Manuscript title: Inequality in Child Mortality Persists Between Generations in the Netherlands, 1835-1919

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Abstract: In historical the Netherlands, child mortality was distributed unequally between families and this inequality persisted across generations. Using family reconstitution data for the province of Zeeland (LINKS) containing over 200.000 children born 1835-1914, I show that mortality was higher among children under age 5 whose parents lost siblings before age 5. This intergenerational persistence of child mortality existed independently from socioeconomic differences in child mortality. Inequalities accumulated, as child mortality was highest for low-SES children whose parents originated from high-mortality, low-socioeconomic status families. Intergenerational transmission in child mortality persisted even when child mortality had declined in the early 20th century.

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Data and replication files:
Data available here: https://hdl.handle.net/10622/QUJNCD
Code and replication files available upon request

1. Introduction

Child mortality is commonly considered a key indicator of well-being and the population living standard and its level is used for comparative purposes of inequality in the living standard in the world (Sen 1998). Young children are highly dependent on their families to survive, and child mortality and characteristics that contribute to the risk of early death concentrate in families (van Dijk 2019b). Inequalities between families in their likelihood of child loss capture broad inequality in sociodemographic, behavioral and spatial characteristics that shape living conditions and affect the likelihood of child death. Moreover, intergenerational persistence of high child mortality shows how some families face such unfavorable conditions over more than one generation. By examining the magnitude of intergenerational persistence of child mortality, the accumulation of risk factors for early-life mortality in a specific group of families can be addressed.

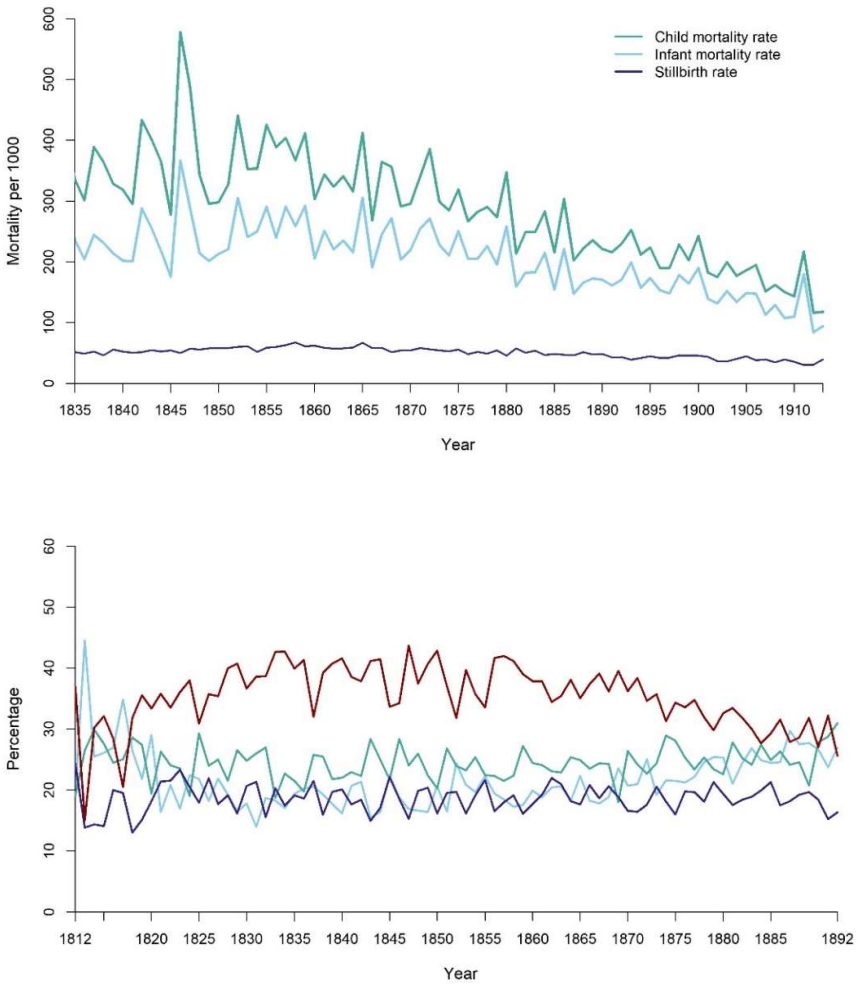
The time-trend in intergenerational persistence of child mortality is of particular interest to understand the long-term development of inequality in living standards in the population. Inequalities in child mortality may have changed during the demographic transition, when child mortality declined. Improvements in child survival may particularly have benefited the most disadvantaged families. On the other hand, when child deaths declined, child deaths could have increasingly been concentrated in a small set of deprived families. In this paper, I address long-term trends in intergenerational persistence of child mortality in the Netherlands between 1835-1919. In this period, levels of child mortality fell from around 365 to 117 deaths per 1000 live-born infants (see Figure 1). Changes in the degree of intergenerational persistence in child mortality throws light on a crucial indicator of the population's living standard, the capacity of families to keep their children alive and inequality therein over time.

Across generations, parents and children face similar challenges in taking care of their families and helping their children survive. Poverty and low socioeconomic status, behavioral patterns including breastfeeding and weaning of children, and other social factors are often similar between parents and children. Intergenerational persistence of such characteristics could therefore make an important contribution to increased child mortality in more than one generation. For contemporary (Hajizadeh, Nandi, and Heymann 2014) and historical populations (Antonovsky and Bernstein 1967; Dribe and Karlsson 2022; Van Poppel, Jonker, and Mandemakers 2005), it is well established that child mortality is higher among lower social class groups. At the same time, previous research has shown that intergenerational persistence of infant mortality exists even after taking into account social class of mothers and grandmothers (van Dijk and Mandemakers 2018). Other social, behavioral, spatial, and biological factors that are shared between generations through processes of social reproduction, socialization, shared living conditions (Preston, Hill, and Drevenstedt 1998) and genetic inheritance (Vandezande and Matthijs 2013; van Dijk 2019a) likely also contribute to these inequalities.

Earlier studies have documented the intergenerational transmission of child and infant mortality from mother to daughter. Two studies using sibling and offspring surveys established a strong intergenerational persistence in child mortality in developing countries 2004-2017 (Lu and Vogl 2023) and 1970-2000 (Bhalotra and Rawlings 2011). For historical populations, Quaranta and Sommerseth (Quaranta and Sommerseth 2018) show that intergenerational transmission of infant mortality from mother to daughter is found in a number of historical populations in Western Europe, including Zeeland (van Dijk and Mandemakers 2018). There has been surprisingly little attention for intergenerational persistence of child mortality from fathers to their surviving sons. In contrast, for the intergenerational persistence of social status, an overwhelming majority of work focuses on persistence from fathers to sons. Intergenerational transmission of child mortality, a broader indicator of early-life mortality than infant mortality, has not been studied for historical Europe, and finally, interactions with socioeconomic factors have been neglected.

This paper has two main aims. First, I show the extent to which social class inequalities existed between families in young-age child mortality in historical the Netherlands over this period. Second, I show the intergenerational persistence of inequalities in child mortality across time. Did grandparents and parents have similar patterns of child loss in times of declining child mortality when child deaths became less common? I show that child mortality was distributed unequally between families and that this inequality persisted across generations. Parents, both fathers and mothers, with elevated sibling child mortality had increased risk of deaths among their own young children. Intergenerationally high risk of child death exists next to a social class gradient in mortality but cannot be explained by it. Both in high and low social class families, intergenerational similarities in high child mortality existed. Among parents that grew up in high mortality, low-SES families with low adulthood SES had the highest under-five mortality among their children, so that inequalities in child mortality accumulate in families. Further, intergenerational transmission is found even for a period when child mortality had declined strongly. Inequalities in child mortality persist across generations in families, over and above the social gradient in mortality.

