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Call the Midwife

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Abstract

The Nordic countries have the lowest maternal and child mortality rates in the world. This has not always been the case. In 1887 the mortality rates in Norway were similar to those of developing countries today. During the next 34 years, Norwegian maternal mortality was halved and infant mortality fell by 40 percent. Investigating the relationship between health personnel and mortality at the local level during this period, we find a large and robust effect of midwives on reduced maternal mortality. No clear effect is found for other types of health personnel or on infant mortality.

JEL-Codes: H410, I180, N330.

Keywords: health policy, public service provision, history, mortality.

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1 Introduction

During most of human history, life expectancy has been low and maternal and child mortality have been high. The changes to life expectancy that came in the late 19th and early 20th century in the western world have been dramatic and their reasons are suggested to be improved material living standards, better access to health care, and improvements in medicine (Deaton, 2013). In this paper we investigate the role of health personnel for the improvement in health outcomes in Norway, utilizing the fact that the rollout of personnel at the local level was uneven and staggered, implying that we can flexibly control for a vast array of other potential confounding variables.

Pregnancy and childbearing are major determinants of female health, particularly in developing countries. It is estimated that almost 300.000 women die every year in relation to childbirth (van Lerberghe et al., 2005). High maternal mortality also has wider developmental ramifications. Motherless children are less likely to attend school, they have poorer health, and an increased risk of early death (ibid.). Reproductive age often corresponds to economically productive age, and if the family loses an income its members may descend into poverty.

A prerequisite to ensure sound maternal health is thought to be the provision of adequate maternal health care services, such as antenatal care and professional birth assistance (e.g. van Rijsbergen and D'Exelle, 2013). Lazuka (2016) find that there are also long term positive health effects on the children that are delivered in births assisted by midwives. While maternal care is well-developed in many Western countries today, little is known about how its roll-out more than 100 years ago influenced maternal and child mortality. Moreover, when programs are implemented on a national scale, impacts may be hard to distinguish from general impacts of economic growth and developments in health technology.

Using historical Norwegian data of very good quality, we investigate the causal effects of health personnel on mortality. We observe the number of health personnel and various health outcomes at the medical district level annually from 1887 to 1921 and use this to study local variation in welfare provision within Norway using panel data techniques. While the present-day Norwegian welfare state has a strong emphasis on equal provision of services throughout the country, this was not always the case. At the turn of the twentieth century, when the number of social insurance and health initiatives expanded fast, provision was predominantly at either the occupation or the local level. The roll-out of the Norwegian welfare state at the local level offers a setting where we can investigate the emergence and consequences of welfare state policies.

The effect of the expansion of midwifery on health and mortality has been explored both in historical perspective in affluent countries and in contemporary perspective in poorer countries. Østby et al. (2016) show, in a cross country regression, that maternal health care service utilization is negatively associated with maternal deaths at the national level in 31 African countries using data from the demographic and health surveys. Comparing mortality rates across countries in repeated cross sections does not allow for causal interpretations. In particular, there are so many other differences across countries and time periods that may affect both mortality and access to health personnel. Others have therefore analyzed the relationship within countries.

One case that has received quite some attention is Indonesia's *Midwife in the Village* program, which increased the number of rural midwives more than tenfold during the 1990s. Frankenberg and Thomas (2001) find that this improved health outcomes of women in reproductive age, but not men or older women, and Frankenberg et al. (2005) find positive impact on child health. However, Triyana (2016) find that the program did not have long term effects.

Apart from the program in Indonesia, there are a few studies using a research design suitable for causal inference to study related outcomes. Cesur et al. (2017) analyze the gradual expansion of the Turkish Family Medicine Program, but their emphasis is on the effect of increased access to physicians. Anderson et al. (2016) use the introduction of midwife licensing in the early 20th century US in a difference in differences setup to identify the effect of professional birth help compared to informal assistance. They find a strong decline in maternal mortality, but only quite modest effects on infant mortality. The variation used is at the state level.

The most similar paper to ours is a working paper by Pettersson-Lidbom (2015), who investigates the effects of midwives on maternal and infant mortality using yearly data from 25 Swedish regions between the years 1830 to 1894. Pettersson-Lidbom (2015) claims to identify a causal effect by using a difference in difference estimator with region specific time trends. He finds that increasing the number of trained midwives decreases maternal mortality. He also uses the opening of a midwifery school and find similar effects on maternal mortality for areas close to the new school. Our study supplements Pettersson-Lidbom (2015) by studying a different country and a later time period. However, and most importantly, the data used here is at a much finer geographical level. This is potentially important as there is large variation within regions. We are also able to control for poverty levels using local data on poverty support. To the best of our knowledge there is no previous study on the effects of health personnel on mortality over such a long time period on such a fine level of aggregation.

We find that an increased number of midwives lead to reduced maternal mortality, particularly in rural areas. We find no robust effects on other types of mortality nor do we find any effects of other types of health personnel. Together with the results in Pettersson-Lidbom (2015) and Anderson et al. (2016) a clear picture emerges, showing that midwives had a causal effect on maternal mortality in different settings.

2 Data and context

2.1 Sources

Most of the data we use in this paper is drawn from annual medical reports ("Beretning om Sundhedstilstanden og Medicinalforholdene i Norge"), a series of annual reports where local physicians reported on the medical conditions in their locality. [1]

From the 18th century, the Norwegian central government started to pay more attention to public health for at least two reasons. First, the government perceived an increased need of control of the geographically vast country, including its health conditions and epidemics. Second, the prevailing mercantilist doctrine emphasized a large and healthy population as a precursor to a strong nation. Public health was a key policy to achieve this. As a consequence, the government both increased public health care provision and introduced more systematic reporting of health conditions (Moseng, 2003).

From 1794, all publicly paid doctors, priests, and property owners should report local health conditions to the district governor ('amtsmann'). In 1803 it was announced that all medical doctors, including those on the public payroll, were required to provide such reports. The first reports date from 1804, and consist of a collection of hand written documents.[2]

From 1852 on, each doctor was required to report to the district or city doctor, who would compile these and report to the national authority. This resulted in the first collected and printed report in 1853, a year often seen as the "Birth of Norwegian medical statistics".[3] During the period 1853-72 the final report was produced by the Ministry of the Interior. In 1873 the task was taken over by the Director of the Civil Medical Authority, and from 1922 until the end of the report series the reports were produced by Statistics Norway.

Initially, the reports mostly contain non-structured reports of the health conditions in

[1] Full details of the reports are given in Appendix A.5.

[2] See Schjønsby (2005) for an extended overview of the first reports.

