 0–1							1.99	0.99–3.98	.053	2.09	1.28–3.43	.003	0.97	0.24–3.89	.962	1.88	0.60–5.89	.277
Mother dies 0–1							4.89	3.64–6.57	.000	1.72	0.92–3.20	.089	0.55	0.08–3.92	.552	1.30	0.32–5.24	.709
No death between 1–5							—			ref.			ref.			ref.		
Father dies 1–5							—			1.19	0.67–2.10	.552	1.47	0.86–2.51	.157	1.47	0.80–2.68	.216
Mother dies 1–5							—			2.68	1.82–3.94	.000	2.17	1.40–3.38	.001	0.73	0.32–1.64	.444
No death between 5–12							—			—			ref.			ref.		
Father dies 5–12							—			—			1.78	1.08–3.17	.025	1.65	1.11–2.46	.013
Mother dies 5–12							—			—			1.85	1.03–3.05	.037	1.50	0.99–2.28	.055
No death between 12–20																ref.		
Father dies 12–20																1.87	1.19–2.92	.006
Mother dies 12–20																1.72	1.03–2.85	.037
Number of Events	4,772			4,772			2,657			1,347			412			356		
Number of Observations	17,866			17,866			17,866			15,209			13,862			13,450		

Notes: Father or mother deaths within age group under analysis are shaded; lagged effects are shown above the diagonal (e.g., effect of parental death between ages 0–1 on mortality between ages 1–5). Effects are hazard rates from proportional hazard Cox models. Models 2–6 control for the effects of birth order, socioeconomic status, region, period, and death of the other parent, as well as death of the parent in an earlier period (see Table 1). HR=hazard ratio.

death was significantly related to increased mortality. In this age group, having lost a mother before age five remained a contributing factor in male mortality, albeit only marginally significantly ($p = .071$). However, having experienced maternal or paternal death while in infancy was not associated with higher mortality at ages 5–12, which may be related to the low number of deaths among this age group. Finally, we find no evidence for a further effect of experiencing parental death on survival at ages 12–20 (Model 6), except among boys whose father died in the preceding period (at ages 5–12). Again, the total number of deaths in this period appears to be rather small.

The results for female mortality displayed in panel B of Table 2 indicate that the effect of experiencing parental death on mortality risk in infancy (ages 0–1) and young childhood (ages 1–5) was similar for boys and girls, with the exception that experiencing paternal death during young childhood was not associated with increased mortality risk among girls. Among girls in older childhood (ages 5–12) and adolescence (ages 12–20), both losing a mother and losing a father were associated with a higher mortality risk. This finding might indicate that the reductions in resources or care were not equally distributed among male and female offspring, as girls often had to perform more household and care work than boys after the death of a parent.

We conducted a number of robustness checks. The regression results did not change substantially after controlling for total sibship size instead of birth order, or for birth year instead of birth cohort. In our models, we also added interactions between experiencing parental death and socioeconomic status, but found no consistent evidence for interaction effects. Furthermore, we found that among boys, the relationship between losing a father and mortality was especially strong for the oldest boy in a family and weaker for his younger brothers. By contrast, we observed no relationship between losing a mother and the older boy's mortality specifically (see Table S8 in the online supplement). Finally, we excluded from the analyses child deaths that occurred within 14 days of the death of a parent, and the results remained largely similar, suggesting that it is unlikely that these deaths were driven by shared causes of death, such as mutual infections.

To address changes over time, we run separate models for the three birth cohorts described above (1850–1879, 1880–1899, 1900–1922); these models can be found in the online supplement. Losing a parent was found to be associated with a higher infant mortality risk throughout the entire research period (except for experiencing paternal death among boys born between 1900 and 1922 and among girls born between 1850 and 1879), and losing a mother was shown to be particularly harmful for infant boys and girls from the first birth cohort (1850–1879) onward. However, for the remaining age groups (1–5, 5–12, 12–20), the association between losing a parent and mortality weakened as expected toward the end of the research period and was no longer significant for children born in the 1900–1922 period.

