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

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**Abstract**

This paper explores the long-term effects of being born with the assistance of a qualified midwife on health and skills, using longitudinal register-based data for individuals born in rural Swedish parishes between 1881 and 1930 and followed from birth until age 80. In the setting of home deliveries, midwives strictly followed hygiene instructions and monitored the health of the mothers and newborns for 3 weeks after birth, and the study observes these individual-level treatments. The results from empirical strategies controlling for observables, using instrumental variables and mother fixed effects are consistent. This paper first finds that treatment by qualified midwives at birth reduced neonatal mortality. It further concludes that individuals treated by qualified midwives at birth had substantially lower mortality from cardiovascular diseases and diabetes at ages 40–80 and that males had lower morbidity and better skills at ages 19–21 than those treated by traditional birth attendants.

## 1. Introduction

Every day 7,300 newborns die across the world (WHO, 2017). The majority of these deaths occur in the first week of life, mainly due to preventable and treatable causes, such as infections, birth asphyxia and prematurity. Neonatal deaths constitute an increasing proportion of child deaths (46% in 2016), because, in the recent decades, the decrease in neonatal mortality has been slower than that from the post-neonatal period to age 5. As a result of slow progress in preventing neonatal deaths, the reduction in child mortality failed to meet one of the main Millennium Development Goals by 2015, having reached a half instead of two-thirds (UN, 2015). Currently, most neonatal deaths occur in the setting of home deliveries with poor access to health services, and it has been estimated that universal coverage by low-cost and affordable services could avert up to 70% of these deaths (Darmstadt et al., 2005). In such a setting, midwifery, when provided by midwives who are educated, licensed and regulated, has been shown to be the key to improvements in neonatal and maternal health and survival (Renfrew et al., 2015). Such evidence suggests that, if every umbilical cord could be handled with disinfection, the number of neonatal lives saved could reach a million. The effective actions for contemporary global initiatives, such as the Global Strategy for Women's, Children's and Adolescent's Health and the Every Newborn Action Plan, together with the UN 2030 development agenda, prioritize skilled delivery by midwives and the availability of emergency obstetric facilities as solutions to high neonatal mortality.

The individual-level outcomes of quality midwifery could extend beyond the short term. Microeconomic theoretical models suggest that favourable environmental conditions surrounding birth and childhood, among other health inputs made in early life, directly improve health and skills in an individual's adolescence and adulthood (Cunha et al., 2006; Cunha and Heckman, 2007). Similarly to other components of human capital, early-life health determines the accumulation of later-life health and skills, and facilitates productivity of childhood investment, eventually leading to higher incomes in adulthood (Heckman, 2007). However, formation of health capital supposedly begins at the earliest stages of an individual's life and has limited opportunities for remediation in late childhood, unlike with other components. Benefits from better conditions and health in early life could be also latent until adulthood and then result in decreased morbidity and mortality risks due to certain chronic diseases, most consistently due to cardiovascular disease (Kuh and Ben-Shlomo, 2007). An individual's health should therefore be studied from a life-course perspective, where the roles of biological and socio-economic pathways between early life and adulthood are illuminated. The basis for the current empirical microeconomic investigations has been laid down by the previous epidemiological research that consistently demonstrated strong associations between early-life environmental conditions, such as exposure to infection, malnutrition or poor socio-economic status in childhood, and later-life health and cognition (Strauss and Thomas, 2008).

Recently, from microeconomic empirical studies, we have also begun to learn that altering the environmental conditions with beneficial or policy-driven treatments is linked to alterations in an individual's later-life outcomes (Almond and Currie, 2011; Currie and Vogl, 2013; Currie and Rossin-Slater, 2015). The current paper contributes to this literature in several ways. This paper explores the effects of treatment by a qualified midwife in a very narrow time window — at birth and for 3 weeks after birth — on mortality, morbidity and skills throughout the entire life course of the individuals (from birth until the age of 80), being a pioneering study of such kind. The regulations put forward starting from 1881 in Sweden prescribed rural midwives to apply careful hygiene instructions at birth and monitor the health of mothers and their newborns in conditions of both home childbirth and the public provision of qualified midwifery. An alternative treatment – by traditional or no midwives – included harmful health behaviour, such as the transmission of infectious disease and other forms of misconduct at childbirth. As one contribution, this paper studies the long-term health effects of treatment by qualified midwives, which appears to be the first historical public health initiative that benefited neonates and which has not been investigated previously from such an angle. Another contribution is that, rather uniquely, information about the treatment by midwifery is available at the individual level. Overwhelmingly, previous studies have investigated the consequences of public health initiatives at the group level, with a long period of exposure and multiple treatment components, which, as a disadvantage compared with the current paper, makes it difficult to discern whether some developmental periods are critical to beneficial treatments and which kind of early-life treatments have a strong influence on individuals' future health. Finally, due to the use of recent data with limited age depth, previous studies have tended to follow people in their outcomes for a short period, at best until late childhood or young adulthood. A follow-up until late adulthood or old age, as performed in the current study and emerging as its additional contribution, is necessary to allow the treatment effects, which are supposedly latent until these stages, to be realized fully.

This study applies several empirical approaches to study the effect of qualified midwifery on health and skills from birth until the age of 80. The data for this study is obtained from the rich high-quality individual-level dataset, where I observe a total population in a compact rural area in southern Sweden born between 1881 and 1930 (Scanian Economic Demographic Database [SEDD], Bengtsson et al., 2014). One approach is to estimate the treatment effect of midwifery, identified at the individual level, while controlling for a variety of community, family, mother and individual characteristics, usually lacking in the existing studies with such a long follow-up. Additionally, I am applying an instrumental variables (IV) approach by exploiting geographical and cohort variation in the number of qualified midwives employed by the community as an instrument for the individual-level treatment by midwifery, which allows me to control for the potential influence of unobserved confounder variables. One more approach used in this paper is to apply a mother fixed-effects (MFE) method, thereby comparing the outcomes between siblings who are treated and untreated by qualified midwives at birth, which should eliminate the possibility of confounding from shared family and mother background characteristics, both observed and unobserved. Based on these approaches, this study consistently finds that having a qualified midwife at birth and for 3 weeks after birth leads to a 49%–61% lower mortality risk in the neonatal period. In the long term (ages 40–80), such early-life treatment leads to a 35%–55% decrease in mortality risk due to cardiovascular disease and diabetes. Long-term effects already emerge in young adulthood, because males (aged 19–21) treated by qualified midwives have lower morbidity and better skills as well as both males and females (aged 15–39) having lower all-cause mortality, although the latter effects are not consistently robust. This paper demonstrates that treatment from neonatal conditions to human capital later in life is not modified by individuals' socio-economic conditions, measured in childhood and adulthood. The long-term effects stemming from treatment by qualified midwifery at birth and for 3 weeks after birth are at least as large as those previously demonstrated with regard to the importance of the in-utero environment.

The paper is organized as follows. Section 2 provides an overview of the related microeconomic empirical literature. Section 3 describes the setting under study. Sections 4 and 5 provide detailed discussions of the data and methods. Section 6 reports the results obtained following the approaches described as well as those that shed light on the mechanisms behind the long-term effects. The paper ends with a discussion and conclusions in section 7.

## 2. Previous research

In large part, evidence on importance of qualified midwifery for survival of newborns and their mothers is based on studies for Sweden and other industrialized countries. Due to bacteriological breakthroughs in the 1870s–1880s, both improved hygienic techniques and health monitoring were introduced into skilled childbirth practice in countries in Northwestern Europe. The policy mechanism put forward is a long tradition of home deliveries by well-trained and well-supervised midwives who consistently used antiseptic techniques and other preventive measures from the time they were introduced (Andersson et al., 2000; Woods, 2000). In addition, competent midwives were employed by the local communes and provided to patients at almost no cost. Several micro-studies in Sweden, for which data are available far back in time and which are able to isolate the effects of midwifery from other potentially important influences, have shown that beginning from the time that educated public midwives arrived in the parishes maternal mortality (in 1830–1894) and infant mortality (in 1894–1925) decreased substantially (Pettersson-Lidbom, 2015; Lazuka et al., 2016). Licensed midwifery, supposedly due to antiseptic use and cleanliness, handling birth complications and encouragement of breastfeeding, led to modest reductions in non-white infant mortality in the US between 1900 and 1940 (Anderson et al., 2016). Based on a contemporary developing setting, recent studies show that expansion of access to midwives, who provided pregnancy, childbirth and postnatal healthcare services across rural villages, led to short-term improvements in height in early childhood (Frankenberg et al., 2005) and in cognitive performance in late childhood (Cas, 2012).

To date, the long-term, those beyond childhood, health effects of development of qualified midwifery have not been previously investigated. Nevertheless, the applied microeconomic literature studying the consequences of various early-life health and environmental conditions has recently expanded (Strauss and Thomas, 2008; Almond and Currie, 2011), with the most recent literature exploiting policy-generated treatments. Related to the current study, a few studies exploring the long-term effects of health care infant programmes with a large home-visit component initiated in the 1930s in Scandinavian countries have shown beneficial effects on all-cause mortality and mortality from cardiovascular and infectious diseases at ages around

40 until 70, and less consistently on education and income (Bütikofer et al., 2015; Bhalotra et al., 2017; Hjort et al., 2017). While the programmes had multiple components, the scholars suggest that preventive care, better hygiene, and nutrition were among the most influential. Several studies explicitly point to the income or nutrition enhancement, not public health, as a source of better adult outcomes. For instance, access to cash transfers in childhood, due to the mother's pension programme in the US in 1911–1935, among disadvantaged families led to lower all-cause mortality in old ages of survivors (Aizer et al., 2016). Resulting from another, more recent, intervention, better access to food in early childhood owing to the food stamp programme in the US between 1961 and 1975 has been found to have positive effects on the incidence of metabolic syndrome in adulthood, with strongest effects for treatment in pre- and postnatal periods (Hoynes et al., 2016). In a review of studies exploring the effects of the most recent early-life programmes, Currie and Rossin-Slater (2015) conclude that public health insurance and nutritional and home-visiting programmes targeting infants were among the most efficient in terms of health outcomes, and that the bulk of the effects, usually to be found in late adulthood, is yet to come.

The explanations for the long-term effects originating from better early-life health demonstrated in the microeconomic studies are to be found in the medical literature. Early on, based on the analysis of individual birth records from hospitals and midwifery journals throughout the archives in Britain connected to death certificates, Barker et al. (1989) and Barker (1994) showed that low weight at birth and during infancy and exposure to respiratory or diarrhoeal infections during infancy predicted death from cardiovascular disease, diabetes, and lung obstructive diseases in adulthood. Whereas in later works Barker strongly emphasised the importance of intrauterine environment, other scholars have claimed the relative importance of exposure to infectious diseases early in life, especially in infancy (Finch and

Crimmins, 2004; Crimmins and Finch, 2006). Better hygiene and reduced exposure to microbial infectious diseases in the early neonatal period are associated with early atherosclerotic lesions and chronic inflammatory markers in adulthood, which, in turn, are predictive of risks of cardiovascular and metabolic diseases (Willerson and Ridker, 2004; McDade et al., 2010). The level of maternal and midwifery care, such as time spent nursing, in the early neonatal period could have a critical influence on the development of stress response and may alter the long-term inflammatory process with links to chronic diseases (Miller et al., 2011; Danese and McEwen, 2012). Early detection of health problems through measurements at childbirth performed by midwives could help to divert additional maternal resources from a healthier mother to the child, especially those fragile at birth, potentially discouraging the development of future disease (Calkins and Devaskar, 2011). Direct inputs could also occur due to better maternal health and survival resulting from skilled childbirth assistance. All environmental factors acting in early life, in particular prolonged breastfeeding, can affect almost any aspect of the immune system leading to a decreased later-life risk of cardiovascular disease and diabetes (Andersson et al., 2009; Leifer and Dietert, 2011).

## 3. Setting

The individuals analysed in this study were born in five parishes (Kävlinge, Hög, Halmstad, Sireköpinge, and Kågeröd) located in close proximity to each other and approximately 10 km from the coast in western Scania, Malmö county, the southernmost province of Sweden. These parishes remained rural until the 1890s and afterward began to invest in the building of a railway network and markets, leading to partial rural-located industrialisation of the area (Bengtsson and Dribe, 2010a). From 1880 to the 1910s, the total population residing in the parishes grew from 4,900 to 6,500, mainly due to an inflow of industrial workers, and stayed constant afterwards. The occupational structure of the labour force also shifted towards a higher share of professional, administrative, and managerial workers and a lower share of agricultural workers (Dribe et al., 2015). Only one provincial doctor took care of the rural parishes until 1889, and by 1900 the parishes belonged to local health districts with locally employed health district doctors, one in Halmstad, Sireköpinge, and Kågeröd (administered by the neighbouring parish Teckomatorp), and another one in Kävlinge and Hög (Lazuka et al., 2016). In addition to doctors, new qualified midwives were employed by the communes. Until the late 1930s, all birth deliveries were carried out at home with the help of midwives. Local epidemical hospitals existed, which served to isolate the sick and provide their supportive cure and never admitted women in labour. The share of deliveries occurring in maternity hospitals located in the neighbouring cities grew after this period. The reader can consult Appendix A for a comparison of parishes across the array of socio-economic and demographic characteristics.