[3] See Statistics Norway (1952) and Bore (2007) for an in depth discussion of the history of the printed reports.

each region. The 1860 Health Act introduces compulsory reporting of epidemic diseases that were treated by the public. Starting in 1864, the format of the reports was harmonized by the Director and an increased amount of regional statistics were introduced including quite detailed age separated mortality data. Increasingly, the reports also contain information about medical personnel, and from 1879 the reports contain a standardized table with the number of medical doctors, midwives, and assistant vaccinators (later extended to also include dentists) per municipality.

We have digitized the figures from the tables. For each municipality, we have the number of doctors, dentists, midwives and vaccinators. This is also aggregated to the medical district and county level. Number of births, stillbirths, deaths, infant (first year, first day) and child mortality, maternal mortality, accidental deaths and sucicides is reported at the medical district level. Moreover, each report lists the number of inhabitants as of the latest decennial census and the land area of the municipalities.

There are substantial changes in the structure of municipalities and medical districts in Norway in the period studied. We base our municipal structure on lists of municipalities by year made available by the Norwegian Municipal Data Service (NSD). In some cases the year of change is not the same in the medical reports and the NSD data; in those cases, we follow the medical reports. The number of medical districts also increase substantially, so that the average number of municipalities in each medical district (and the average medical district population) decreases over time. To ensure that our analysis is not affected by these changes in regional aggregation, we also construct our analysis at a harmonized medical district level, where the medical districts in any given period are aggregated up to form a unit that does not change over time.

In total, there are between 583 and 704 municipalities and between 156 and 384 medical districts (depending on year) across Norway's 20 counties. These can be aggregated to form 109 time-invariant units. Reliable numbers on the total population in each municipality and medical district is only available in Census years – for the period at hand the years 1891, 1900, 1910 and 1920.

Descriptive statistics for each of the three regional aggregations are given in Table 1. We now describe some of the main patterns in the data.

	Level of aggregation			
Year and Variable	Municipality	Medical district	Harmonized medical district	Country
Midwives	1.66 (1.76)	5.58 (4.31)	9.41 (8.60)	1025.23
Births		280 (275)	480 (466)	52306
Midviwes (per 1000 births)		24.28 (12.74)	21.93 (9.37)	19.60
Doctors	1.03 (2.24)	3.45 (4.63)	5.89 (7.17)	641.86
Maternal mortality		3.91 (13.65)	4.20 (5.64)	3.49
Infant mortality		69.96 (36.91)	75.56 (35.58)	74.73
Day-one mortality		7.14 (7.79)	7.22 (5.88)	7.67
Number of districts	644	223	109	1

Table 1: Descriptive statistics, average of all years 1887-1921. Standard deviations in parentheses. Births and deaths are not available at the municipal level.

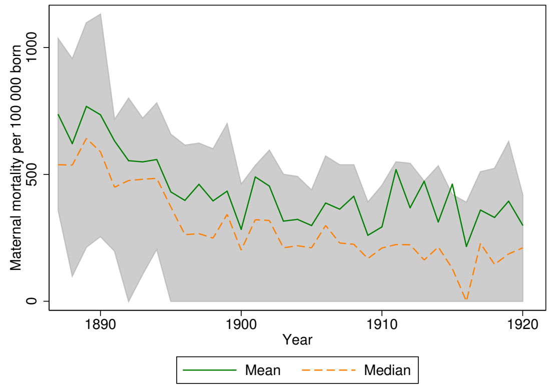
2.2 Health in Norway at the turn of the 19th century

We now consider the data on mortality for the period 1887-1921. The data was assembled and reported by the district doctors. In Panel (a) of Figure 1 we present average of maternal mortality per 100,000 children born by medical district.[4] It is notable that the levels are very high in the beginning of the period and the decrease over the time period is as remarkable.[5]

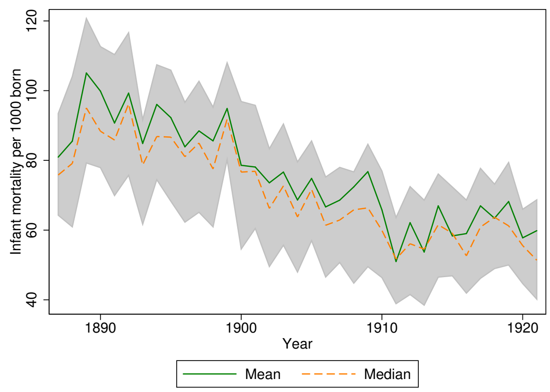
The infant mortality rate (IMR) is the number of infants dying before reaching one year of age, per 1,000 live births in a given year. In Panel (b) of Figure 1 we present the infant mortality rate in Norway during our period. Panel (c) of Figure 1 shows the mortality rate during the first day after birth. Infant mortality also shows a clear downward trend over the period, whereas day one mortality seems to remain fairly stable over time albeit with a high

[4]We divide by the number of children born as total population is only available for census years.

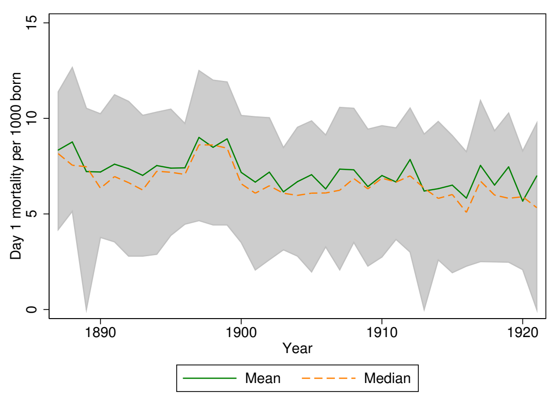
[5]The rates are actually higher at the beginning of the period than the rates in today's Sub-Saharan Africa (which have a maternal mortality rate of 480 deaths per 100,000 live births).



