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The long-term health benefits of receiving treatment from qualified midwives at birth

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Abstract
Socio-economic differences in health and mortality are substantial and increasing today in many developed countries. The sources of these differences remain unclear. There is an expanding literature showing that early-life conditions are linked to health in adulthood and old age. However, our knowledge about whether beneficial treatments in early life influence later health is still limited. Using longitudinal individual-level data from the Scanian Economic Demographic Database (Sweden) for individuals born between 1881 and 1930 and observed from birth until the age 80, this paper explores the long-term health effects of being born assisted by a qualified midwife. Treatment data is obtained from midwife reports for approximately 7,200 children, which includes information on the type of treatment at birth as well as child and mother health. In a setting of home deliveries, midwives not only provided skilled assistance at childbirth, but also strictly followed disinfection instructions and checked child and mother health within three weeks after birth. Our findings show that individuals treated by qualified midwives at birth and in the first month of life have lower all-cause mortality between ages 15 and 39 and lower mortality from cardiovascular diseases and diabetes between ages 40 and 80, compared to individuals delivered by traditional midwives. The effects are larger for individuals originating from more affluent families. These findings are linked to reductions in exposure to infectious diseases and their interplay with family responses to better infant health.
Key words: early-life, qualified midwifery, mortality, morbidity, life-course, Sweden
JEL codes: I15, J13, H41

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INTRODUCTION

Socio-economic differences in health and mortality are strong today in the developed countries of Western Europe and North America (Mackenbach et al. 2008; Torrsander and Erikson 2010; Chetty et al. 2016). All-cause mortality attenuates with higher socio-economic class mainly among people in working ages, and in older ages these effects are much stronger for cardiovascular disease than for cancer (Marmot et al. 1991; Mackenbach et al. 2008). Even if socio-economic health differences are found to be uniform across contemporary developed countries, the sources of these differences remain unclear and debated. A social gradient in mortality is most likely to be a very recent phenomenon, beginning from the 1950s, and may be explained by the disease environment and the tools available to combat the disease (Bengtsson and Dribe 2011; Bengtsson and van Poppel 2011). In the conditions of the highly communicable diseases it is difficult to prevent the disease at an individual or class level, but nowadays, when diseases are rare and treatable, various factors, such as inequality, economic and social stress, life-style factors and access to medical and non-medical resources, may produce differences in later health (Kawachi 2002; Lynch et al. 2000; Chetty et al. 2016). According to this line of reasoning, the sources of health inequalities should be searched for in adulthood. Additionally, there is an expanding literature showing that early-life health is a determinant of later health and socio-economic status (Case and Paxson 2010; Bleakley 2010). Better child health, both due to higher parental resources and more favourable conditions surrounding birth and childhood, leads to better health in adulthood, with links to cognitive development and incomes (Heckman 2007; Currie 2009). Individual's health should be therefore studied from a life course perspective, where the role of biological and social pathways between childhood and adulthood is critically strengthened (Kuh and Ben-Shlomo 2004).

At the country level, the link between childhood conditions and later-life mortality is well established. Looking at the changes in age-specific mortality rates for developed countries, demographers found the close relationship between mortality in childhood and mortality throughout the life course (Kermack et al. 1934). By using European and American data, Fogel (1990, 1994) found strong links between height and adult mortality and suggested that a decrease in net-nutrition, either due to the lack of nutrients or increased demands because of disease during childhood, may lead to chronic diseases in later life. More recently, with cohort-specific mortality data for Sweden, Finch and Crimmins (2004) demonstrated that exposure to infections during infancy causes future diseases, such as cardiovascular diseases and other adult morbidities. In their explanation, adverse later-life health effects emerge due to direct damage to the body and cells or chronic immunity responses launched in early life. Inspired by the macro findings, the well-known works of Barker (1991, 1995), which found significant correlations between low birth weight and the development of diabetes, and cardiovascular and respiratory infectious diseases in later life, further promoted contemporary research on early-life effects. Barker proposed that the developing body may adapt to environmental signals and, if the environment experienced in later life is different, these adaptations lead to the development of diseases. It is generally suggested that the early neonatal period is one of the most sensitive periods in life during which exposure to infectious diseases may alter life prospects (Finch and Crimmins 2004).

With an individual as a unit of analysis, the opportunities of the contemporary studies to investigate the link between health in childhood and throughout the life course are usually limited by high requirements to the data. Primarily, the age-depth of the majority of the datasets, including long-term cohort follow-ups and register data, enables currently to study the prime working ages and does not cover the age periods where the majority of the deaths happen and therefore the entire life course (Bengtsson and Mineau 2009). As a result, the bulk of the studies are based on retrospective information surrounding first years of the individual's life, such as environmental conditions, the timing and severity of epidemics and famines, and public health initiatives (Almond and Currie 2011). Apart for the methodological problem of the selectivity of the survivors in the analysis samples, these studies are lacking important individual-level information, such as socio-economic status of the family or maternal birth history, which are possibly the factors mediating the accumulation of child health. In these regards, studies using historical databases with full information about individuals' life courses are more helpful in investigating the link between early and later-life health. If such data is detailed enough, these works can also provide evidence on the social and biological mechanisms lying behind early-life health effects.

The majority of the contemporary individual-level studies show that negative early-life exposures, related to infectious diseases, strongly influence later-life health and well-being. Numerous studies have showed that early-life effects pronounce themselves in adulthood and older age, for moderate and severe shocks, for different health and non-health endpoints, and in various contexts (for a review see Almond and Currie 2011). Variations in disease load, from non-subtle outbreaks of infectious disease to pandemics, have been systematically shown to generate various long-term consequences during human lives. Based on the same data source used in this study, several studies linked early life exposure to infectious diseases to later-life health. In the nineteenth-century rural Sweden, individuals exposed to epidemics of infectious diseases in infancy had greater probabilities of dying from early adulthood, while females also experienced worse reproductive health (Quaranta 2013). In addition, poorer health and occupational outcomes are also observed for individuals exposed to disease shocks of lesser severity (Bengtsson and Lindström 2003; Bengtsson and Broström 2009). Similar results, linking exposure to infectious diseases in infancy with later-life mortality, were obtained for few other settings in Belgium and Canada, where historical life-course follow-ups were available (Bengtsson and Alter 2007; Gagnon and Mazan 2009) In the US, mild increases in the early-life infectious disease environment and pandemics equally led to lower educational and labour-force performance for individuals born in the first half of the twentieth century (Almond 2006; Case and Paxson 2009; Barreca 2010).

Early life conditions can vary as a result of public health interventions and beneficial treatments, but our knowledge about their effects on adult health is still limited. None of the existing studies covers total population at risk and full exposure. One set of these studies established early-life beneficial effects from reforms aiming at reducing exposure to infectious disease. For instance, in the US, the eradication of hookworm disease after 1910 led to an increase in literacy in later life (Bleakley 2007), while the introduction of sulfa drugs in 1937 reduced neonatal mortality from pneumonia and thereby affected the cognitive ability and labour performance of the treated cohorts (Bhalotra and Venkataramani 2013). Additional studies have also found that the eradication of malaria or water supply reform led to later-life improvements in the context of developing countries. Most recently, interest has emerged in studying the long-term effects of publicly-provided programs that target general population. Few studies exploring the long-term effects of child care infant programs, initiated in the 1930s, have been conducted based on data for different Scandinavian countries. They have shown that opening of the child care centers with a large home-visiting component had positive effects on education, lifetime earnings, and longevity of the affected individuals (Bütikofer, Løken and Salvanes 2015; Hjort, Solvsten and Wüst 2014; Bhalotra, Karlsson and Nilsson 2015).