By the 1870s, a special ‘quackery paragraph’, allowing traditional birth attendants to assist in childbirth in the case of a shortage of qualified midwives in rural parishes, remained in the otherwise strict state regulations of midwifery in Sweden (Högberg, 2004). By the 1880s, the education of a qualified midwife, eligible to use obstetrical instruments, lasted two years, including both theoretical training in bacteriology and practical exercises, and was more than twice as long as a basic course in manual childbirth (Lundquist, 1940, 138–140). Newly graduated midwives overwhelmingly stayed in the cities, which were obliged to employ only qualified midwives. As a result, until the 1930s, throughout rural Sweden, the majority of women delivered their children with the assistance of traditional midwives, whereas skilled deliveries were rare, barely covering one-third of total births. After the establishment of the provincial doctoral districts starting from the 1880s, newly assigned doctors in different parts of the country documented the presence of numerous traditional practitioners working throughout the areas but regarded them as a common feature of rural life (Vallgårda, 1996). The availability of qualified midwives in the southern region was worse than that in the rest of rural Sweden, amounting to a ratio of one to six, mainly due to closer proximity to the midwifery school in Lund that educated only in basic childbirth (see Figure 1; Banggaard, 2002). The doctors in the area under study observed the difference in competences of different midwives in practice: traditional midwives were usually not competent in the use of antiseptics and other preventive measures, managing birth complications and in medical knowledge that 'modern circumstances required' (Regionarkivet Lund, 1900–1930). Unqualified midwives were also prohibited from using obstetrical instruments.

[Figure 1]

Regulations put forward from 1881 by the Swedish authorities assigned midwives' duties related to the prevention of infectious diseases in the birthing environment. These regulations not only improved the services performed by acting qualified midwives but also encouraged the local administration to employ new ones. Such new recruitment became necessary, because the authorities recognized the resistance of the traditional midwives, who were experienced and respected, to radical innovations in delivery practices (Öberg, 1996). More specifically, in 1881, owing to bacteriological discoveries, the antiseptic law obliged qualified midwives to use strict hygiene techniques during home deliveries in rural areas (Högberg, 2004). These regulations also prescribed each qualified midwife to keep detailed clinical records on all deliveries using a standardised form, a midwife diary (*Barnmorskans dagbok*). Included as an introductory part of a midwife's diary, the National Health Board's 13 June 1881 circular provided detailed instructions for qualified 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 ensure 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 the elbows and instruments should be washed*

> *with soap and sterilized with carbolic acid. 5. If a treated woman develops puerperal sepsis, a midwife should … avoid practicing for a week* (Svensk författningssamling, 1881).

With such a manual, the state regulations intended to abandon the old system that assigned doctors' duties to midwives in addition to childbirth. In this system, traditional midwives participated in inspecting and treating infectious diseases by means of bloodletting, cupping and supportive care, thereby being carriers of disease rather than curers, and their participation in childbirth could transmit infection to both a mother and a child (Öberg, 1996). Other components of potentially harmful health behaviour conducted by traditional midwives included the misuse of drugs, the induction of miscarriage, the manual hastening of delivery and the use of certain surgical procedures during childbirth despite the ban. Within the reformed midwifery, the treatment of the sick was assigned to medical nurses or community doctors, who also controlled and supervised qualified midwives in their childbirth duties. In addition to cleanliness at childbirth, regulations strengthened the importance of hygiene and disinfection of the umbilicus. In 1914, qualified midwives began to disinfect the eyes of newborns with silver nitrate, a technique known as Credé's prophylaxis, to prevent neonatal blennorrhoea (Ericsson, 1990). Midwives' notes had to be kept carefully, reported to the community doctor, and, when midwives used instruments, registered by the higher health authorities. To perform their service, qualified midwives had an employment contract with a parish or, rarely, with a group of parishes and could serve only within an assigned area, and a diary was kept to provide the detailed accounts of this local service (Lundquist, 1940, 117).

In addition to improved hygiene, qualified midwifery included not only highly skilled assistance of childbirth but also health monitoring of the infant and the mother (see Figure 2). Qualified midwives became a source of information about infant care because they were able to recognise childhood diseases and were obliged to give prescriptions about early and prolonged breastfeeding, necessity of boiling milk, and the isolation of infants from sick family members. Moreover, by the 1880s, midwifery childbirth competences were extensive, enabling midwives to handle birth complications and save preterm neonates. More specifically, the skilled delivery included the use of manual delivery techniques and obstetrical instruments, as well as surveillance of the third stage of labour. In 1914, the monitoring period after delivery of the lying-in woman and child was extended from 10 days to three weeks, and the child's health at birth began to be checked and measured more thoroughly. Qualified midwives began to provide women in labour with calming, pain-relieving and fever-reducing drops, analyse protein in the urine to diagnose eclampsia, and resuscitate a neonate in cases of perinatal asphyxia and prematurity. The qualified midwives had to purchase all the medical and disinfectant items by themselves from their own salary, with a receipt signed by a health district doctor, and usually received a refund from the commune. These regulations imposed restrictions to the use of the delivery means among traditional midwives, who were also not properly educated. For a long time, drugstores existed only in the large cities, which were located between 10 and 30 km away, whereas closer to the area under analysis, one pharmacy was opened in 1905 in Kävlinge and one in 1912 in a parish neighbouring with Sireköpinge (Statistiska Centralbyrån, 1870–1946). In the period under study, midwives did not assess women during pregnancy. This system stayed unchanged until the late 1940s, when together with the introduction of the maternity hospital system, the duties of public midwives evolved into prenatal and infant care (Sundin and Willner, 2007, 155).

[Figure 2]

## 4. Data

### *4.1 Individual-level demographic and socio-economic data*

In this study longitudinal individual-level data, further linked to individual data from midwife reports, were obtained from the SEDD, version 4.0 (Bengtsson et al., 2014), which cover the total population in the five parishes under study. Individuals were observed within the parishes until 1968, and after 1968 were tracked across the entire country based on personal identifiers through Swedish national registries and using data from Statistics Sweden. This allows me to follow individuals throughout their entire life course, beginning from birth, or even pre-conception, to old age, and to take into account their community-level, family-level, and maternal information. The quality of the data, where family reconstitutions were performed using register-type data, is high and discussed elsewhere (Bengtsson and Dribe, 2010b). It enables me to obtain various maternal indicators, including maternal birth history, survival status of older children, marital status, and age at childbirth. The annual data on individuals' occupations and land ownership are also included in the database and further classified into socio-economic groups, measured consistently over time, such as a historical international social class scheme (HISCLASS, van Leeuwen and Maas, 2011). In addition to parish of birth, this information provides measures of socio-economic class in childhood (based on parental data) and in adulthood. Based on HISCLASS, this study distinguishes among elite (classes 1 to 5), skilled workers (classes 6 and 7), farmers (class 8), and industrial and farm workers (classes 9 to 12), and it takes into account information on landholdings to distinguish more precisely between farmers and farm workers. For males, the database contains information from universal conscripts' inspection records, linked to the data, such as height and health diagnoses, undertaken by doctors, and indication whether the individual had any certificates or skills, checked and complemented at the interviews (see Öberg, 2014 for the quality of the data).

In addition to the date of death, the cause of death is also known from these sources. In the SEDD in the period 1881–1968, the diagnoses, which were certified by a medical practitioner according to national regulations and registered by the clergymen, are very reliable and valid. I utilised the classification of these data in terms of the cause of death rather than symptoms, which was developed by Bengtsson and Lindström (2003). After 1968, data on cause of death originated from the Swedish cause-of-death register that is based on international classifications of diseases (ICD), which are homogenous with the earlier classifications. For the main diagnoses used in this study, the validity of the long-term follow-ups is very high (Ludvigsson et al., 2011). I used the cause-of-death data for mortality after the age of 15 because the share of unknown causes among children is rather large (42% for infants, 30% for individuals aged 1–14, 4% for individuals aged 15–39, and 0.3% for those aged 40–80) and midwives could participate in the registration of a child's death. To obtain consistent cause-of-death groups, I distinguish the following: deaths from infectious and respiratory diseases (including infectious and parasitic diseases, influenza/pneumonia, chronic obstructive pulmonary disease, and other respiratory diseases), cardiovascular diseases and diabetes, and cancers. The extracted data are in intermediate data structure (Alter et al., 2009) and were changed into a rectangular episode using a programme written by Quaranta (2015). Descriptive statistics for the estimation samples are presented in Appendix B.

Across the estimation samples analysed in this study, sample attrition in general did not systematically differ between the treatment groups (see Appendix C). The presence of differences in attrition across midwifery treatment groups could introduce bias to the estimates of the treatment on the outcomes under study. Attrition due to outmigration or premature death was identical between the treatment groups for all the age groups and conscripts, except for children aged 1–14. The differential attrition in childhood can be explained by compositional differences between the treatment groups, with a 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 is more likely to be observed later on. Individuals originating 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 were similar in their likelihood to stay in the sample.

### *4.2 Midwifery diaries and community-level data*

In this study, data on treatment by different types of midwives are available at the individual level. They were obtained from local midwife reports gathered for individuals born in five parishes in rural southern Sweden between 1881 and 1930. In the database, individuals born or ever resided in the parishes analysed were searched for in the diaries of midwives directly employed by these parishes and also by the neighbouring parishes that formed joint health districts (Billeberga, Ekeby, Brödåkra, Konga, Ask, Ottarp, Svalöv, and Lackalänga). All individuals found in the diaries whose mothers resided in the five parishes under analysis were successfully identified in the subsequent population of newborns. Individuals who were not observed in these diaries were assumed to have been assisted at birth by traditional midwives or no midwives. In case some of the studied individuals treated in reality by qualified midwives are not registered, they fall into the group of those delivered by traditional or no midwife, thereby leading to the underestimation of the true treatment effects. The midwife reports contain detailed information on the type of treatment received during and after delivery, the health status of the child at birth, and the mother's health conditions during and after birth. According to the data, in each delivery, qualified midwives implemented a set of standard techniques, such as disinfection and during- and after-delivery health check-ups (see also Figure 2). Information on additional specific routines, such as the use of sharp obstetric instruments, calming drugs, and the assistance of a doctor during the delivery, was also available in the data and indicated the presence of childbirth complications rather than any exclusive treatment. In total, among those born in any of five parishes, information on 7,211 newborns is available, of whom approximately one sixth was treated by qualified midwives, and other newborns were delivered by traditional midwives or no midwives. All of these individuals were delivered at home, and the few individuals who were delivered in hospitals were not included in the estimation sample (10 individuals). The initial sample of individuals found in the midwife diaries (up until 1946) was restricted to those born between 1881 and 1930 to avoid overlapping with later public health interventions, such as the introduction of institutionalised child delivery, the arrival of antibiotics, and water supply improvements (Kommunarkivet Kävlinge, 2010, 18).

The completeness of the midwifery reports has been carefully assessed in several sources. Primarily, there is no reason to suspect that qualified midwives did not register all childbirths that they assisted. Following the state regulations, a provincial doctor extradited a personal diary to each midwife, regularly assessed the completeness of the records, and withdrew it to the community archives when the diary was filled in or the midwife relocated to another parish or retired (Regionarkivet Lund, 1881–1930b; Bäckstrom et al., 1991). In addition, the qualified midwives had an economic incentive to register births in full. According to the local ledger books, midwives received the bulk of their salary, free housing and firewood from the commune and supplemented it with a payment of approximately 1.0–1.5 SEK per assisted delivery from the parents (equivalent to 3% of monthly income in the lowest socio-economic group in the area in 1905) and subsidised by the commune for poor mothers (Kommunarkivet Kågeröd, 1876–1930; Kommunarkivet Kävlinge, 1881–1930). A more important concern is whether I had in my possession all of the midwife diaries. The individual-level demographic dataset under analysis (SEDD) provides annual information about occupations, and decennial censuses 1880–1910 contain the occupations of the residents of both of the parishes under analysis and the neighbouring parishes (Riksarkivet, 2014). The total number of qualified midwives indicated in both sources, which is 20, is equivalent to the number of midwives according to the midwifery registers. As mentioned above, the fraction of qualified midwives working in the rural parishes of the entire region of southern Sweden did not exceed 20% and resembles rather well the fraction of qualified births in the dataset under analysis. Although it is impossible to completely rule out that some midwifery diaries could be lost, as a tentative robustness check of the estimates, one can exclude cohorts where no individuals in each parish in a given year of birth were treated by a qualified midwife, which provide the same results as for the full sample (see Appendix C).

In addition to the individual-level treatment details, I gathered information on the number of qualified midwives employed in the parishes and starting dates of their contracts based on archival sources, such as daily provincial doctors' journals with correspondence and annual reports verified with annual reports of the local health boards and ledger books, which is further used to instrument the individual treatment by midwifery at birth (Kommunarkivet Kågeröd, 1876–1930; Kommunarkivet Kävlinge, 1881–1930; Regionarkivet Lund, 1881–1930a, 1881–1930b, 1881–1930c, 1900–1930). Moreover, from the dataset, I constructed various parish-level socio-economic and demographic characteristics varying by year of birth, deemed important for analysis, such as crude birth rate, mortality rate due to infectious diseases at ages 1–15, landholding (measured in productivity units, such as mantal), share of elite, share of single mother families, and share of unmarried adults. As a complement, parish-level real investment per capita for 1881–1930 comes from official statistical sources (Statistiska Centralbyrån, 1880–1917; Statistiska Centralbyrån, 1918–1930).

