

THE EFFECT OF OCCUPATIONAL LICENSING ON CONSUMER WELFARE: EARLY MIDWIFERY LAWS AND MATERNAL MORTALITY

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Abstract

Occupational licensing is intended to protect consumers. Whether it does so is an important, but unanswered, question. Exploiting variation across states and municipalities in the timing and details of midwifery laws introduced during the period 1900-1940, and using a rich data set that we assembled from primary sources, we find that requiring midwives to be licensed reduced maternal mortality by 6 to 7 percent. In addition, we find that requiring midwives to be licensed may have led to modest reductions in nonwhite infant mortality and mortality among children under the age of 2 from diarrhea. These estimates provide the first econometric evidence of which we are aware on the relationship between licensure and consumer safety, and are directly relevant to ongoing policy debates both in the United States and in the developing world surrounding the merits of licensing midwives.

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1. INTRODUCTION

Requirements that workers hold an occupational license as a condition of employment have become increasingly common in recent decades. Indeed, the fraction of licensed workers today is nearly three times larger than the roughly 11 percent of workers in labor unions (Gittleman and Kleiner 2016). Despite the rapid growth in the prevalence of licensure requirements, there has been relatively little empirical work assessing their effects, with the bulk of studies focusing on the outcomes of licensees as opposed to the outcomes of consumers served by these workers.¹

Whether consumers are helped or hurt by occupational licensure is theoretically ambiguous. Licensure has historically been justified on the grounds that requiring licensees to, for instance, pass an exam or receive formal training should push low-quality providers out of the market and raise the quality of those who remain, both of which should improve the health and safety of consumers (Shapiro 1986, Kleiner 2000, Gittleman and Kleiner 2016). On the other hand, theory suggests possible adverse consequences of licensure that could counteract, and possibly even override, the benefits to consumers from improved provider quality. Perhaps the most important among these is the possibility that licensure could lead to higher prices and reduced access to the service in question, causing consumers to substitute towards cheaper, inferior alternatives (Shepard 1978; Adams et al. 2003; Kleiner and Kudrle 2000; Kleiner et al. 2016). Moreover, because licensees are insulated from competitive pressure, their incentive to provide high-quality service may be diminished, and they may even engage in behavior that strictly lowers quality.²

¹ A number of papers have shown, across a variety of sectors, that persons holding occupational licenses have higher earnings (Kleiner and Kudrle 2000; Timmons and Thornton 2008; Kleiner and Krueger 2010; Kleiner and Krueger 2013; Thornton and Timmons 2013; Kleiner et al. 2016). Carroll and Gaston (1981) and Kleiner and Kudrle (2000) assessed the effects of licensing restrictions for dentists on measures of dental health. Larsen (2015) and Sass (2015) studied the relationship between teacher licensure and student achievement. See Kleiner (2015) for an excellent review of the literature.

² Carroll and Gaston (1979) suggested several mechanisms through which licensing could negatively impact quality in health care, including self-substitution towards inferior products or services, reduction in the time spent with each

Not only is theory ambiguous about how licensure should affect consumer health and safety, but there is very little previous empirical work on this question. A reason for this paucity of research may be that outcomes in the modern health care system generally depend upon the actions of a host of specialists, making it difficult for researchers to convincingly disentangle how health is causally affected by licensing standards that pertain to one specific type of specialist. Establishing the causal relationship between licensing the providers of a particular medical service and consumer health would seem to require a tight link between the actions of these providers and the particular health outcome being measured.

In this study, we examine how the adoption of state midwifery licensing requirements in the early 20th century affected the likelihood of dying from complications of pregnancy and childbirth among American women. In our view, this historical episode represents a unique natural experiment that can be leveraged to document the causal effect of licensing on health. Unlike today, American women in the early 20th century typically gave birth at home, where they were attended by a single health care provider, either a doctor or midwife, who had sole responsibility for the health of the mother and infant (Leavitt 1983). By drawing upon historical data, we are able to estimate the relationship between requiring that a group of health care providers (midwives) be licensed and a specific consumer health outcome (maternal mortality) over which they had a direct, immediate and profound impact.

Another advantage of examining the early adoption of state licensing requirements for midwives is that, before their adoption, the market for midwifery services was wholly unregulated. By contrast, in the modern health care sector, where a large number of specialists are already licensed, loosening or tightening licensing requirements for a specific type of health care provider

customer (e.g., briefer office visits) and location choices more in line with provider preferences than consumer needs (e.g., doctor shortages in rural areas).

represents only an incremental change in the overall licensing regime. The effect of this incremental change might be quite different from the effect of going from an unregulated market to requiring all providers to pass an exam or receive formal training. Thus, the adoption of midwifery laws in the early 20th century represents an opportunity to explore what happens when licensing requirements are first imposed in a context where nothing of their kind had existed previously.

Our analysis uses data from 1900-1940, a period when 22 states, and at least a dozen municipalities, adopted midwifery licensing requirements. Drawing on various primary sources, we assembled information on these requirements, including their dates of passage and key provisions, which varied dramatically across states. For instance, applicants for licenses in Mississippi were judged based on their character, cleanliness and intelligence, but were not required to take an exam or graduate from a school of midwifery. By contrast, midwives in California, Washington and Wisconsin were required to graduate from a recognized school of midwifery and to pass an examination administered by their State Board of Medical Examiners. By exploiting geographical and temporal variation in the adoption of requirements such as these, we are able to assess their impact on maternal mortality. In addition, we are able to explore their effects on infant mortality as well as mortality among children under the age of 2 due to diarrhea.

Our main data source is *Mortality Statistics*, published on an annual basis by the U.S. Census Bureau. It contains mortality counts by cause at the state level for the period 1900-1940. Using these counts, we estimate a series of models that relate maternal mortality in a particular state and year to whether midwives were required to be licensed in order to practice. The models control flexibly for state and year effects; mortality from non-pulmonary tuberculosis and typhoid serve as proxies for milk and water quality (Clay et al. 2014). Because *Mortality Statistics* provides mortality counts by cause at the municipal level for the period 1900-1917, we are also able to estimate similar models that exploit the adoption of local ordinances requiring midwives to be licensed.

We find that the introduction of licensing requirements for midwives was associated with a 6 to 7 percent reduction in maternal mortality. This result is robust across a variety of specifications, including controlling for state-specific linear time trends. Because state and local initiatives to combat various infectious diseases could have been correlated with the adoption of midwifery laws and maternal mortality, we conduct several falsification tests. Specifically, we test whether midwifery laws were related to mortality from pulmonary tuberculosis, influenza, malaria and diabetes. The results provide additional evidence that the relationship between midwifery licensing requirements and maternal mortality is causal. Finally, we turn our attention to infant, as opposed to maternal, mortality. We find that requiring a license in order to practice midwifery is associated with reductions in nonwhite infant mortality and mortality among children under the age of 2 from diarrhea, although we argue that these results should be viewed as more tentative than the maternal mortality results described above.