(a) Maternal mortality



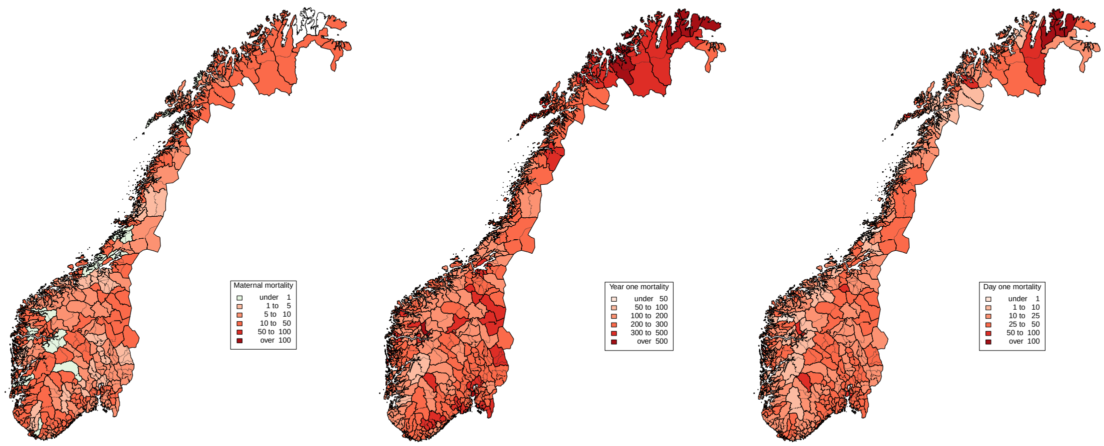
(b) Infant mortality



(c) Day 1 mortality

Figure 1: Mortality over time

Notes: The figure show yearly averages and means of maternal, infant (first life year), and first day of life mortality across medical districts. The bands show 25 and 75 percentiles of the distribution.



(a) Maternal mortality (b) Infant mortality (c) Day 1 mortality

Figure 2: Mortality in 1900

Notes: The figure show maternal, infant (first life year), and first day of life mortality per 100 000 residents measured in 1900 by medical district.

variance. Figure 2 shows the distribution of mortality per 100 000 residents by municipality in 1900. Mortality is higher in most of the Northern areas as well as the central eastern areas.

These figures correspond well to the review of the development of mortality in Norway over time given by Backer (1961). Backer emphasises a steady fall in mortality from the 1880s onward. Important drivers of this fall were improvements in infection control and a substantial fall in deaths from tuberculosis. In addition, an improvement in hygiene and public health services is emphasised as explanatory factors. Child mortality also fell throughout the period, but mortality for the youngest children was relatively stable in the later decades of the nineteenth century, only starting to fall after 1900.

2.3 Evolution over time in health personnel

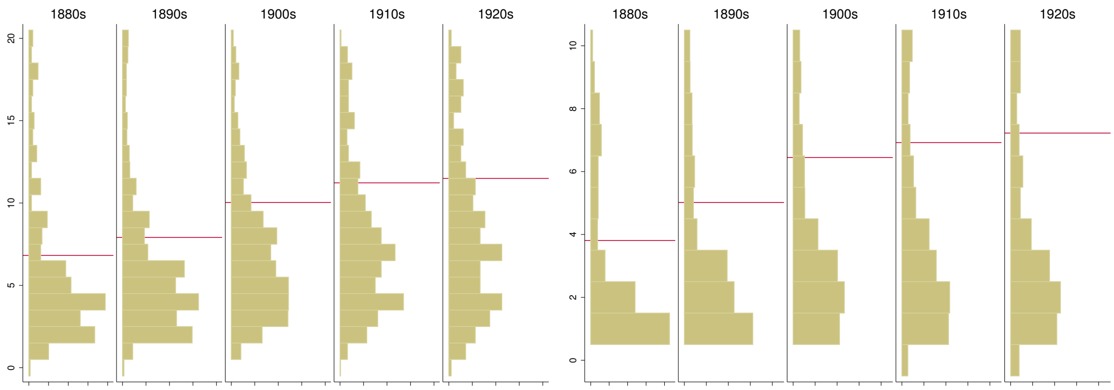
Until the early 19th century, most doctors located outside of the big cities of Norway had no academic training and were mostly surgeons. In 1836, the roles of medical doctors and surgeons were merged and a system of district doctors ('distriktsleger') was introduced (Sandvik, 2000). These doctors were responsible for quality control of assistant vaccinators, midwives, and pharmacies. Initially, each regional doctor was responsible for a vast district, but over time districts were divided up. The Health act ('Sunnhetsloven') of 1860 introduces permanent medical commissions in all cities and municipalities, headed by the district doctor (Schiøtz, 2003). Among the roles of this commission was the supervision of work on increasing hygiene in the municipality. Also, from the late 19th century onward, a number of new medical discoveries helped medical doctors in actually curing a number of diseases.

Norway has had midwives since the 16th century, two centuries after the profession first occurred in Germany.[6] Birth helpers without professional training, 'nærkoner', had however been helping mothers for ages. By the introduction of the new Church ritual in 1685, there should be a midwife in every church district. At the time, one of the key reasons for having midwives was to give emergency baptism to dying babies. About a century later, a midwife school opened in Copenhagen, and totally 65 women were trained in there before Norwegian independence in 1814.

In 1818, the first Norwegian midwife school, 'Fødselstiftelsen', opens in Christiania (today Oslo). Initially, midwives to be were trained for 9 months, in 1830 this was extended to a full year. A second midwife school opened in Bergen in 1861, mostly training midwifes from the western and northern parts of the country. Midwife students were told how to rotate a fetus in case of complicated births. Unlike in Sweden, however, they were not trained in or allowed to used medical instruments such as obstetric forceps before 1902 – only medial doctors were allowed to use tools.[7] However, from the mid-1880s, midwife students were introduced to antiseptics which had a major impact on the health of both mothers and babies. An important secondary role of midwives throughout the 18th century

[6] The historical overview of midwives is based on Farstad (2016) and Kjærheim (1987).

[7] The school in Bergen had a more relaxed attitude to the forceps, teaching it's use from the mid-1880s.



(a) Midwives (b) Doctors

Figure 3: Distribution of midwives and doctors over time

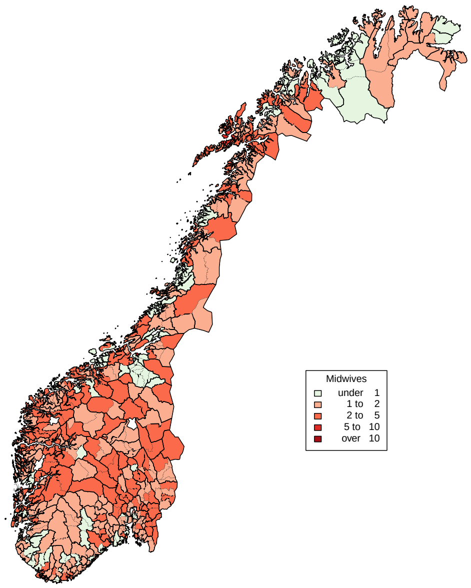
Notes: The figures show the change in the distribution of health personnel per medical district across decades. The red line shows the decade average. Histograms are capped at 20 midwives and 10 doctors.

was as vaccinators, particularly administering smallpox vaccines in rural areas.