## 5. Methods

To study the effect of qualified midwifery at birth and for 3 weeks after birth on health and skills throughout an individual's life course, this study applies three empirical methods: controlling for observables, IVs and mother fixed effects. Whereas the first method can control for selection into treatment by quality midwifery based on observable characteristics, the latter two methods intend additionally to difference out the potential influence of unobserved characteristics on the estimates.

### *5.1 Selection into treatment by qualified midwifery*

Before I describe the main methods, it is important to investigate the factors underlying the allocation of treatment by a qualified midwife across mothers with different socio-economic and health characteristics. This will help to indicate the potential selection of certain individuals into treatment and support the importance of the empirical strategies to be applied in this study.

The journals of provincial doctors provide a local picture of qualified midwives treating the parturient women of different socio-economic classes equally (Regionarkivet Lund, 1881–1930b, 1881–1930c, 1900–1930). A midwife was called to attend childbirth after the start of the labour, with no prior agreement, implying the importance of proximity to the nearest midwife. Difficult roads and reachability of the patients occasionally impeded the timely arrival of a midwife. Qualified midwives were obliged to attend deliveries of both married and unmarried women and made an oath not to divulge the father's name in the latter case. Traditional midwives called for or gave advice to contact a qualified midwife in the case that unmanageable birth complications arose during delivery. Compared with the full security of qualified midwives, who were employed by the parish, numerous traditional midwives were often involved part time in birth assistance and held their main employment in agriculture (usually as farm servants) with low salaries. Due to this, traditional midwives were strongly committed to established clientele, 'respected customers' who [wrongly] viewed them as experienced and skilled in both assisting in childbirth and providing folk medicine. Such conditions were similar to those in the countryside of northern Sweden, where qualified midwives did not prioritize the wealthiest or more educated expectant mothers due to their principally public provision; instead, proximity to the nearest midwife and an established relationship were crucial (Curtis, 2005, 2011).

To support the a priori expectations related to the components of midwifery treatment, I examine the issue empirically. In the dataset, a fraction of qualified midwives, albeit not all, recorded a distance between their house and patients' houses and the time between the call for a midwife and her arrival. The analysis suggests no significant differences in the midwife's geographical location in terms of the various measures of socio-economic position of the family or maternal health (see Table 1). In terms of the actual receipt of midwifery treatment, the analysis shows economically and statistically significant differences in certain observable characteristics. While there is no full socio-economic gradient in access to a qualified midwife, children of farmers had higher chances of being treated by qualified midwives, probably due to opportunities to transport a midwife, than children of working-class parents, and single-parent families had lower chances. In the latter case, unmarried mothers were likely to self-select into assistance by traditional midwives, presumably fearing public dispraise. Additionally, women who were nursed by a competent midwife during their first birth tended to be nursed by her again during subsequent births, pointing to the importance of a trustworthy relationship rather than of public knowledge about both the relative complexity of the first childbirth and the skills of a qualified midwife. The fraction of newborns treated by a qualified midwife was different across some parishes, although these differences do not correlate with parish wealth and health conditions.

[Table 1]

### *5.2 Controlling-for-observables strategy*

The majority of the control variables considered below could potentially affect both treatment receipt and health outcomes, and they are therefore added to control for selection bias. For instance, if individuals raised in more affluent families and more likely to be treated by qualified midwives, and such differences are not controlled, had better outcomes, the treatment midwifery effect will be biased upwards. In contrast, if mothers were more likely to call for a qualified midwife in case of birth complications, potentially predisposing worse health outcomes for their newborns in the future, the treatment midwifery effect will be biased downwards in the model without the related controls. To implement the analysis based on controlling for observables, I first estimate several models for different health outcomes, among which an array of community-, family-, mother- and individual-level observable variables is introduced stepwise in addition to the midwifery treatment variable:

$$Y_i = \alpha + \beta \mathit{QualifiedMidwife}_i + \varphi X_i + \varepsilon_i \quad (1)$$

$\mathit{QualifiedMidwife}_i$ is defined as an indicator of whether a child was treated by a qualified midwife versus treated by a traditional or no midwife; $\varphi X_i$ denotes a set of control variables to be added; and $Y_i$ is health outcome at different stages of the life course (hazard of death at different ages, height, rejected at conscription for being unfit, and diagnosed with disease). *Individual-level control factors* include birth year (linear), sex, and parish of birth (Kävlinge, Hög, Sireköpinge, Halmstad, or Kågeröd). The results stay essentially unchanged if year-of-birth dummies are used instead of the linear variable, although I prioritize the latter due to the relative scarcity of events (deaths) per parameter to be included into the model (see e.g. Ogundimu et al., 2016). *Parish-of-birth control factors* include crude birth rate, mortality rate due to infectious diseases at ages 1–15, landholding, share of elite, share of single mother families, share of unmarried adults, and real investment per capita, all varying by year of birth. *Maternal health at birth factors* control for maternal health prior to/at birth, such as indicators of previous birth (first born/previous child singleton/multiple/stillbirth; all previous children survived/any dead/no previous children), maternal age (younger or at the age of 32/older than 32), and indicators of the current birth (current birth singleton/multiple). *SES in birth and* *childhood factors* incorporate the socio-economic class of the family, measured as a highest parental SES below age 15 (elite, skilled workers, farmers, and industrial and farm workers); the mother's marital status at an individual's birth (married/unmarried); and maternal parity at an individual's birth (first parity/second/third and higher). The use of SES at birth instead of in childhood produces the same results. *SES in adulthood* (elite, skilled workers, farmers, and industrial and farm workers) is also added.

The study considers several health and skill outcomes. The effects on *all-cause mortality* are estimated using Cox proportional hazard models (Cox, 1972). The survival to different ages, such as to 28 days or ages 15, 40, or 80, is modelled starting from birth, because in the presence of lasting effects across the life course, survival to older ages could be endogenous. To control for the treatment effect obtained at younger ages, each subsequent specification additionally introduces an interaction between the previous age group and a midwifery dummy. The test for the proportional hazard assumption for the qualified midwifery variable showed no violation in any of the models. In addition to all-cause mortality, cause of death is studied specifically for the diagnostic groups after the age of 15, for which the number of deaths was sufficient, such as *infectious and respiratory diseases* for ages 15–39, *cardiovascular diseases and diabetes* for ages 40–80, and *cancer* for ages 40–80, using the Fine–Gray competing risk regression (Fine and Gray, 1999). Because evidence regarding early-life origins of cancer mortality is more tenuous compared to the above cause-specific outcomes (Potischman et al., 2007), one should expect the effect of quality midwifery to be more attenuated or absent for this category. The morbidity outcomes, available for males aged 19–21, are also analysed including *height* (in cm), inspection outcome (*rejected due to unfit/accepted*), and an indication of being diagnosed with a disease based on the doctor's examinations (*has any disease/not*). Moreover, skills are measured as a dichotomous variable indicating whether a conscript was *skilled or not*.

Regardless of the availability of numerous child characteristics, already added, other plausibly important factors are not captured in the data, largely the mother's and midwife's preferences, plausibly leading to upward bias, and direct measures of prenatal health, plausibly leading to downward bias. When implementing a strategy controlling for observables, selection into treatment due to observable characteristics is probably informative of the full set of the possible characteristics that have the potential to influence the results. Under this strong assumption, the stability of the coefficient estimates for quality midwifery to the inclusion of different sets of observed characteristics across specifications could signal that the unobserved confounder bias is limited. Further approaching the issue and relying on the above assumption, I calculate Altonji et al. (2005) (AET) ratios for each outcome that measure the amount of selection on unobservables relative to selection on observables required to eliminate the treatment effects of quality midwifery. Nevertheless, ideally one should estimate the models with the expectation that the behaviour of the unobservable characteristics could differ.

### *5.3 IV strategy*

One credible method that should eliminate the potential influence of the unobservable confounder variables applied in this paper is the IV approach. I consider one instrumental variable: the number of qualified midwives employed at the parish and year of birth (see Figure 3). Similar geographic-level variables were successfully used as instruments in the previous research (e.g. review in Skinner, 2012). In the area under study, the number of qualified midwives ranges from zero to four, reaching the highest number in some parishes by 1920, and exhibits an increase in each parish over time, with even one midwife making a difference in such small parishes. The share of qualified midwives in the number of women of childbearing age is discontinuous in the same years as for the number of midwives. The rationale for the use of the number of midwives as an instrument is that individuals would have a higher chance of being treated by a qualified midwife at birth in parishes and years of birth in which the number of qualified midwives is higher.

[Figure 3]

Historical records suggest that variation in the local number of midwives should be seen as being related to supply shocks rather than to the demand for midwives. The first qualified midwives were employed in the parishes after an investigation performed by the higher health authorities in Malmö county that concluded the impossibility of educating and disciplining privately acting midwives (Regionarkivet Lund, 1881–1930b). According to the doctors' records, traditional midwives, with a few exceptions, had their 'own rural understanding of cleanliness and dirtiness' that did not meet the strict hygiene standards, had obsolete training in childbirth and newborns' recovery and were usually old. Furthermore, almost every traditional midwife caused negative outcomes in her practice, such as an injured newborn or maternal death. In these conditions, health boards recommended newly graduated midwives and refused to finance repetition courses for traditional midwives, thereby prioritizing knowledge of modern obstetrics over limited practical experience (Regionarkivet Lund, 1881–1930a). Since 1881, doctors serving the parishes under study examined the competences of the practising midwives on an annual basis, evaluated the fatalities during childbirth and made a decision about the necessity for repetition courses designed to teach progress in childbirth or to employ new qualified midwives. Additionally, some employment was encouraged by the appointment of health district doctors lobbying for greater availability of skilled personnel. One more factor encouraging the local supply of midwives was epidemic outbreaks. The rise in infant mortality due to diphtheria and whooping cough in the parishes in the 1900s was linked to sudden outbreaks rather than to unsatisfactory general health care and encouraged new recruitment to prevent the spread of disease. The high frequency of quackery cases and the subsequent dissemination of infectious diseases demonstrated the relative proficiency of qualified midwives and stimulated new recruitments. For instance, extra midwives were hired in 1919 after a doctor investigated several cases of maternal and neonatal death: a traditional midwife, presumably a carrier of disease, conducted an internal examination of an expectant mother before a qualified midwife arrived, and the careful procedures implemented afterwards became useless (Regionarkivet Lund, 1881–1930c).

In addition to qualitative evidence, to be valid, the IV strategy with a number of qualified midwives as an instrument has to satisfy several assumptions. Quantitative tests for the instrument, reported further for each model, suggest that it is not weak: in terms of the magnitude, employment of one additional qualified midwife (around one SD) leads to at least 17.4% higher chances to be treated (around a half of SD, p-value 0.000, 95%CI 0.152–0.196, F-statistics 234.8). I correlate the instrument with parish-of-birth characteristics and find that it is positively associated only with crude birth rate and not with wealth or any other socio-economic characteristics of the parish (see Table 2). The number of qualified midwives in the parish is outside of the control of the individual: qualified midwives, as mentioned earlier, were employed at the parish with a contract under control of a public doctor, public and judicial authorities and served strictly the supervised areas. In order to enhance the plausibility that the instrument, conditional on observable characteristics, is independent of confounders (untestable, 'independence' assumption), I estimate the IV models in same set of specifications, including various community-, family-, mother- and individual-level characteristics as exogenous covariates. Additionally, I make the 'exclusion restriction' assumption, also untestable, that the sharp employment of additional qualified midwives does not have an effect on later-life health other than through the assistance at the individual's birth. It is deemed to be a highly plausible assumption due to several considerations: (a) a qualified midwife was not allowed to participate in general health care other than childbirth; (b) a qualified midwife had to perform surgical operations by herself in the case of birth complications, rarely requesting a doctor's presence; and (c) in the pre-antibiotic period, both midwives and provincial doctors had no means to cure infectious diseases, and no other public health initiatives occurred in parallel (Lazuka et al. 2016). A formal test of this exclusion restriction assumption, reported below, also suggests that it is likely to hold.

[Table 2]

In this study, the IV approach was applied using two methods: control function method (also called two-stage residual inclusion method, 2SRI) for all-cause and cause-specific mortality and the linear two-stage least squares method (2SLS) for conscript outcomes, such as height, morbidity (having any disease and being rejected for being unfit) and skills. The 2SRI method has been shown to yield consistent estimates among different IV-based approaches for non-linear models, including duration models (Terza et al., 2008; Terza, 2017), which are used in this study. More specifically, I estimate the following model:

$$Y_i = \alpha + \beta \mathit{QualifiedMidwife}_i + \varphi X_i + \eta \mathit{res}_i + \nu_i \quad (2)$$

where $\mathit{res}_i$ is residual from linear regression of $\mathit{QualifiedMidwife}_i$ on *number of qualified midwives* at parish-of-birth and year-of-birth level and exogenous covariates presented before, the same at first and second stages. The models with decadal fixed effects provide similar results for the point estimates, although I choose a linear year of birth due to efficiency (see discussion in Garrido et al., 2012). The estimate for $\mathit{res}_i$ will also provide the direction of unobserved confounder bias, and its statistical significance will suggest whether the variable $\mathit{QualifiedMidwife}_i$ is indeed endogenous. Because for fully linear models 2SRI estimates are equivalent to 2SLS estimates (Klungel et al., 2015), I apply the latter method in its traditional form for conscripts' morbidity outcomes. These models additionally introduce *age at inspection* among the individual covariates. When satisfying the assumptions, the IV method estimates the average 'marginal' effect of treatment by qualified midwifery at birth over the range of values of treatment across the IV groups.