Figure 1. Infant and child mortality and stillbirth rates 1835-1913 (top panel) and frequency of sibling deaths over time (bottom panel)



Panel A: Yearly child and infant mortality rate and the stillbirth rate in the province of Zeeland, the Netherlands, 1835-1913. Panel B: Number of mother's sibling deaths in childhood, by mother's birth year, 1812-1892. Source: Author calculations, LINKS Zeeland (R. J. Mourits et al. 2022)

2. Intergenerational inequalities in child mortality: Earlier literature

Studying inequality in mortality is fundamental to understanding overall inequality in the population's living standard (van Raalte, Sasson, and Martikainen 2018). Inequality in the distribution of child mortality has been studied largely in relation to measurable social factors of specific individuals, such as family socioeconomic status, maternal age and child sex. In another approach, maternal bereavement has been studied using indicators of child mortality levels and survey data (Smith-Greenaway et al. 2021). In this paper I use a third approach and study the extent to which inequality in child mortality persists between generations. Strong intergenerational persistence of child mortality flags low equality of opportunity and high inequality in the distribution of the length of life, already at the start of life. The degree to which the risk of death before age 5 is related to the experience of the previous generation shows the concentration of child mortality in a specific subset of families and the extent to which mothers and fathers have a similar experience as their own parents regarding child loss. Reversely, if mothers and fathers are more successful in keeping their infants and children alive than their own parents this illustrates progress, at least in that family. Intergenerational persistence in child mortality thus captures the overall inequality between families in their possibilities to keep young children alive, and flags crucial inequality between children already at the start of life.

Socioeconomic factors could be an important reason that parents and children are similar in their likelihood of experiencing death among their infants and young children. Socioeconomic status has been argued to be a fundamental cause of mortality, as regardless of place, time and the dominant disease environment, resources could contribute to disease prevention, treatment, and in handling the consequences of exposure to health risks (Link and Phelan 1995). Depending on the period and the disease environment, socioeconomic inequalities in child mortality could emerge through a range of characteristics in which social classes differ and that directly affect mortality (Dribe and Karlsson 2022). The large literature on infant and child mortality shows the importance of nutrition, sanitation, immunization, breastfeeding and care taking practices for child survival and improvements therein in the 19th and 20th century.

Mosley and Chen (1984) provide a framework regarding socioeconomic status and proximate determinants of child mortality. They argue that socioeconomic factors indirectly contribute to child mortality through a set of proximate determinants that consist of maternal factors, nutrition, health care, injuries and environmental contamination. Socioeconomic factors can put children at an increased risk of exposure to disease pathogens, weaken children's health through insufficient nutrition or care, access to health care after injury or disease, and increasing risk of death due to external factors (Mosley and Chen 1984). Overall, such factors could increase risk of child death for a subset of mothers (Das Gupta 1990). Socioeconomic status may affect these proximate determinants through mechanisms relating to economic resources, cultural factors and the place of residence. More resources may improve quality of nutrition, reduce crowding in the home and improve access to health care, and reduce harmful exposures to pathogens in the environment, with better hygiene and access to clean water.

While this framework usefully links socioeconomic factors to more direct determinants of mortality, broader social inequalities than inequalities based on social class of the household alone also contributed to the survival chances of young children in the past. As a result, SES of families may only capture part of the social stratification in child mortality (van Dijk 2019b). Moreover, the extent to which these mechanisms affecting child mortality were linked to SES of families could have changed over time, so that socioeconomic status could be a poor indicator of the risk of child mortality in some periods. Earlier research has shown that infant and child mortality were relatively equally distributed between the social classes in 19th century Sweden, before the demographic transition, but that inequalities grew over time (Dribe and Karlsson 2022). Similarly, in 19th century the Netherlands the social gradient in child

survival was small in comparison to regional differences in child mortality (Van Poppel, Jonker, and Mandemakers 2005), even if children of unskilled workers had a higher likelihood of death before the fifth birthday. A social disadvantage in child mortality for the underprivileged persisted into the 20th century. For Amsterdam, such differences were related to sociodemographic characteristics, residential environment, water supply, and religious groups. Housing and neighborhood characteristics were especially related to mortality in late infancy (Ekamper and van Poppel 2019). Moreover, the absence of a social welfare system and the generally lower standard of living implied that parental death often had catastrophic consequences for the survival chances of young children (Quanjer, van Dijk, and Rosenbaum-Feldbrügge 2023).

Taken together, these findings imply that although socioeconomic status mattered for child survival, a range of other social factors also could have been important, and part of these mechanisms can affect individuals across generations. Surviving children may have faced similar challenges as their parents in keeping their children alive, in relation to shared living conditions or behavioral features. Detrimental events in the family, for example, illegitimacy of the birth of a child in Sweden at a time that this was not socially acceptable (Modin, Koupil, and Vågerö 2009) has previously been shown to be associated with intergenerational persistence of mortality and ill health. Learned behavior (Vandezande and Matthijs 2013) including feeding, weaning and nursing children may have affected the likelihood of infection with disease, especially during the summer months (Walhout 2010), which could have affected mortality across generations (Vandezande and Matthijs 2013).

It should be noted that intergenerational persistence of child mortality is an indicator of the *overall level* of inequality between families in their abilities to keep their young children alive, regardless of whether they are related to socioeconomic, spatial, or behavioral factors. Measuring intergenerational persistence of child deaths is therefore a distinct approach from earlier studies on social inequalities in child mortality in that it does not necessarily set out to study a specific factor that contributes to child mortality but addresses the extent to which mortality concentrates in a specific subset of the population. This makes it possible to look at developments in the overall level of inequality in child mortality between families, even if the mechanisms that contribute to these inequalities change over time. Analytically, there are parallels to studying the intergenerational persistence of social status or poverty. Like intergenerational persistence in socioeconomic status, similarities between grandparents and parents in offspring loss capture mobility or lack thereof from one generation to the next. Importantly, intergenerational persistence in child mortality also captures the extent to which the second generation manages to escape the disadvantage of the first generation in survival of young children.

Over time, child mortality rates fell sharply. Knowledge about the origins of disease became common, treatment options more widespread, improvements in public infrastructure benefited the whole population, and the nutritional standard of the population improved. Social differences in mortality can especially be expected once the origins of disease are known and resources can be used to guard oneself against disease (Clouston et al. 2016), although social differences in mortality can also relate to the living standard itself (nutrition, housing and the ability to care for sick relatives). With improvements in knowledge and how well diseases could be treated, it is possible that the intergenerational similarities in mortality declined. Improved routines in taking care of infants and children and knowledge about hygiene may have resulted in smaller inequalities in how well children were cared for. Improvements in the living standard and increases in social mobility over time may have benefited especially the most vulnerable families. A previous study on intergenerational persistence of health has shown that maternal indicators of poor health in childhood and adulthood both contribute to increased mortality and stunting among their children, and that inequalities in Africa grew between 1970 and 2000 (Bhalotra and

Rawlings 2011). Moreover, intergenerational persistence of mortality in low- and middle income countries 2004-2017 fell with aggregate child mortality (Lu and Vogl 2023).

In this paper, I study both the socioeconomic gradient in child mortality and intergenerational persistence of high child mortality. I contrast estimates of the role of SES in child survival with estimates of the intergenerational persistence in child mortality, to show what part of the persistence of mortality can be explained by intergenerational deprivation. This is only one social factor of many possible sources of variation in child mortality, but it is an important one, and widely studied in almost all literature on inequality in child mortality. The paper contributes to the existing literature on social inequalities in child mortality by addressing how, in a period of declining child mortality, high child mortality was related across generations – and what part, if any, of the social gap in child mortality was related to socioeconomic resources. I document the trend in intergenerational transmission of high mortality, as well as the trend in SES and child mortality in the Netherlands. The long-term development in such inequality is important as evidence for overall inequalities in the population living standard. I include not only SES of the household in which the child grows up (measured using father's SES based on his occupation), but also SES of the grandparental households using maternal grandfather and paternal grandfather's occupation and contrast the influence of the household of origin of the mother and the father.