Our results are directly relevant to ongoing policy debates. One set of debates have to do with the modern practice of midwifery in the United States, where there are, broadly speaking, two types of midwives. Nurse midwives, who typically work in hospitals, are required to be licensed.³ In contrast, “lay” or “direct-entry” midwives typically attend births that occur outside of the hospital – most commonly at home. Licensure rules for lay midwives differ dramatically across states. In some states, lay midwives are required to meet specific conditions in order to obtain a license and practice, while in other states they are essentially unregulated (Rooks 1997; Rausch 2008; Reaves 2010; Rini 2015). Over the course of the last decade, the number of women choosing to deliver

³ In many states, certified nurse midwives (CNMs) are subject to “scope of practice” laws, which restrict the procedures they are allowed to perform. Using U.S. data for the period 1994-2012, Markowitz et al. (2016) found that allowing CNMs to practice independently was unrelated to maternal health behaviors and birth outcomes, but was associated with fewer C-sections. Using U.S. data for the period 1989-1999, Miller (2006) found that mandating insurance coverage of services provided by CNMs was associated with an increase in midwife-attended births and reductions in neonatal and infant mortality.

outside of hospitals has increased sharply (Belluck 2015), raising questions as to whether the presence or stringency of licensing rules for lay midwives affect maternal health outcomes. Although our estimates are from an earlier period in U.S. history, we are aware of no other evidence on this issue.⁴

Given the levels of health, medical technology and wealth that prevailed in the United States during the time period we study, our results may be even more relevant to ongoing policy debates about the merits of training and licensing midwives in developing countries today, where maternal mortality rates are often comparable to U.S. rates at the turn of the 20th century.⁵ In many developing nations, the majority of births are attended by traditional birth attendants (TBAs), who have no formal education or training.⁶ Experts have claimed that replacing TBAs with trained and licensed midwives would substantially reduce infant and maternal mortality (WHO 2005 pp. 68-72; Thompson et al. 2011; UNFPA 2011 pp. 2-7). This claim is based, in large part, on historical studies showing that Sweden had a lower maternal mortality rate than a handful of other industrialized countries (including the United States) during a period lasting roughly from when its municipalities were first required to employ a trained midwife in the early 19th century until 1940 (De Brouwere et al. 1998; Adegoke and van den Broek 2009; Loudon 2000a; UNFPA 2011). However, these studies do not isolate the effect of Sweden's midwifery policies from other potentially important influences.⁷

⁴ Using data from the Netherlands for the period 2000-2008, Daysal et al. (2015) examined the effect of giving birth at home, as opposed to the hospital, on newborn mortality and Apgar scores. Home births were associated with increased newborn mortality, but hospital births in the Netherlands are typically attended by a midwife, not an obstetrician.

⁵ At the turn of the 20th century, the U.S. maternal mortality ratio (MMR, maternal deaths per 100,000 live births) was approximately 700 (Woodbury 1924; Loudon 2000a, 2000b). In comparison, the MMR in Sub-Saharan Africa today is estimated to be between 380 and 730 (WHO 2014).

⁶ See United Nations Population Fund Report (UNFPA 2011).

⁷ Two such potential influences were the introduction of anti-septic technology and better nutrition (Högberg et al. 1986; Tomkins 2001). Swedish midwives practicing in the 19th century were required by law to receive training, but TBAs were allowed to attend births if a trained midwife was not available (Högberg 2004, p. 1315). Over the course of the 19th century, trained midwives gradually supplanted TBAs in Sweden. Sixty percent of births to Swedish mothers were attended by TBAs in 1861; by 1900 only 22 percent of births to Swedish mothers were attended by TBAs (De

Moreover, the credibility of cross-country comparisons is severely limited by the fact that in the late 1800s (when the first midwife laws were introduced in the United States) through the early 1900s, maternal mortality was not coded in a uniform fashion across countries (Loudon 1999). Our results and methods contribute credible evidence to this important policy issue.

The remainder of the paper is organized as follows. We begin with a historical overview of the midwifery debate and laws in the United States at the turn of the 20th century. In Section 3, we describe our empirical approach; in Sections 4 and 5 we report the principal maternal mortality results based on state- and municipal-level data, respectively. In Section 6, we explore the effect of midwifery laws on infant mortality, and in Section 7 we examine midwifery laws and the supply of midwives. Section 8 concludes.

2. HISTORICAL OVERVIEW

In the mid-1800s, the field of obstetrics was in its infancy and the vast majority of births in the United States were attended by midwives without formal training (Leavitt 1983; Drife 2002). As obstetrical knowledge and practices advanced, middle- and upper-class women increasingly relied on doctors to deliver their babies. By the turn of the 20th century, doctors attended roughly half of U.S. births (Jacobson 1956).⁸

Brouwere et al. 1998, p. 772). Using data from Sweden for the period 1830-1894, Pettersson-Lidbom (2015) found that increases in the supply of trained midwives were associated with substantial reductions in maternal mortality. Pettersson-Lidbom (2015) concluded that being attended by a trained midwife, as opposed to a TBA, led to an 80-86 percent reduction in the risk of dying during childbirth.

⁸ According to Leavitt (1983, p. 295), “Most of these births took place in the woman's home.” By 1933, approximately one-third of all births took place in the hospital (Leavitt 1983, p. 301).

This emerging preference for doctors as birth attendants can be attributed, at least in part, to the widespread perception that they were more competent than midwives (Rooks 1997, pp. 22-23).

There is, however, reason to believe that women's trust in doctors was misplaced.

In general, midwives were loath to intervene in the birthing process (Leavitt 1983). In contrast, doctors in the early 1900s routinely used forceps and anesthesia (ether or chloroform) during delivery. Being trained in the use of forceps was an important advantage if the labor was prolonged or the baby was in breech position, but the overuse of forceps came with significant risks to the mother and child. The leading cause of maternal mortality at the turn of the 20th century was "childbed" or puerperal fever (Loudon 2000a).⁹ According to Leavitt (1983, p. 292):

Inappropriate forceps use and the careless administration of ether and chloroform introduced serious lacerations and breathing disorders that otherwise might not have developed. Most significant, physicians carried puerperal fever, which was potentially disastrous, to birthing women. Because their medical practices included attending patients with communicable diseases, doctors were more likely than midwives to bring with them on their hands and on their clothing the agents of infection.