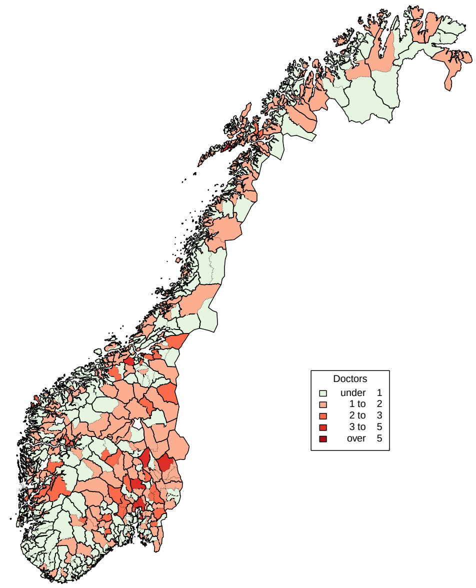
Starting with the midwife law of 1810, midwives were paid jointly by the region ('amt'), the district, and by the users. To assure the payment of the midwives, they were given a monopoly on providing birth help services. However, the monopoly was difficult to sustain and was abolished twenty years later. From 1898 onward, the midwives were paid jointly by the central government, the region, and the municipality.

Each medical district would have one or several midwife districts, where the midwife of the district was responsible for all births within her district. If the midwife was ill, the midwife of a neighboring district would take over. This was also the case if the position was not filled, which happened quite frequently both due to the wage costs, which led regional councils to delay hiring midwifes, and due to the low wages so it was difficult to get qualified applicants.

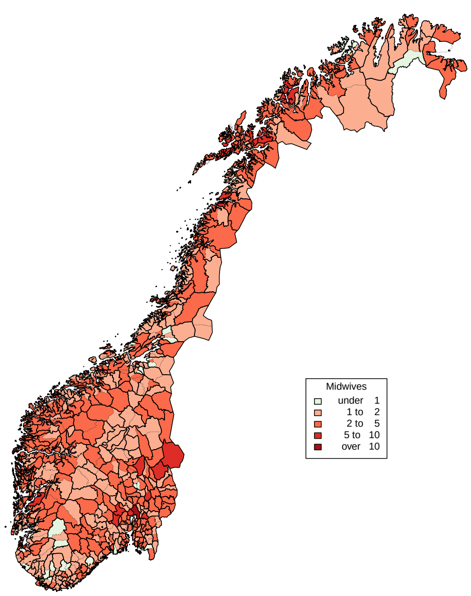
Panel (a) of Figure 3 shows the evolution of the number of midwives per municipality over time. There are on average 1.28 midwives per municipality in 1891, increasing steadily to 1.89 in 1920. The increase is mostly due to the upper tail of the distribution becoming thicker – although some municipalities maintain low numbers of midwifes, the number of municipalities with numerous midwives increase. As can be seen from the maps in Figure 4, there is also substantial spatial variation. The evolution of the number of medical doctors follow a similar pattern (Panel (b) of Figure 3), but the numbers are smaller and doctors are to a larger extent concentrated around the large cities (Panels (b) and (d) of Figure 4).



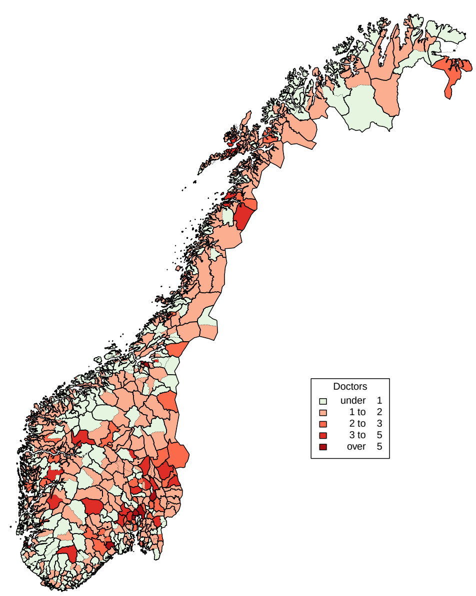
(a) Midwives 1890



(b) Doctors 1890



(c) Midwives 1920



(d) Doctors 1920

Figure 4: Geographic distribution of medical personnel.

3 Findings

3.1 Empirical strategy

There are many reasons why districts may have different shares of health personnel and different rates of mortality. When assessing the effects of health personnel on mortality we are particularly worried about other factors that are not controlled for but that may be linked to both the dependent and the independent variable of interest. For instance, some areas may have a culture that is more focused on health, which is likely to be correlated with more spending on health and lower mortality. To control for such factors, we estimate the relationship between mortality and health personnel using multivariate OLS regression with the specification:

$$Mortality_{dt} = \alpha + \beta Personnel_{dt} + \gamma_t + \theta_d + \delta_d t + \epsilon_{dt}, \tag{1}$$

where d is harmonized medical district and t is year. The district fixed effects capture geographical heterogeneity, the year fixed effects capture aggregate shocks, and the district specific time trends capture differential development across space, e.g. in income growth.

The year and district fixed effects lead to a typical "difference-in-differences" (DiD) setup, where the underlying assumption is that all districts would follow the same mortality path (albeit from different starting points) in the absence of health personnel changes. In the DiD setup, we control for the fact that districts with more health personnel are likely to differ from districts with less. In particular, we are comparing the change in districts with increased personnel to the change at the same point in time for districts not increasing their personnel at this specific time. The district and year fixed effects imply that we are controlling for all differences that are stable across districts over time. This involves many strong predictors for mortality such as culture and climate.

The main assumption in this type of analysis is that all districts would follow the same trend in the absence of personnel changes. One potential confounding factor is that there may be different trends in the districts and we therefore allow for a more flexible specification using district-specific time trends. This relaxes the assumption of similar trends further, as there is a linear time trend for each district and that the change in personnel will lead to deviations from that trend. This setup allows for differences in development between districts even without changes in personnel, such as in economic development.

We use log transformations on both the dependent and the main independent variables. The measured effect can then be read directly as an elasticity and the specification becomes less sensitive to outliers. The standard errors are clustered at the district level.

3.2 Baseline results

In Table 2 we regress mortality rates on the number of midwives with year and district fixed effects, as well as district specific linear time trends.[8] We find that an increase in the density of midwives decrease maternal as well as day one infant mortality, but the effects are only significant at the 10 % level. There is no significant effect on year one infant mortality.