3. Data

Analyses are based on a large-scale historical demographic dataset for the historical province of Zeeland, Netherlands (LINKS). LINKS (Linking System for historical family reconstruction) Zeeland links together indexed civil certificates to historical individuals, reconstructing vital events during their life course, and linking individuals to their parents, partners, and children across many generations. LINKS has been used extensively for historical demographic research on the Netherlands and has been subject to thorough checks of quality and reliability (van den Berg et al. 2021).

The largely Protestant province of Zeeland is situated in the southwestern corner of The Netherlands and consists largely of islands. The population had very high fertility throughout the study period, with a mean number of children of around 8 for married couples (see Table 1 for descriptive statistics). A lack of potable water existed due to problems with salinity and especially in dry summers diarrhea-related mortality among young children peaked. Life expectancy was low, both at birth and for infants and children, with child mortality reaching 50% before the fifth birthday in some years, with high levels of epidemic disease in particularly affected communities (Hoogerhuis 2003; Poppel and Mandemakers 2002).

The LINKS data consists of linked digitized indexes of civil certificates. These originate from obligatory vital event registration, which was introduced in The Netherlands in 1812. The certificates include information on the names of born, married and deceased persons, the municipality of the vital event, the individuals' place of birth, age, occupational titles, and names of parents. Life course events of the same individuals have been linked together through name-based linkage of certificates pertaining to the same individuals, using first and last names of the ego and his or her parents, spouses, and children. The full database contains information on 1,930,189 individuals from Zeeland who experienced a vital event in that province between 1812 and 1914 for births, 1812 and 1927 for marriages, and 1812 and 1957 for deaths. For the analysis, 217,330 children are selected, born between 1834 and 1914, whose parents and grandparents are known and whose parents both have at least one sibling. They are the descendants of more than 40 thousand mothers and fathers and more than 26 thousand maternal and paternal grandmothers and grandfathers. For a full overview of selection criteria, see Figure A1. The data

structure allows us to follow individuals through their life course and also contains information on their siblings, parents, aunts, uncles, and grandparents, plus the children of these relatives. The birth cohorts 1833–1913 are included, following children's survival until 1918.

A death date or observation after age 5 is available for 75.3% of the children. A death date is available for 49.1% of the index persons included in the analyses. For a further 26.2% of the index persons a civil record is linked after childhood which is not their death certificate (e.g. their own marriage or their child's birth, marriage, or death). It is assumed that children for whom no further certificates are linked (24.6%) survived until age 5[1]. For a minority of the cases, a certificate of death may not have been indexed or linked although the child died before the age of five. These cases likely weaken associations between our variables of interest. Child mortality in the sample was somewhat lower than in the population (see Figure Appendix 2).

Children who were lifeless upon registration are excluded from the analysis. These cases encompass both stillbirths and births of infants who died before they were reported to the municipality, which had to be completed within 3 working days after birth (Vulsma 1988). Estimates suggest that 71% of lifeless reported infants concern stillbirths and 29% concern live births of infants who died before municipal registration of birth (Van Poppel et al. 2012). As it is unclear which children were born alive and for how long they lived after birth, lifeless registered children are excluded from the analyses of child death, which will lead to a slight underestimation of infant deaths in the neonatal period and to conservative estimates of the intergenerational relation in child mortality risk.

Descriptive statistics may be found in Table 1. I include characteristics of the observed children, their family of origin, and childhood circumstances of their parents. Demographic characteristics of the children include birth order and if the child has a twin. For both fathers and mothers, an indicator is included for first birth at a young age (before age 21). Other characteristics of interest concern whether the birth interval to the previous child was short (< 18 months) and if the father or mother died before the child's fifth birthday. Young children are highly dependent on family members for survival in their early life, and the death of a parent can therefore detrimentally affect the chances of survival of infants and young children (Quanjer, van Dijk, and Rosenbaum-Feldbrügge 2023). For some children, there is no known date of death of one or both of their parents and there is no observation after their fifth birthday (for 12.4% of the children, the mother has no death date, and she is not observed after the child's fifth birthday or death date. For 12.9% of the children, this applies to their father). In these cases, it is assumed that the parents survived until the fifth birthday or – in case the child died before the fifth birthday – until death.

Due to high childhood mortality in the province of Zeeland in the research period, it is common that parents lost at least one sibling in childhood (see Figure 2, panel B). I include separately the number of child deaths in the sibling group of the parent (0, 1, 2 or more deaths). In a robustness check that produces largely the same findings, the number of sibling deaths is expressed as a proportion of the number of siblings of the parent. Socioeconomic status (SES) of children's families of origin, and the socioeconomic status of the family of origin of their parents are included. SES was measured using the highest known occupational title of the father and the grandfathers using HISCLASS scores across all indexed civil certificates linked to one person. HISCLASS is a system that groups historical occupational titles into broad occupational classes. This broad status indicator is recoded into 6 occupational groups:

[1] The percentage of index persons without a known death date or other civil event linked increases from 15.0% in the birth cohort 1835-1860 to 36.8% for index persons born after 1900. This is expected, as follow-up is shorter for the last-born birth cohorts, and increases our confidence that a large majority of the individuals for whom no date of death is available survived their early childhood.

Higher occupations, higher skilled workers, medium skilled workers, lower skilled workers, unskilled workers, farmers and fisherman, and a separate category for missing observations (Van Leeuwen and Maas 2011). Occupational titles from the Netherlands have been standardized in previous work (Mandemakers et al. 2020). In the research period, men were usually the primary breadwinner. Female labor market participation was severely under registered (Janssens 1997). In line with previous research, I therefore rely on the occupation of the husband.

Table 1. Descriptive statistics

All	Index persons	Fathers	Mothers
Year of birth	1886	1853	1855
HISCLASS family of origin			
Higher occupations	4.27	7.70	7.52
Higher skilled workers	16.20	12,00	11.81
Medium skilled workers	11.96	10.79	9.77
Lower skilled workers	8.81	18.33	18.24
Farmers	17.12	7.20	6.86
Missing	16.20	28.71	29.97
Unskilled workers	25.45	15.27	15.83
Parent variables			
Sibship size	-	8.08	8.11
Sibling child deaths (age 0-5)	-		
None	-	21.29	20.46
1 sibling child death	-	24.68	24.20
2 sibling child deaths	-	18.75	18.71
More than 2 sibling child deaths		35.28	36.63
Child variables			
Sex: Girl	48.83	-	-
Birth order	4.36	-	-
Twin birth	2.58	-	-
Birth cohort			
1835-1859	28.34	-	-
1860-1879	35.19	-	-
1880-1899	27.59	-	-
1900-1914	28.34	-	-
Mother age at birth		-	-
Age 13-20	2.82		
Age 21-29	47.39		
Age 30-34	25.86		
Age 35-50	23.93		
Short interval to preceding birth	34.56	-	-
Father death before age 5	2.28	-	-
Mother death before age 5	2.60	-	-
Unique individuals	217,330	42,418	43,312
Deaths before age 5	23.76	-	-

Source: Author calculations, LINKS Zeeland

4. Results

In Figure 2, the concentration of child deaths in families in historical the Netherlands is shown. There are more mothers observed (filled line) that escape deaths among infants and children altogether than expected (dotted line) based on total child mortality rate in the population. Thus, there are more women without deaths than expected, and a higher number of women experiencing several deaths than expected based on the total child mortality rate. This implies a concentration of sibling deaths in a subset of the families. Perhaps this finding is unsurprising, as this concentration of child deaths in certain families suggests that it is not just chance that determined which children survived their childhood;

other factors, operating at the level of the family or the communities in which these families lived, also determined the likelihood of survival of children.