### 5.4 *MFE strategy*

Another useful method for solving the potential problem of the unobservable confounder variables in this paper is the MFE approach. Using an MFE regression, I compare the outcomes of siblings who differ in their midwifery treatment status but share the same mother and household, thereby controlling for confounding due to both observed and unobserved factors that do not vary between siblings, including parenting style and genetic predisposition (see e.g., Strauss and Thomas, 2008). In this extremely strict examination, I additionally supplement the model with family and mother characteristics that vary between siblings to exclude the influence of residual confounding. It is reasonable, in addition to individuals born in 5 parishes in 1881–1930 and already included in the sample (7,211 individuals), to consider siblings born before 1881 who migrated from rural parishes and siblings born from 1881 who migrated from parishes that formed joint health districts (3,356 individuals), because their treatment status is also known from the database. The model to be estimated is as follows:

$$Y_i = \alpha + \beta \mathit{QualifiedMidwife}_i + \varphi X_i + \mu_m + \tau_i \quad (3)$$

where $\mu_m$ are MFE. $\varphi X_i$ denotes control variables, such as parish and year of birth, SES at birth and maternal marital status, which are identified for families that have differences across these variables for their children. Adding more control variables produces similar results. In addition to changing circumstances, parents could respond to better infant health, and to elaborate the issue I study the impact of being assisted at previous childbirth by qualified midwifery on the fertility of the mothers for second and higher-order births using piecewise constant hazard rate models with six-month periods for the baseline hazards truncated at eight years. Other mechanisms behind the midwifery treatment effects are studied by investigating the heterogeneity of the effects across various subpopulations.

## 6. Results

### *6.1 Controlling-for-observables estimates*

Figure 4 presents the raw cumulative hazards of death distinguished by the differences in midwifery treatment. The curves show that the cumulative risks of dying were much lower by age one for the individuals treated by qualified midwives compared to those treated by traditional or no midwives. They also suggest the development of additional advantages from treatment at birth in middle adulthood and in older ages. In midlife, this cleavage was achieved by both an accelerated accumulation of deaths among the individuals treated by traditional midwives and delays in deaths among cohorts treated by qualified midwives. In old age, the deaths of individuals treated by qualified midwives at birth are postponed. Obviously, the cumulative hazards might be affected by the entire range of potentially observed and unobserved covariates, whose influence the models below take into account.

[Figure 4]

Table 3 displays the estimates from the models for all-cause mortality at the chosen age thresholds, as estimated stepwise by adding the different control variables. The models for mortality in the first 28 days of life show significant favourable effects of treatment by a qualified midwife on the mortality risk of newborns, with a decrease of at least 49% across different specifications. The bivariate coefficient for qualified midwifery was slightly attenuated by adding other control variables, although the difference between treatment coefficients is not statistically significant. In the models for all-cause mortality under age 15, the estimates show that individuals treated by a qualified midwife did not obtain an additional advantage in terms of lower mortality throughout childhood in any of the specifications. This suggests that the effects might be latent until older age.

[Table 3]

Throughout the life course, the results for all-cause mortality in adulthood (below age 40) and old age (below age 80) suggest that individuals have an additional advantage from treatment by qualified midwives. The coefficients for qualified midwifery are strongly negative, at least at a 40% lower risk of dying for the analysed cohorts, although statistically significant only at 10% significance level for ages 15–39. The bivariate association between the qualified midwifery dummy and hazard of death in adulthood reduces mainly after adding individual-level controls, and in other specifications stays similar. The reader can observe that the last model additionally controls for socio-economic status in adulthood, and the treatment coefficient is similar to those in other models. In the models for mortality until age 80, the estimate for qualified midwifery substantially attenuates and loses statistical significance compared to a bivariate model after a set of controls is added.

Also, following the controlling-for-observables strategy, Table 4 presents the estimates for cause-specific mortality after age 15. Across the different models for mortality from infectious and respiratory diseases at ages 15–39, the coefficient for qualified midwifery suggests a decrease in the risk of dying from these causes of 42%–55%. However, this coefficient is not statistically significant in the majority of the models. The results are explained mainly by the decreases in mortality from respiratory diseases, such as pneumonia and pulmonary tuberculosis. The estimates for qualified midwifery show a strong and statistically significant reduction in mortality risk due to these causes of 33%–39% across different specifications, including confounding and mediating factors. The results for mortality from cardiovascular diseases and diabetes are driven by ischaemic heart disease and cerebral haemorrhage. The results for the mortality risk from cancer at ages 40–80 are not statistically significant in any of the specifications.

[Table 4]

Table 5 complements the analysis with results for several health outcomes obtained from the military records for males aged 19–21. The results show no systematic effects of qualified midwifery on height, and the estimates are not statistically different between specifications with various controls. Across the specifications for the probability of being rejected due to being unfit, the coefficients for qualified midwifery were of the expected sign, indicating a lower chance of being rejected at conscription, albeit not statistically significant. 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 with a disease, such as tuberculosis, heart disease, or chronic weakness. The estimates across all specifications show high statistical significance and a similar magnitude of 17%–21%, most conservative in specification with parish-of-birth factors and a lower chance of being diagnosed with health problems if treated by a qualified midwife. There is a beneficial, robust and statistically significant effect of qualified midwifery on individual skills. Individuals treated by qualified midwives had at least 10% higher probability to report acquired technical or language skills at conscription; being able to drive and handle a machine or horse, knowledge of foreign languages, or being suited for a desk duty are among the most common.

[Table 5]

The coefficient estimates reported above are rather stable across different specifications, providing the first piece of evidence that they are not likely to be influenced by unobserved confounder variables. The AET ratios, reported for each outcome and calculated – rather conservatively – relative to the results from the baseline specification with no controls, further support this indication. The threshold value equals one for this statistic, higher values indicating the unlikely case that the unobservable factors can account for the results. In my models, for the estimates with mortality outcomes, such as all-cause mortality in the neonatal period and all-cause, infectious/respiratory disease and cardiovascular disease/diabetes mortality in adulthood, the AET ratios range between 1.9 and 7.5. These ratios suggest that the influence of unobservables is required to be between 1.9 and 7.5 times greater than the influence of observables to explain the entire effect of quality midwifery. As for the conscript outcome ‘diagnosed with disease’, the ratios are largely negative, suggesting that the unobservable confounder bias leads to underestimation of the midwifery effects. The ratios for individual skills as an outcome are slightly below one, although they are also negative compared with the models with year- and parish-of-birth controls.

### *6.2 IV estimates*

Following the IV strategy, the 2SRI estimates and first-stage estimates of the treatment by the qualified midwives compared to traditional midwives for all-cause and cause-specific mortality are presented in Table 6. In general, residual from the first stage is not statistically significant across all specifications and age thresholds, equals to more than one, and emerges to be statistically insignificant even without controls. This suggests that an array of community-, family-, mother- and individual-level covariates, already considered in the models, picks up the effects of potentially important unobserved confounders. The second-stage estimates for qualified midwifery, similar to the estimates in the models controlling for observables, suggest a reduced risk of dying in the neonatal period of a magnitude of at least 51% and in middle adulthood of a magnitude of at least 40% for individuals treated by qualified midwives compared to those treated by traditional/no midwives. Similarly to previous models, the estimates for cause-specific mortality indicate a reduced risk of dying from infectious and respiratory diseases of at least 52% at ages 15–39, although the coefficient is not statistically significant in many specifications, and a reduced risk of dying due to cardiovascular diseases and diabetes, which coefficient is statistically significant, of at least 55% at ages 40–80. These results are not statistically different from those if to use a ratio of qualified midwives to childbearing women as an instrument (see Appendix F).

[Table 6]

Table 7 presents the 2SLS estimates for being treated by qualified midwives for height and morbidity outcomes of males at conscription. Whereas for height no beneficial effects from treatment at birth are found, there are statistically and economically significant effects for other outcomes. The results suggest that being treated by a qualified midwife, compared to being treated by traditional birth attendants, reduces the probability of being rejected for being unfit at conscription examination by at least 10% as well as the probability of being diagnosed with disease by at least 59%. The 2SRI estimates, equivalent to the 2SLS estimates reported here, produce positive and statistically significant estimates for residuals in the first stage for these outcomes, suggesting a downward bias in the baseline estimates. For the skills, the results are equivalent in size to those in the adjustment models, although they lose their statistical significance.

[Table 7]

The IV estimates rely on the assumption that qualified midwives influenced the health of newborns only through assistance at delivery and check-ups during the following three weeks. To challenge this assumption, one could argue that midwifery recruitment coincided with other preventive health care initiatives in the parishes or that midwives by themselves participated in their provision, each leading to improvements in environmental conditions and in child health and questioning the internal validity of the IV method. With the insight of the conventional falsification tests, I consider that the instrument, to be relevant, would not predict either the health outcomes for an unrelated population or an unrelated outcome of a treated population. In my case, it is hard to find an outcome that is potentially unaffected by qualified midwifery.

Instead, I estimate the effect of midwifery treatment instrumented with the number of qualified midwives on the all-cause mortality of fathers, who should not be affected, following them for a decade after the births of their children with different treatment statuses. Presented in Table 8, the results from models with different control variables indicate no effect of qualified midwifery on the survival of fathers, implying that the exclusion restriction assumption is likely to hold.

[Table 8]

### *6.3 MFE estimates*

Table 9 shows the MFE estimates for qualified midwifery with all-cause and cause-specific mortality as outcomes. In this strict analysis, the results support a strong decrease in neonatal mortality for newborns delivered with the assistance of qualified midwives compared with their siblings assisted by traditional or no midwives, accounting for 55% of all-cause mortality risk. The estimates for qualified midwifery for individuals aged 15–39, albeit not statistically significant, demonstrate that the risk of all-cause mortality is further reduced. Compared with the estimates without MFEs, the negative effect of qualified midwifery on mortality from infectious or respiratory diseases disappears (see Appendix H). For the ages 40–80, the MFE results show an additional strong reduction of 31% in all-cause mortality risk for siblings assisted at birth by qualified midwifery. Compared with the baseline sample, this provides a novel finding pointing to detrimental birthing conditions of older siblings added to the sibling sample. Similar to the previous results, a decrease in old-age mortality is driven by decrease in mortality from cardiovascular diseases and diabetes, with a magnitude of a 44%. Whereas the estimates of the effect of qualified midwifery on cancer mortality suggest attenuated risks, they, as before, never attain statistical significance. The MFE estimates including sex, year and parish of birth change marginally if they are supplemented with socio-economic and maternal marital status at birth.

[Table 9]

Table 10 displays the MFE coefficient estimates for different conscript outcomes. The estimates suggest that males assisted at birth by qualified midwives are on average 1.7 cm taller, 7.1% less likely to be rejected due to being unfit and 19.8% less likely to be diagnosed with any disease at conscription compared with their brothers who were assisted at birth by traditional or no midwives. The coefficient estimate for qualified midwifery in the model with a skills outcome points to an accentuated probability of being skilled, although it is not statistically significant. Otherwise, its comparison with the baseline sample should be made with some caution, as the estimates for a sample of brothers with varying treatment statuses and without MFEs emerge as similar in magnitude and statistical insignificance. Again, the inclusion of family and maternal control variables affects the results for conscript outcomes only marginally.

[Table 10]

### *6.4 Mechanisms*

The midwifery treatment had multiple treatment components (physiological components), including better hygiene and prevention of the transmission of disease, monitoring of the health of neonates and mothers, provision of information about the importance of breastfeeding and isolation of an infant, qualified assistance at delivery and the ability to take emergency actions in the case of birth complications. Furthermore, mothers or parents could respond to better neonatal health (social component). This section provides insights into these mechanisms behind the longer-term outcomes.

The treatment effects by subgroups distinguished based on the child's and mother's characteristics are studied to shed light on the physiological mechanisms behind them. According to Table 11, while in general no strong and statistically significant differences in treatment effects across different subgroups are found, there are indications pointing to certain mechanisms. The results tentatively suggest that long-term effects were generated by particular midwife competences. They show that influences from qualified assistance differ by health and delivery conditions at birth, with full-term newborns taking all benefits from delivery and gaining survival advantage in longer term and preterm newborns or those whose mothers developed complications at childbirth experiencing much worse survival trajectories. Individuals born in years with high disease prevalence are inclined to benefit more in terms of lower mortality in the first month of life and in adulthood, whereas effects for individuals born in years with low disease prevalence 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 diarrhoea, have endemic presence and therefore are transmittable to all newborns. 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 infant care due to knowledge gained if previous births were treated.

[Table 11]

To continue, I investigate whether the midwifery treatment effect comprised a social component by studying the fertility responses among the mothers of the cohorts under analysis with the different treatments during childbirth (see Appendix I). Specifications with a different set of control variables show that mothers whose previous births were attended by a qualified midwife have an approximately 1.3–2.2 times higher risk of experiencing a second or higher-order birth compared to mothers previously treated by a traditional midwife. Although maternal deaths, those occurring within 42 days of childbirth, are almost entirely focused among the women previously treated by traditional birth attendants, they are too few (16 deaths) to account for the treatment effects on fertility. Instead, these positive fertility responses, leading to the underestimation of the physiological effects from qualified midwifery, 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. It is noteworthy that the rarity of maternal death in the period in question suggests that qualified midwifery's effects on children's outcomes cannot be driven by a greater likelihood of the presence of their mothers and hence better care throughout their childhood, compared with the children whose mothers were assisted by traditional or no midwives at childbirth.