In fact, contemporary studies provide strong evidence that mortality rates were higher among mothers attended by a doctor than among mothers attended by a trained midwife (Jacobi 1912; Mendenhall 1917; Levy 1918, 1923; Sobel 1918). Despite this evidence, doctors and public health officials argued forcefully that midwives were to blame for puerperal fevers (Cody 1913; Plecker 1915; Edgar 1916; Frizzelle 1917; Terry 1917; Stedman 1920; Howe 1921; Rude 1922), and a variety of solutions to the so-called "midwife problem" were proposed. The abolition of midwifery was prominent among these solutions (Emmons and Huntington 1912; Williams 1912; Huntington

⁹ Puerperal fever, an infection of the reproductive tract during labor or its aftermath, was typically caused by Group A streptococcus bacteria (Nathan and Leveno 1994; De Costa 2002). Described as "the classic example of iatrogenic disease--that is, a disease caused by medical treatment itself" (Wertz and Wertz 1977, p. 128), puerperal fever accounted for about half of all deaths related to childbirth at the turn of the 20th century; only tuberculosis killed more women of childbearing age in the United States (Woodbury 1924; Loudon 2000a, 2000b). In our sample, which covers the period 1900-1940, 38 percent of maternal deaths were due to puerperal fever.

1913; De Lee 1915; Holmes 1920). However, some physicians conceded that abolition was impractical and, as an alternative, recommended the licensing and increased supervision of midwives coupled with teaching antiseptic technique and how to recognize pregnancy complications (Edgar 1916; Hardin 1925).

Midwives, many of whom were black or foreign-born, lacked the political and social clout to effectively counter the physician-led campaign against them (Rooks 1997, p. 24), and the demand for midwifery services continued to fall.¹⁰ By 1935, only 11 percent of births in the United States were attended by midwives; of these, 63 percent were to nonwhite mothers (Jacobson 1956, p. 254). By 1940, the last year of our analysis, 9 percent of births were attended by midwives; of these, 68 percent were to nonwhite mothers (Jacobson 1956, p. 254).

2.1. EARLY MIDWIFERY LAWS

The practice of midwifery was wholly unregulated in the United States until 1877, when Illinois became the first state to require licensure (Rooks 1997, pp. 17-22; Sandvick 2009). Under the Illinois Medical Practice Act, licensure was required of any person “practicing medicine, in any of its departments.” Licenses were issued by the newly created State Board of Health, which was empowered to give examinations to practitioners who had not graduated from a recognized medical

¹⁰ Information on the race and national origin of midwives is available from a variety of contemporary sources. Crowell (1907) surveyed 500 midwives practicing in New York City; 96 percent were foreign born and 30 percent were “unable to speak English.” Koehler and Drake (1911, p. 25) estimated that, of the 485 midwives practicing in Chicago, “35 per cent are Slavic and 6 per cent are Italian.” Jeidell and Fricke (1912) surveyed 119 midwives living in Anne Arundel County, Maryland. Of these, 95 were identified as “Negroes”, 17 were identified as “Americans” and the remainder were identified as foreign born. Thirty-four had registered with the Board of Health and only 21 were licensed to practice midwifery. According to Williams (1915), 326 midwifery licenses were issued by the State of New York between November 16, 1914 and April 15, 1915. Eight of the licensed midwives were identified as “American”, 1 was identified as “Colored” and the remaining midwives were identified as foreign born (Williams 1915). The Texas Bureau of Child Hygiene (1925) provided background information on 485 midwives practicing in 6 Texas counties. Of these, 76 percent were identified as “Colored”, 18 percent were identified as “Mexican” and 6 percent were identified as either “White” or “American.” Finally, according to Smith (2005, p. 62), by “the mid-1920s the state [of Washington] had licensed...at least 40 Japanese midwives out of a total of 60 midwives.”

institution.¹¹ Although midwifery was nowhere mentioned in the Act, the Board of Health contended that it made “the same requirement of midwives as of physicians” (Illinois State Board of Health 1879, p. 54).

The Illinois Medical Practice Act of 1877 served as a model for other state legislatures interested in regulating the practice of medicine (Sandvick 2009). By the turn of the 20th century, most states required physicians to be licensed (Hamowy 1979), but only 8 states (Connecticut, Illinois, Indiana, Louisiana, Minnesota, New Jersey, Ohio and Wyoming) required midwives to be licensed.¹² Under increasing pressure from public health officials and members of the medical profession to address the “midwife problem” (Kobrin 1966; Rooks 1997, p. 23), 16 states passed laws requiring the licensure of midwives between 1900 and 1920 (see Figure 1 and Appendix Table 1). Cities and towns also took up the cause. During this same period, at least 12 municipalities (including Los Angeles and New York City) adopted ordinances requiring practicing midwives to obtain a license, certificate or permit. North Carolina, which did not require licensure until 1935, nonetheless required midwives to wash their hands before touching a patient and banned women who were addicted to drugs or alcohol from the practice of midwifery (van Blarcom 1913).

Licensing requirements varied considerably across states. For instance, applicants in Mississippi did not have to take an exam or graduate from a school of midwifery. Instead, they were judged based on their character, cleanliness, intelligence, and “reputation for calling a doctor in difficult or abnormal cases” (Mississippi Board of Health 1921).¹³ In contrast, states such as

¹¹ One year after the Act came into effect, the State Board of Health estimated that no fewer than 1,400 “non-graduates” had been forced out of the state for practicing medicine without a license (Illinois State Board of Health 1879, p. 5).

¹² In addition to requiring a license to practice, New Jersey prohibited midwives from attending breech births and administering any type of medicine or drugs; Ohio not only prohibited midwives from attending breech births, but also forbade the use of instruments such as forceps. In 1896, midwives in the District of Columbia were required to pass an exam administered by the board of medical supervisors.

¹³ Although Texas required that midwives be of “good moral character” and graduates of a “bon fide, reputable” medical school, the law did “not apply to those who do not follow obstetrics as a profession, and who do not advertise

California, Washington and Wisconsin required applicants to graduate from a recognized school of midwifery and to pass an examination administered by their State Board of Medical Examiners (Wisconsin 1909; Washington 1919; Henning and Hyatt 1921).¹⁴

3. DATA AND EMPIRICAL FRAMEWORK

The U.S. Census Bureau began publication of *Mortality Statistics* in 1900. The initial issue contained mortality counts by cause, age and sex for 10 registration states. Mortality counts from additional registration states became available over time, and, by 1933, mortality counts from all 48 states were available (see Appendix Table 2). For our primary analysis, we digitized maternal mortality counts by state and year for the period 1900-1940. We also digitized maternal mortality counts by urbanicity and by cause (puerperal fever versus other causes), infant mortality counts by race, and mortality counts for diabetes, influenza, malaria, tuberculosis (pulmonary and non-pulmonary) and typhoid.

As described above, the effect of midwifery laws on maternal mortality is, *a priori*, ambiguous. Licensing requirements could have stimulated the formation of human capital and prevented the least competent midwives from practicing (Shapiro 1986). However, by restricting

themselves as obstetricians or midwives” (Texas 1916). Likewise, women in Missouri who did not practice midwifery as a profession and did not charge for their services were not required to obtain a license (Missouri 1909). Utah required anyone practicing obstetrics to obtain a license, but permitted the practice of obstetrics “in case of emergency” and in communities “where there are no licensed practitioners” (Egan 1910).