In Panel B the concentration of child deaths in families by SES is shown. SES is grouped into the two main categories: White collar workers (higher and lower managers and professionals), and blue-collar workers (medium skilled workers, lower skilled workers, and unskilled workers). The figures show that the concentration of deaths in families is stronger among blue collar workers (red filled line) than in white collar families (blue filled line). There are more women who do not experience any child deaths at all, but this proportion is larger among white collar women. There are also more women that experiencing many child deaths, among both white- and blue-collar women, but the proportion of blue-collar women that experience high numbers of deaths is higher than among white collar women.

Figure 3 shows the relationship between parental SES (HISCLASS-5) and the risk of child death (lower panel) in Zeeland, the Netherlands, 1835-1918. The figure shows the hazard rate of mortality before the fifth birthyear for SES groups indicated in the panel heading in comparison to the children of unskilled workers (lower managers, professionals, and clergy). Analyses are separated by children's birth cohort. I include five socioeconomic status groups, in reference to children from unskilled workers: Higher managers and professionals, lower managers, medium skilled workers, farmers and lower skilled workers. A large difference in the mortality hazard becomes apparent already for the birth cohort 1835-1859. Children from all SES groups have significantly lower mortality than children of unskilled workers, except children from lower skilled workers' families, where the difference is not significant 1835-1879 and from 1880, mortality is significantly higher than among children of unskilled workers.

4.2 Intergenerational transmission of inequality in infant and child mortality

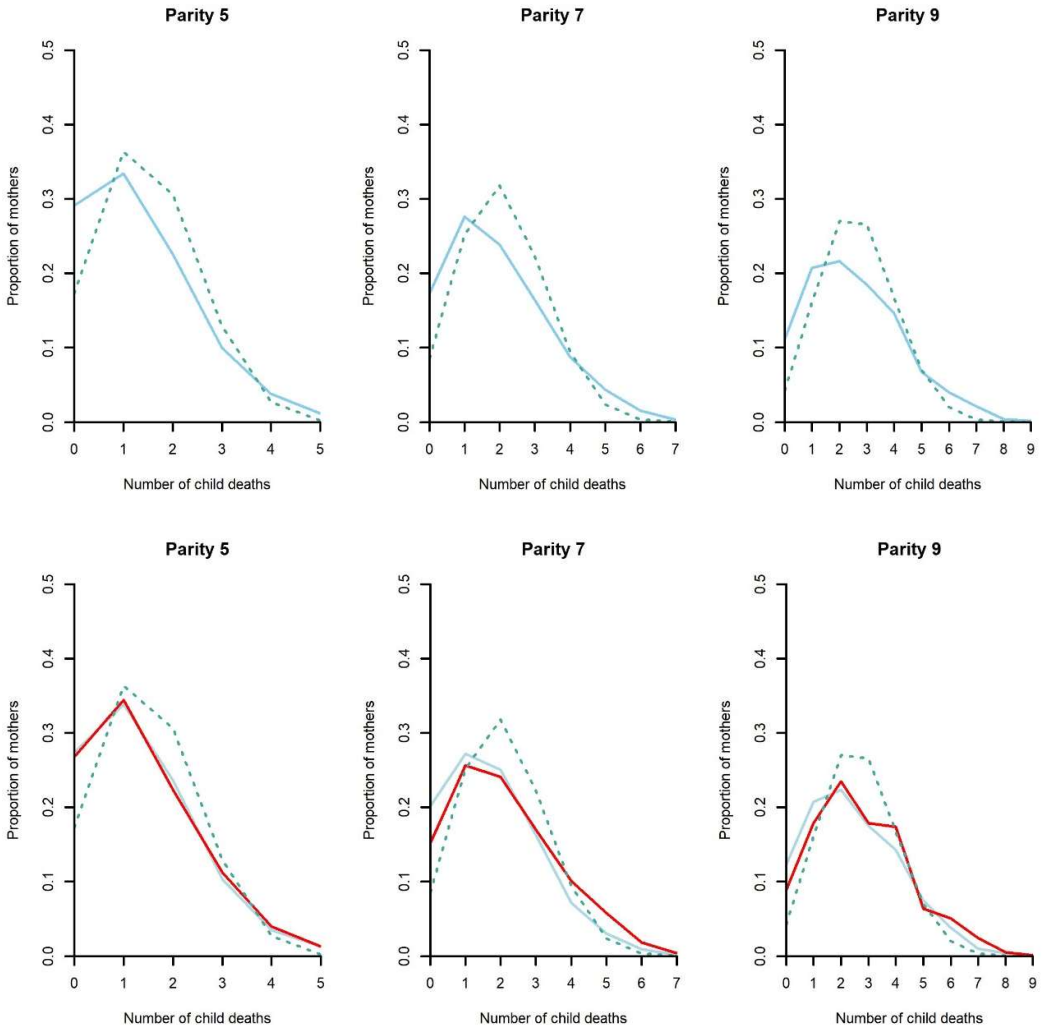
Next, I show the overall intergenerational correlation in child mortality in families, using clustered Cox proportional hazard models of survival between birth and the fifth birthday. Observations are censored at age five. The main independent variables are sibling deaths of the mother and the father and SES of the households of origin of mother and father. Analyses are clustered on the mother level to estimate standard errors that are robust for the fact that the same parents can have multiple observed children in the sample. In Model 1 (Table 2), only sibling deaths of the father and the mother are included, next to a range of control variables: sex and birth year of the child, birth order and birth interval, age of the mother, death of the father and mother before the child's fifth birthday or death.

The results show that the hazard ratio of child mortality is higher if parents are from sibling groups with several child deaths before age 5. Especially if there were three or more deaths among the siblings, the risk of death of the child is higher. Mother's sibling deaths are more strongly related to child mortality than father's sibling deaths before age 5. In Model 2, SES of the household of origin is included, as well as SES of the household of origin of the father and the mother. I find that the relation between child mortality among parents' siblings persists, but effect estimates are smaller than previously, although the differences are not significant. Thus, the intergenerational persistence in child mortality is not explained by the socioeconomic status of the parents.

I include SES of the grandparents (maternal and paternal) and the children's households of origin, using father's social class based on his recorded occupation. While in the analyses presented in Table 2 a finer SES-scale was used, here the distinction between white collar (higher and lower managers and professionals), and blue-collar workers (medium skilled workers, lower skilled workers, and unskilled workers) is reported. Farmers and individuals with missing values are reported separately. Results are shown in Supplementary Material Table S2. Model 1 shows the effects of the dichotomized parental siblings' child mortality on the hazard ratio of mortality before age 5 among their children. I control for a range of characteristics including parental and grandparental SES. As before, the HR of mortality for

children whose parents had elevated child mortality among their own siblings is higher. For the interaction with SES of the household of origin, I expected that children at the greatest risk of before-5 mortality would be children who are from a deprived household, whereas more resources (a higher SES) could ameliorate the risk of high child loss in previous generations. However, the findings show that while parental SES again explains part of the intergenerational persistence in child loss, there is no evidence for an interaction between intergenerational persistence in child loss and SES. Intergenerational persistence of child mortality is thus not stronger for blue collar workers than for white collar workers.

Figure 2: Expected and observed child loss clustering in families (Panel A) and observed child loss by SES (Panel B) for all birth cohorts.