## 7. Discussion and conclusions

Beginning from the seminal work of Barker (1994) until the more recent literature, the findings on whether early-life events affect health and skills later in life are largely based on adverse exposures (Almond and Currie, 2011). The empirical literature on whether public health interventions or beneficial treatments produce lasting health consequences is limited, albeit currently expanding (Currie and Vogl, 2013; Currie and Rossin-Slater, 2015). This study advances the field by exploiting the long-term effects of beneficial treatments for a population of individuals who underwent different treatments by qualified and traditional midwives in a narrow time window in life – at birth and for 3 weeks after birth – and were followed until the age of 80. Based on empirical methods that are credible from a causal perspective, this study finds that the competences of midwives had favourable consequences not only for the survival of newborns but also for their health and skills later in lives. In the neonatal period, treatment by qualified midwifery led to a 49%–61% decrease in mortality risk. Between the ages of 15 and 39, due to this early-life treatment, surviving individuals experienced a lower risk of dying from all causes of death; in particular, the results tentatively indicate reduced mortality from respiratory diseases. The advantages in health and skills were already apparent in young adulthood, at the ages of 19–21, because males delivered by qualified midwives had a lower probability of being diagnosed with health problems (17.3%–56.4%) and a higher probability of being skilled (5.1%–12.7%). At the ages of 40–80, surviving individuals had a significantly decreased risk of dying from cardiovascular diseases and diabetes, by 35%–55%, resulting from early-life treatment by qualified midwives.

It is reasonable to benchmark the findings of this study against those pointing to the importance of the in-utero environment. Measuring prenatal conditions with birth weight, the estimates from Barker (1994) based on the British midwifery records linked to death certificates for cohorts in 1911–1930 suggest that individuals with a low birth weight had 13%–21% higher mortality from cardiovascular diseases and 54%–64% higher mortality from ischemic heart disease than others between the ages of 20 and 74. More recently, in one of the largest studies on the lasting impacts of birth weight that controlled for potential confounding by introducing MFEs, Black et al. (2007) showed that an increase in birth weight by one-third (roughly equivalent to an increase from low to average) led to a 40% decrease in mortality at age 1 and for males at conscription to a 1.7 cm increase in height and a 3.7% increase in IQ among Norwegian cohorts in 1967–1997. The investigators found that these effects were attenuated in comparison with models that controlled solely for observable characteristics. Studies for other settings, reviewed in e.g. Almond and Currie (2011) or Currie and Rossin-Slater (2015), in general have found similar or smaller effects. The provision of quality midwifery at birth and for three weeks after birth can therefore generate effects on health and skills that are at least of the same magnitude as those emerging from in-utero shocks.

This study points to certain physiological mechanisms behind the permanent effect of early-life health on health later in life. The treatment by qualified midwifery in 1881–1930 in Sweden comprised components of preventive, supportive and emergency care and the provision of information and did not include prenatal care. Such qualifications stand out in comparison with routines conducted by traditional birth attendants and are incomplete without the following consideration. Specifically, a counterfactual treatment at birth in the study's setting was likely to be detrimental, because traditional birth attendants participated in population health care, leading to the transmission of infectious disease to parturient women and their newborns, and were guilty of other forms of misconduct. Following the insight of Finch and Crimmins (2004), this study contributes to the literature by pointing more explicitly to infection and inflammation as a physiological pathway between the competences of qualified midwives and the later-life outcomes. First, quality midwifery led to sizable improvements in the environmental conditions of the individuals that were reflected in reductions in neonatal mortality, in which infectious diseases appeared to be a major cause of death. Next, the results tentatively indicate that the presence of a qualified midwife was necessary for the short- and long-term effects to emerge and that information about infant care derived from previously treated childbirth was not salutary. In addition, the long-term effects are found in the mortality risks related to respiratory and, much consistently, to cardiovascular diseases and diabetes, in strong accordance with the previous literature underlining the importance of early-life inflammation. Finally, the stability of the estimates of qualified midwifery to the inclusion of the variables of maternal health in pre-conception and pregnancy strongly supports the lasting importance of early neonatal factors.

The findings from this study suggest that a social component of early-life treatment is likely to be compensatory or absent. The effect of a qualified midwife on the mortality and health outcomes was virtually unchanged when the models accounted for a range of socio-economic pathways. The analysis rather suggests that the treatment groups were confounded by the composition of year and parishes of birth between the groups, and once these factors are taken into account the treatment effects are only marginally affected by other community-, family- and mother-level factors. The IV and MFE approaches, absorbing the potential influence of unobserved and observed confounders, produce similar strong and statistically significant treatment effects from qualified midwifery throughout different stages of the life course. Moreover, this study finds that treatment by qualified midwives led to higher fertility among the mothers of the affected cohorts, which resulted in larger families in which the children treated by a qualified midwife in the neonatal period grew up. The large families were associated with elevated pathogen exposure and resource constraints (e.g. Currie, 2009; Cohen et al., 2010), and in late childhood, this should generate an effect in the opposite direction of the physiological benefits of the midwifery treatment, rather leading to its attenuation. These findings are not only in line with previous studies linking heavy disease load in infancy to adult mortality and socio-economic position in the same area (Bengtsson and Lindström, 2003; Bengtsson and Broström, 2009) with those showing that environmental exposures severely hit historical populations (Case and Paxson, 2010), but also with studies in contemporary settings adjusting negative physiological effects for adult conditions (Galobardes et al. 2004; Cunha and Heckman, 2008).

The absence of the effects of qualified midwifery for certain health outcomes studied in this paper are seemingly consistent with the above interpretations. One of these is old-age cancer mortality, for which the coefficient estimates are economically and statistically insignificant in any specification with control variables. According to the reviews by Galobardes et al. (2004) and Potischman et al. (2007), previous studies, if they detected the effects, were able to link disadvantageous socio-economic conditions or diarrheal infections to the development of certain cancers. The compound cause-of-death category for cancer in this case represents rather an amalgam of diseases restraining the study of more specific groups. Another health outcome is height, for which the estimates of qualified midwifery, expect for the MFE estimates, are not significant. Previous studies using country-level data for Sweden have found strong associations between cohort infant mortality, as a measure of inflammation, and height, both for historical (Crimmins and Finch, 2006) and for contemporary periods (Bozzoli et al., 2009). While such evidence in general is provided for other settings based on micro data (Currie and Vogl, 2013), previous micro studies for these parishes failed to detect any effects. For instance, using the same data as in this study, Öberg (2015) found that the effects of exposure to infectious disease or nutritional shocks in infancy of the 1814–1948 cohorts on height at conscription were weak and not robust to abundant socio-economic controls and MFEs. The use of micro data for height and controls for living conditions may therefore lead the country effects to disappear, implying that they are related to confounding. In addition, it has been acknowledged that height in non-genetic components is influenced by the interaction between nutrition and disease claims in childhood, those with a diarrheal manifestation being the most important (Elo and Preston, 1992). Both the absence of a socio-economic component in the long-term midwifery effect and a particular disease panorama, in which respiratory diseases prevailed and diarrheal diseases accounted for one-tenth of neonatal deaths, might preclude the lack of a midwifery influence on height and cancer in this study. Conversely, the exposure to respiratory infection in the first six months of life has been found to have long-term effects on mortality (Quaranta, 2014), and prevention aiming to stop the spread of this disease, like the use of antiseptics by midwives and isolation hospitals, has been successful with regard to neonatal mortality (Lazuka et al., 2016).

The findings of this paper could be extended far beyond the local population of five parishes in southern Sweden. For the cohorts under analysis, the setting experienced similar health development, including the disease environment and cohort life expectancy, and – despite its predominant orientation towards grain production – similar socio-economic development to other rural areas, which covered three quarters of the total population in Sweden (Lazuka, 2017). As discussed in the contextual section, the public health reforms, including the employment and supervision of qualified midwifery, implemented in the rural parishes under study and throughout Sweden strongly resembled each other, following strict state regulations. Otherwise, the local area enjoyed the largest overall availability of midwives in the country, although it fell behind in the availability of qualified midwives. Given this situation, the findings demonstrated in this paper are likely to be valid for other rural parts of Sweden. Beyond historical populations, the use of antiseptics and basic prescriptions in neonatal care is directly linked to the health of infants through public health provisions, which has potential relevance for developing countries. Neonatal mortality dropped from 67 to 34 per 1000 live births in this study's setting, which is high according to the current worldwide rates and implies that the findings apply to the least developed regions. Otherwise, a report recently published by the international organisations showed that low- and middle-income countries, which have less than half of the world's midwives, account for almost all of the world's maternal and neonatal deaths (Day-Stirk et al., 2014). This notion has also been addressed in both developed and developing countries, indicating that there is a universal shortage of both health workers with the midwifery skills and investments in educating midwives with the skills needed (WHO, 2016). Moreover, the focus on infant health is relevant due to the increasing global burden of chronic diseases, the most common of which is cardiovascular disease (WHO, 2014). This paper not only supports the short-term effects of the provision of quality birth assistance but also adds a long-term dimension to these assertions, promising better health, reduced cardiovascular mortality and spillovers to human capital.

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**FIGURES**

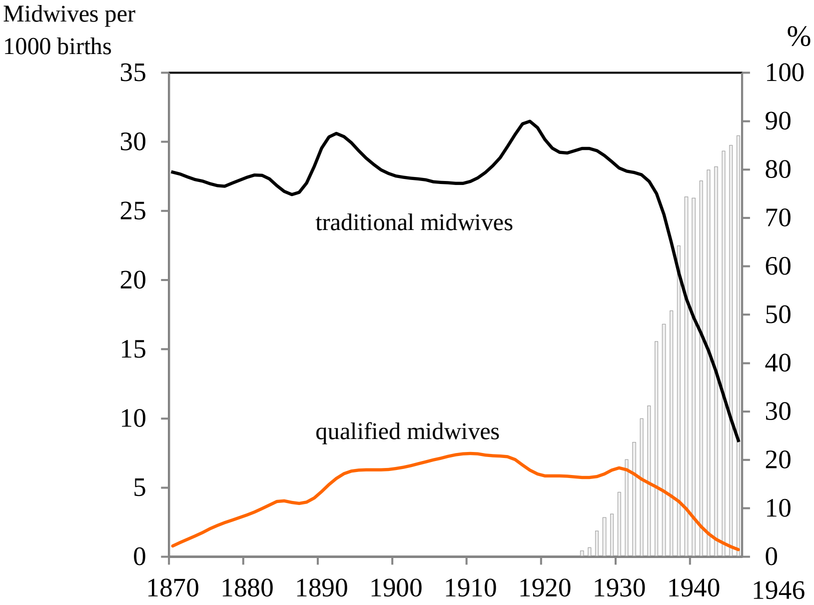


Figure 1 – Midwifery development in southern Sweden (rural areas) 1870–1946
*Note*: number of midwives per 1,000 births (left axis); bars denote share of hospital births in total births (right axis)
*Source*: calculated based on Statistiska Centralbyrån (1870–1946).