¹⁴ Midwives practicing in New York were perhaps subject to the most stringent licensing requirements in the country. As of 1907, midwives practicing in New York City were required to attend at least 20 deliveries under the supervision of a physician (New York Department of Health 1909). In addition, applicants had to be 21 years of age, of “moral character”, able to read and write and “show evidences...of habits of cleanliness.” The homes and equipment of midwives had to be available for inspection “at all times.” As of 1914, the New York City Board of Health required applicants to graduate from a registered school of midwifery (New York Bureau of Child Hygiene 1915). Under a state law passed in 1913, midwives practicing outside of New York City and Rochester had to show evidence of “habits of cleanliness” and had to graduate from a recognized midwifery program or receive instruction from a physician in at least 15 deliveries (New York Department of Health 1915; Williams 1915). Because over half of its residents lived in New York City, we coded New York as requiring midwives to be licensed as of 1907.

supply and insulating midwives from competition, midwifery laws could have reduced the quality of services provided (Carroll and Gaston. 1979). For instance, if licensed midwives attended more births than their unlicensed counterparts (or intervened more often in an effort to hasten delivery), then their clients would have been at greater risk of puerperal fever.

Figure 2 compares pre- and post-licensing maternal mortality trends. The solid line represents the average maternal mortality rate per 100,000 females for the treated states (i.e., those that passed a midwifery law at some point during the period 1900-1940). The dashed line represents the average maternal mortality rate for a set of control states (i.e., those in which midwifery was unregulated during the period 1900-1940). Year 0 on the horizontal axis represents the year in which a midwifery law was passed and mortality rates are expressed relative to Year -1. Control states were randomly assigned Year 0.

Maternal mortality begins a clear downward trend in the treated states immediately following the adoption of licensing requirements. In the control states, maternal mortality is essentially flat after Year 0. Moreover, there is no evidence that maternal mortality trends were different in the treated versus control states prior to the adoption of licensing requirements, suggesting that midwifery laws were not systematically preceded by, for instance, other state initiatives aimed at improving maternal health.

To further explore how early midwifery laws affected maternal mortality, we estimate the following baseline regression:

$$(1) \quad \ln(\text{Maternal Mortality}_{st}) = \beta_0 + \beta_1 \text{Midwifery License Required}_{st} + \mathbf{X}_{st}\boldsymbol{\beta}_2 + v_s + w_t + \varepsilon_{st},$$

where s indexes states and t indexes years. Our independent variable of interest, *Midwifery License Required*, is equal to one if midwives in state s were required by state law to be licensed in year t . The

coefficient β_i is our parameter of interest. It is the combined effect of the various mechanisms by which a state's decision to require occupational licensing for midwives affected maternal mortality, including any effect operating through increased human capital among providers, changes in the price charged by (or ease of access to) providers, and any switching to cheaper, inferior providers. We measure maternal mortality as deaths due to complications from pregnancy or childbirth per 100,000 female population.¹⁵ More specifically, maternal mortality counts included women in the “puerperal state”, which lasted through pregnancy and continued for 42 days after delivery (Guyer et al. 2000). Women who died from infectious diseases during the puerperal state were included in these counts (Loudon 1999).

The controls, represented by the vector \mathbf{X} , are listed in Table 1, along with descriptive statistics and definitions. They include state-level demographic characteristics (*% Pop < 18*, *%Pop 18-65*, *% White*, *% Black*, *% Urban*, *% Female*, *% Foreign*, *Physicians per Capita*), which are from the Census and estimated using linear interpolation for intercensal years. Policy controls include *Physician Diploma*, an indicator for whether the state required a diploma to practice medicine, and *Physician Education*, an indicator for whether medical boards were empowered to set pre-professional education standards.¹⁶ We also include a department of child hygiene indicator, a women's suffrage indicator and Sheppard-Towner Act spending for the period 1922-1929. Miller (2008) found that allowing women to vote led to substantial increases in public health spending by municipalities and an 8 to 15 percent reduction in child mortality. The Sheppard-Towner Act, passed in 1921, funded

¹⁵ Maternal mortality rates are typically measured per live births (Thomasson and Treber 2008; Jayachandran et al. 2010), but information on births at the state-year level is unavailable until 1915 (Linder and Grove 1947). Using information on live births for the period 1915-1940, we calculated the correlation between maternal mortality per 100,000 female population and maternal mortality per 100,000 live births to be .83. We also experimented with using the maternal mortality rate per 100,000 females aged 15-45. These results were very similar to those reported below.

¹⁶ Information on educational requirements for physicians is from Hamowy (1979). As shown in Table 1, most of the variation in these laws occurred before 1900.

the training of midwives and the establishment of health care clinics; public health nurses used Sheppard-Towner funds to visit new and expectant mothers (Moehling and Thomasson 2014).¹⁷

The terms ν and w represent state and year fixed effects, respectively. The state fixed effects, ν , control for state-level determinants of maternal mortality that are constant over time; the year fixed effects, w , control for nation-wide shocks to maternal mortality due to, for instance, innovations in medical technology.¹⁸

Next, following Clay et al. (2014), we augment the baseline estimating equation by including mortality from typhoid as a proxy for water quality and mortality from non-pulmonary tuberculosis as a proxy for milk quality. Water quality was an important determinant of health at the turn of the 20th century (Cutler and Miller 2005; Alsan and Goldin 2015). Local and state policies aimed at improving milk quality were introduced in response to alarmingly high rates of infant mortality (Wolf 2003), but adult mortality due to non-pulmonary (e.g., bovine) tuberculosis was not inconsequential (Olmstead and Rhode 2004a, 2004b). The augmented estimating equation is:

$$(2) \quad \ln(\text{Maternal Mortality}_{st}) = \beta_0 + \beta_1 \text{Midwifery License Required}_{st} + \mathbf{X}_{st}\boldsymbol{\beta}_2 + \beta_3 \text{Typhoid}_{st} \\ + \beta_4 \text{Non-Pulmonary TB}_{st} + \nu_s + w_t + \varepsilon_{st},$$

¹⁷ Information on the establishment of departments of child hygiene and when suffrage was granted to women is from Moehling and Thomasson (2012). Data on Sheppard-Towner spending are from the U.S. Children's Bureau (1931). Moehling and Thomasson (2012) argued that prior establishment of a department of child hygiene may have explained variation in state participation in Sheppard-Towner.