These overall results mask a substantial differences between rural and urban areas, however. In Table 3, we split the sample by urban and rural status. We notice a strong relationship between midwives and maternal mortality stronger in rural areas. A 10 % increase in the number of midwives would lead to a 12.7 % reduction in maternal mortality and a 2.7 % reduction in day 1 mortality. Hence for the average medical district, the addition of one midwife would reduce maternal deaths by 0.890 (90% CI: $(0.335, 1.443)$) and deaths before day one by 0.346 (90% CI: $(0.029, 0.661)$) per 1000 children born.[9]

As stated above, rural medical districts covered much larger geographical areas, and

[8]Specifically, we use the transformation $x \to log(1+x)$ for mortality rates and the number of midwives to maintain zeros. We show below that results are robust to this choice of specification.

[9]This calculation is based on going from 5.58 to 6.58 midwives (17.9% increase) times $\beta = 1.27$ times 3.91 maternal deaths and $\beta = 0.27$ times 7.14 day 1 deaths per 1000 born.

Table 2: Midwives and mortality

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-0.76*	-0.22*	0.0024
	(0.40)	(0.13)	(0.065)
Mean dep. var	4.13	1.75	4.23
No. of observations	3705	3814	3814
No. of districts	109	109	109
R-squared	0.09	0.06	0.25

Notes: The dependent variables are logged ratios. All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

initical coverage of health personnel was lower than in cities. There are also other differences between cities and rural areas that are potentially important, such as the generally lower mortality (Backer, 1961, chap. 10) and lower income inequality (Modalsli, 2016) in rural areas. Consequently, we focus the analysis on the rural sample in what follows. Baseline results for the total sample are shown in Appendix A.3.

We note that there is a positive relationship between the number of midwives and the number of vaccinators (see Table 4). Controlling for the other types of health personnel may therefore be important and the results of such an estimation is presented in Table 5. We observe that the coefficient on the number of doctors and vaccinators are lower in magnitude, sometimes even with the opposite sign, and never statistically significant. The results for midwives are not substantially different from the baseline specification, although the statistical significance for day one mortality is reduced.

The current specification and particularly the addition of one to avoid zeros may seem restrictive. We show in Appendix A.1 that the results are robust to the choice of specification. In Appendix Table A.1 we present results results without district specific trends and results with the dependent variables represented in levels instead of in logs can be found in Appendix Table A.2. Finally, we show in Appendix Table A.3 that the baseline results are very similar if we use the inverse hyperbolic sine transformation, which closely resembles the log function

Table 3: Midwives and mortality in rural and urban areas

	Rural areas			Urban areas		
	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality	(4) Maternal mortality	(5) Day 1 mortality	(6) Infant mortality
Logged nr of midwives	-1.27**	-0.27*	0.0077	0.14	-0.088	-0.012
	(0.48)	(0.15)	(0.080)	(0.65)	(0.18)	(0.12)
Mean dep. var	3.85	1.65	4.19	4.68	1.97	4.30
No. of observations	2470	2541	2541	1235	1273	1273
No. of districts	74	74	74	38	38	38
R-squared	0.10	0.06	0.25	0.11	0.12	0.27

Notes: The dependent variables are logged ratios. All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table 4: Midwives and other medical personnel. Rural areas

	(1) Doctors	(2) Vaccinators
Logged nr of midwives	0.042	0.30***
	(0.065)	(0.064)
Mean dep. var	1.27	1.75
No. of observations	2541	2541
No. of districts	74	74
R-squared	0.53	0.64

Notes: The dependent variables are logged. All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table 5: Medical personnel and mortality. Rural areas

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-1.30**	-0.21	0.0060
	(0.53)	(0.18)	(0.085)
Logged nr of doctors	0.45	-0.097	-0.031
	(0.36)	(0.16)	(0.058)
Logged nr of vaccinators	0.053	-0.16	0.0099
	(0.67)	(0.23)	(0.093)
Mean dep. var	3.85	1.65	4.19
No. of observations	2470	2541	2541
No. of districts	74	74	74
R-squared	0.10	0.06	0.25

Notes: The dependent variables are logged ratios. All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

but accept zeros, instead of taking the log (see e.g. Burbidge et al., 1988).

In Appendix Tables A.4 and A.5 we show results for the other categories of health personnel separately and we note that they are not statistically significantly related to mortality in such specifications.

We also present results for three different time periods (1887-1897, 1898-1907, and 1908-1920) in Appendix Tables A.8 to A.13. The coefficients for midwives is always negative for all three types of mortality, but not statistically significant. The coefficient for doctors on infant mortality is always negative, and statistically significantly so in the period 1898-1907.

4 Placebos, timing, and mechanisms

In this section we assess the main threats to the identification strategy by testing if there is any "placebo" effect on outcomes that should not be affected and by testing whether there is an "effect" before the midwives appear. To assess a possible mechanism for why midwives have an effect, as opposed to e.g. doctors, we also investigate whether the services seem to be allocated in different ways with respect to poverty.

4.1 Placebos

In our dataset we have information about deaths that are likely to be unrelated to (or at least less related to) health personnel. In particular, we have data on murders, accidents, and suicides. If there is some other factor shifting at the same time as the change in medical personnel, and this factor affects mortality irrespective of the health system, we should expect to find differences also on these variables. Table 6 shows that these deaths are unrelated to the density of health personnel, and hence that there are no such "effects". In the last two columns, we also include a measure of other deaths, i.e. deaths in the district that are not maternal, neonatal, or infant deaths. The number of midwives is positively associated with these other causes of deaths, indicating that if there is a bias in our baseline estimates (Table 3) it is towards zero.

Table 6: Health personnel and placebo causes of death. Rural areas

	(1) Murder	(2) Murder	(3) Accident	(4) Accident	(5) Suicide	(6) Suicide	(7) Other	(8) Other
Logged nr of midwives	0.043	0.039	0.052	0.071	-0.019	-0.071	6.64*	2.04
	(0.056)	(0.062)	(0.17)	(0.16)	(0.14)	(0.15)	(3.93)	(3.69)
Logged nr of doctors		0.00027		0.056		-0.040		-1.42
		(0.041)		(0.099)		(0.12)		(2.28)
Logged nr of vaccinators		0.012		-0.073		0.18		15.5**
		(0.060)		(0.18)		(0.16)		(5.87)
Mean dep. var	0.08	0.08	2.58	2.58	0.57	0.57	0.56	0.56
No. of observations	2541	2541	2541	2541	2541	2541	2470	2470
No. of districts	74	74	74	74	74	74	74	74
R-squared	0.04	0.04	0.04	0.04	0.05	0.05	0.35	0.35

Notes: The dependent variables are logged ratios. All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

4.2 Timing of the effects

As the data at hand is annual data, we can not observe when during the year a change in the density of health personnel occurs. It is plausible to believe that some of the observed births occurred before the change in health personnel, and some after. For infant mortality, which occurs sometime between the 1st and the 365th day of a child's life, it the timings of the arrival of the health personnel may matter for observed effects. For day one mortality it is least problematic to measure the instantaneous effect and for maternal mortality it is in between. To overcome these challenges, we study the effect of lagged health personnel.