Parental Death and Boys' Young Adult Height

Figure 4 presents the results of the ordinary least-squares regressions, with young adult height as the dependent variable and maternal or paternal death as the main independent variable. The models produced an adjusted R^2 of just over .1, which is similar to the values found in other studies using height on an individual level (e.g.,

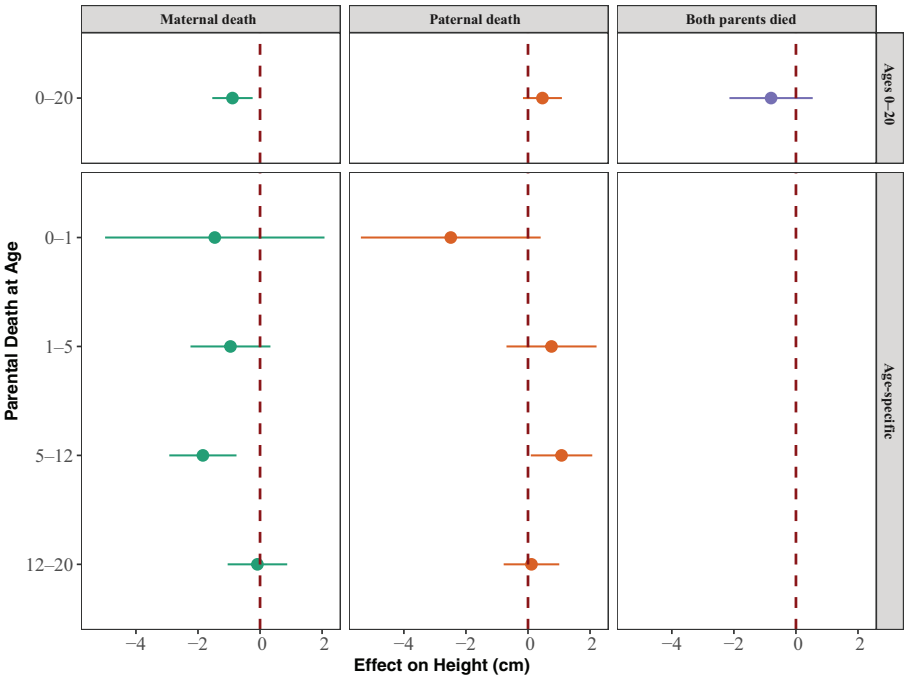

Fig. 4 Effect of the timing of parental death on boys' stature in centimeters (with 95% confidence intervals). The estimates are based on a linear regression model that controlled for socioeconomic status, birth region, birth cohort, and birth order. N=4,166; reference group with both parents alive, N=3,041; both parents died, N=101; paternal death for ages 0–1 (21), 1–5 (87), 5–12 (192), and 12–20 (237); and maternal death for ages 0–1 (14), 1–5 (113), 5–12 (158), and 12–20 (202).

special issue on height and articles therein; Öberg 2017). The reference group is made up of boys who did not experience parental death before their height was registered at conscription. In the first regression, displayed in the upper panel of Figure 4, we differentiate between maternal death, paternal death, and full orphanhood. Although experiencing maternal death before age 20 was significantly associated with a lower stature of almost one centimeter, experiencing paternal death or full orphanhood was not significantly related to young adult height.

The second panel of Figure 4 shows the relationship between the timing of parental death and height by introducing parental death in the previously discussed age groups. As very few of the boys experienced full orphanhood before conscription, we do not further differentiate this group by their exact age at the death of the parent. While experiencing maternal death in older childhood (ages 5–12) was associated with lower young adult height (−1.8 cm), remarkably, experiencing paternal death in the same age range was significantly associated with taller stature (1.1 cm). In the other age groups, there was no significant association between experiencing parental death and stature. Thus, our results suggest that the main effect of experiencing parental death on height was concentrated between ages five and 12.

Regarding changes between cohorts in the relationship between experiencing parental loss and stature, we do not observe a consistent weakening of the relationship

Table 3 Within-family comparison (family fixed effects) of parental death at the given age interval versus no parental death between the given age interval, in centimeters

	Death Between Ages 0–1	Death Between Ages 1–5	Death Between Ages 5–12	Death Between Ages 12–20
Parental Death				
No death in age interval	ref.	ref.	ref.	ref.
Paternal death	−1.12	−0.06	0.68	−0.47
Maternal death	−2.08	1.21	−1.91*	1.07
Intercept	166.4	166.0	165.8	165.5
Adjusted R^2	.733	.475	.481	.535
Number of Observations	27	163	319	371
Number of Families	11	64	125	147

Note: All models are controlled for a time trend (secular trend in heights).