Filled line: Observed proportion of mothers with a certain number of child deaths. Dotted line: Expected proportion of mothers with a certain number of child deaths. Red line: Blue collar families. Blue line: White collar families. Source: Author calculations, LINKS Zeeland

Figure 3. Socioeconomic status and HR of child mortality across birth cohorts

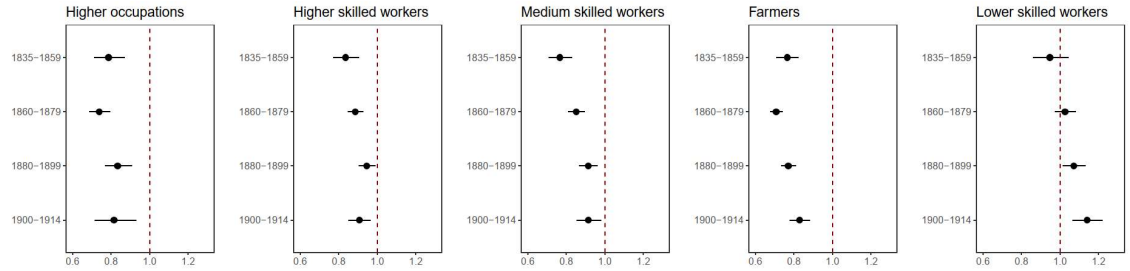


Figure notes: HR is hazard ratio from Cox Proportional Hazard (survival) models, in reference to children of unskilled workers. Analyses are by birth cohort and control for sex, birth year, birth order, mother age at birth, short interval to preceding birth, and father and mother's death before the child's fifth birthday or own death. Source: LINKS Zeeland. For the estimates, see Table S1. Number of individuals (deaths) by birth cohort; Birth cohort 1835-1859 19,302 (6,787); Birth cohort 1860-1879 61,588 (18,444); Birth cohort 1880-1899 76,470 (16,734); Birth cohort 1900-1914 59,970 (9,685). Source: Author calculations, LINKS Zeeland

4.3 Time-trend in intergenerational persistence of child mortality

In Table 3, the intergenerational persistence of child mortality over time is shown for four birth cohorts: 1835-1859, 1860-1879, 1880-1899 and 1900-1914. Mother's and father's sibling deaths before age 5 are included simultaneously and in Model 2, a control is added for socioeconomic status as well as for socioeconomic status of the household of origin (uncontrolled effects can be found in Table S3A and S3B for fathers and mothers, respectively). Between the first and the last birth cohort, profound change occurred in the survival chances of young children. The child mortality rate (before the fifth birthday) was almost halved, and year-to-year variation strongly reduced given declining impact of epidemic disease on child mortality in this period (see Figure 1). As discussed above, socioeconomic factors remained an important predictor of child mortality (see Figure 3). I find that the same applies for intergenerational persistence of child mortality: Over time, whether mothers and fathers originated from a family in which several children died before age 5 remains a significant predictor of child mortality among their own children.

Especially child mortality among the mother's siblings is consistently a strong predictor of child mortality. Particularly if child mortality was high (more than two child deaths among mother's siblings), the hazard ratio of mortality among her children was high. For sibling deaths among father's siblings, a reduction in the effect is observed over time, whereby less high child mortality among his siblings is no longer a significant predictor for the birth cohort 1860 – 1879. If there were more than two childhood deaths among his siblings, the hazard ratio of mortality among his children is significantly higher over the entire period studied here, but the effect decreases with time and is significantly less strong for the birth cohorts 1880-1899 and 1900-1914.

4.4 Change in the role of intergenerational persistence of child loss and SES over time

Figure 4 shows intergenerational persistence of child mortality and the intergenerational persistence of child mortality over time after controlling for SES for the four birth cohorts. Although effects are somewhat attenuated for each birth cohort after controlling for SES, socioeconomic status of the parents' family of origin and the family in which the child grows up do not significantly reduce the intergenerational transmission of child mortality. Thus, inequalities accumulate. The highest child mortality is found with families carrying the dual burden of low SES and high child mortality in previous generations. At the same time, I did not find evidence for a statistically significant interaction effect between social status and high mortality in the previous generation (see Table S2). Moreover, the hazard ratio of child mortality in relation to child mortality in the family of origin is relatively stable between

periods (see Figure 4), except for fathers, for whom the effect appears stronger in the first birth cohort included than for later birth cohorts.

Table 2. Cox proportional hazard models of child mortality age 0-5 by parental sibling child mortality age 0-5 in Zeeland, the Netherlands, 1834-1918

	Model 1 HR	95% CI Lower	Upper	Model 2 HR	95% CI Lower	Upper
Mother's sibling mortality: None	*Ref*			*Ref*		
1 sibling death	1.074	1.041	1.109	1.069	1.036	1.103
2 sibling deaths	1.105	1.068	1.143	1.092	1.056	1.129
More than 2 sibling deaths	1.257	1.221	1.293	1.235	1.200	1.270
Mother's childhood SES: Unskilled workers						
Higher occupations				0.954	0.913	0.996
Skilled workers				0.957	0.922	0.992
Medium skilled workers				1.002	0.964	1.040
Lower skilled workers				0.939	0.908	0.971
Farmers				1.064	1.019	1.111
Missing				0.983	0.952	1.015
Father's sibling mortality: None	*Ref*			*Ref*		
1 sibling death	1.034	1.002	1.066	1.027	0.996	1.059
2 sibling deaths	1.066	1.031	1.102	1.057	1.022	1.092
More than 2 sibling deaths	1.133	1.101	1.166	1.116	1.085	1.148
Father's childhood SES: Unskilled workers				*Ref*		
Higher occupations				0.863	0.826	0.902
Skilled workers				0.929	0.894	0.965
Medium skilled workers				0.951	0.914	0.990
Lower skilled workers				0.937	0.905	0.969
Farmers				1.023	0.980	1.067
Missing				0.962	0.931	0.995
HISCLASS: Unskilled workers				*Ref*		
Higher occupations				0.864	0.818	0.912
Skilled workers				0.945	0.913	0.978
Medium skilled workers				0.910	0.875	0.947
Lower skilled workers				0.819	0.789	0.849
Farmers				1.049	1.009	1.091
Missing				0.913	0.883	0.944
N mothers	43,312			43,312		
N fathers	42,418			42,418		
N children	217,330			217,330		
Deaths age 0-5	51,650			51,650		