To date, the long-term effects of the expansion of qualified midwifery, which appears to be the first historical public health initiative that targeted mortality, has not been investigated. Due to the bacteriological breakthroughs beginning from the 1870s-1880s, antiseptic and aseptic techniques were introduced into the skilled childbirth practice. In the countries of northwestern Europe, such as Sweden, Denmark, Norway and the Netherlands, disinfection procedures and the observation of the development of infectious disease after childbirth has been found to be responsible for infant and maternal mortality decline starting from the late nineteenth century. The reason put forward is a long tradition of home deliveries by well-trained and well-supervised midwives who consistently used antiseptic techniques from the time they were introduced (Loudon 2000; Woods, Løkke and van Poppel 2006). In addition, competent midwives were employed by the local communes and were provided to the general public at almost no costs. This stays in contrast to the early twentieth-century England, where the choice of birth attendants was fully determined by wealth of the family (Reid 2012). Several micro-studies for Sweden, for which the data is available far back in time, have shown that infant mortality decreased substantially beginning from the time the educated public midwives arrived at the parishes (Andersson, Högberg and Bergström 2000; Lazuka, Quaranta, and Bengtsson 2016). The fewer studies that have looked at the impact of midwives on the newborn children and their mothers in other historical and contemporary settings have also found decreases in death rates (Reid 2012; Carlo et al. 2010; Loudon 1992, 2000).

Given that qualified midwives led to positive effects on health of the newborns, differences in treatment by midwifery could be seen as differences in individuals' early-life conditions surrounding birth. Using longitudinal data for approximately 7,200 children born in rural parishes in southern Sweden between 1881 and 1930 and followed until the age of 80, this study uses a life-course approach to look at the effects of being treated by a qualified midwife at birth and in the neonatal period on later-life health. Treatment by midwifery is observed at the individual level. Explicitly, the following research questions are addressed in this paper: (i) Given that being treated by a qualified midwife at birth implies better health during infancy, what are the health outcomes of this treatment throughout life course? (ii) What is the plausible biological mechanism behind long-term effect of treatment by qualified midwifery at birth? (iii) Are these early-life effects mediated by family-level factors? This study is encouraged by the previous findings showing that for the same rural population in southern Sweden, which is considered in this study, sharp employment of midwives qualified in antiseptic knowledge in 1890-1925 reduced by three times the risk of dying during the neonatal period and was efficient in the post-neonatal period (Lazuka et al. 2016). The context of rural Swedish parishes, where total population at risk is known, provides a nearly ideal setting to study the early-life health effects. All birth deliveries were conducted at home implying no selection of the observed individuals based on either delivery conditions or family socio-economic status. Additionally, qualified midwifery was provided to the community at negligible costs. Following the 1881 Antiseptic law, treatment by midwifery exploits differences between qualified and traditional midwives in limiting the spread of infectious diseases to an infant.

This paper is based on the high-quality micro-level longitudinal database, such as Scanian Economic Demographic Database version 4.0 (SEDD, Bengtsson et al. 2014), that provides several advantages in studying the issue. This database contains demographic and socio-economic information covering all individuals born or ever resided in five parishes in southern Sweden (Kävlinge, Hög, Sireköpinge, Halmstad and Kågeröd), which are followed until the present days. In the dataset, we are able to follow the studied cohorts from their date of birth until their death or their date of out-migration from the parishes between 1881 and 1968. For the period between 1968 and 2011, due to the data merged from the national registries of Statistics Sweden, we are able to follow individuals regardless of their geographic location in Sweden. We have now linked individual-level information about delivery conditions to it, obtained from the diaries of the midwives working in the studied area between 1881 and 1946, which appears to be a unique piece of information worldwide. This information is merged to both newborns and their mothers that enable to include the relevant maternal and family level characteristics, surrounding individuals' births, into the analysis. Given all, this study becomes first that uses individual-level treatment by midwifery to study the long-term health effects of such treatment based on longitudinal data covering entire individuals' life courses. It also allows us to explore the treatment uptake in the first month of life and the effects of such treatment throughout the life course, and to avoid the problem of selection of individuals into the group of survivors. Additionally, this paper enhances our understanding of the mechanisms behind early exposure and later-life mortality due to the availability of detailed information on the treatment procedures undertaken by midwives, child health at birth, cause-of-death data and family characteristics.

SETTING

Individuals analyzed in this study were born in five parishes located in southern Sweden, which between 1880 and 1930s stayed homogenous in terms of economic and population development and public health. All parishes remained rural until the 1890s, when two of the southern parishes – Kävlinge and Hög – became partially industrialized due to the development of the railway networks and markets (Bengtsson and Dribe 2010). In the 1880-1910s, total population resided in the parishes grew from 5,000 to 6,500, mainly due to the inflow of industrial workers, and stayed constant afterwards. Until 1889, only one provincial doctor took care of the rural parishes in the county. By 1900, parishes belonged to local health districts, one in Halmstad, Sireköpinge and Kågeröd administered by the neighbouring parish, Teckomatorp, and another one in Kävlinge and Hög. The local epidemical hospitals were established, which served for the isolation of the sick, their supportive cure, but never admitted women in labour, as well as additional qualified midwives were employed (Lazuka et al. 2016). Until the late 1930s, all birth deliveries were carried out at home with help of midwives. The share of the deliveries taking place in hospitals located in the neighbouring cities had grown afterwards.

By the 1870s, regulations obliged cities to employ only qualified midwives (*examinerade barnmorskor*) but allowed traditional midwives (*hjälpkvinnor*) when a qualified midwife was not available in rural parishes (Högberg 2004). As a result, until the 1930s, throughout rural Sweden, the majority of women delivered their children with assistance of traditional midwives whereas skilled deliveries were rare (see Fig. 1). For instance, after the establishment of provincial doctoral districts in the 1890s, newly assigned doctors from different parts of the country documented the presence of numerous traditional practitioners working throughout the areas but regarded them as a common feature of the rural life (Romlid 1997). In the area under analysis, between 1880 and 1930s, on average two out of ten midwives living in the parishes were qualified (see Tab. 1). The doctors in the studied area noted that traditional midwives were not competent in the use of antiseptics and general medical knowledge (Regionarkivet Lund, 1901). The uncertified midwives were also prohibited to use obstetrical instruments.

[Table 1]

[Figure 1]

Regulations put forward from late nineteenth-century by the Swedish authorities assigned midwives duties related to prevention from infectious diseases in birthing environment. In order to conduct their service, qualified midwives were recruited by a commune and worked under close supervision and control with a health district doctor. In 1881, owing to the bacteriological discoveries, the Antiseptic law obliged midwives to use antiseptic and aseptic techniques at home deliveries in rural areas (Rehn and Boström 2013: 47). These regulations also prescribed each public midwife to keep detailed clinical records on all deliveries in a standardized form (*Barnmorkan dagbok*). More specifically, included as an introductory part of a midwife's diary, national health board's 13 June 1881 circular provided detailed instructions for midwives with particular focus on preventing the spread of disease: "1. A midwife should keep her clothes and instruments clean and disinfected. 2. A midwife should avoid touching dead bodies. 3. A midwife should endure that a delivery is taking place in a room where recently there were no lying-in sick family members. 4. A midwife's hands up to elbows and instruments should be washed with soap and sterilized with carbolic acid. 5. If a treated woman developed puerperal sepsis, a midwife should … avoid practicing for a week" (Medicinalstyrelsens 1881). Importance of hygiene and disinfection of umbilicus were therefore additionally strengthened. In 1914, midwives began to disinfect newborn's eyes with silver nitrate, a technique known as Credé's prophylaxis, to prevent neonatal blennorrhea (Ericsson 1990). Midwives' notes had to be kept carefully and reported to the community doctor and, when midwives used instruments, registered by the higher health authorities.