Investigating the timing of effects also gives us the opportunity to investigate another threat to the identification strategy: sluggish and gradual changes. Suppose for instance that there is some slowly evolving factor, say "modernity", that affects both healthcare spending and health outcomes. This could lead to a spuriously significant lead coefficient. In Table 7, we show the results when including two lags and two leads. We find it comforting that the leads are not statistically significant. We also see that the one year lag coefficient seems to be larger that the contemporaneous coefficient for maternal mortality. When testing whether the lag plus the contemporaneous coefficient is different from zero we find indications that

Table 7: Midwives and mortality, dynamic effects. Rural areas

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-0.37	-0.18	0.11
	(0.72)	(0.25)	(0.18)
Lagged midwives	-1.02	-0.25	-0.095
	(0.77)	(0.27)	(0.17)
2 lags midwives	-0.16	0.28	0.15
	(0.73)	(0.29)	(0.17)
Forward midwives	-0.32	-0.089	-0.042
	(0.80)	(0.23)	(0.19)
2 leads midwives	-0.37	-0.0053	-0.10
	(0.77)	(0.32)	(0.11)
Mean dep. var	3.76	1.64	4.20
No. of observations	2251	2251	2251
No. of districts	74	74	74
R-squared	0.10	0.06	0.25

Notes: The dependent variables are logged ratios. All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

they are for maternal mortality and for day one mortality ($p < 0.1$ in both cases).

4.3 The role of poverty

A possible threat to our results could be that health personnel and health outcomes shift with economic shocks. Richer areas having more health care or different trends in different areas would be controlled for by the district fixed effects and district specific trends, and are hence not challenges to identification. Still, a shock to poverty could reduce both health spending and affect mortality differentially at exactly the same time. For this to be a threat to our identification strategy, we should see that services correlate with poverty shocks, that poverty shocks affect mortality, and that the effect of services disappears when we control for the time varying level of poverty. We investigate the three aspects in turn.

We base our measure of poverty on the number of heads-of-households receiving poverty support. Poverty support was awarded by municipalities and is reported annually (at the municipality level) in reports published by Statistics Norway.[10] The "poor share" is then

[10] We use transcriptions of this data provided by the NSD Municipal Database (Norwegian Centre for

Table 8: Service provision and poverty shocks. Rural areas

	(1) Midwives	(2) Doctors	(3) Vaccinators
Share poor people in the district	0.042	-0.0019	0.032
	(0.033)	(0.034)	(0.036)
Mean dep. var	1.88	1.28	1.76
No. of observations	290	290	290
No. of districts	74	74	74
R-squared	0.50	0.28	0.24

Notes: The dependent variables are logged. All regressions control for year and district fixed effects. Robust standard errors clustered at the medical district level in parentheses.

the number of poor divided by total population in the municipality. As total population is only available in Census years, these investigations are only done for the years 1891, 1900, 1910 and 1920. It should also be kept in mind that the exact implementation of supplying poverty support was partially a municipal decision. Hence it may be that more affluent or generous areas report higher level of poverty because the rules where more inclusive.

The share of poor people in the rural districts range from 0.5 to 8 percent. Hence we measure the effect of one standard deviation change in poverty on our outcomes (one standard deviation conveniently corresponding to 1 percentage point in our data as well). In Table 8, we present the results. We drop the district specific linear trends as we only have four years of data. We see that service provision is positively correlated with poverty shocks (except for doctors), but the effects are not statistically significant. Similarly, in Table 9 we see that maternal mortality and neonatal mortality is negatively correlated with poverty shocks, but infant mortality is positively so. Neither these results are statistically significant.

Hence, poverty shocks do not seem to pose a threat for our identification strategy. Nonetheless, differences in poverty across districts may still be correlated with service provision, and as such they may help us understand the mechanisms behind the effects. We therefore present analyses where we only control for year fixed effects to see the distribution

Research Data, 2017).

Table 9: Mortality and poverty shocks. Rural areas

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Share poor people in the district	-0.46 (0.37)	-0.055 (0.13)	0.013 (0.037)
Mean dep. var	3.73	1.62	4.19
No. of observations	290	290	290
No. of districts	74	74	74
R-squared	0.09	0.01	0.31

Notes: The dependent variables are logged ratios. All regressions control for year and district fixed effects. Robust standard errors clustered at the medical district level in parentheses.

Table 10: Service provision and poverty levels. Rural areas

	(1) Midwives	(2) Doctors	(3) Vaccinators
Share poor people in the district	-0.068 (0.050)	0.010 (0.050)	-0.077 (0.047)
Mean dep. var	1.88	1.28	1.76
No. of observations	290	290	290
R-squared	0.09	0.05	0.05

Notes: The dependent variables are logged. All regressions control for year fixed effects. Robust standard errors clustered at the medical district level in parentheses.

of services. We still cluster the standard errors at the district level to account for the fact that observations are not independent within districts over time.

In Table 10 we see that a standard deviation in the share of poor people is not statistically significantly associated with more or less personnel. In Table 11 we see that poorer districts have higher infant mortality (statistically significant at the 10 percent level). They do not have higher maternal and neonatal mortality.

Table 11: Mortality and poverty levels. Rural areas

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Share poor people in the district	-0.020 (0.21)	-0.074 (0.098)	0.071* (0.040)
Mean dep. var	3.73	1.62	4.19
No. of observations	290	290	290
R-squared	0.06	0.01	0.20

Notes: The dependent variables are logged ratios. All regressions control for year fixed effects. Robust standard errors clustered at the medical district level in parentheses.

5 Conclusion

High infant and maternal mortality has been and is still on of the realities in life in most parts of the world. This paper is the first to use high-quality regionally disaggregated data to study how increased access to medical personnel helped reduce mortality in Norway around the turn of the 20th century. We find that increased access to midwives had a strong effect on reducing maternal mortality and also an effect on day one mortality. There are no signs of medical doctors decreasing mortality in this period.