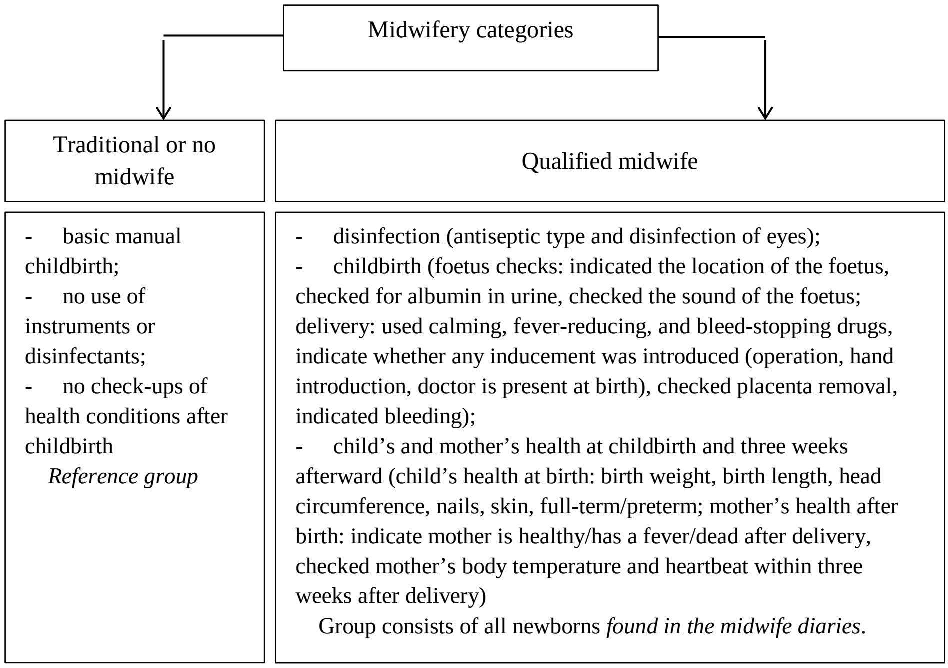


Figure 2 – Midwifery treatment groups and their competences, 1881–1930

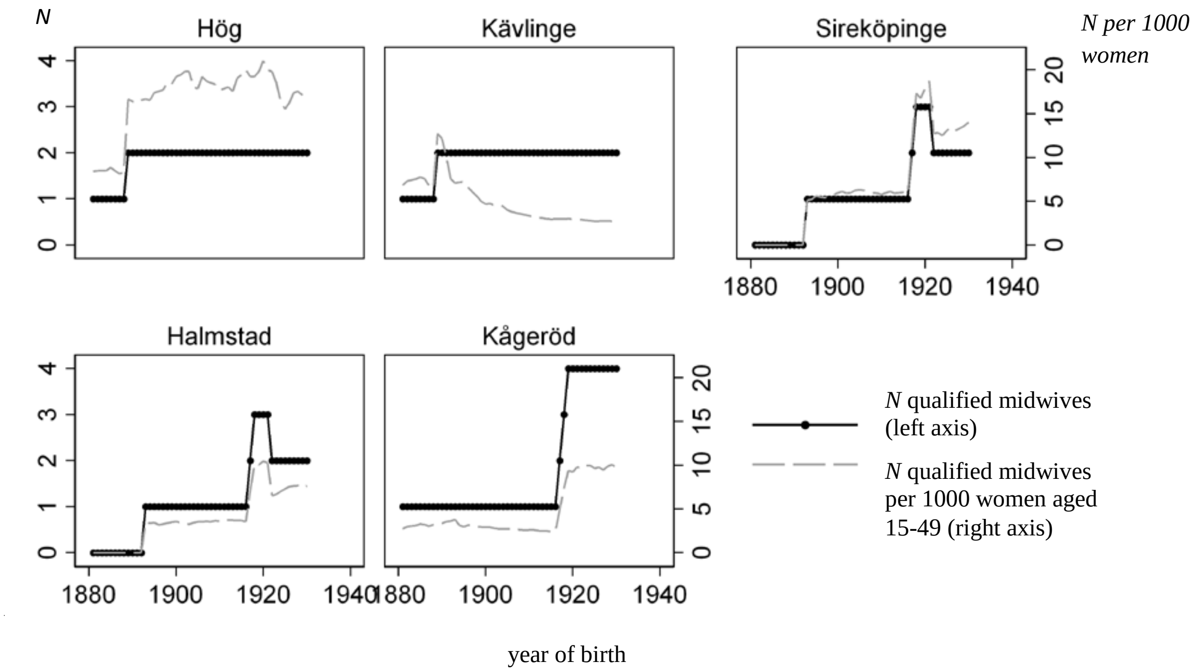


Figure 3 – Number of qualified midwives in parishes under study, southern Sweden 1881–1930

*Note*: For exact dates of midwifery employments see Appendix C. Number of qualified midwives in each parish with these dates is used as an instrument for individual midwifery treatment. In a Kävlinge district, where the records indicate that a full-time position of a qualified midwife was turned into a reserve, because there is only a dozen of births delivered by her afterward in the database, in the analysis a number of midwives is put to null starting from 1897.

*Sources*: Kommunarkivet Kågeröd (1876–1930); Kommunarkivet Kävlinge (1881–1930); Regionarkivet Lund (1881–1930a, 1881–1930b, 1881–1930c, 1900–1930).

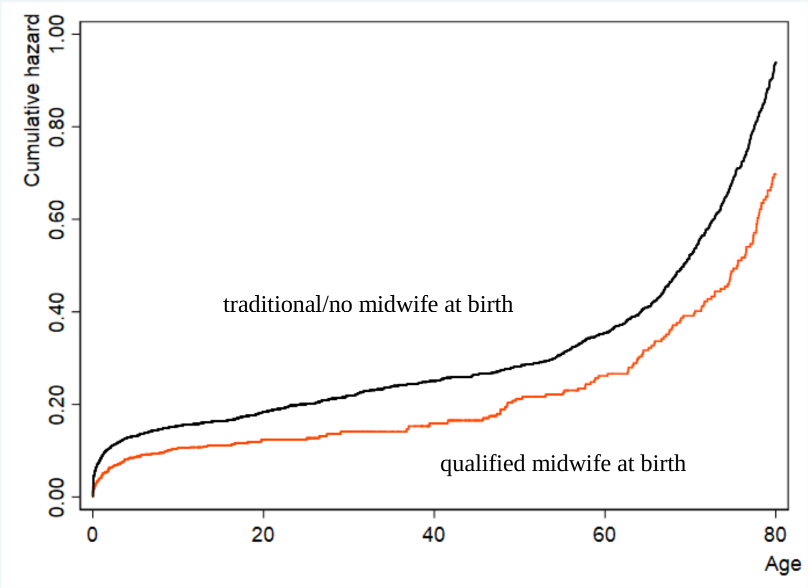


Figure 4 – Raw impact of treatment by qualified midwifery at birth on all-cause mortality from birth until age 80, southern Sweden cohorts 1881–1930

*Note*: Nelson-Aalen cumulative hazard estimates

*Source*: estimations based on SEDD 4.0.

**TABLES**

Table 1 – Allocation of treatment by a qualified midwife at birth, southern Sweden cohorts 1881–1930

| | Proximity | | |
|---|---|---|---|
| | time between arrival and call | distance between midwife and patient | Actual treatment |
| *A – Maternal health* | | | |
| prev. mother's birth singleton (ref) | | | |
| prev. mother's birth stillbirth | -1.740 | -0.364 | -0.053 |
| | (0.120) | (0.677) | (0.150) |
| prev. mother's birth multiple | -1.268 | -0.514 | 0.071 |
| | (0.168) | (0.489) | (0.100) |
| curr. mother's birth singleton (ref) | | | |
| curr. mother's birth multiple | -1.623** | -0.366 | -0.016 |
| | (0.024) | (0.477) | (0.516) |
| all older siblings survived (ref) | | | |
| any older sibling dead | -0.585 | -0.364 | -0.048*** |
| | (0.298) | (0.403) | (0.002) |
| no prev. siblings (first born) | 0.303 | 0.165 | -0.012 |
| | (0.135) | (0.311) | (0.177) |
| mother young (ref) | | | |
| mother old | 0.025 | -0.324** | -0.006 |
| | (0.903) | (0.046) | (0.465) |
| mother unknown | 0.367 | -0.168 | -0.037** |
| | (0.479) | (0.688) | (0.041) |
| *B – SES at birth/childhood* | | | |
| Kävlinge (ref) | | | |
| Hög | - | - | -0.071*** |
| | | | (0.000) |
| Sireköpinge | -0.343 | -0.104 | 0.026** |
| | (0.243) | (0.635) | (0.041) |
| Halmstad | - | - | 0.006 |
| | | | (0.587) |
| Kågeröd | -0.201 | 1.263*** | 0.101*** |
| | (0.445) | (0.000) | (0.000) |
| industrial or farmworker (ref) | | | |
| elite | -0.372 | -0.287 | -0.012 |
| | (0.299) | (0.328) | (0.363) |
| skilled | -0.162 | 0.020 | -0.009 |
| | (0.652) | (0.950) | (0.453) |
| farmer | 0.048 | -0.099 | 0.041*** |
| | (0.842) | (0.595) | (0.001) |
| married mother (ref) | | | |
| unmarried mother | 0.426 | 0.152 | -0.047*** |
| | (0.215) | (0.594) | (0.000) |
| mother's parity first | 0.370 | 0.034 | -0.030*** |
| | (0.151) | (0.870) | (0.006) |
| mother's parity second (ref) | | | |
| mother's parity third and higher | -0.004 | -0.266 | -0.028** |
| | (0.988) | (0.219) | (0.011) |
| mother's parity unknown | 0.518 | -0.095 | -0.060*** |
| | (0.337) | (0.827) | (0.003) |
| Individuals | 762 | 605 | 7,211 |

*Source*: estimations based on SEDD 4.0.

*Note*: OLS regression estimates. Models are estimated separately for each explanatory variable. Models for treatment allocation additionally control for month and year of birth (interaction of dummies), parish of birth, and sex. Models for residential location additionally control for year of birth (linear), parish of birth, and sex. The variables are equivalent to the factors that determine the choice of the patient made by the midwife within a month and parish of birth. The estimates not reported are not estimated due to small numbers.

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

Table 2 – Testing independence assumption: Associations between a number of qualified midwives (instrument) and parish-of-birth characteristics, southern Sweden 1881–1930

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| crude birth rate, per 1000 | 0.021** | | | | | | | 0.018* |
| | (0.023) | | | | | | | (0.076) |
| infectious-disease mortality rate, ages 1-14 per 1000 | | 0.006 | | | | | | 0.010 |
| | | (0.584) | | | | | | (0.349) |
| landholding, males ages 20–55 | | | -0.842 | | | | | -0.847 |
| | | | (0.121) | | | | | (0.189) |
| share elite, males ages 20–55 | | | | 1.334 | | | | 1.310 |
| | | | | (0.191) | | | | (0.212) |
| share single mother families | | | | | 0.669 | | | 2.146 |
| | | | | | (0.531) | | | (0.102) |
| share unmarried, ages 35–45 | | | | | | -0.201 | | -0.729 |
| | | | | | | (0.786) | | (0.405) |
| real public investment per capita | | | | | | | 0.007 | 0.008 |
| | | | | | | | (0.213) | (0.144) |
| Mean of independent variable | 18.833 | 2.985 | 0.204 | 0.187 | 0.132 | 0.214 | 30.174 | |
| Parish-years | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| R-sq | 0.273 | 0.259 | 0.265 | 0.263 | 0.259 | 0.258 | 0.263 | 0.295 |

*Source*: estimations based on SEDD 4.0, Statistiska Centralbyrån (1880–1917, 1918–1930).

*Note*: OLS regression model estimates. Outcome is mean number of qualified midwives in a parish-year. Models additionally control for year of birth (linear) and parish-of-birth fixed effects.

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

Table 3 – All-cause mortality from birth until age 80 in relation to treatment by a qualified midwife at birth, southern Sweden cohorts 1881–1930

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| *<28 days* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | |
| qualified midwife at birth | 0.461*** | 0.508*** | 0.500*** | 0.509*** | 0.511*** | 0.506*** | |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | |
| AET ratio | | 5.800 | 7.500 | 4.667 | 4.763 | 3.857 | |
| Log likelihood | -3475 | -3468 | -3466 | -3443 | -3435 | -3433 | |
| Wald chi2 | 17.75 | 32.09 | 33.29 | 97.76 | 116.0 | 120.3 | |
| *<age 15* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | |
| qualified midwife at birth | 0.825 | 0.956 | 0.964 | 0.952 | 0.962 | 0.976 | |
| | (0.153) | (0.737) | (0.785) | (0.714) | (0.776) | (0.860) | |
| AET ratio | | [<0] | [<0] | [<0] | [<0] | [<0] | |
| Log likelihood | -7502 | -7459 | -7455 | -7432 | -7418 | -7414 | |
| Wald chi2 | 20.46 | 106.9 | 110.0 | 175.6 | 201.7 | 206.2 | |
| *<age 40* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.511** | 0.586* | 0.590* | 0.580* | 0.583* | 0.592* | 0.596* |
| | (0.026) | (0.078) | (0.081) | (0.073) | (0.076) | (0.085) | (0.089) |
| AET ratio | | 3.312 | 3.312 | 3.134 | 2.893 | 2.856 | 2.109 |
| Log likelihood | -8520 | -8468 | -8462 | -8443 | -8429 | -8423 | -8383 |
| Wald chi2 | 21.27 | 127.7 | 133.0 | 189.6 | 214.7 | 220.3 | 280.8 |
| *<age 80* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.776** | 0.939 | 0.946 | 0.932 | 0.943 | 0.954 | 0.958 |
| | (0.022) | (0.584) | (0.632) | (0.541) | (0.605) | (0.683) | (0.706) |
| AET ratio | | 1.556 | 1.300 | 1.706 | 1.556 | 1.421 | 1.421 |
| Log likelihood | -12543 | -12478 | -12473 | -12457 | -12446 | -12441 | -12414 |
| Wald chi2 | 26.18 | 157.7 | 167.2 | 192.2 | 208.3 | 222.9 | 283.5 |
| Individual factors | | yes | yes | yes | yes | yes | yes |
| Parish-of-birth fixed effects | | yes | yes | yes | yes | yes | yes |
| Parish-of-birth factors | | | yes | | | yes | yes |
| Maternal health at birth factors | | | | yes | yes | yes | yes |
| SES in childhood factors | | | | | yes | yes | |
| SES in adulthood | | | | | | | yes |

*Note*: Exponentiated Cox proportional hazard model estimates. All models, except for the model for *<28days*, control for the effect of qualified midwifery in the previous age group (*qualified X <28 days*, *qualified X <age 15*, or *qualified X <age 40*, respectively). The sample includes 7,211 individuals; number of deaths: 401 (*<28 days*), 868 (*<age 15*), 1004 (*<age 40*), and 1596 (*<age 80*). Individual factors include *year of birth* and *sex*. Parish of birth factors include *crude birth rate, infectious-disease death rate among aged 1–14, landholding, share of elite, share of single mother families, share of unmarried*, and *real public investment per capita*. Maternal health at birth factors include *mother's previous childbirth indicator, mother's current childbirth indicator, survival status of older siblings, mother's age,* and *whether mother unknown*. SES in childhood factors include *parish of birth, SES in childhood, mother's marital status*, and *mother's parity*. SES in adulthood factors include *SES in adulthood*. For the full set of estimates see Appendix D.