In addition to disinfection, qualified midwifery included not only highly skilled assistance of childbirth but also the subsequent care of the infant. Midwives became a source of information about child care, as they were able to recognize childhood diseases and obliged to give prescriptions about early breastfeeding and isolation of infant from sick family members. Moreover, by the 1880s, midwifery childbirth competences were extensive, enabling to handle birth complications and save preterm neonates. More specifically, the skilled delivery included the use of manual delivery techniques and obstetrical instruments, and surveillance of the third stage of labour. In 1914, the period of after-delivery observation of the lying-in women and the child was extended from ten days to three weeks, as well as the child health at birth began to be checked and measured more thoroughly. Midwives began to provide woman in labour with calming and fever-reducing drops, analyze protein in the urine to diagnose eclampsia, and resuscitate a neonate in case of perinatal asphyxia and prematurity. Qualified midwives had to purchase all medical and disinfectant items by themselves from their own salary with a receipt signed by a health district doctor that obviously restricted their use among traditional midwives. For a long time, drugstores were located only in the large cities, whereas close to the area under analysis one pharmacy was opened in 1905 in Kävlinge and one in 1912 in Teckomatorp (Statistiska Centralbyran 1875-1930). In the period under study, midwives did not check women during pregnancy. This system stayed unchanged until the late 1940s, when together with introduction of maternity hospital system, duties of public midwives turned into prenatal and infant care (Sundin and Willner 2007).

DATA

In this study, data on treatment by midwives is available at the individual level (see Fig. 2). It is obtained from the local midwife reports gathered for individuals born in five parishes in rural southern Sweden between 1881 and 1930. Individuals born in the parishes analyzed were searched for in the diaries of midwives directly employed by these parishes, but also by the neighbouring parishes which formed joint health districts (Billeberga, Ekeby, Brödåkra, Konga, Ask, Ottarp, Svalöv in the Teckomatorp district; Lackalänga in the Kävlinge district). Individuals who were not found in these diaries are assumed to be assisted at birth by traditional midwives or no midwives. The midwife reports contain detailed information on type of treatment received during and after delivery, child health status at birth and mother health conditions during and after birth. According to the data, in each delivery, communal midwives implemented a set of standard techniques, such as disinfection, during- and after-delivery check-ups of health. Also available in the data, information on additional specific routines, such as the use of sharp obstetric instruments, calming drugs, and the assistance of delivery by a doctor, indicate the presence of childbirth complications rather than any exclusive treatment. In total, information on 7,211 newborns is available, of which approximately one fifth was treated by qualified midwives and other newborns were delivered by traditional or no midwives. All these individuals were delivered at home, and those few delivered in the hospitals are not included into the estimation sample (10 individuals). The initial sample of individuals found in midwife diaries (up until 1946) is restricted to those born between 1881 and 1930 to avoid overlapping with later public health interventions, such as introduction of institutionalized child delivery, arrival of antimicrobials and water supply improvements (Kävlinge kommunarkiv 2010). Descriptive statistics for the estimation sample are presented in Tab. 2.

[Figure 2]

[Table 2]

Individual data from midwife reports has been linked to longitudinal individual-level data, obtained from the SEDD version 4.0, covering total population in the five parishes under study. It therefore allows us to follow individuals throughout the whole life course, beginning from birth to the old age, as well as to take into account their family-level and maternal information. The quality of the data is high and discussed elsewhere (Bengtsson and Lundh 1994;

Bengtsson and Dribe 2010). In this database, the family reconstitutions were performed using register type data. Data on occupations and landownership of the head of the individual's family of origin is also included in the database and further classified into socio-economic groups, such as HISCLASS (van Leeuwen and Maas 2011). Individuals were observed within the parishes until 1968, and after 1968 were followed across the entire country based on personal identifiers through Swedish national registries, using data from Statistics Sweden. For all males, we also have information from universal conscripts' inspection records, such as height and health diagnoses (for description of the data see Öberg 2015).

In addition to the date of death, the cause of death is known from these sources. In SEDD, in the period 1881-1968, the diagnoses were certified by a medical practitioner according to the national regulations and registered by the clergymen, are very reliable and valid. We utilize the classification of these data in terms of cause of death rather than symptoms made by Bengtsson and Lindström (2000). After 1968, data on cause of death come from the Swedish cause-of-death register that is based on international classifications of diseases (ICD), which are homogenous with earlier registrations. For the main diagnoses used in this study the validity of the long-term follow-ups is very high (Ludvigsson et al. 2011). We use the cause-of-death data for mortality after the age 15, as the share of unknown causes among children is rather large (50% for infants, 35% for individuals aged 1-14, 13% for individuals aged 15-39, and 2% for those aged 40-80) as well as certified midwives participated in registration of a child death. In order to obtain the consistent cause-of-death groups, we distinguish the following groups: deaths from infectious diseases, cardiovascular diseases and diabetes, and cancer. The extracted data is in the Intermediate Data Structure (Alter et al. 2009), and was changed into a rectangular episode using a program written by Quaranta (2015).

METHODS

To estimate the long-term effects of treatment by qualified midwifery on mortality, we apply the following model:

$$\ln h_{icpt}(a) = \ln h_0(a) + \beta qualified\_midwife_i + \delta_p + \mu_c + l_{ct} + \varphi x_i \quad (1)$$

where $qualified\_midwife_i$ is defined as an indicator of whether a child was delivered by a qualified midwife at birth versus delivered by a traditional midwife; φx_i denotes a set of relevant individual (sex and multiple/singleton), family (socio-economic class at birth, father present) and maternal characteristics fixed at birth (maternal age, survival status of the previous child, birth interval, previous child multiple/singleton, and parity); $h_{icpt}(a)$ is the hazard of death (for the individual i from parish p born in year c) at age a; $\ln h_0(a)$ is the baseline hazard, that is for the individual who has the value zero for all the covariates. The model also includes parish of birth δ_p and year of birth μ_c fixed effects, and therefore effect of treatment by qualified midwifery is identified by comparing the average hazard of death of individuals treated by qualified midwives to those treated by traditional midwives within parish and year of birth, conditional on the whole set of maternal and family observables. The survival to different ages, such as to 28 days, age 15, 40, and 80, is modelled conditional upon birth because survival to older ages is endogenous; to control for the treatment effect obtained at younger ages, each subsequent specification introduces an interaction between the previous age group and a midwifery dummy. Additionally, in all models, except of the model for neonates, we control for cohort trends in mortality by including linear cohort fixed effects, l_{ct}. In addition to all-cause mortality, cause of death is studied specifically for the major diagnostic groups after the age 15. We use Cox proportional hazards regression for all-cause mortality (Cox 1972) and the Fine-Gray competing risk regression for cause-specific mortality (Fine and Gray 1999), and report results as exponentiated hazard and sub-hazard ratios respectively.