Over the period at hand, the number of midwives per (harmonized) medical district increases from 4.53 to 8.03 in rural areas. Taking our elasticity of 1.27, the increased access to midwives would lead to a 62 % reduction in maternal mortality. This more than explains the observed decline of 59.6 % observed in rural areas..

We have argued that our results cannot be due to general improvements in living standards and technology or the uneven development in different parts of the country. Neither can it be driven by high levels of poverty affecting both mortality rates and the provision of health services. Hence it seems that the true effect of access to midwives explains most of the decline in mortality. Doctors, however, seem to have little or no effect on either maternal or infant mortality during the period at hand.

The main policy conclusion that can be drawn is that for today's poor countries, improving access to maternal care may be key to reducing high mortality rates among mothers and infants. Medical doctors today do of course have a much large range of tools, particularly effective medication, at their disposal than did the doctors in Norway a century ago. Hence the conclusion that doctors have no effect on mortality may not be applicable to a contemporary setting.

The paper at hand have attempted to estimate average effects of medical personnel. In future research, it would be interesting to go further into social gradients in the effect. one conjecture is that the lower classes (albeit maybe not the very lowest) were the groups most benefiting from midwifery services.

References

ANDERSON, D. M., R. BROWN, K. K. CHARLES, AND D. I. REES (2016): "The Effect of Occupational Licensing on Consumer Welfare: Early Midwifery Laws and Maternal Mortality," IZA Discussion Paper 10074.

BACKER, J. (1961): "Dødeligheten og dens årsaker i Norge 1856-1955," *Statistisk sentralbyrå: Samfunnsøkonomiske studier*, 10.

BORE, R. R. (2007): "Om helsestatistikken: "Befolkningen er nøgtern og ædruelig, men Sædeligheden staar lavt"," in *På liv og død. Helsestatistikk i 150 år*, ed. by R. R. Bore, Statistics Norway, chap. 1, 7–28.

BURBIDGE, J. B., L. MAGEE, AND A. L. ROBB (1988): "Alternative Transformations to Handle Extreme Values of the Dependent Variable," *Journal of the American Statistical Association*, 83, 123–127.

CESUR, R., P. M. GÜNEŞ, E. TEKIN, AND A. ULKER (2017): "The value of socialized medicine: The impact of universal primary healthcare provision on mortality rates in Turkey," *Journal of Public Economics*, 150, 75–93.

DEATON, A. (2013): *The great escape. Health, wealth, and the origins of inequality*, Princeton: Princeton University Press.

FARSTAD, A. (2016): *På liv og død. Distriktsjordmødrenes historie*, Oslo: Samlaget.

FRANKENBERG, E., W. SURIASTINI, AND D. THOMAS (2005): "Can expanding access to basic healthcare improve children's health status? Lessons from Indonesia's "Midwife in the Village" programme," *Population Studies*, 59, 5–19.

FRANKENBERG, E. AND D. THOMAS (2001): "Women's health and pregnancy outcomes: Do services make a difference?" *Demography*, 38, 253–65.

Kjærheim, K. (1987): *Mellom kloke kvinner og kvitkledde men. Jordmorvesenet på 1800-tallet*, Oslo: Samlaget.

Lazuka, V. (2016): "The long-term health benefits of receiving treatment from qualified midwives at birth," Tech. rep., Department of Economic History, Lund University.

Modalsli, J. (2016): "The regional dispersion of income inequality in nineteenth-century Norway," *Statistics Norway Discussion Paper*, 842.

Moseng, O. G. (2003): *Ansvaret for undersåttenes helse 1603-1850*, vol. 1 of *Det offentlige helsevesen i Norge 1603-2003*, Oslo: Universitetsforlaget.

Norwegian Centre for Research Data (2017): "Kommunedatabasen [Municipal database]," `https://trygg.nsd.uib.no/kdbbin/kdb_start.exe`.

Pettersson-Lidbom, P. (2015): "Midwives and maternal mortality: Evidence from a midwifery policy experiment in Sweden in the 19th century," Tech. rep., mimeo.

Sandvik, H. (2000): "Distriktslegen (1836–1984)," *Tidsskrift for Den norske legeforening*, 120, 3160–1.

Schiøtz, A. (2003): *Folkets helse – landets styrke 1850-2003*, vol. 2 of *Det offentlige helsevesen i Norge 1603–2003*, Oslo: Universitetsforlaget.

Schjønsby, H. P. (2005): "The medical reports from the district physicians – an indispensable source to the Norwegian medical past," *Michael*, 3, 218–35.

Statistics Norway (1952): "Sunnhetstilstanden og medisinalforholdene 1952," NOS XI. 196.

Østby, G., H. Urdal, A. F. Tollefsen, A. Kotsadam, R. Belbo, and C. Ormhaug (2016): "Armed conflict and maternal health care Micro-level evidence from Sub-Saharan Africa," Mimeo. Peace Research Institute Oslo (PRIO).

Triyana, M. (2016): "The effects of Indonesia's "Midwife in the Village" programme 10 years post-launch," *Population Studies*, 70, 365–376, pMID: 27310221.

van Lerberghe, W., A. Manuel, Z. Matthews, and W. Cathy (2005): *The World Health Report 2005-make every mother and child count*, World Health Organization.

van Rijsbergen, B. and B. D'Exelle (2013): "Delivery care in Tanzania: A comparative analysis of use and preferences," *World Development*, 43, 276–287.

Appendix

A.1 Robustness

Table A.1: Midwives and mortality (logged). Two way fixed effects regressions without district specific time trends

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-0.78*	0.0072	0.064
	(0.40)	(0.11)	(0.065)
Mean dep. var	3.85	1.65	4.19
No. of observations	2470	2541	2541
No. of districts	74	74	74
R-squared	0.07	0.02	0.21

Notes: All regressions control for year and district fixed effects. Robust standard errors clustered at the medical district level in parentheses.