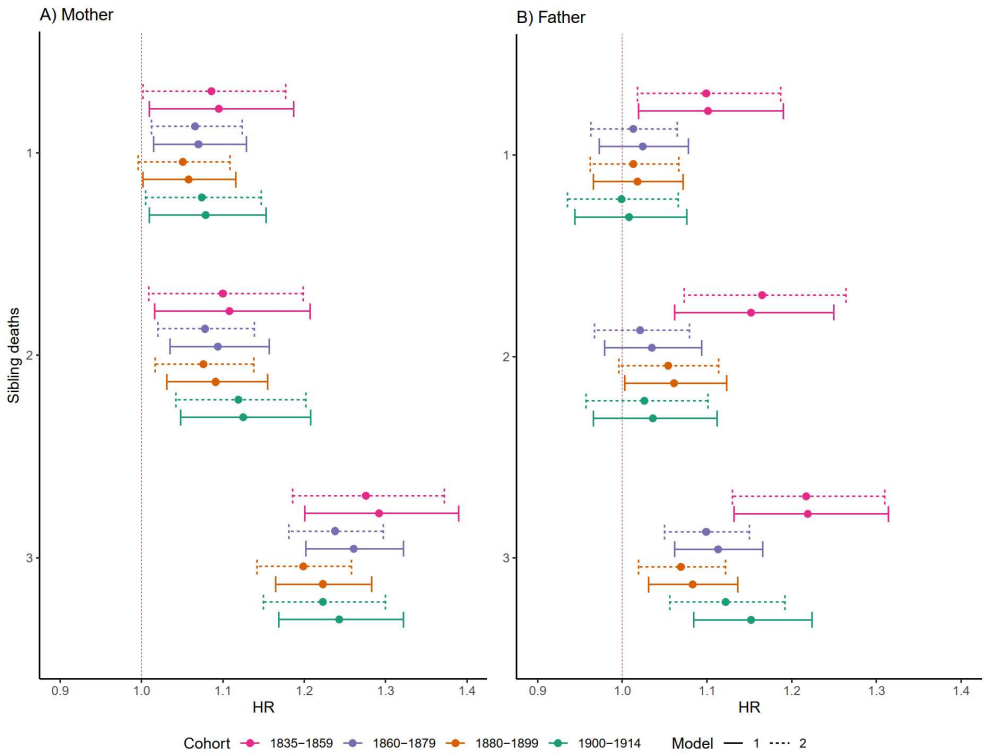
HR is hazard ratio from Cox Proportional Hazard (survival) models. Analyses by birth cohort and control for sex, birth order, mother age at birth, short interval to preceding birth, and father and mother's death before the child's fifth birthday or own death. The models are clustered at the level of the mother to provide robust standard errors. Source: LINKS Zeeland.

Table 3. Cox proportional hazard models of child mortality age 0-5 by parental sibling child mortality age 0-5 in Zeeland, the Netherlands, 1834-1914

	Birth cohort 1835-1859			Birth cohort 1860-1879			Birth cohort 1880-1899			Birth cohort 1900-1914		
		95% CI			95% CI			95% CI			95% CI	
	HR	Low	Upp	HR	Low	Upp	HR	Low	Upp	HR	Low	Upp
Mother's sibling mortality: None	*Ref*			*Ref*			*Ref*			*Ref*		
1 sibling death	1.086	1.002	1.177	1.066	1.012	1.124	1.051	0.996	1.109	1.074	1.005	1.147
2 sibling deaths	1.100	1.009	1.199	1.078	1.020	1.139	1.076	1.017	1.138	1.119	1.042	1.202
> 2 sibling deaths	1.276	1.186	1.372	1.238	1.181	1.297	1.199	1.142	1.258	1.223	1.150	1.300
Father's sibling mortality: None	*Ref*			*Ref*			*Ref*			*Ref*		
1 sibling death	1.099	1.018	1.187	1.013	0.963	1.065	1.013	0.962	1.067	0.999	0.935	1.066
2 sibling deaths	1.165	1.073	1.264	1.021	0.967	1.079	1.054	0.996	1.114	1.026	0.957	1.101
> 2 sibling deaths	1.217	1.130	1.310	1.099	1.050	1.150	1.069	1.019	1.122	1.122	1.056	1.192
HISCLASS: Unskilled workers	*Ref*			*Ref*			*Ref*			*Ref*		
Higher occupations	0.982	0.892	1.081	0.853	0.78	0.933	0.874	0.793	0.964	0.878	0.751	1.025
Skilled workers	0.941	0.848	1.045	0.957	0.904	1.013	0.970	0.916	1.028	0.930	0.863	1.002
Medium skilled workers	0.957	0.862	1.063	0.918	0.861	0.978	0.930	0.869	0.996	0.954	0.877	1.038
Lower skilled workers	0.961	0.883	1.045	0.801	0.755	0.850	0.814	0.764	0.867	0.882	0.814	0.955
Farmers	1.059	0.940	1.192	1.039	0.972	1.110	1.058	0.989	1.131	1.129	1.043	1.221
Missing	0.938	0.863	1.019	0.891	0.844	0.940	0.914	0.865	0.967	0.980	0.910	1.055
N mothers	5,186			14,762			20,074			19,938		
N fathers	5,118			14,495			19,852			19,859		
N children	19,302			61,588			76,470			59,970		
Deaths age 0-5	6,787			18,444			16,734			9,685		

HR is hazard ratio from Cox Proportional Hazard (survival) models. Analyses are by birth cohort and control for sex, birth order, mother age at birth, short interval to preceding birth, father and mother's death before the child's fifth birthday or own death, HISCLASS of the parents of the child, and HISCLASS of the parents' families of origin. The models are clustered at the mother level to provide robust standard errors. Source: LINKS Zeeland.

Figure 4. Effect of intergenerational transmission of child mortality over time



Source: LINKS Zeeland. Estimates of the effect of parents' sibling deaths before age 5 on the hazard of child death before age 5. Filled lines are bivariate estimates, dotted lines are controlled for socioeconomic status (HISCLASS) of the parents of the child, of the parents' families of origin, sex, birth interval, birth order, parental death before age 5 or death of the child, and mother age at birth. Uncontrolled effects can be found in Table S3A (mothers) and S3B (fathers). Controlled effects can be found above in Table 3.

To show changes in the absolute effect over time, I compute the average marginal effect on a child death over time, by mother and father's number of sibling deaths before age 5. Average marginal effects are based on a logistic regression analysis of the likelihood of death before age 5. The chance of a child death before age 5 increases with around 4 percentage points on average over the study period if the mother's family of origin experienced two or more child deaths before age 5. In the first study period, the increase is 7 percentage points if the mother lost two siblings under age 5. The effect size decreases somewhat over time but in the final period remains significant at 3 percentage points by the final period (see Table 4). For fathers, like before, effects are somewhat weaker and not always significant for the loss of one sibling before age 5. The average marginal effect of two or more sibling deaths remains linked most consistently to an increase in the likelihood of death before age 5 of about 2 percentage points.

4.5 Predicted probabilities

Regarding absolute chances of a child death, predicted probabilities based on the average marginal effects shown in Table 4 illustrate the differences between different types of families. For a boy with an average-aged mother, a birth interval to the previous child that's not particularly short, with birth order 3, and whose father is a low-skilled worker, the probability of death before age 5 is 22.8% if the mother had no sibling deaths. This figure increases to 27.4% if she had two or more sibling deaths. Both estimates are for a boy whose father had no sibling deaths. For fathers, the probability rises from 22.8% to 25.1% if the father's family of origin experienced two or more sibling deaths. If neither parent had had a sibling death before age 5, and they came from a high socioeconomic status group and maintained this status in adulthood, the predicted probability of a child death was only 17.8%. The differences between families in the chance of a child death were large, both between the poor and the rich, and between families with a history of increased child deaths and without such a family history.

Table 4. Average marginal effects from logit models of child death before age 5 by parental sibling child mortality under age 5, in Zeeland, the Netherlands, 1834-1918