¹⁸ One such innovation was the widespread adoption of sulfa drugs in 1937, which had the effect of dramatically reducing maternal mortality (Jayachandran et al. 2010). This period also saw a shift in childbirth from the home to the hospital. At the end of the 19th century, only homeless women or those who could not receive in-home assistance delivered in hospitals (Leavitt 1986). As the 20th century progressed, childbirth in hospitals became commonplace. By 1940, over half of births in the United States took place in the hospital (Leavitt 1986). Thomasson and Treber (2008) concluded that this shift in where deliveries occurred did not lead to a reduction in maternal mortality until the widespread adoption of sulfa drugs.

where *Typhoid* is equal to mortality due to typhoid per 100,000 population and *Non-Pulmonary TB* is equal to mortality due to non-pulmonary tuberculosis per 100,000 population.

Finally, we include state-specific linear time trends ($\Theta_s \cdot t$) to account for the possibility that mortality rates evolved at different rates in states that adopted licensing requirements as compared to states that did not:

$$(3) \quad \ln(\text{Maternal Mortality}_{st}) = \beta_0 + \beta_1 \text{Midwifery License Required}_{st} + \mathbf{X}_{st}\boldsymbol{\beta}_2 + \beta_3 \text{Typhoid}_{st} \\ + \beta_4 \text{Non-Pulmonary TB}_{st} + v_s + w_t + \Theta_s \cdot t + \varepsilon_{st}.$$

The actual effect of midwifery laws on maternal mortality is an empirical question, to which we now turn our attention.

4. RESULTS BASED ON STATE-LEVEL DATA, 1900-1940

Estimates of β_1 using annual data for the period 1900-1940 are presented in Table 2. The regressions are weighted by the female population of state s in year t , and the standard errors are corrected for clustering at the state level (Bertrand et al. 2004). During the period under study, 22 states required midwives to be licensed. Pre- and post-treatment mortality data were available for 18 of these states. Figure 1 shows when each midwifery law was adopted and Appendix Table 1 provides a brief description of these laws as well as our sources, most of which are contemporary.¹⁹

The estimate of β_1 reported in the first column of Table 2 is from a model that only controls for state-level demographic characteristics, state fixed effects and year fixed effects. It suggests that the licensing of midwives leads to a 6.0 ($e^{-.062} - 1 = -.06$) percent reduction in maternal mortality, or

¹⁹ Appendix Table 2 lists the years of data available for each of the states used in the analysis.

roughly 1.7 fewer deaths per 100,000 women relative to a mean of 27.9. Controlling for whether women had the right to vote in state s and year t , Sheppard-Towner spending and the other policies listed in Table 1 has a negligible impact on this estimate. Likewise, controlling for mortality from typhoid and mortality from non-pulmonary tuberculosis (our proxies for water and milk quality, respectively), has very little impact on the estimated relationship between licensing and maternal mortality. Although we do not observe every public health initiative at the state and/or local level that may have affected maternal mortality, and therefore cannot account for their influence, the remarkable stability of the estimates reported in Table 2 is reassuring.²⁰

In column (4), we control for state-specific linear time trends. Their introduction has no effect on the magnitude of our estimate of β_1 , which remains statistically significant at the 5 percent level. In the final column of Table 2, we test the parallel trends assumption by adding a lead to the model, equal to 1 if a midwifery law was passed in year $t + 1$, and equal to 0 otherwise. The estimated coefficient of the lead, although negative, is small and not statistically significant.²¹

²⁰ Miller (2008) showed that the passage of women's suffrage laws led to substantial increases in public health spending at the municipal level on charities, corrections and hospitals. Although this spending was negatively and significantly related to infant mortality from infectious diseases, it was essentially unrelated to maternal mortality (Miller 2008, p. 1310). Other local public health initiatives undertaken during this period were mostly aimed at reducing infant, as opposed to maternal, mortality (Kotelchuck 2007, p. 108). For instance, the Chicago Health Department sent nurses into neighborhoods with the highest infant mortality rates to promote breastfeeding; in Minneapolis, public health workers helped new mothers with lactation-related problems (Wolf 2003). The Sheppard-Towner Act funded a wide variety of public health initiatives at the local and state level that could have potentially affected maternal mortality. Moehling and Thomasson (2014) found that Sheppard-Towner spending was negatively related to infant mortality, but did not examine its relationship to maternal mortality. During the period under study, maternity dispensaries were opened in several large cities (e.g., Boston, Los Angeles, Manhattan, and Pittsburgh). These dispensaries provided obstetrical services, typically free of charge and performed by a medical student, to poor women giving birth at home (Huntington 1912; Ziegler, 1912). Controlling for the presence of a maternity dispensary had little effect on the estimates reported in Table 2.

²¹ In columns (1) and (2) of Appendix Table 3, we add a series of leads to the model. They are, without exception, statistically indistinguishable from zero. In the last two columns of Appendix Table 3, we replace *Midwifery License Required* with an indicator for the year in which a midwifery license was required (*Year of Law Change*) and 3 lags. One to two years after coming into effect, requiring a license is associated with a 5.4 to 5.7 percent decrease in maternal mortality. Five or more years after coming into effect, requiring a license is associated with a 6.5 to 8.9 percent decrease in maternal mortality.

4.1. FALSIFICATION TESTS

Until the 1920s, public health officials focused their efforts on reducing infant, as opposed to maternal, mortality (Kotelchuck 2007, p. 108). However, state and local initiatives to combat tuberculosis and other infectious diseases (such as influenza and malaria) could have been correlated with the adoption of midwifery laws, potentially biasing our estimates of their effects on maternal mortality.²² Such initiatives included the application of insecticides and other methods of pest control (Kitron and Spielman 1989), waste management (Centers for Disease Control and Prevention 1999), forming local and state anti-tuberculosis associations (Knopf 1922) and passing anti-spitting laws (O’Conner 2015).

We address this potential issue by conducting a series of falsification tests. Specifically, we examine the relationship between midwifery laws and mortality due to the following causes: pulmonary tuberculosis, influenza, malaria and diabetes.

The results of these falsification tests are reported in Table 3.²³ If state-specific linear trends are not included, requiring midwives to be licensed is associated with a statistically significant *increase* in mortality due to diabetes. When the state-specific trends are included, all of the estimated coefficients of the midwifery law indicator are positive, but insignificant. This pattern of results suggests that the adoption of midwifery licensing requirements was not related to maternal health through public health initiatives aimed at combating tuberculosis and other infectious diseases.

²² As noted above, during the period under study, many states used a broad definition of maternal mortality that included women who died in pregnancy, during labor and up to 42 days after delivery due to infectious diseases such as influenza and tuberculosis (Loudon 1999). Almond (2006), in fact, used maternal mortality to measure the intensity of the 1918 influenza epidemic.

²³ Mortality rates are logged except in the case of malaria, which was equal to zero for a number of states and years. Instead of taking the natural log of mortality due to malaria, we take its quartic root. This method of dealing with zeros has been used by Thomas et al. (2006), Tarozzi et al. (2014) and Ashraf et al. (2015), among others. Marginal effects are reported in brackets. Defining the dependent variable as $\ln(1 + \text{Malaria})$ yielded similar results.