*$p < .05$

between the three birth cohorts (see Table S9 in the online supplement). However, the overall importance of maternal death for stature weakens with time. The specific timing of maternal death that is important for stature varies slightly across cohorts, but the most consistent finding across time is that maternal death at age 5–12 is negatively related to stature.

The results are not sensitive to replacing birth order by sibship size (so that children born after the observed individual are accounted for) or a dummy variable for the eldest son (to address possible preferential treatment). Therefore, we do not find consistent evidence that losing a parent affected later-born children, children with more siblings, or eldest sons differently. Moreover, we find no consistent and substantial evidence for interactions between socioeconomic status and parental death.

To reduce the influence of unobservable, time-invariant family factors, the analyses reported in Table 3 use the brother sample to estimate the corresponding family fixed-effects models. The number of observations per model was inherently low because conducting the analysis required both an individual who experienced parental death within the given interval and a brother who experienced the death outside the given interval and survived until age 20. As a result, most of the estimates were insignificant. However, experiencing maternal death between ages five and 12 was associated with a height reduction of 1.9 centimeters relative to the height of brothers who were older or younger at the mother's death. This result supports the earlier finding that experiencing maternal death between ages five and 12 was related to significantly lower height outcomes. However, the previous result indicating that experiencing paternal death between ages five and 12 was significantly associated with a height advantage is not supported in the family fixed-effects model. Although the point estimate was in the same direction, the effect was not estimated very precisely.

The Role of Stepparent Entry

We additionally investigate how the entry of a stepparent into a family moderated the effect of losing a parent on a child's health outcomes. In the Netherlands, each couple traditionally formed an independent household upon marriage. Thus, in the study period, most children were born into a nuclear household in which only the child's parents and siblings were present (Kok et al. 2011). After experiencing the death of a parent, a half-orphaned child with several brothers and sisters may have faced competition over scarce remaining resources, but may also have benefited from higher levels of mutual support (Öberg 2017; Quanjer and Kok 2019). Similarly, the entry of a stepparent into the family may have had conflicting consequences for the child's health and survival. On the one hand, the presence of a stepparent may have reduced the harmful impact of losing a parent by providing additional family income or parental care (Rosenbaum-Feldbrügge 2019). On the other hand, the arrival of a stepparent may have resulted in escalating conflicts within the family or endangered the most vulnerable members of the newly formed household (Willführ and Gagnon 2013). In general, widowed fathers were much more likely to remarry than widowed mothers, which may be seen as a paternal strategy to ensure the provision of care and housework (Rosenbaum-Feldbrügge 2018). By contrast, widowed mothers—particularly those with young children—were typically eligible to receive benefits from municipal, church, and private poor relief organizations (Schmidt 2007; van Leeuwen 1998).

Table 4 shows the results of the stepparent models of both the mortality and the height analysis for males. The mortality model indicates that the association between experiencing parental death and child mortality was weaker among boys who experienced the entry of a stepparent into the family. Boys with a widowed father who remarried experienced a lower mortality hazard (2.14) than boys with a father who did not (2.71). The same pattern is observed for boys with a mother who remarried (0.68) relative to boys with a mother who did not (1.57). These differences were significant (result not shown). In addition, for boys with a mother who remarried, we do not find a significantly increased mortality risk relative to that of boys whose parents both survived until they reached age 20.

Regarding stature, experiencing parental death was significantly associated only with shorter height for boys with a father who remarried after their mother died; these boys were, on average, 1.3 cm shorter than nonorphaned boys. Among boys with a father who did not remarry, the reduction in height was 0.6 cm, which was insignificant compared with the height of boys who did not lose their mother. These findings might indicate that the entry of a stepmother into the family increased the survival chances of particularly vulnerable boys, who nevertheless did not succeed in catching up in terms of height and health during childhood and adolescence. However, caution is advised when interpreting this result. As the height analysis includes only boys who survived until age 20, the entry of a stepmother into the family was strongly correlated with the boys' number of siblings and age at the death of the parent. However, we cannot discard the possibility that stepmothers might have favored their own children at the cost of their stepsons when it came to the health of the surviving children.