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

Table 4 – Cause-specific mortality from birth until age 80 in relation to treatment by a qualified midwife at birth, southern Sweden cohorts 1881–1930

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| *Infectious/respiratory diseases, ages 15-39* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.448* | 0.521 | 0.576 | 0.514 | 0.521 | 0.574 | 0.556 |
| | (0.059) | (0.143) | (0.206) | (0.138) | (0.144) | (0.203) | (0.179) |
| AET ratio | | 2.373 | 2.424 | 2.477 | 2.324 | 2.275 | 1.897 |
| Log likelihood | -577.5 | -558.4 | -554.9 | -556.0 | -552.6 | -548.9 | -542.7 |
| Wald chi2 | 3.565 | 50.16 | 57.45 | 3252 | 3062 | 2284 | 1854 |
| *CVD and diabetes, ages 40-80* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.611*** | 0.639** | 0.647** | 0.620*** | 0.622*** | 0.627** | 0.632** |
| | (0.005) | (0.012) | (0.014) | (0.009) | (0.010) | (0.011) | (0.013) |
| AET ratio | | 4.955 | 3.852 | 5.550 | 4.458 | 3.517 | 2.359 |
| Log likelihood | -1911 | -1895 | -1893 | -1890 | -1889 | -1887 | -1886 |
| Wald chi2 | 8.062 | 44.08 | 48.28 | 54.99 | 59.46 | 62.46 | 65.12 |
| *Cancer, ages 40-80* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.856 | 0.957 | 0.958 | 0.986 | 0.996 | 1.002 | 0.974 |
| | (0.418) | (0.826) | (0.840) | (0.945) | (0.984) | (0.992) | (0.902) |
| AET ratio | | 1.130 | 1.450 | 0.885 | 0.750 | 1.042 | 0.485 |
| Log likelihood | -1310 | -1308 | -1301 | -1303 | -1303 | -1296 | -1294 |
| Wald chi2 | 0.657 | 4.603 | 18.69 | 1855 | 1854 | 1685 | 1438 |
| Individual factors | | yes | yes | yes | yes | yes | yes |
| Parish-of-birth fixed effects | | yes | yes | yes | yes | yes | yes |
| Parish-of-birth factors | | | yes | | | yes | yes |
| Maternal health at birth factors | | | | yes | yes | yes | yes |
| SES in childhood factors | | | | | yes | yes | |
| SES in adulthood | | | | | | | yes |

*Note*: Exponentiated Fine-Gray competing risk model estimates. Samples include 3,334 individuals (*ages 15-39*), and 1,356 individuals (*ages 40-80*); number of deaths: 77 (*infectious/respiratory disease ages 15-39*), 275 (*CVD and diabetes ages 40-80*), 187 (*cancer ages 40-80*); number of competing deaths: 56 (*infectious/respiratory disease ages 15-39*), 317 (*CVD and diabetes ages 40-80*), 405 (*cancer ages 40-80*). Individual factors include *year of birth* and *sex*. Parish of birth factors include *crude birth rate, infectious-disease death rate among aged 1–14, landholding, share of elite, share of single mother families, share of unmarried,* and *real public investment per capita*. Maternal health at birth factors include *mother's previous childbirth indicator, mother's current childbirth indicator, survival status of older siblings, mother's age,* and *whether mother unknown*. SES in childhood factors include *parish of birth, SES in childhood, mother's marital status,* and *mother's parity*. SES in adulthood factors include *SES in adulthood*. For the full set of estimates see Appendix D.

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

Table 5 – Health and skills in relation to treatment by a qualified midwife at birth, southern Sweden cohorts, 1881–1930, males ages 19–21

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| *Height* | | | | | | |
| traditional or no midwife at birth (ref) | | | | | | |
| qualified midwife at birth | 0.969* | 0.461 | 0.190 | 0.485 | 0.320 | -0.022 |
| | (0.072) | (0.400) | (0.736) | (0.376) | (0.559) | (0.970) |
| AET ratio | | 0.907 | 0.244 | 1.002 | 0.493 | [<0] |
| R-sq | 0.004 | 0.041 | 0.053 | 0.049 | 0.069 | 0.085 |
| *Rejected due to unfit* | | | | | | |
| traditional or no midwife at birth (ref) | | | | | | |
| qualified midwife at birth | -0.037 | -0.030 | -0.024 | -0.028 | -0.024 | -0.018 |
| | (0.164) | (0.306) | (0.402) | (0.347) | (0.423) | (0.556) |
| AET ratio | | 4.286 | 1.846 | 3.111 | 1.846 | 0.947 |
| R-sq | 0.002 | 0.011 | 0.015 | 0.021 | 0.034 | 0.038 |
| *Diagnosed with disease* | | | | | | |
| traditional or no midwife at birth (ref) | | | | | | |
| qualified midwife at birth | -0.210*** | -0.218*** | -0.178*** | -0.219*** | -0.216*** | -0.173*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| AET ratio | | [<0] | 5.563 | [<0] | [<0] | 4.676 |
| R-sq | 0.026 | 0.045 | 0.098 | 0.056 | 0.064 | 0.118 |
| *Skilled* | | | | | | |
| traditional or no midwife at birth (ref) | | | | | | |
| qualified midwife at birth | 0.228*** | 0.104** | 0.111** | 0.107** | 0.102** | 0.108** |
| | (0.000) | (0.018) | (0.014) | (0.016) | (0.021) | (0.017) |
| AET ratio | | 0.839 | 0.949 | 0.884 | 0.810 | 0.900 |
| R-sq | 0.039 | 0.175 | 0.183 | 0.179 | 0.191 | 0.200 |
| Individual factors | | yes | yes | yes | yes | yes |
| Parish-of-birth fixed effects | | yes | yes | yes | yes | yes |
| Parish-of-birth factors | | | yes | | | yes |
| Maternal health at birth factors | | | | yes | yes | yes |
| SES in childhood factors | | | | | yes | yes |

*Note*: OLS regression estimates. Samples include 890 individuals (*height*), 931 individuals (*rejected due to unfit/diagnosed with disease*), and 805 individuals (*skilled*). Mean of the outcome for the reference group: 172.8 (*height*), 0.134 (*rejected due to unfit*), 0.416 (*diagnosed with disease*), and 0.188 (*skilled*). Individual factors include *year of birth*, *age at inspection* and *sex*. Parish of birth factors include *crude birth rate, infectious-disease death rate among aged 1–14*, *landholding, share of elite, share of single mother families, share of unmarried*, and *real public investment per capita*. Maternal health at birth factors include *mother's previous childbirth indicator, mother's current childbirth indicator, survival status of older siblings, mother's age,* and *whether mother unknown*. SES in childhood factors include *parish of birth, SES in childhood*, *mother's marital status*, and *mother's parity*. For the full set of estimates see Appendix D.

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

Table 6 – 2SRI regressions of all-cause and cause-specific mortality in relation to treatment by a qualified midwife at birth, southern Sweden cohorts 1881–1930

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | | | *Second stage: All-cause mortality* | | | | |
| *<28 days* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | |
| qualified midwife at birth | 0.316*** | 0.421** | 0.389** | 0.494** | 0.481** | 0.453** | |
| | (0.000) | (0.016) | (0.012) | (0.043) | (0.038) | (0.029) | |
| Log likelihood | -3474 | -3468 | -3466 | -3443 | -3435 | -3433 | |
| Wald chi2 | 20.24 | 32.21 | 33.20 | 98.03 | 115.2 | 119.1 | |
| *<age 15* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | |
| qualified midwife at birth | 0.535*** | 0.890 | 0.838 | 0.972 | 0.967 | 0.919 | |
| | (0.003) | (0.634) | (0.475) | (0.905) | (0.891) | (0.731) | |
| Log likelihood | -7499 | -7459 | -7455 | -7432 | -7417 | -7413 | |
| Wald chi2 | 28.07 | 107.0 | 109.6 | 175.9 | 203.0 | 207.3 | |
| *<age 40* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.344*** | 0.552* | 0.521* | 0.596 | 0.583 | 0.553 | 0.544* |
| | (0.002) | (0.099) | (0.072) | (0.149) | (0.135) | (0.101) | (0.092) |
| Log likelihood | -8517 | -8468 | -8462 | -8443 | -8431 | -8426 | -8385 |
| Wald chi2 | 28.98 | 127.7 | 132.5 | 189.9 | 208.9 | 214.1 | 275.8 |
| *<age 80* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.578*** | 0.898 | 0.859 | 0.930 | 0.928 | 0.888 | 0.876 |
| | (0.000) | (0.540) | (0.390) | (0.682) | (0.674) | (0.503) | (0.452) |
| Log likelihood | -12539 | -12478 | -12473 | -12457 | -12450 | -12445 | -12417 |
| Wald chi2 | 35.14 | 157.7 | 167.0 | 192.2 | 200.7 | 215.7 | 276.7 |
| | | | *Second stage: Cause-specific mortality* | | | | |
| *Infectious/respiratory diseases, ages 15-39* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.280** | 0.470 | 0.439 | 0.480 | 0.458 | 0.413 | 0.395 |
| | (0.033) | (0.367) | (0.348) | (0.377) | (0.352) | (0.317) | (0.283) |
| Log likelihood | -577.1 | -558.4 | -554.8 | -556.0 | -552.1 | -548.3 | -542.2 |
| Wald chi2 | 5.069 | 50.43 | 57.77 | 3248 | 3100 | 2327 | 1871 |
| *CVD and diabetes, ages 40-80* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.550** | 0.484** | 0.486** | 0.452** | 0.456** | 0.461** | 0.452** |
| | (0.032) | (0.040) | (0.037) | (0.024) | (0.027) | (0.027) | (0.023) |
| Log likelihood | -1911 | -1895 | -1893 | -1890 | -1888 | -1886 | -1885 |
| Wald chi2 | 8.171 | 45.35 | 49.55 | 57.47 | 62.06 | 65.55 | 68.74 |
| *Cancer, ages 40-80* | | | | | | | |
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.908 | 1.539 | 1.293 | 1.631 | 1.634 | 1.376 | 1.270 |
| | (0.773) | (0.305) | (0.534) | (0.244) | (0.250) | (0.448) | (0.569) |
| Log likelihood | -1310 | -1307 | -1301 | -1302 | -1302 | -1295 | -1294 |
| Wald chi2 | 0.717 | 6.223 | 19.49 | 1844 | 1863 | 1656 | 1487 |
| | | | *First stage* | | | | |
| *Qualified midwife at birth* | | | | | | | |
| number of qualified midwives | 0.181*** | 0.202*** | 0.211*** | 0.203*** | 0.203*** | 0.211*** | 0.211*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| F-stats | 1363.2 | 951.4 | 996.4 | 956.4 | 951.6 | 994.3 | 996.6 |
| R-sq | 0.259 | 0.278 | 0.297 | 0.281 | 0.284 | 0.302 | 0.302 |
| Individual factors | | yes | yes | yes | yes | yes | yes |
| Parish-of-birth fixed effects | | yes | yes | yes | yes | yes | yes |
| Parish-of-birth factors | | | yes | | | yes | yes |
| Maternal health at birth factors | | | | yes | yes | yes | yes |
| SES in childhood factors | | | | | yes | yes | |
| SES in adulthood | | | | | | | yes |

*Note*: Two-stage residual inclusion estimates. OLS regression estimates for first stage. Exponentiated Cox proportional hazard model estimates for all-cause mortality for second stage, and exponentiated Fine-Gray competing risk model estimates for cause-specific mortality for second stage. All-cause mortality models, except for the model for *<28days*, control for the effect of qualified midwifery in the previous age group (*qualified X <28 days*, *qualified X <age 15*, or *qualified X <age 40*, respectively). The samples and control variables are the same as in Tables 3 and 4. For the full set of estimates see Appendix E.
P-values in parentheses * p<.10, ** p<.05, *** p<.01

Table 7 – 2SLS regressions of health and skills in relation to treatment by a qualified midwife at birth, southern Sweden cohorts 1881–1930

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| *Height* | | *2SLS estimates* | | | | |
| traditional or no midwife at birth (ref) | | | | | | |
| qualified midwife at birth | 1.245 | -0.354 | -0.542 | -0.398 | -0.949 | -1.220 |
| | (0.230) | (0.760) | (0.641) | (0.732) | (0.412) | (0.298) |
| *Qualified midwife at birth* | | *First stage* | | | | |
| number of qualified midwives | 0.175*** | 0.195*** | 0.196*** | 0.196*** | 0.197*** | 0.196*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| F-stats | 231.3 | 138.6 | 135.6 | 138.2 | 139.6 | 134.2 |
| R-sq | 0.310 | 0.326 | 0.363 | 0.328 | 0.330 | 0.366 |
| *Rejected due to unfit* | | *2SLS estimates* | | | | |
| traditional or no midwife at birth (ref) | | | | | | |
| qualified midwife at birth | -0.105*** | -0.123** | -0.127** | -0.111** | -0.096* | -0.102* |
| | (0.007) | (0.020) | (0.016) | (0.034) | (0.066) | (0.052) |
| *Qualified midwife at birth* | | *First stage* | | | | |
| number of qualified midwives | 0.174*** | 0.200*** | 0.202*** | 0.201*** | 0.202*** | 0.203*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| F-stats | 234.8 | 152.1 | 152.6 | 151.7 | 153.2 | 151.5 |
| R-sq | 0.302 | 0.322 | 0.353 | 0.325 | 0.326 | 0.357 |
| *Diagnosed with disease* | | *2SLS estimates* | | | | |
| traditional or no midwife at birth (ref) | | | | | | |
| qualified midwife at birth | -0.404*** | -0.564*** | -0.486*** | -0.557*** | -0.550*** | -0.475*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Qualified midwife at birth* | | *First stage* | | | | |
| number of qualified midwives | 0.174*** | 0.200*** | 0.202*** | 0.201*** | 0.202*** | 0.203*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| F-stats | 234.8 | 152.1 | 152.6 | 151.7 | 153.2 | 151.5 |
| R-sq | 0.302 | 0.322 | 0.353 | 0.325 | 0.326 | 0.357 |
| *Skilled* | | *2SLS estimates* | | | | |
| traditional or no midwife at birth (ref) | | | | | | |
| qualified midwife at birth | 0.404*** | 0.110 | 0.127 | 0.111 | 0.082 | 0.097 |
| | (0.000) | (0.223) | (0.162) | (0.221) | (0.362) | (0.289) |
| *Qualified midwife at birth* | | *First stage* | | | | |
| number of qualified midwives | 0.174*** | 0.180*** | 0.181*** | 0.180*** | 0.181*** | 0.182*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| F-stats | 226.6 | 103.4 | 101.6 | 103.2 | 103.5 | 100.1 |
| R-sq | 0.362 | 0.377 | 0.412 | 0.379 | 0.381 | 0.417 |
| Individual factors | | yes | yes | yes | yes | yes |
| Parish-of-birth fixed effects | | yes | yes | yes | yes | yes |
| Parish-of-birth factors | | | yes | | | yes |
| Maternal health at birth factors | | | | yes | yes | yes |
| SES in childhood factors | | | | | yes | yes |

*Note*: Two-stage least squares estimates. Samples and control variables are the same as in Table 5. For the full set of estimates see Appendix E.