4.2. HETEROGENEOUS EFFECTS

In 8 of the 18 states for which we have pre- and post-treatment maternal mortality data, a license could be obtained by receiving basic instruction from a public health nurse or county health officer.²⁴ Five states required applicants to pass an examination, typically administered by the State Board of Health, and 5 required applicants to graduate from a recognized school of midwifery.²⁵ We begin by estimating the fully saturated model, allowing the effect of midwifery laws to differ based on these basic classifications.

The results, which are reported in the first column of Table 4, suggest that adopting even the most basic licensing requirements led to a small (3.5 percent) reduction in maternal mortality. We also find evidence that the relationship between midwifery laws and maternal mortality was more pronounced in states that required applicants to pass an exam or graduate from a recognized school of midwifery. However, these estimates are not precisely measured. In fact, we cannot formally reject the hypothesis that all three types of midwifery laws had comparable effects on maternal mortality.

In the second and third columns of Table 4, we focus on urban versus rural status. Specifically, urban mothers are defined as those who lived in a city or town with a population greater than 10,000.²⁶ Maternal mortality was substantially higher among these women than among their

²⁴ Specifically, these states were DE, GA, KY, MS, NC, SC, VA and WV.

²⁵ We observe maternal mortality in CO, MD, NM, PA and RI before and after midwives were required to pass an exam. We observe maternal mortality in CA, FL, NY, WA and WI before and after midwives were required to graduate from a recognized school of midwifery. We include Florida in this third category despite the fact that applicants had the option of attending 15 deliveries under the supervision of a physician in lieu of graduating from a recognized school of midwifery (Hanson 1931). Likewise, we include New York in this category despite the fact that New York City did not require applicants to graduate from a registered school of midwifery until April 1, 1914 (New York Department of Health 1915), and applicants outside of New York City and Rochester had the option of receiving instruction in at least 15 deliveries from a physician in lieu of graduating from a recognized school of midwifery (Williams 1915).

²⁶ Prior to 1910, *Mortality Statistics* defined “urban” as cities or towns with a population greater than 8,000. The inclusion of year fixed effects should account for any effect this change in definition might have had on maternal mortality.

rural counterparts (17.7 per 100,000 population versus 11.6), but enforcement of midwifery laws was, by many accounts, much stricter in urban areas (Borst 1995, pp. 55-60; Molina 2006, p. 105). Consistent with these accounts, the results suggest that the relationship between licensing and maternal mortality was strongest in urban areas. In fact, although negative, the estimated coefficient of *Midwifery License Required* is not statically significant when our attention is restricted to mothers living in rural areas.

In the remaining columns of Table 4, we distinguish between maternal mortality due to puerperal fever and maternal mortality from other causes (e.g., breech births, hemorrhaging, albuminuria, or infectious diseases such as tuberculosis). Requiring a license is associated with a nearly 7 percent reduction in maternal mortality due to puerperal fever, suggesting that the focus on antiseptic technique and non-intervention was effective.²⁷ It is also associated with a 5.4 percent reduction in maternal mortality from other causes, suggesting that licensed midwives could, at a minimum, identify birth complications and ask for assistance from a physician in a timely fashion.²⁸

²⁷ Midwifery laws often required applicants to demonstrate their “cleanliness” (Williams 1915; Mississippi Board of Health 1921; Hansen 1931), while midwifery instruction and textbooks emphasized antiseptic technique and discouraged the use of forceps except in the case of emergency (Jewett and Jewett 1901; Johnstone 1913; Dodd 1920; Leavitt, 1983).

²⁸ Some states prohibited midwives from attending breech births or twins (Egan 1910; Levy 1921), while exams and instruction emphasized recognizing birth complications in advance. For instance, licensed midwives in North Carolina were taught basic “danger signals” and when to call a physician or take a patient to the nearest clinic (Dodd 1920, p. 865). In Wisconsin, students at a prominent school of midwifery were taught “what not to do, and when to seek the aid of a practising physician” (Borst 1988, p. 617). A copy of the exam administered by the Wisconsin Medical Board of Examiners to Dora Larson, a Norwegian-born, apprentice-trained midwife, is available at: http://ebeling.library.wisc.edu/historical/wi-women/exam_questions.pdf. The exam consisted of 12 questions, including, “When you examine a woman in labor, how do you determine if the position is normal?” and, “What are the symptoms of kidney trouble in a pregnant woman?” We have reproduced the questions from this exam in Appendix Table 4. It is also possible that the imposition of licensing restrictions reduced maternal mortality through discouraging midwives from performing abortions. At the turn of the 20th century, the prosecution of midwives for performing abortions was commonplace (Crilley 2014), and midwifery laws often explicitly required women to provide evidence of “good moral character” (see Appendix Table 1). Unfortunately, *Mortality Statistics* did not distinguish between maternal deaths due to abortion complications and other causes until 1930.

5. RESULTS BASED ON MUNICIPAL-LEVEL DATA, 1900-1917

We turn now to an analysis of the relationship between midwifery laws and maternal mortality at the municipal level. Again, we use annual data drawn from the U.S. Census Bureau's *Mortality Statistics*. The initial issue contained mortality counts by cause and age for over 300 registration cities. By 1917, mortality counts from over 500 cities are available, although we restrict our attention to the 384 municipalities that contributed at least 10 years of data and had a population greater than 10,000.²⁹

There are several advantages to adding municipal-level results to our analysis above, which exploited state-level variation. First, 9 municipalities adopted midwifery licensing requirements during this period before the state in which they were located did, representing an alternative source of policy variation (see Appendix Table 5). Second, the municipal-level data allow us to focus on mothers living in urban areas, where the results in Table 4 suggest that the effect of midwifery laws should be most pronounced. Third, a number of cities began reporting maternal mortality counts before this information was available at the state level. For instance, Texas required midwives to be licensed in 1907, but state-level mortality counts are not available for Texas until 1933. However, municipal-level data are available for the city of Galveston for the period 1906-1917 and for San Antonio for the period 1900-1917. We report the states and years covered in the municipal-level data set in Appendix Table 6. Using municipal-level data allows us to capture policy variation for Missouri, Texas and Utah not exploited in the state-level results. A serious limitation of using municipal-level data is that our models no longer include pre- and post-treatment mortality counts

²⁹ On average, each municipality contributed 17.7 observations to the analysis. *Mortality Statistics* provides mortality counts through 1922, but we chose to focus on the period 1900-1917 in order to avoid confounding the effect of midwifery laws with the 1918 influenza epidemic. It should be noted that the state-level results discussed above are robust to excluding the years 1918-1920.

for 10 states (Delaware, Georgia, Kentucky, Mississippi, New Mexico, North Carolina, Rhode Island, South Carolina, Virginia and West Virginia).