In order to study the mechanisms possibly explaining the link between midwifery treatment and later-life mortality, we further look at the treatment effect in eq.1 by sub-groups. The effects of different midwifery competences can be disentangled by interacting the qualified midwifery dummy with IMR thresholds in the year of birth, midwives with different core competences (disinfection and childbirth competences for 1880-1913 and improved child and maternal care competences for 1914-1930), treatment status among siblings, and child (full term or preterm) and maternal health status at birth and shortly afterwards (complications or natural childbirth). We also investigate the mediating role of family resources by distinguishing individuals by socio-economic origin and family size in the treatment groups.

In addition to mortality, based on controlling for the observables, this study explores the effects of qualified midwifery on other health measures. Height and inspection outcomes are directly obtained for males in the ages 16-21 at inspection. In using this data, one should keep in mind that for the period under study there was a formal minimum height requirement, ranging from 154 to 161 cm at different periods existed and individuals shorter but otherwise healthy were not recorded (Öberg 2015). Also, diagnoses for all inspected males, such as general weakness and chronic sickness, and causes for rejection, which were freed permanently or temporarily from conscription duty, are available that are consistently reported for the whole period based on the doctor's examinations. For health diagnoses, the reference categories are individuals with no reported information but otherwise inspected which are likely to represent the adverse group. The models additionally introduce age at inspection among the covariates and are estimated by the OLS.

The models for mortality also exploit information on multiple children per family. As a robustness check, we cluster errors at the family level to account for between-sibling correlation of unobserved factors. In our setting, family or mother characteristics are likely to differ between siblings with different treatment status. We also introduce family fixed effects into the equation 1. As suggested by Almond and Mazunder (2013), systematically smaller (larger) sibling fixed effects estimates compared to the baseline estimates could suggest that parents compensated (reinforced) the siblings' differences in initial health induced by qualified midwifery. Additionally, the within-family variations in treatment status at birth may reflect that some unobservable maternal characteristics changed over time, such as health during pregnancy or delivery conditions. The qualitative evidence suggests that traditional midwives were agreed to call for a qualified midwife or a doctor if complications arose during birth (Curtis 2005). To further investigate family responses to better child health, we study the impact of qualified midwifery on fertility of the mothers. For fertility, piecewise constant hazard rate models with six-month periods for the baseline hazards truncated at eight years are applied. These models control for the year (continuous), parish of residence, SES, age, parity and survival status of a previous child.

In our sample the treatment by qualified midwifery might be underreported for some years due to the loss of diaries. We carefully checked which diaries are missing based on the information from health districts in the National Archive (Riksarkivet 2015). As a robustness check, we therefore run the models while excluding cohorts where no individuals in each parish in a given year were treated by a qualified midwife.

In our study, allocation of treatment by midwifery at the individual level is not dependent on either socio-economic class or maternal health at childbirth (see Tab. 3). A qualified midwife had no priority for childbirth assistance between wealthy and poorer families. Compared to married mothers, unmarried mothers were less likely to be assisted by a qualified midwife, as they were usually nursed either by help-women or by professionals in maternity homes. The absence of socio-economic gradient in access to educated midwives is not surprising given that the bulk of their salary was comprised of the amount paid by the community board and the church, with a negligible part contributed by the parents (Romlid 1997). The estimates also suggest that health of the mother, measured by age of the mother or length of birth interval, is not different between the two treatment groups. Instead, women who were nursed by a qualified midwife at first birth tend to be nursed by her again at the following births. These findings are seemingly consistent with evidence suggested by micro-studies looking at the diffusion of the competent delivery in rural and semi-urban parishes of northern Sweden (Curtis 2005, 2011). In a setting similar to ours, access to a qualified midwife was not dependent on wealth, occupation, education or age of the mother; instead, proximity to the nearest midwife and established relationship with a mother were crucial.

[Table 3]

Across estimation samples analyzed in this study, sample attrition in general does not systematically differ between the treatment groups (see Supplementary material). Except for children in the ages 1-14, attrition is identical between treatment groups for all age groups and conscripts. The differential attrition in childhood can be explained by compositional differences between the treatment groups, with higher proportion of children from larger families that are less movable among the individuals treated by qualified midwives, or by lower mortality in this group that are more likely to be observed later on. Individuals originated from richer families were more likely to be observed in each age group. However, among the individuals treated by qualified midwives at birth both socio-economic groups are similar in the likelihood to stay in the sample.

RESULTS

The raw cumulative hazards of death distinguished by differential midwifery treatment at birth are presented in Fig. 3. The estimates show that cumulative risks of dying are much lower by the age one for individuals delivered by qualified midwives compared to those delivered by traditional midwives. The curves also suggest the development of additional advantage from the treatment by certified delivery at birth between the ages 15-40, and again in older ages. In middle life, this cleavage is achieved by both accelerated accumulation of deaths among individuals treated by traditional midwives and delays of deaths among cohorts treated with certified midwives. In old age, deaths of individuals treated with qualified midwives at birth are postponed. Obviously, these cumulative hazards estimates might be influenced by the whole range of potentially important covariates, such and year and parish of birth as well as family and maternal characteristics.

[Figure 3]

Table 4 displays the results for all-cause mortality from the hazard rate models at the chosen age thresholds. Results for all causes of death show significant positive effects of treatment by a qualified midwife on survival in the neonatal period. Individuals delivered by qualified midwives have at least 40% lower risk of dying within a month after birth. Throughout the life, comparatively to the individuals assisted by traditional midwives at birth, individuals treated by qualified midwives obtain additional advantage in survival, more than 40% lower mortality risk, between the ages 15-39. Results indicate no treatment effects on all-cause mortality in childhood until the age 15, and after the age 40. Regarding the absolute size of the early-life effect, we find it in the age where all-cause mortality is moderate. In our setting, taken in rough terms for the untreated cohorts per 100,000, the death rate amounts to approximately 640 persons between the ages 1-14, 360 persons between the ages 15-39, and 1530 persons between the ages 40-80. Our baseline estimates are robust to different specifications. When clustering the standard errors around mothers, the estimates keep their statistical significance. The statistical power decreased when we excluded cohorts for which treatment at birth was underreported, but the age-specific results remain qualitatively similar to our main results.

[Table 4]

Table 5 presents the estimates for cause-specific mortality after age 15. Results suggest that there are benefits from qualified midwifery in the major cause-of-death group both throughout adulthood and in older ages. More specifically, our previously observed decreases in mortality between the ages 15-39, induced to by the qualified midwifery, occurred mainly due to decreases in mortality from respiratory infectious diseases, such as pneumonia, influenza and pulmonary tuberculosis. Between the ages 40-80, there is statistically significant treatment effect of qualified midwifery on mortality risk from cardiovascular diseases and diabetes, among which the main contributors are ischemic heart disease and cerebral hemorrhage. No similar patterns can be observed for cancer or other causes.