Table 4 Survival of boys ages 0–20 and conscription height, by parental death and remarriage

	Mortality Analysis			Height Analysis		
	HR	95% CI	*p*	Coef.	95% CI	*p*
Both Parents Alive (ref.)	1.000			—		
Mother died, no remarriage	2.71	2.19 to 3.35	.00	−0.62	−1.45 to 0.21	.15
Mother died, father remarried	2.14	1.75 to 2.60	.00	−1.26	−2.22 to −0.30	.01
Father died, no remarriage	1.57	1.20 to 2.05	.00	0.55	−0.12 to 1.22	.11
Father died, mother remarried	0.68	0.36 to 1.27	.22	0.05	−1.51 to 1.52	.24
Number of Events	5,499			—		
Number of Observations	18,541			4,166		

Notes: In the mortality analysis model, full orphans are excluded and the effects are hazard rates from the proportional hazard Cox models. The effect of the death of the parent is measured dynamically, and the survival follow-up is divided between children with a surviving parent who remarried within three years of the death and children with a surviving parent who remained unmarried three years after the death. In the height analysis, full orphans are included as a separate group, but they are only compared with the reference category, and thus do not affect the other outcomes. Effects are based on OLS regression models with the effect in centimeters. Mortality and height models control for birth order, socioeconomic status, region of residence, and birth cohort.

Discussion and Conclusion

In this work, we used the Historical Sample of the Netherlands to analyze how experiencing parental death in infancy, childhood, or adolescence was associated with both mortality before age 20 and young adult height. Our main results indicate that experiencing paternal—and particularly maternal—death in infancy or young childhood was strongly associated with increased mortality risk, but not with young adult height. These results suggest that the adverse conditions children experienced after losing a parent in early life were reflected in childhood mortality, but not in young adult stature. These findings point to a distinct shortcoming of height analyses among populations with high levels of infant and child mortality: that is, stature is known only for those individuals who ultimately survived until the moment of measurement. As a result, mortality selection limits the sample size for certain subgroups, which results in lower statistical power and may even lead to a positively selected subgroup of individuals who survived until adulthood. Mortality selection might also explain why other researchers did not find a negative effect on adult height of subsistence crises during infancy and early childhood (Depauw and Oxley 2019). Accordingly, to obtain more reliable insights into the overall effects of early-life adversity, young adult height in high mortality regimes should be studied, if possible, in unison with other health outcomes, such as infant and child mortality.

For children in historical populations, the death of a parent was related to an elevated poverty risk and to a decline in the resources and care typically provided by

parents. Therefore, we hypothesized that the main effect on children of experiencing a father's death would be increased resource deprivation, whereas the main effect of experiencing a mother's death would be a reduction in caregiving (Dribe et al. 2007; Rosenbaum-Feldbrügge 2020; van Poppel 1995). In terms of survival, our results show that the children in our sample were most vulnerable to the effects of losing a parent in infancy and early childhood, a period of life in which they were highly dependent on the provision of care. In particular, the abrupt ending of breastfeeding in infancy has been shown to have devastating consequences for child health in historical populations (Reher and González-Quiñones 2003). Thus, experiencing maternal death in infancy was associated with higher mortality risks than experiencing paternal death. However, as the children aged, the mortality risk associated with experiencing maternal death decreased and ultimately became insignificant for boys aged 5–12 and 12–20. These findings demonstrate that the children were less dependent on maternal care for their survival after age five. At this stage, stepmothers—who have been shown to be positively associated with child survival—may sometimes have been able to step in as the main caregiver. Earlier research has shown that other female kin, such as aunts and grandmothers, could also serve as substitute caregivers (Sear and Mace 2008). However, among girls aged 5–12 and 12–20, maternal death was still associated with an increased mortality risk, which might be attributed to a combination of these girls having lower nutritional intake and a larger workload because they were expected to take on care responsibilities at home after their mother's death. Other studies have shown that in rural areas (Devos 2000) and among unskilled workers (van Poppel et al. 2009), there was excess mortality among adolescent girls; however, no specific effect on girls' childhood (ages 0–5) mortality was found for families that experienced high levels of mortality (van Dijk 2019).