We estimate municipal-level regressions similar to those used in the state-level analysis. We first estimate the municipal-level analog to equation (1), and then augment that specification by adding controls for mortality from typhoid, non-pulmonary tuberculosis and municipality-specific linear time trends. This estimating equation is thus

$$(4) \quad \begin{aligned} \text{Maternal Mortality}_{mt} = & \beta_0 + \beta_1 \text{Midwifery License Required}_{mt} + \mathbf{X}_{mt} \boldsymbol{\beta}_2 + \beta_3 \text{Typhoid}_{mt} \\ & + \beta_4 \text{Non-Pulmonary TB}_{mt} + v_m + w_t + \Theta_m \cdot t + \varepsilon_{mt}, \end{aligned}$$

where m indexes municipality and t indexes year. Our independent variable of interest, *Midwifery License Required*, is equal to 1 if midwives in municipality m were required by either state law or a municipal ordinance to be licensed.³⁰ Because maternal mortality at the municipal level can be zero, we take its quartic root, which mimics the natural log function for positive numbers.³¹ Marginal effects are reported in brackets. This method of dealing with zeros has been used by Thomas et al. (2006), Tarozzi et al. (2014) and Ashraf et al. (2015), among others.

The results are reported in Table 5 and provide additional evidence that requiring midwives to be licensed is associated with reductions in maternal mortality. When we do not control for state- or municipality-specific linear time trends, estimates of β_1 in the municipal-level results are, in fact,

³⁰ The variables included in \mathbf{X} are listed in Appendix Table 7. In addition to the policy controls used in the state-level analysis, we also control for the presence of a state public health department. We observed no variation in this policy for the state panel.

³¹ Specifically, there are 585 observations for which *Maternal Mortality* is equal to zero. We also estimated a version of equation (4) in which the dependent variable was set equal to $\ln(1 + \text{Maternal Mortality})$. These estimates are qualitatively similar to those reported in Table 5. It should also be noted that *Maternal Mortality* for the municipal-level analysis is defined as the rate per 100,000 population, not per 100,000 females. Data on municipal populations by sex were not available.

larger than those reported in Table 2. These point estimates imply that licensing was associated with a decrease in maternal mortality of 16 to 19 percent. When state- or municipality-specific trends are added to the regressions, the estimates remain negative, albeit smaller in absolute value and no longer statistically significant at conventional levels. If taken at face value, they would suggest that licensing was associated with a decrease in maternal mortality of 4 to 6 percent, which is comparable in magnitude to the estimates based on state-level data reported in Table 2.

6. INFANT MORTALITY

Our analysis has thus far focused on maternal mortality. However, there are at least two reasons why licensing and training midwives could have also affected mortality among infants. First, midwifery instruction and textbooks emphasized the importance of breastfeeding.³² During the time period under study, most American mothers did not exclusively breastfeed, but instead supplemented their breast milk with cow's milk and weaned their infants within three months of birth (Wolf 2003).³³ Advice from midwives could have altered these practices and affected mortality as a result. Second, licensed midwives were trained in antiseptic technique and artificial respiration, and would have been able to recognize and handle common birth complications such as breech position or a nuchal cord (Jewett and Jewett 1901; Johnstone 1913).³⁴ The possibility that this kind of training could have reduced the number of infants dying shortly after birth during the early 1900s is supported by recent research in Zambia, the results of which suggest that teaching TBAs about

³² For instance, one popular textbook for midwives unequivocally stated: "In all cases an infant should be suckled by its mother unless definite contra-indications exist" (Johnstone 1913, p. 407). See also Jewett and Jewett (1901, pp. 188-189) and Smith (2005, p. 130). It might also be noted that breastfeeding would have, in all likelihood, ceased if the mother died as a result of, for instance, puerperal fever.

³³ Most cities did not require cow's milk to be pasteurized until the 1920s (Brosco 1999) and, as a consequence, it was often spoiled or contaminated with bovine tuberculosis (Wolf 2003; Olmstead and Rhode 2004a).

³⁴ A nuchal cord occurs when the umbilical cord becomes wrapped around the baby's neck.

newborn care (including training in cleanliness, resuscitation and how to diagnose birth complications) can lead to dramatic reductions in 7-day neonatal mortality due to asphyxia and infection (Carlo et al. 2010).

Table 6 presents estimates of the relationship between midwifery laws and infant mortality. The first three columns report results based on the state-level panel for the period 1900-1940, while the last six columns report results based on the municipal-level panel for the period 1900-1917. An advantage of the state-level data is that information on infant mortality by race is available for most state-year combinations.³⁵ The estimate in the first column is small, positive and insignificant, suggesting that the licensing of midwives had no effect on the overall infant mortality rate. When we examine the relationship between midwifery laws and infant mortality by race, it appears to be strongest among nonwhites.³⁶ Specifically, requiring a license is associated with 12.4 fewer deaths relative to a mean of 248.9, or roughly a 5 percent reduction in the nonwhite infant mortality rate. This pattern of results is, in retrospect, not surprising. The demand for midwives appears to have been much higher among blacks than among whites throughout the period under study (Dart 1921; Cornely 1942; Jacobson 1956; Robinson 1984).³⁷ Better training coupled with the forced retirement of incompetent midwives could have had a substantial impact on the health of black infants.³⁸

³⁵ Infant mortality counts by race were available for most states from 1910 onwards. Maryland made infant mortality counts by race available starting in 1906.

³⁶ For the nonwhite infant mortality regression, we take the quartic root of the mortality rate. There are 36 observations for which *Nonwhite Infant Mortality* is equal to zero. We also experimented with using $\ln(1 + \text{Nonwhite Infant Mortality})$ as the dependent variable. The resulting estimate was similar to the one reported in Table 6.

³⁷ Even in 1940, almost half of all births to nonwhite mothers were attended by midwives (Jacobson 1956, p. 254).

³⁸ There is anecdotal evidence that the adoption of licensing restrictions substantially improved the quality of midwives serving black communities in the South. For instance, Dodd (1920, p. 863), the Director of Child Hygiene and Public Health Nursing, described the typical midwife practicing in South Carolina prior to the imposition of licensing requirements:

In South Carolina, she is usually the grandmother or grand-aunt or old friend of the family who goes in to “help out” in the emergency of child birth. When she becomes too old and too decrepit to be of any further use of earth, she takes up midwifery. She cannot fill out a birth

Next, we turn our attention to the municipal-level data. While infant mortality counts by race are not available for most registration cities, we have information on diarrhea mortality counts.³⁹ The so-called “urban mortality penalty” at the turn of the 20th century was due, at least in part, to diarrheal diseases (Haines 2001). In addition to encouraging breastfeeding, which helps maintain hydration, trained midwives had an effective treatment for diarrhea at their disposal (Johnstone 1913, p. 413).⁴⁰

Similar to our findings from the state-level analysis, there is little evidence of a relationship between licensing and overall infant mortality in the municipal data. Licensing is, however, associated with a 3 to 10 percent reduction in the mortality among children under the age of 2 from diarrhea.⁴¹

certificate because she cannot write her own name. She has no standards, her remuneration is negligible, and her number is legion.