	Any birth cohort			Cohort 1835-1859			Cohort 1860-1879			Cohort 1880-1899			Cohort 1900-1914		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	AME	Low	Upp	AME	Low	Upp	AME	Low	Upp	AME	Low	Upp	AME	Low	Upp
Mother's sibling mortality: None	*Ref*			*Ref*			*Ref*			*Ref*			*Ref*		
1 sibling death	.014	.009	.019	.022	.002	.041	.016	.005	.027	.010	.001	.019	.010	.001	.018
2 sibling deaths	.018	.013	.024	.026	.005	.047	.018	.006	.030	.014	.005	.023	.016	.007	.025
> 2 sibling deaths	.045	.041	.050	.069	.051	.087	.052	.042	.062	.035	.027	.043	.030	.022	.038
Father's sibling mortality: None	*Ref*			*Ref*			*Ref*			*Ref*			*Ref*		
1 sibling death	.005	.000	.010	.025	.006	.044	.003	-.008	.014	.004	-.005	.013	.000	-.008	.009
2 sibling deaths	.010	.005	.016	.043	.022	.064	.006	-.005	.018	.010	.001	.020	.005	-.004	.014
> 2 sibling deaths	.023	.018	.027	.056	.038	.074	.023	.013	.033	.014	.006	.022	.018	.010	.026
HISCLASS: Unskilled workers	*Ref*			*Ref*			*Ref*			*Ref*			*Ref*		
Higher occ.	-.032	-.042	-.023	-.032	-.063	-.002	-.042	-.060	-.024	-.025	-.041	-.009	-.019	-.037	.000
Skilled workers	-.031	-.037	-.025	-.031	-.055	-.007	-.018	-.030	-.005	-.007	-.017	.003	-.010	-.020	.000
Medium skilled	-.035	-.042	-.028	-.050	-.075	-.025	-.024	-.038	-.010	-.015	-.027	-.004	-.007	-.018	.005
Lower skilled	-.057	-.063	-.051	-.055	-.078	-.031	-.059	-.071	-.046	-.040	-.050	-.030	-.018	-.028	-.008
Farmers	-.011	-.018	-.004	-.009	-.039	.022	.007	-.009	.023	.009	-.004	.021	.019	.007	.030
Missing	-.035	-.041	-.029	-.030	-.053	-.008	-.033	-.045	-.022	-.019	-.028	-.009	-.003	-.013	.006
N mothers	43,312			5,186			14,762			20,074			19,938		
N fathers	42,418			5,118			14,495			19,852			19,859		
N children	217,330			19,302			61,588			76,470			59,970		
Deaths age 0-5	51,650			6,787			18,444			16,743			9,685		

Analyses are by birth cohort and control for sex, parents' HISCLASS, HISCLASS of the families of origin of the parents, birth order, short preceding birth interval, and mother age at first birth. Source: LINKS Zeeland.

4.5 Robustness checks

The main results are tested for robustness using a somewhat different selection of families from the data by selecting only selected children whose parents have two or more known siblings (are from families of at least three children), so that all parents in the analyses are at risk for having at least 2 sibling deaths. This results in the selection of 199,060 children (a reduction of 18,249 children or about 8 percent). Results can be found in the Supplementary Material (Table S4) and are almost identical to the analyses presented here. Next, I include sibling mortality as a proportion of the number of children in the family of origin of the parents. Results are in Table S5. Effects are somewhat stronger in this single indicator of childhood mortality among the siblings of the parents, but results are similar: increased mortality for children whose mothers and fathers came from a high-childhood-mortality family, with stronger effects for mothers than fathers, and effects that persist over time. These models are not chosen as the main model as they are less intuitive in their interpretation and the proportion of child deaths depends on the number of siblings that mothers and fathers have.

5. Conclusion and discussion

Child mortality was distributed unequally between families, and this inequality persisted between generations in historical the Netherlands. Analyses based on full population family reconstitution data (LINKS) for a province in the Netherlands, Zeeland, 1835–1919 show that both socioeconomic status and parents' families' level of child mortality contribute to the risk of child death before age 5. Children of mothers and fathers who experienced a larger number of sibling child deaths had an increased risk of death before their own fifth birthday. Importantly, intergenerational persistence of child mortality is not driven by social class of parents or grandparents. Inequalities accumulate, as low-SES families of which both parents originated from high mortality families had the highest level of mortality.

Like earlier authors, I show that there is a social gradient in child mortality in the period studied. Higher socioeconomic status groups had lower child mortality than unskilled and lower-skilled workers. Effects are largely similar over time, except for lower skilled workers, among whom mortality becomes even higher than among unskilled workers in the last two periods studied here. In historical the Netherlands, social mobility was low (Knigge 2016) so that low SES across generations could contribute to the intergenerational persistence of child mortality. Yet, high risk of child death is not explained by socioeconomic characteristics of the family in which a child grows up, nor their grandparents' socioeconomic status.

However, there is a correlation between grandparental socioeconomic status and grandchild hazard of mortality before age 5, even after controlling for socioeconomic status of the household in which the child grows up, using occupation of the father. Grandparental effects on grandchildren, for example social status attainment of grandchildren, have in the past been interpreted as a broad effect of grandparental resources and social networks on grandchildren (Mare and Song 2023; Knigge 2016). Such studies have shown that socioeconomic factors affect social status attainment not just over one generation – father to child – but also over several generations of relatives – grandfather to grandchild (Dribe and Helgertz 2016). Such effects persist even if grandparents and children never met nor if the competition over grandparental resources is larger, so that such residual effects of socioeconomic status can point to imprecisely measured socioeconomic status effects that work through resources of the family of origin of the child (Helgertz and Dribe 2022). If only the occupation of the father is included, unexplained variance because of measurement error could be captured by grandparental measurements of social status (Engzell, Mood, and Jonsson 2020). Similarly, the contribution of grandparents' social status to grandchild survival, after considering the socioeconomic status of the

parents, may be related to imprecise measurements of parents' SES. Yet, grandparents could also have contributed resources, knowledge and help in times of need. Further research should establish what drives this relationship.

Over time, child mortality declined strongly in the Netherlands. Intergenerational transmission effects are found even when child mortality had declined strongly, particularly for women. For mothers to children, effects remained largely similar over time, with increased mortality particularly for children of mothers originating from families where several child deaths occurred among their siblings. This finding implies that even among women with the strongest disadvantage – in terms of both a low socioeconomic status and elevated mortality in their household of origin – the absolute risk of losing their young children decreased over time. Yet, compared to other families in the population, these women and their children remained at the strongest disadvantage over time. For fathers, the magnitude of the intergenerational effect declined when child mortality rates decreased, particularly for more average experiences of sibling mortality (e.g. loss of one or two siblings in childhood).

It is unclear why the intergenerational persistence of child mortality is stronger from mother to her children than from father to his children. Commonly, studies investigating persistence of social status find the opposite: a stronger intergenerational persistence from father to son or daughter than from mother to son or daughter (Dribe and Helgertz 2016), although some work has shown a stronger influence of maternal economic participation on her daughter's than sons' status attainment (Brea-Martinez 2023). In this work, a higher hazard ratio of mortality is observed for children whose mothers came from high-mortality households than for children whose fathers originated from high mortality households. A possible reason is the larger role for women in caretaking of children in this period (Janssens 1997), and possibly, girls learned child-care practices such as unsuitable feeding practices in the household of origin and used these for their own children (Das Gupta 1990). The possible help of grandmothers, for example after childbirth or when children were sick, could be gendered, and a previous literature has established that in some contexts the help of a mother's own mother could make a crucial difference for child survival in historical Europe (Sear and Mace 2008). In families where grandmothers raised their children in unfavorable conditions, indicated by her own high child loss, they may neither have had the health nor knowledge to assist their daughters and daughters in law with the care of their grandchildren – and instead, their outdated knowledge or own need of help may have been a burden on their daughters and daughters in law.

Studying the time-trend in intergenerational persistence of high mortality shows the long-term development in equality of opportunity. Over time, high mortality in the families of origin of the mother and father show a persistent correlation to the mortality hazard of young children, despite sibling child deaths becoming less common. Thus, intergenerational persistence of high child mortality is a clear marker of inequality in historical the Netherlands. To study such intergenerational inequalities in other contexts, such as contemporarily developed societies, it is essential to study mortality over a broader age range as mortality at young ages contemporarily tends to be mercifully low. In children's health, however, broader patterns of intergenerational persistence may still be a key indicator of inequality in the standard of living.