Earlier research has indicated that experiencing high food prices during adolescence was associated with shorter stature in adulthood (Depauw and Oxley 2019). Our results, in contrast, demonstrate that experiencing parental death in adolescence was not associated with young adult stature and that experiencing maternal death at younger ages (ages 5–12) was most detrimental for young adult height. This finding was supported by the sibling fixed-effects models. Experiencing high food prices and parental death may have affected health outcomes differently for different age groups. In the past, food prices were very volatile and a sharp increase could have a detrimental short-term impact on children's nutritional status and health (Depauw and Oxley 2019). By contrast, losing a parent most likely initiated a long-lasting period of misery and deprivation for children, particularly for those younger than 12 (Horrell et al. 1998; Oris and Ochiai 2002). However, half-orphaned adolescent children older than 12 were less dependent on household resources and may have had—in the absence of a serious subsistence crisis—sufficient access to social support and the labor market to enable them to cope with the death of a parent.

To conclude our interpretation of the results, the findings for the effects of experiencing paternal death on the 5–12 age group appear to be inconsistent. While the boys and girls in this age group who lost their father had significantly higher mortality hazards than nonorphaned children, the boys also had higher stature. It is possible that there were two different mechanisms at play in these findings that partially offset each other. On the one hand, compared with their nonorphaned counterparts, children who experienced their father's death may have tended to have worse housing

conditions, lower nutritional intake, and a larger workload through an earlier entry into the labor force or increased care responsibilities at home (Horrell et al. 1998), which may have negatively affected their health. On the other hand, it is possible that after their father died, sons were given a more important role in the family that coincided with a larger share at the dinner table. In line with this argumentation, Horrell and Oxley (2013) have shown that in the absence of a breadwinner exercising a major claim on resources, resource distribution among siblings was more even, which resulted in better overall health for all of the children in the family. Nevertheless, our finding of a positive association between experiencing paternal death and young adult height should particularly be interpreted with caution, as this relationship was not supported by the sibling fixed-effects models.

We would like to point to three major limitations of our study. First, in the height analysis, we only studied men, as height information on women is not available in the Dutch historical sources. Boys and girls might have been affected by parental death differently in terms of, for example, the changes in their household tasks (taking care of the sick, manual labor) and the timing of their labor market entry. These potential differences, in addition to the gender differences found in the mortality analysis, prevent us from generalizing our height findings to girls. Second, the number of observations in the height sample declined from the birth cohort 1894 onward, as not all archives kept their post–World War I records. Although the geographic and socioeconomic status distribution of our data was not affected, we were unable to study height into the middle of the twentieth century, as by that time losing a parent may have no longer affected the health of (half) orphans. Third, a correlated disease environment may lead to higher rates of both paternal and child mortality. At the same time, in high-mortality populations, such as that of the Netherlands in the second half of the nineteenth century, the effect on height of postneonatal mortality—which is a strong proxy for the disease environment—has been shown to be very limited (Akachi and Canning 2010; Bozzoli et al. 2009; Öberg 2015). We added the municipal crude death rate to our height models as a proxy for the external disease environment and it did not alter the main estimates of the impact of parental death. In addition, in a sensitivity analysis, we excluded child deaths occurring within two weeks of the parental death (20 cases) and obtained very similar—albeit slightly attenuated—results. Therefore, we are confident that the results are not driven by the shared disease environment.

To conclude, in this study, we have shown that analyses of mortality and height in historical demography allow researchers to overcome the distinct biases and shortcomings associated with studying these health indicators separately. Whereas the study of mortality covers many aspects of child health in the first five years of life, it is less suitable for studying health effects among older children and adolescents. While the study of young adult height suffers from high mortality selection in the first years of life, it is better able than the mortality analysis to identify health effects beyond age five. The claim that analyses of mortality and height complement each other very well was demonstrated particularly with regard to the impact on child health of experiencing maternal death. Although we found that children's mortality hazards were high immediately after their mother died, we also observed that as their care needs declined with age, their mortality hazards decreased and became insignificant. Nevertheless, in contrast to the mortality analysis, the height analysis showed that the health of boys experiencing maternal death between ages five and 12 was

also negatively affected, as indicated by their shorter stature in young adulthood. Therefore, it appears that studying both mortality and height adds to our understanding of how external circumstances affect child health. These insights are also relevant for studying child health in today's low- and middle-income countries. As mortality rates among infants and children continue to decline in these countries, trends in stature may have become a better indicator of the overall changes in the health of birth cohorts (Akachi and Canning 2010). ■

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