[Table 5]

The results suggest that long-term effects were generated by particular midwife competences (see Tab. 6). Individuals born in years with high disease prevalence, measured with IMR, benefit more in terms of lower mortality in the first month of life and in the medium life, while effects for individuals born in years with low disease prevalence years are smaller in magnitude and not significant. In the population under analysis, the majority of infectious diseases, such as pneumonia, whooping cough, diphtheria, meningitis and diarrhea, have endemic presence and therefore are transmittable to all newborns. Pointing to the same direction, beneficial early-life effects emerge mainly due to disinfection among the major midwifery competences. Our results further show that influences from qualified assistance differ by health and delivery conditions at birth. Full-term newborns take all benefits from delivery and gain survival advantage through midlife but only if there were no delivery complications at their birth. Preterm newborns were more likely to die even if they were treated by qualified midwives comparatively to the total population of newborns assisted by traditional midwives. Distinguished by the treatment status of the older siblings, the estimates show that ceasing influences on death at birth and over the life are produced for individuals with the qualified midwife present at their birth, whereas there is no advantage if only mothers could apply better child care due to knowledge gained if previous births were treated.

[Table 6]

Treatment effects also differ across groups with different family characteristics. Analysis indicates that there are no socio-economic differences in responses to the treatment by qualified midwifery in infancy. However, a socioeconomic gradient in the treatment impacts is substantial starting from childhood, with the richest receiving most of health advantage up until the age 40. Additionally, the results indicate that treatment effects on mortality are apparent through the whole life for individuals which grew in smaller families probably implying importance of family resources in order to sustain the health effects.

We further investigate family-level responses by looking at the impact of qualified midwifery on fertility among the mothers. Table 7 shows that mothers whose previous births were attended by a qualified midwife have approximately three times higher risks of experiencing second and higher order birth comparatively to mothers previously treated by a traditional midwife. This stays in line with mother fixed effects estimates, which reduce the early-life effect, especially for newborns with poor health at birth, and suggests that parents compensated the differences in initial health of their children generated by improvements in midwifery (see Supplementary material). Such family behavior might have been deliberate, through the change in desired family size, or automatically induced due to the beneficial effects of competent treatment on maternal health. In the period of analysis, maternal mortality already declined to low levels similar to the national pattern, and amounted to 4 maternal deaths per 1000 live births. So, the treatment effects do not emerge through the likelier maternal survival but probable benefits to maternal recovery after childbirth cannot be disregarded. Noteworthy, the existence of influences of midwifery on fertility of mothers implies that our previously reported estimates for mortality are affected but ambiguously, as both shorter birth intervals and more frequent birth incidence increase infant mortality but improved maternal health suppresses it.

[Table 7]

We complement our main analysis with results for several health outcomes estimated based on the military records for males aged 16-21 (see Tab. 8). There are no differences in height and in the proportion of rejected to the military service due to unfitness between the two treatment groups. In the data, being diagnosed with specific health conditions did not necessarily lead to rejection, thus only 10% were freed from military training but 50% had been diagnosed. Our estimates show that individuals treated with qualified midwives at birth were approximately 15 percentage points less likely to be recorded with health problems, such as poor vision, sickness or chronic diseases, and these estimates are strong and robust to different specifications.

[Table 8]

DISCUSSION

Based on unique longitudinal data, where treatment is observed at the individual level, this paper studied the effects of treatment by qualified midwifery at birth on health throughout the life course. Our main findings indicate that competence of midwives not only substantially improved neonatal health, but also had beneficial later-life health consequences for the treated cohorts, such as reduced all-cause mortality between the ages 15-39, and reduced mortality from cardiovascular diseases and diabetes between the ages 40-80. The health advantages were apparent already in young adulthood, as males delivered at birth with qualified midwives had lower probability to be diagnosed with health problems at conscription inspections at the ages 16-21, compared to individuals assisted by traditional midwives at birth. These findings correspond well to other recent studies that establish the long-term influence of both negative and positive exposure in early life on old age mortality, as well as extend such influence to the working ages (e.g. Bengtsson & Lindström 2003, Quaranta 2015; Hjort et al. 2014).

Previous research suggested several pathways linking mortality and morbidity in adulthood and old age to the early-life environment. They include long-run maladaptation to environmental signals or permanent damage to the body, and chronic immunity responses launched in early life (see Hostinar and Gunnar 2013 for a review; Barker 1991, 1995; Gluckman et al. 2008; Finch and Crimmins 2004; Willerson and Ridker 2004). All explanations emphasize exposure to infectious diseases as an important early-life environmental factor. To date, the empirical literature has used exposure to epidemics in the prenatal period and infancy to study the long-term mortality effects, and the mechanisms behind this link (Bengtsson and Lindström 2000, 2003; Quaranta 2014; Myrskylä et al. 2013). Our study extends this literature by showing the positive long-term health effects of beneficial treatment related to improvements in the disease environment at birth and during the first month of life. Our results show that all midwifery competences, including delivery, supportive care and disinfection, led to better survival of newborns in infancy, but only those related to the reductions in exposure to infectious disease generated long-run health effects. Consistent with the previous literature, these effects are found in mortality risks related to respiratory infectious diseases and cardiovascular diseases and diabetes.

Our findings show that beneficial treatment of newborns by midwifery was mediated by parental factors. To date, the empirical early-life literature is not conclusive on the direction of the parental responses, as studies find responsive, compensatory or even neutral decisions (e.g. Conti et al. 2014; Almond and Mazunder 2013). Our results establish that families, in response to preventive treatment of newborns by qualified midwifery compromised resources in their childhood. Primarily, the early-life effects on survivorship are concentrated to a large extent among individuals from wealthier families and are weaker otherwise, which should be the opposite absent any family changes. A more convincing finding is that treatment by qualified midwives led to higher fertility among the mothers of the affected cohorts resulting in larger families where the treated children grew up. The social effects therefore go in the direction opposite to the biological benefits from the midwifery treatment and hence to their underestimation.

In our study, allocation of treatment by a qualified midwife at birth is not random but it does not depend on family or maternal characteristics. This corresponds well to other similar settings where the diffusion of certified midwives did not occur faster across wealthier, more educated or younger mothers, but women in labour called to the nearest or familiar midwife (Curtis 2011). It is not surprising given that rural communal midwives were provided to general public at no or negligible costs. However, the plausible influence of other unobserved factors on the obtained estimates should not be ignored. If treated mothers were more conscious about the health and well-being of their children, the unaccounted effects push the obtained estimates in the opposite direction. In the event that health is potentially depleted for the treatment group, our results are underestimated. Our results favour the latter proposition. The effects are completely robust to the inclusion of different maternal, family and individual characteristics. Moreover, the results suggest that qualified midwives were able to save a much larger share of all newborns including the less healthy ones, compared to traditional midwives.

In total, our findings demonstrate that qualified midwifery, positively affecting survival and vitality at birth and in early neonatal period, produced divergence in health inequalities in individuals' later life. These results are entirely consistent with the recent indications of increasing health gaps between socio-economic classes in developed countries (Mackenbach et al. 2008; Chetty et al. 2016). In the studied population, this outcome emerged due to the interplay between better infant health, induced by the qualified midwifery, and family-level responses to it. Given that the treatment by qualified midwifery affected newborns from all socio-economic classes equally, this should have resulted in stronger long-term health effects among individuals from the poor families, and therefore to the mitigation of health disparities. Parental responses to better infant health suppressed these health effects, thereby benefiting children from wealthier families already in late childhood and until the old age. In addition to midwifery, childhood socio-economic class therefore became an important part of the later-life health trajectories. Additionally, beneficial treatment from qualified midwifery mattered over long run for cohorts with higher baseline levels of infectious diseases, and did so mainly through the abilities of midwives to limit the spread of infectious diseases to an infant. These findings thus provide a plausible explanation for the health inequalities being the very recent phenomenon (Bengtsson and Dribe 2011; Bengtsson and van Poppel 2011). In our setting, the cohort determinants are important for adult mortality at the times when disease could not be treated individually but partially prevented from its spread by the action at the community level, such as public provision of the qualified midwives.