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

Table 8 – Falsification test. 2SRI regressions of all-cause mortality of fathers in a decade following a birth of their child with different midwifery treatment status, fathers of cohorts 1881–1930, ages 15–65

| | (1) | (2) | (3) |
|---|---|---|---|
| traditional or no midwife at birth (ref) | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 1.156 | 1.087 | 1.096 |
| | (0.611) | (0.784) | (0.766) |
| Log likelihood | -725.2 | -722.9 | -719.9 |
| Wald chi2 | 0.260 | 4.864 | 11.45 |
| *Qualified midwife at birth* | | *First stage* | |
| number of qualified midwives | 0.216*** | 0.237*** | 0.236*** |
| | (0.000) | (0.000) | (0.000) |
| F-stats | 464.15 | 342.31 | 341.39 |
| R-sq | 0.265 | 0.282 | 0.285 |
| Individual factors | | yes | yes |
| Parish-of-residence fixed effects | | yes | yes |
| SES in adulthood factors | | | yes |

*Note*: Two-stage residual inclusion estimates. OLS regression estimates for first stage. Exponentiated Cox proportional hazard model estimates for second stage. Sample includes 2,833 fathers, number of deaths is 115. Individual factors include *year*. SES in adulthood factors include *current SES of fathers*. For the full set of estimates see Appendix G.
P-values in parentheses * p<.10, ** p<.05, *** p<.01

Table 9 – MFE regressions of all-cause and cause-specific mortality in relation to treatment by qualified midwife at birth, cohorts 1846–1930 southern Sweden

| | *All causes* | | | | *Infectious/ respiratory* | *CVD and diabetes* | *Cancer* |
|---|---|---|---|---|---|---|---|
| | *<28 days* | *<age 15* | *<age 40* | *<age 80* | *ages 15-39* | *ages 40-80* | *ages 40-80* |
| | *MFE, year of birth, parish of birth and sex* | | | | | | |
| traditional/no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.453*** | 1.145 | 0.533 | 0.692** | 1.175 | 0.463** | 0.823 |
| | (0.007) | (0.501) | (0.230) | (0.044) | (0.814) | (0.021) | (0.524) |
| Wald chi2 | 76.26 | 146.3 | 132.7 | 94.77 | 13.32 | 23.71 | 12.41 |
| Log-likelihood | -489.3 | -1471 | -1702 | -2173 | -108.3 | -181.1 | -114.9 |
| | *MFE, year of birth, parish of birth, sex, SES and maternal marital status in childhood* | | | | | | |
| traditional/no midwife at birth (ref) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| qualified midwife at birth | 0.429*** | 1.157 | 0.527 | 0.683** | 1.173 | 0.517** | 0.738 |
| | (0.005) | (0.470) | (0.235) | (0.039) | (0.823) | (0.047) | (0.333) |
| Wald chi2 | 89.74 | 156.1 | 144.3 | 114.3 | 13.32 | 30.48 | 18.78 |
| Log-likelihood | -481.0 | -1466 | -1697 | -2166 | -108.3 | -179.6 | -112.6 |

*Note*: Exponentiated Cox proportional hazard model estimates. All-cause mortality models, except for the model for *<28days*, control for the effect of qualified midwifery in the previous age group (*qualified X <28 days*, *qualified X <age 15*, or *qualified X <age 40*, respectively). For all-cause mortality, the sample includes 10,567 individuals; number of deaths: 447 (*<28 days*), 1102 (*<age 15*), 1302 (*<age 40*), and 2110 (*<age 80*); 3,409 mothers. For cause-specific mortality, samples include 5,628 individuals (*ages 15-39*), and 1,924 individuals (*ages 40-80*); number of deaths: 111 (*infectious/respiratory disease ages 15-39*), 361 (*CVD and diabetes ages 40-80*), 229 (*cancer ages 40-80*); 1,754 mothers for infectious/respiratory disease mortality and 1,073 mothers for CVD and diabetes and cancer. For the full set of estimates see Appendix H.

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

Table 10 – MFE regressions of health and skills in relation to treatment by qualified midwife at birth, cohorts 1846–1930 southern Sweden, males ages 19–21

| | *Height* | *Rejected due to unfit* | *Diagnosed with disease* | *Skilled* |
|---|---|---|---|---|
| | *MFE, year of birth and parish of birth, age at inspection* | | | |
| traditional/no midwife at birth (ref) | | | | |
| qualified midwife at birth | 1.715** | -0.071* | -0.198*** | 0.051 |
| | (0.022) | (0.069) | (0.004) | (0.582) |
| R-sq | 0.058 | 0.021 | 0.027 | 0.038 |
| | *MFE, year of birth and parish of birth, SES and maternal marital status in childhood, age at inspection* | | | |
| traditional/no midwife at birth (ref) | | | | |
| qualified midwife at birth | 1.812** | -0.078** | -0.206*** | 0.056 |
| | (0.016) | (0.046) | (0.003) | (0.557) |
| R-sq | 0.067 | 0.030 | 0.043 | 0.049 |

*Note*: OLS regression estimates. Samples include 1,161 individuals (*height*), 1,242 individuals (*rejected due to unfit/diagnosed with disease*), and 955 individuals (*skilled*). Number of mothers: 663 mothers (*height*), 690 mothers (*rejected due to unfit/diagnosed with disease*), and 563 mothers (*skilled*). For the full set of estimates see Appendix H.

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

Table 11 – Heterogeneous effects of treatment by a qualified midwife at birth on mortality, southern Sweden cohorts 1881–1930

| | *Poor mother's and newborn's birth* | | | | *Mother old* | | | |
|---|---|---|---|---|---|---|---|---|
| | <28days | age<15 | age<40 | age<80 | <28days | age<15 | age<40 | age<80 |
| qualified midwife at birth | 0.338*** | 0.946 | 0.446** | 0.974 | 0.622** | 1.024 | 0.527 | 1.017 |
| | (0.000) | (0.713) | (0.039) | (0.827) | (0.049) | (0.902) | (0.165) | (0.913) |
| *Variable* | | | | | 0.918 | 1.145* | 1.119 | 1.079 |
| | | | | | (0.432) | (0.070) | (0.106) | (0.172) |
| qualified midwife at birth X *Variable* | 2.883*** | 1.055 | 2.380 | 0.915 | 0.635 | 0.865 | 1.312 | 0.841 |
| | (0.004) | (0.861) | (0.145) | (0.760) | (0.261) | (0.595) | (0.646) | (0.423) |
| Log likelihood | -3464 | -7454 | -8464 | -12475 | -3161 | -6854 | -7829 | -11732 |
| Wald chi2 | 38.29 | 118.6 | 137.8 | 167.2 | 25.01 | 99.69 | 122.7 | 130.8 |
| | *High IMR during infancy* | | | | *Cohorts 1914–1930* | | | |
| | <28days | age<15 | age<40 | age<80 | <28days | age<15 | age<40 | age<80 |
| qualified midwife at birth | 0.702 | 1.116 | 0.703 | 0.950 | 0.668 | 1.195 | 0.595 | 0.825 |
| | (0.160) | (0.540) | (0.369) | (0.725) | (0.108) | (0.263) | (0.131) | (0.331) |
| *Variable* | 1.617*** | 1.303*** | 1.195*** | 1.148** | 0.803 | 0.809 | 0.835 | 0.928 |
| | (0.000) | (0.000) | (0.008) | (0.011) | (0.279) | (0.151) | (0.191) | (0.452) |
| qualified midwife at birth X *Variable* | 0.554 | 0.739 | 0.679 | 1.003 | 0.619 | 0.592* | 1.358 | 1.204 |
| | (0.113) | (0.251) | (0.512) | (0.989) | (0.228) | (0.086) | (0.554) | (0.440) |
| Log likelihood | -3458 | -7452 | -8464 | -12474 | -3466 | -7455 | -8465 | -12475 |
| Wald chi2 | 51.3 | 120.4 | 134.6 | 163.2 | 30.66 | 104.5 | 119.3 | 151.6 |
| | *Older sibling treated* | | | | *Large family in childhood* | | | |
| | <28days | age<15 | age<40 | age<80 | <28days | age<15 | age<40 | age<80 |
| qualified midwife at birth | 0.549** | 0.977 | 0.599 | 0.948 | 0.527*** | 0.979 | 0.749 | 0.943 |
| | (0.010) | (0.895) | (0.190) | (0.719) | (0.007) | (0.907) | (0.433) | (0.689) |
| *Variable* | 0.907 | 1.009 | 0.984 | 0.976 | 0.954 | 1.117 | 1.112 | 1.039 |
| | (0.700) | (0.967) | (0.963) | (0.881) | (0.674) | (0.143) | (0.129) | (0.493) |
| qualified midwife at birth X *Variable* | 0.942 | 0.919 | 1.048 | 0.977 | 0.973 | 0.935 | 0.598 | 0.977 |
| | (0.897) | (0.806) | (0.945) | (0.930) | (0.946) | (0.809) | (0.405) | (0.914) |
| Log likelihood | -3162 | -6856 | -7831 | -11733 | -3162 | -6855 | -7830 | -11733 |
| Wald chi2 | 24.25 | 97.92 | 119.1 | 130.4 | 24.37 | 100.2 | 121.5 | 130.4 |
| | *Low SES in childhood* | | | | *Low SES in adulthood* | | | |
| | <28days | age<15 | age<40 | age<80 | <28days | age<15 | age<40 | age<80 |
| qualified midwife at birth | 0.500** | 0.721 | 0.501 | 0.911 | | | 0.806 | 1.241 |
| | (0.030) | (0.194) | (0.175) | (0.592) | | | (0.536) | (0.322) |
| *Variable* | 1.130 | 1.289*** | 1.280*** | 1.218*** | | | 1.428*** | 1.221*** |
| | (0.270) | (0.001) | (0.000) | (0.000) | | | (0.000) | (0.001) |
| qualified midwife at birth X *Variable* | 1.026 | 1.506 | 1.251 | 1.035 | | | 0.400 | 0.697 |
| | (0.947) | (0.164) | (0.717) | (0.875) | | | (0.172) | (0.139) |
| Log likelihood | -3467 | -7451 | -8459 | -12468 | | | -8450 | -12470 |
| Wald chi2 | 33.88 | 126.2 | 144.7 | 176.4 | | | 157.9 | 168.3 |

*Note*: Exponentiated Cox proportional hazard model estimates.

The sample includes 7,211 individuals, and for models with maternal information excludes those with unknown mothers (363 individuals). Individual controls include *year of birth* (linear), *sex*, and *parish of birth*, in addition to those reported in the table. Each model, except for the model for neonates, includes a control for the effect of the qualified midwifery in the previous age, *qualified X < 28 days*, *qualified X < age 15*, or *qualified X < age 40*, respectively. Information for *poor mother's* and *newborn's birth* is available only for individuals treated by a qualified midwife at birth, and thus the base estimate is not reported. *Poor mother's and newborn's birth* includes individuals preterm at birth (preterm at birth, head circumference <34cm, length at birth <49 cm, birth weight<2,500 gm, or nails shorter than a fingertip) or whose mothers had complications at childbirth (protein in urine, doctor was present at birth, hand inducement implemented, birth delivery instrumented, any drugs were used, mother's bleeding after delivery >1,000 kbcm, and mother's body temperature after delivery >=38 °C or she had a fever). *High mother old* refers to individuals born to mothers older than age 31. *IMR during infancy* refers to individuals born in years with infant mortality rate above the long-term trend calculated using a Hodrick–Prescott filter. *Older sibling treated* refers to individuals whose any older sibling was assisted by a qualified midwife at birth. *Large family in childhood* refers to individuals born as a third or higher parity. *Low SES in childhood* refers to individuals born to families of industrial or farm workers. *Low SES in adulthood* refers to industrial or farm workers; because it is own SES, estimates for age <15 are omitted

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