Table A.2: Midwives and mortality (not logged). Two way fixed effects regressions with district specific time trends

	(1) Maternal mortality	(2) Infant mortality	(3) Day 1 mortality
Midwife	-31.4**	-0.67	-0.23*
	(13.7)	(0.57)	(0.13)
Mean dep. var	461.02	73.28	6.90
No. of observations	2377	2451	2451
No. of districts	74	74	74
R-squared	0.16	0.28	0.05

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table A.3: Midwives and mortality (logged inverse hyperbolic sine transformation). Two way fixed effects regressions with district specific time trends

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-1.15***	-0.28*	0.011
	(0.43)	(0.16)	(0.073)
Mean dep. var	4.27	2.07	4.87
No. of observations	2470	2541	2541
No. of districts	74	74	74
R-squared	0.10	0.06	0.24

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

A.2 Other categories of health personnel

Table A.4: Doctors and mortality (logged). Two way fixed effects regressions with district specific time trends

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of doctors	0.42	-0.10	-0.031
	(0.37)	(0.15)	(0.058)
Mean dep. var	3.85	1.65	4.19
No. of observations	2470	2541	2541
No. of districts	74	74	74
R-squared	0.10	0.06	0.25

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table A.5: Vaccinators and mortality (logged). Two way fixed effects regressions with district specific time trends

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of vaccinators	-0.39	-0.23	0.011
	(0.63)	(0.20)	(0.088)
Mean dep. var	3.85	1.65	4.19
No. of observations	2470	2541	2541
No. of districts	74	74	74
R-squared	0.10	0.06	0.25

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

A.3 Baseline results in the total sample

Table A.6: Midwives and other types of personnel (logged). Two way fixed effects regressions with district specific time trends

	(1) Doctors	(2) Vaccinators
Logged nr of midwives	0.050	0.25***
	(0.048)	(0.050)
Mean dep. var	1.58	1.81
No. of observations	3815	3815
No. of districts	109	109
R-squared	0.60	0.61

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table A.7: Midwives and mortality (logged). Two way fixed effects regressions with district specific time trends, controlling for other types of health personnel

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-0.77*	-0.18	-0.0045
	(0.42)	(0.14)	(0.067)
Logged nr of doctors	0.35	-0.022	-0.042
	(0.32)	(0.13)	(0.052)
Logged nr of vaccinators	-0.027	-0.14	0.036
	(0.48)	(0.16)	(0.066)
Mean dep. var	4.13	1.75	4.23
No. of observations	3705	3814	3814
No. of districts	109	109	109
R-squared	0.09	0.06	0.25

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

A.4 Different time periods

Table A.8: Midwives and mortality 1887-1897 (logged). Two way fixed effects regressions with district specific time trends

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-1.95	-0.55	-0.15
	(1.22)	(0.68)	(0.12)
Mean dep. var	4.65	1.71	4.41
No. of observations	814	814	814
No. of districts	74	74	74
R-squared	0.14	0.10	0.19

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table A.9: Midwives and mortality 1887-1897 (logged). Two way fixed effects regressions with district specific time trends, controlling for other types of health personnel

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-2.05	-0.45	-0.12
	(1.24)	(0.71)	(0.13)
Logged nr of doctors	0.38	-0.10	-0.17
	(1.12)	(0.35)	(0.11)
Logged nr of vaccinators	0.80	-0.95	-0.10
	(1.64)	(0.74)	(0.20)
Mean dep. var	4.65	1.71	4.41
No. of observations	814	814	814
No. of districts	74	74	74
R-squared	0.14	0.10	0.19

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table A.10: Midwives and mortality 1898-1907 (logged). Two way fixed effects regressions with district specific time trends

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	0.17	-0.58	-0.20
	(1.38)	(0.53)	(0.16)
Mean dep. var	3.61	1.67	4.23
No. of observations	728	728	728
No. of districts	74	74	74
R-squared	0.16	0.16	0.26

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table A.11: Midwives and mortality 1898-1907 (logged). Two way fixed effects regressions with district specific time trends, controlling for other types of health personnel

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	0.096	-0.59	-0.21
	(1.39)	(0.53)	(0.17)
Logged nr of doctors	-0.37	0.27	-0.26**
	(1.20)	(0.36)	(0.11)
Logged nr of vaccinators	1.92	0.38	0.18
	(1.60)	(0.59)	(0.15)
Mean dep. var	3.61	1.67	4.23
No. of observations	728	728	728
No. of districts	74	74	74
R-squared	0.16	0.16	0.26

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table A.12: Midwives and mortality 1908-1920 (logged). Two way fixed effects regressions with district specific time trends

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-0.71	-0.40	0.048
	(1.01)	(0.29)	(0.23)
Mean dep. var	3.33	1.58	4.00
No. of observations	928	999	999
No. of districts	72	72	72
R-squared	0.11	0.09	0.10

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

Table A.13: Midwives and mortality 1908-1920 (logged). Two way fixed effects regressions with district specific time trends, controlling for other types of health personnel

	(1) Maternal mortality	(2) Day 1 mortality	(3) Infant mortality
Logged nr of midwives	-0.36	-0.39	0.062
	(1.12)	(0.33)	(0.24)
Logged nr of doctors	-0.10	0.11	-0.076
	(0.74)	(0.31)	(0.11)
Logged nr of vaccinators	-0.97	-0.034	-0.030
	(1.24)	(0.39)	(0.23)
Mean dep. var	3.33	1.58	4.00
No. of observations	928	999	999
No. of districts	72	72	72
R-squared	0.11	0.09	0.10

Notes: All regressions control for year and district fixed effects as well as district specific time trends. Robust standard errors clustered at the medical district level in parentheses.

A.5 Source list

The reports are all titled "Sundhetstilstanden og medicinalforholdene" (spelled "Sundhetstilstanden og medisinalforholdene" from 1916 onwards) and published one or a few years after the year the report refers to. "NOS" refers to "Norwegian Official Statistics". All reports can be downloaded at `http://www.ssb.no/a/histstat/publikasjoner/histemne-02.html`.

- **1887**: NOS III 95
- **1888**: NOS III 116
- **1889**: NOS III 143
- **1890**: NOS III 162
- **1891**: NOS III 185
- **1892**: NOS III 222
- **1893**: NOS III 252
- **1894**: NOS III 274
- **1895**: NOS III 290
- **1896**: NOS III 317
- **1897**: NOS III 327
- **1898**: NOS IV 1
- **1899**: NOS IV 27
- **1900**: NOS IV 55
- **1901**: NOS IV 77
- **1902**: NOS IV 103
- **1903**: NOS IV 128
- **1904**: NOS V 23
- **1905**: NOS V 55
- **1906**: NOS V 72
- **1907**: NOS V 98

- **1908**: NOS V 122
- **1909**: NOS V 152
- **1910**: NOS V 181
- **1911**: NOS V 216
- **1912**: NOS VI 19
- **1913**: NOS VI 56
- **1914**: NOS VI 94
- **1915**: NOS VI 133
- **1916**: NOS VI 186
- **1917**: NOS VII 3
- **1918**: NOS VII 58
- **1919**: NOS VII 108
- **1920**: NOS VII 138
- **1921**: NOS VII 152