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FIGURES

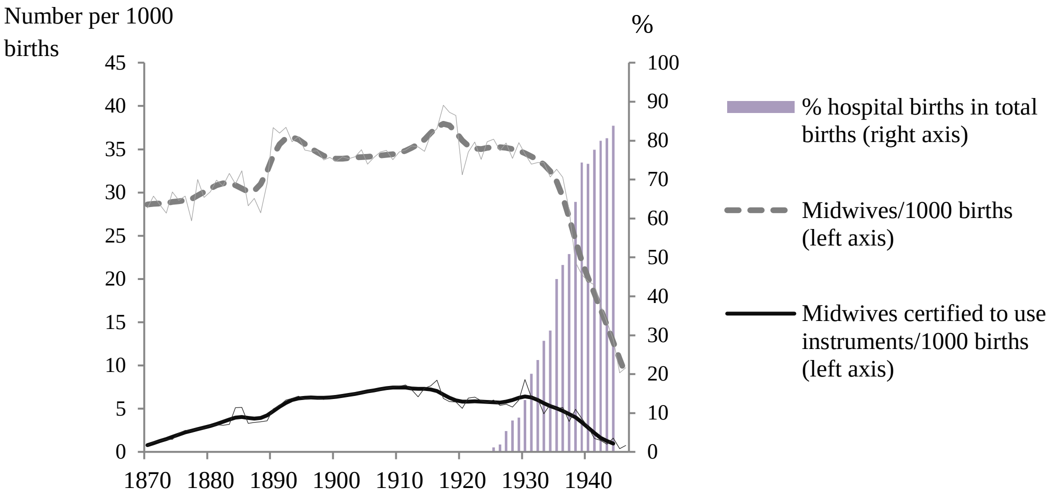

Figure 1 – Midwifery development in southern Sweden (rural areas) 1870-1946, raw values and trends
Source: Statistiska Centralbyran 1870-1946, Regionarkivet Lund, 1892-1946a,b

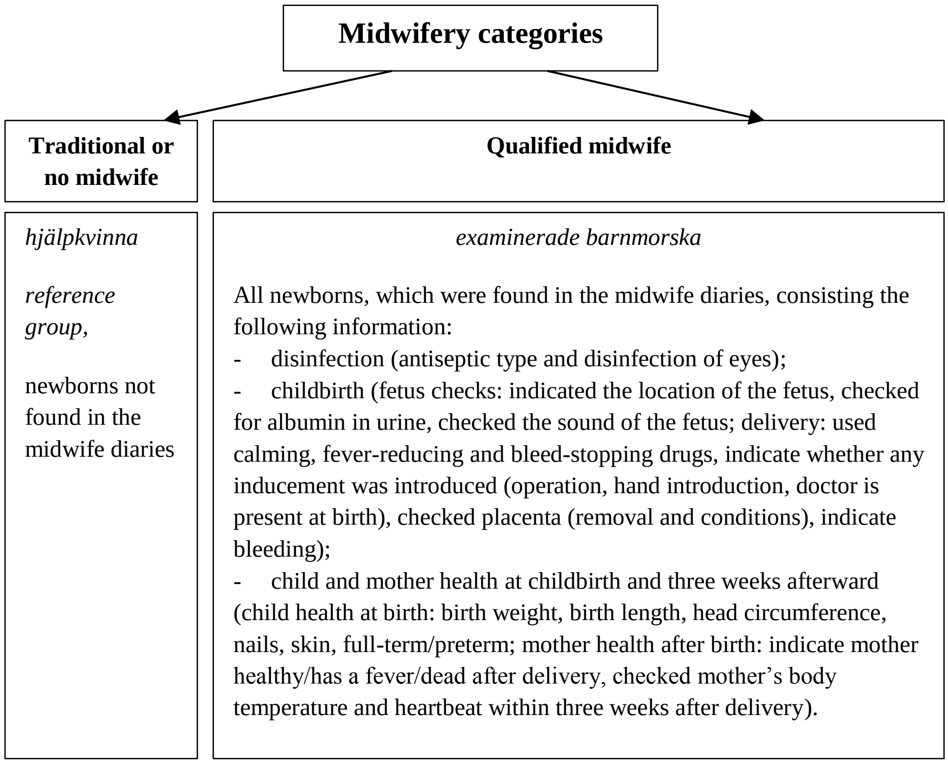

Figure 2 - Midwifery treatment groups

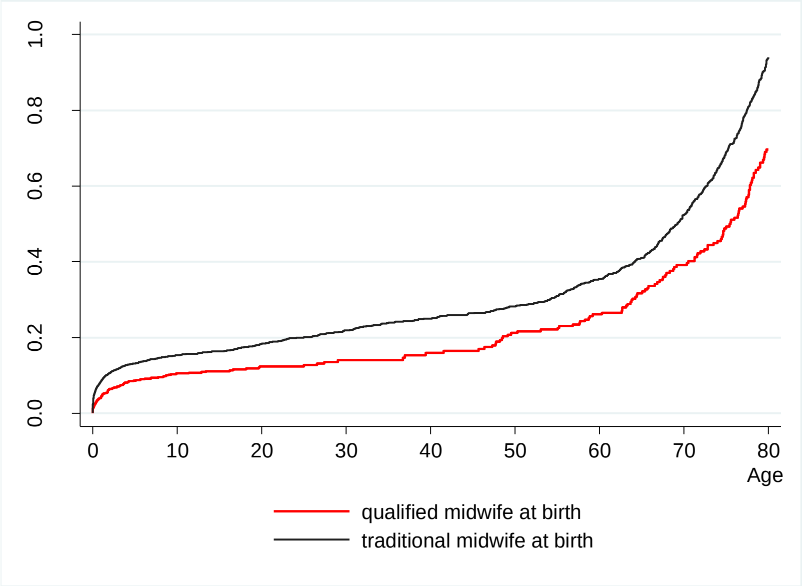

Figure 3 – Raw impact of treatment by qualified midwifery at birth on all-cause mortality throughout the life course, southern Sweden cohorts 1881-1930
Note: Nelson-Aalen cumulative hazard estimates

TABLES

Table 1 - Medical practitioners residing in the area under study, southern Sweden, 1881-1946

	Doctors	**Midwives**	**Medical Nurses**	**Number of births**
1881-1889	-	8	-	1,236
1890-1899	1	17	1	1,550
1900-1909	3	12	2	1,720
1910-1919	4	8	6	1,453
1920-1929	3	10	8	1,144
1930-1946	8	7	14	1,761

Note: The data on doctors, midwives and medical nurses is obtained from SEDD 4.0, based on occupation for individuals in working ages. In 1881-1889 and 1890-1899, out of all midwives, one midwife was hired by a commune; in 1900-1909, 1910-1919, 1920-1929, 1930-1946, two midwives were hired by a commune.