There are some drawbacks to this study. First, the statistical analysis relied on data originating from linked indexes of civil certificates. Individuals are not continuously observed in registers, as they would with, for example, a church or state population register. Although earlier work has shown that for this area and period the resulting life course and family reconstructions generally reflect the result from continuous population register data (van den Berg et al. 2021), important characteristics of individuals and their families are not included in these linked vital event data, including religion, migration movements, and household income. Second, families across Zeeland have been included, so that

regional migrants – who moved for marriage or work opportunities, but not over long distances – can be tracked. Spatial and geographic differences in inequality in child deaths over time were not included in this work. The local conditions for children to grow up in could have been quite different between places of residence, given that Zeeland consists of islands with somewhat different economic opportunities and physical limitations such as access to safe drinking water. Together, the reasons for accumulation of high child mortality across generations beyond poverty and socioeconomic status remain therefore somewhat of a black box. Yet, as was argued previously, the overall accumulation of inequalities in the likelihood of early child death across time is an important indicator of families' relative standard of being and inequality in opportunity in societies.

In a previous study of intergenerational persistence in child mortality, Lu and Vogl (Lu and Vogl 2023) argue that studying the topic of child concentration in mortality is important to study inequality in bereavement. I argue here that it is important to study intergenerational persistence as an indicator of inequality in mortality itself. Some families are more likely to experience child mortality and to have poor health. This phenomenon should not solely be investigated from a socioeconomic perspective (the social gradient in mortality) or in relation to other social and socioeconomic indicators but is worthy of attention and a measurement of inequality in the living standard and the distribution of mortality in itself. Addressing the trend in intergenerational persistence in mortality, and differences between contexts, serves as a measurement of inequality between places and over time.

In conclusion, intergenerational persistence of (high) mortality, as shown in this work, highlights the lack of opportunity for children to achieve a long life already at the time of their birth, given in which family they were born. Intergenerational persistence in young age mortality is of pressing importance as it eradicates opportunities for individuals to live a long and healthy life before their lives have even fully started. This paper shows evidence that there was inequality of opportunity in young-age survival which persisted over time in 19th and early 20th century the Netherlands. Whether this trend continued later in the 20th and 21st century and whether it generalizes to mortality at older ages or health of children are important avenues for future research.

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7. Data availability statement

Data is available from the Institute of Social History, Amsterdam, Netherlands, here: https://hdl.handle.net/10622/QUJNCD. Code and replication files available upon request.

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9. Appendix

10. Supplementary material

S1: Cox proportional hazard models of child mortality age 0-5 by parental SES, age 0-5 in Zeeland, the Netherlands, 1834-1919

S2: Cox proportional hazard models of child mortality age 0-5 by parental sibling child mortality and SES, age 0-5 in Zeeland, the Netherlands, 1834-1919

S3: Table S3A: Mothers' sibling mortality and child mortality over time with and without controls in Zeeland, Netherlands. Table S3B: Fathers' sibling mortality and child mortality over time with and without controls in Zeeland, Netherlands

S4: Cox proportional hazard models of child mortality age 0-5 by parental sibling child mortality age 0-5 in Zeeland, the Netherlands, 1834-1914 for children of parents with more than two siblings

S5: Cox proportional hazard models of child mortality age 0-5 by parental sibling child mortality age 0-5 in Zeeland, the Netherlands, 1834-1914 with the number of sibling deaths of parents as a proportion of the number of siblings

Figure A1. Selection of index persons

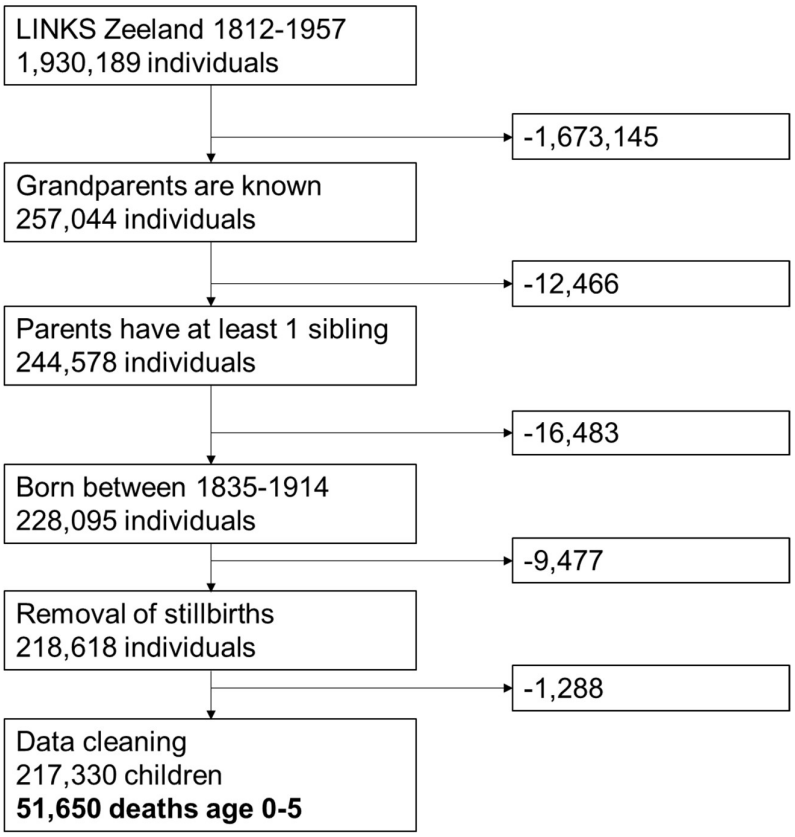
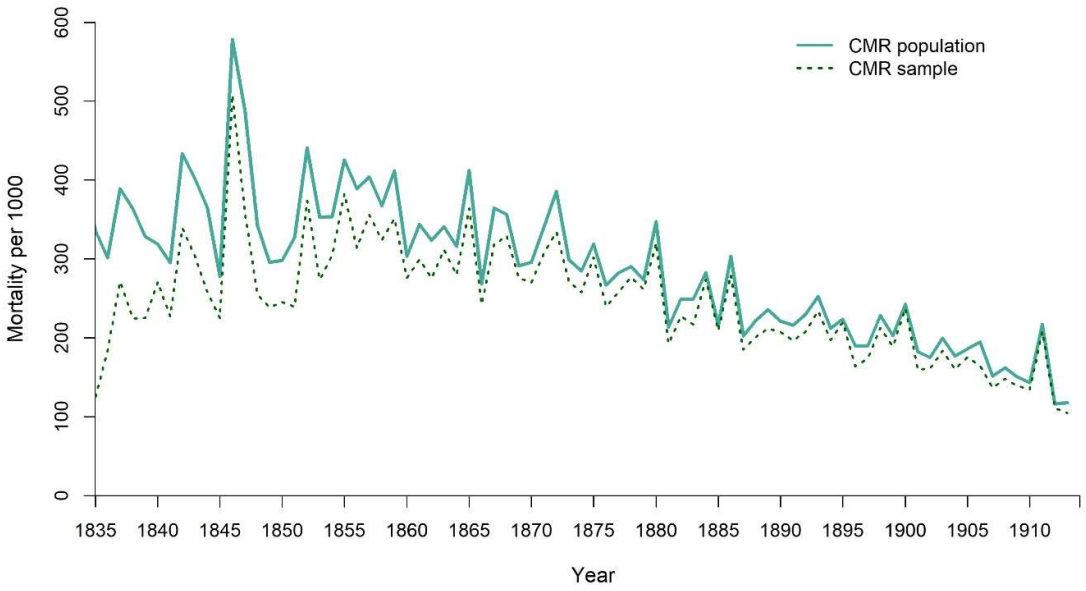


Figure A2. CMR in the population of Zeeland and in the selected sample, birth cohorts 1835-1914



Child mortality rate per 1000 liveborn children in the year of observation. Source: author calculations, LINKS Zeeland