Table 2 – Descriptive statistics: % of time at risk

	<28days	**age<15**	**age<40**	**age<80**
Treatment variables				
qualified midwife	0.28	0.16	0.16	0.17
traditional or no midwife	0.72	0.84	0.84	0.83
full term	0.17	0.11	0.11	0.11
preterm	0.06	0.03	0.02	0.03
complications	0.05	0.02	0.04	0.03
qualified&rich SES at birth	0.12	0.08	0.08	0.09
qualified&poor SES at birth	0.16	0.08	0.08	0.08
qualified&1881-1913	0.05	0.06	0.06	0.05
qualified&1914-1930	0.11	0.10	0.10	0.12
own traditional&older sibling traditional	0.66	0.78	0.78	0.77
own qualified&older sibling qualified	0.11	0.06	0.06	0.07
own qualified&older sibling traditional	0.17	0.10	0.10	0.10
own traditional& older sibling qualified	0.05	0.06	0.06	0.06
<=4 siblings&qualified	0.12	0.10	0.10	0.10
>4 siblings&qualified	0.16	0.06	0.06	0.07
highIMR&qualified	0.15	0.08	0.08	0.08
lowIMR&qualified	0.13	0.08	0.08	0.09
Individual & family controls				
year of birth (mean)	1907.04	1901.69	1902.47	1906.48
parish of birth Hög	0.06	0.07	0.07	0.07
parish of birth Kävlinge	0.31	0.31	0.32	0.33
parish of birth Halmstad	0.13	0.13	0.12	0.12
parish of birth Sireköpinge	0.21	0.19	0.18	0.17
parish of birth Kågeröd	0.29	0.30	0.31	0.31
Male	0.52	0.52	0.54	0.54
Female	0.48	0.48	0.46	0.46
SES at birth elite	0.13	0.14	0.14	0.13
SES at birth middle class	0.13	0.16	0.17	0.16
SES at birth farmer	0.16	0.19	0.21	0.22
SES at birth farm worker	0.31	0.28	0.26	0.25
SES at birth industrial worker	0.26	0.23	0.23	0.24
father present	0.88	0.90	0.85	0.80
father not present	0.12	0.10	0.15	0.20
Maternal controls				
mother <32 years	0.52	0.46	0.46	0.46
mother >=32 years	0.43	0.50	0.51	0.51
mother’s age unknown	0.05	0.04	0.03	0.03
previous child singleton	0.51	0.62	0.63	0.63
previous stillbirth	0.01	0.01	0.01	0.01
previous twin or triple	0.01	0.01	0.01	0.01
previous unknown or firstborn	0.47	0.36	0.35	0.35
previous alive	0.98	0.89	0.89	0.89
previous dead	0.06	0.07	0.08	0.08
previous unknown	0.05	0.04	0.03	0.03
current singleton	0.98	0.98	0.98	0.98
current twin or triple	0.02	0.02	0.02	0.02
first parity	0.42	0.32	0.31	0.31
second parity	0.21	0.21	0.21	0.22
third parity	0.12	0.14	0.15	0.15
fourth and higher parity	0.21	0.29	0.30	0.29
parity unknown	0.05	0.04	0.03	0.03
Person-years at risk	3,086	60,422	101,946	144,877
Individuals	7,211	7,211	7,211	7,211
Deaths	401	868	1004	1596

Table 3 – Allocation of treatment by a qualified midwife at birth

	%	**qualified midwife=1**
SES at birth	0.58	
farm and industrial workers(ref)		
farmer	0.15	0.041**
		(0.001)
skilled	0.15	-0.003
		(0.797)
elite	0.12	-0.018
		(0.146)
poor SES at birth (ref)	0.58	
rich SES at birth	0.42	0.008
		(0.291)
father present(ref)	0.88	
father not present	0.12	-0.047***
		(0.000)
mother young(ref)	0.50	
mother old	0.45	-0.006
		(0.465)
mother unknown	0.05	-0.037*
		(0.041)
previous singleton(ref)	0.53	
previous stillbirth	0.01	-0.053
		(0.150)
previous twin or triple	0.01	0.071
		(0.100)
previous unknown	0.44	-0.015†
		(0.052)
previous alive(ref)	0.88	
previous child dead	0.07	-0.048**
		(0.002)
previous unknown	0.05	-0.040*
		(0.027)
current singleton(ref)	0.97	
current twin or triple	0.03	-0.016
		(0.516)
first parity(ref)	0.40	
second parity	0.21	0.030**
		(0.005)
third and higher parity	0.35	0.001
		(0.866)
parity unknown	0.05	-0.029
		(0.114)
first born	0.40	-0.012
		(0.177)
birth interval <=2.5 years (ref)	0.34	
birth interval >2.5 years	0.21	-0.001
		(0.946)
birth interval unknown	0.05	-0.042*
		(0.026)
Individuals	100.00	7,211

Note: OLS regression estimates. Models control for month and year of birth (interaction of dummies), parish of birth and sex. Models are estimated separately for each explanatory variable.

P-values in parentheses † <.10, * p<.05, ** p<.01, *** p<.001

Table 4 – Mortality in relation to treatment by a qualified midwife at birth, southern Sweden cohorts 1881-1930

	<28days	**age<15**	**age<40**	**age<80**
Full sample, individual controls				
traditional(ref)	1.000	1.000	1.000	1.000
qualified	0.507***	0.955	0.585†	0.939
	(0.000)	(0.739)	(0.077)	(0.577)
Person-years at risk	3,086	60,422	101,946	144,877
Individuals	7,211	7,211	7,211	7,211
Deaths	401	868	1004	1596
Mother clustered errors, individual, family and maternal controls				
traditional(ref)	1.000	1.000	1.000	1.000
qualified	0.553**	1.006	0.550†	0.973
	(0.002)	(0.971)	(0.064)	(0.827)
Person-years at risk	3,086	60,422	101,946	144,877
Individuals	7,211	7,211	7,211	7,211
Deaths	401	868	1004	1596
Excluding years with underreported treatment				
traditional(ref)	1.000	1.000	1.000	1.000
qualified	0.542*	1.014	0.558	0.942
	(0.010)	(0.937)	(0.119)	(0.672)
Person-years at risk	1,728	32,445	53,899	76,867
Individuals	3,872	3,872	3,872	3,872
Deaths	197	441	499	874

Note: Exponentiated Cox proportional hazard model estimates.
P-values in parentheses † <.10, * p<.05, ** p<.01, *** p<.001

Table 5 – Cause-specific mortality in relation to treatment by a qualified midwife at birth, southern Sweden cohorts 1881-1930

	Infectious diseases, ages 15-39	**Cardiovascular diseases/ diabetes, ages 40-80**	**Cancer, ages 40-80**
traditional(ref)	1.000	1.000	1.000
qualified	0.570	0.646*	0.976
	(0.207)	(0.014)	(0.906)
Individuals	3,334	1,356	1,356
Deaths	66	272	184

Note: Exponentiated Fine-Gray competing risk model estimates.
P-values in parentheses † <.10, * p<.05, ** p<.01, *** p<.001

Table 6 – Heterogeneous effects of treatment by a qualified midwife at birth on mortality, southern Sweden cohorts 1881-1930

	<28days	**age<15**	**age<40**	**age<80**
Mother's and child's health at birth				
traditional(ref)	1.000	1.000	1.000	1.000
full term & qualified	0.356***	0.943	0.328**	1.073
	(0.000)	(0.719)	(0.009)	(0.614)
preterm & qualified	2.220*	1.613	2.936	0.972
	(0.023)	(0.241)	(0.120)	(0.920)
complications & qualified	0.625	1.060	1.245	0.798
	(0.272)	(0.874)	(0.729)	(0.316)
Period				
1880-1913 & qualified	0.558†	1.137	0.369†	0.770
	(0.098)	(0.552)	(0.068)	(0.303)
1914-1930 & qualified	0.527†	0.895	0.922	1.068
	(0.071)	(0.708)	(0.877)	(0.694)
IMR during infancy				
highIMR & qualified	0.381***	0.825	0.469†	0.958
	(0.000)	(0.332)	(0.098)	(0.788)
lowIMR & qualified	0.730	1.146	0.712	0.951
	(0.210)	(0.452)	(0.385)	(0.737)
Treatment of older siblings				
own traditional & older sibling traditional	1.000	1.000	1.000	1.000
own qualified & older sibling qualified	0.519†	0.991	0.548	0.930
	(0.053)	(0.970)	(0.205)	(0.673)
own qualified & older sibling traditional	0.582*	1.015	0.559	0.982
	(0.025)	(0.934)	(0.152)	(0.902)
own traditional & older sibling qualified	1.033	0.863	0.821	0.862
	(0.903)	(0.503)	(0.580)	(0.376)
SES at birth				
rich &qualified	0.501*	0.784	0.407†	0.877
	(0.020)	(0.298)	(0.084)	(0.440)
poor &qualified	0.594*	1.172	0.671	1.058
	(0.036)	(0.359)	(0.300)	(0.702)
Family size				
<=4 siblings&qualified	0.544*	0.731	0.448	0.848
	(0.015)	(0.163)	(0.125)	(0.296)
>4 siblings&qualified	0.557†	1.348	0.663	1.171
	(0.073)	(0.123)	(0.290)	(0.341)
Person-years at risk	3,086	60,422	101,946	144,877
Individuals	7,211	7,211	7,211	7,211
Deaths	401	868	1004	1596

Note: Exponentiated Cox proportional hazard model estimates.
Preterm reported as preterm at birth, head circumference <34cm, length at birth <49cm, birth weight<2500gm, or nails shorter than a fingertip. *Complications* at birth are newborns for which mothers protein in urine found, doctor was present at birth, hand inducement implemented, birth delivery instrumented, any drugs were used, mothers bleeding after delivery >1000kbcm, and mother's body temperature after delivery >=38 °C or she had a fever. Individuals both preterm and mother had complications at birth are included in preterm category. *Full term* is otherwise. *Rich* are elite, middle class and large- and medium-scale farmers; *poor* are low-scale farmers, low- and unskilled farm and industry workers. For the previous treatment, all births including stillbirths are considered. *Older sibling qualified* denotes individuals for which any of older siblings was treated by a qualified midwife. *HighIMR* refers to years of birth with IMR above long-term trend calculated using Hodrick-Prescott filter, *LowIMR* is otherwise. *Family size* is measured with a total number of children born to the mother minus one.

P-values in parentheses † <.10, * p<.05, ** p<.01, *** p<.001

Table 7 – Fertility in relation to treatment by a qualified midwife at previous birth delivery, mothers of southern Sweden cohorts 1881-1930

	2+ order births	**2-4 order births**	**5+ order births**
previous birth delivery traditional (ref)	1.000	1.000	1.000
previous birth delivery qualified	2.701***	3.659***	1.053
	(0.000)	(0.000)	(0.641)
Person-years at risk	21,071	15,711	5,360
Females	3,164	3,164	593
Births	3974	3130	844

Note: Exponentiated piecewise constant hazard rate model estimates.
P-values in parentheses † <.10, * p<.05, ** p<.01, *** p<.001

Table 8 – Health in relation to treatment by a qualified midwife, southern Sweden cohorts 1881-1930, males

	Height	**Rejected =1**	**Diagnosed with health problems=1**
traditional (ref)			
qualified	-0.474	-0.032	-0.151***
	(0.452)	(0.348)	(0.000)
mean for reference	172.8	0.134	0.416
Individuals	890	931	931

Note: OLS regression estimates.
P-values in parentheses † <.10, * p<.05, ** p<.01, *** p<.001

Supplementary material

Table A1 – Sample attrition in relation to treatment by a qualified midwife at birth

	Observed in sample=1			
	ages 1-14	*ages 15-39*	*ages 40-80*	*conscripts*
traditional(ref)				
qualified	0.039*	0.001	-0.010	-0.007
	(0.005)	(0.999)	(0.450)	(0.696)
mean for reference	0.810	0.467	0.181	0.245
poor(ref)				
rich	0.104***	0.156***	0.063***	0.084***
	(0.000)	(0.000)	(0.000)	(0.000)
mean for reference	0.773	0.404	0.159	0.208
rich	0.104***	0.156***	0.066***	0.084***
	(0.000)	(0.000)	(0.000)	(0.000)
qualified	0.041*	0.004	0.002	-0.007
	(0.018)	(0.832)	(0.900)	(0.765)
qualifiedXrich	-0.003	-0.004	-0.018	0.002
	(0.900)	(0.892)	(0.458)	(0.943)
Individuals	7,211	7,211	7,211	3,737

Note: OLS regression estimates. *Observed in sample* refers to individuals appeared in the corresponding age group or sample. Individual controls include year of birth (dummies), parish of birth, SES at birth and sex.

P-values in parentheses † <.10, * p<.05, ** p<.01, *** p<.001

Table A2 – Mortality in relation to treatment by a qualified midwife at birth without and with mother fixed effects, southern Sweden cohorts 1881-1930

	<28days	**age<15**	**age<40**	**age<80**
Mothers' pooled sample				
traditional (ref)	1.000	1.000	1.000	1.000
qualified	0.518†	1.410	0.668	0.977
	(0.051)	(0.155)	(0.319)	(0.905)
traditional (ref)	1.000	1.000	1.000	1.000
full-term&qualified	0.270***	1.447	0.379†	1.025
	(0.003)	(0.144)	(0.060)	(0.909)
preterm or complications&qualified	1.622	1.025	2.236	0.867
	(0.263)	(0.961)	(0.130)	(0.641)
Mother fixed effects				
traditional (ref)	1.000	1.000	1.000	1.000
qualified	0.528†	1.828*	0.919	1.160
	(0.058)	(0.010)	(0.837)	(0.504)
traditional (ref)	1.000	1.000	1.000	1.000
full-term&qualified	0.248**	1.896*	0.554	1.327
	(0.003)	(0.010)	(0.260)	(0.269)
preterm or complications&qualified	1.567	1.149	2.424	0.946
	(0.366)	(0.795)	(0.119)	(0.868)
Individuals	1,298	1,298	1,298	1,298
Deaths	57	145	176	318

Note: Exponentiated Cox proportional hazard model estimates. Controls include year of birth (linear), sex, and, in case of mother fixed effects models, mother's identification number (dummies). Each model, except for the model for neonates, includes a control for the effect of the qualified midwifery in the previous age (qualifiedXbefore 28 days, qualifiedXbefore age 15, or qualifiedXbefore age 40, respectively).
P-values in parentheses † <.10, * p<.05, ** p<.01, *** p<.001