After licensing was required in 1920, midwives received instruction in recognizing birth complications and “what *not* to do and the simple rules for ordinary cleanliness” (Dodd, 1920, p. 864). Midwives were also required to attend 4 deliveries under the supervision of a public health nurse. “If the midwife is found to be following instructions, and observing the laws of cleanliness, she will be given a midwife permit” (Dodd 1920, p. 864). According to South Carolina public health officials, the licensing of midwives had a dramatic effect on both infant and maternal mortality among blacks:

It is interesting to note that from 1919 to 1928, the last year for which we have figures tabulated separately for white and colored, there was a decided reduction in the colored rates [of death] for both infants and mothers although there was an increase in both rates for whites. This would seem to indicate that the instruction of midwives, who deliver most of the negro mothers, has not been without value to the State (South Carolina Board of Health (1932) cited in Bonaparte (2014, p. 172)).

³⁹ Deaths due to diarrhea are reported in the same category as deaths due to enteritis and are available by age group for children under the age of 2 and individuals ages 2 and over. Enteritis is inflammation of the small intestine and is generally accompanied by diarrhea.

⁴⁰ Huffman and Combest (1990) reviewed literature on the role of breastfeeding in the prevention and treatment of diarrhea among infants in developing countries. Johnstone’s (1913, p. 413) text for midwives describes the use of albumin water to treat severe diarrhea in children. Han et al. (2009, p. 444) found that normal saline solution and albumin were equally effective for “initial hydration therapy for dehydrated term infants...due to acute diarrhea.”

⁴¹ For the diarrhea mortality regressions, we take the quartic root of the mortality rate. There are 31 observations for which *Diarrhea Under Age 2* is equal to zero. We also experimented with setting the dependent variable equal to $\ln(1 + \text{Diarrhea Under Age 2})$. These estimates were similar to those reported in Table 6.

We view the estimates reported in Table 6 as less definitive than the maternal mortality results reported in Tables 2-5. A wide variety of public health initiatives directed at reducing infant mortality were undertaken during the period 1900-1930 (Kotelchuck 2007). For instance, state and local educational campaigns encouraged breastfeeding (Wolf 2003); public health inspectors visited dairy farms to ensure that milk was processed under sanitary conditions and shipped in refrigerated railroad cars (Atkins 1992). If these initiatives were correlated with the adoption of midwifery laws, the results reported in Table 6 are biased estimates of the effect of licensure, as they partly capture the effect of these other policy changes occurring at the same time licensure rules were introduced. As a falsification test, we examine the relationship between midwifery laws and mortality due to diarrhea among individuals aged 2 years or older. While some (but by no means all) midwives made multiple visits to the mother and child during the first few weeks of the postpartum period (Baker 1913; Dart 1921, p. 29; Smith 2005, p. 130; Bartlett 2008, p. 21), mortality from diarrhea among individuals ages 2 and over should have been unaffected by licensing requirements but may have been affected by latent policy changes occurring at roughly the same time as licensure. Our results show that the relationship between requiring midwives to be licensed and diarrhea mortality among individuals ages 2 and over is small and statistically insignificant, suggesting that the mortality estimates for infants under 2 are unbiased.⁴²

7. MIDWIFERY LAWS AND THE SUPPLY OF MIDWIVES

We conclude our analysis with an examination of the relationship between midwifery laws and the supply of midwives. From the U.S. Decennial Census data for the period 1870-1930, we can

⁴² The sample used to examine diarrhea mortality among individuals ages 2 and over is smaller than the sample used to examine diarrhea mortality for children under the age of 2 because the latter statistic was not consistently reported by some municipalities.

obtain information on the number of women who reported that midwifery was their occupation.⁴³

Aggregating the individual self-reports to the state level, we created a variable, *Midwives*, which measures the number of women in state s and year t whose occupation was recorded as “midwife” per 100,000 women ages 15-45. Presuming that these self-reports are accurate, and importantly that women who were not trained professionals did not describe themselves as “midwives”, this measure can be thought of as capturing the supply of trained, professional midwives as opposed to TBAs. There is, in fact, evidence that women without formal training, but who attended the births of family members and neighbors, did not typically consider themselves to be midwives (Borst 1988; Bickley 1990), and Census enumerators clearly undercounted women who worked on an irregular basis or at informal jobs (Lebergott 1966, pp. 153-154; Goldin 1990; Pudup 1990).

During the period under study, untrained midwives typically attended 1 or 2 births per year (Borst 1995, pp. 54-58; Barney 2000, pp. 62-65). Licensed midwives in Southern states, by contrast, attended, on average, 4 or 5 births per year, while those in Northern and Midwestern states averaged as many as 50 births per year. These numbers suggest that, if the adoption of licensing requirements prevented TBAs from practicing, even small increases in the number of licensed, professional midwives could have easily attended the births that had been handled by TBAs.⁴⁴

⁴³ Specifically, we use IPUMS one percent samples of the Decennial Censuses, housed at the Minnesota Population Center at the University of Minnesota (<https://usa.ipums.org/usa/index.shtml>).

⁴⁴ The number of births per year attended by licensed midwives is available from a variety of contemporary sources and can be estimated based on others. For instance, during the period 1909-1920, licensed midwives in New York City attended an average of 28.2 births per year (New York City Department of Health 1921). Nicholson (1921) surveyed health departments across the country asking how many midwives were practicing in their state and what percentage of births they attended. Based on the responses to Nicholson’s survey and data on births from Linder and Grove (1947), we estimated the average caseloads of licensed midwives. For instance, in Connecticut, licensed midwives attended, on average, 20.1 births per year. In Kentucky, they attended 5.4 births per year, while in Virginia they attended 4.0 births per year. Although Georgia and North Carolina did not require licensure, midwives in these states were required to register. Based on the responses to Nicholson’s survey, we estimate that (unlicensed) midwives in Georgia attended, on average, 3.2 births per year. In North Carolina, they attended 3.1 births per year. In 1911, licensed midwives practicing in Providence, Rhode Island attended, on average, 49.6 births per year, while midwives in Kentucky (who were unlicensed), attended, on average, 4.1 births per year (American Association for the Study and Prevention of Infant Mortality 1913).

We estimate the following equation:

$$(5) \quad \text{Midwives}_{st} = \beta_0 + \beta_1 \text{Midwifery License Required}_{st} + \mathbf{X}_{st}\beta_2 + \nu_s + w_t + \Theta_s \cdot t + \varepsilon_{st},$$

where the independent variable of interest, *Midwifery License Required*, is defined as before.⁴⁵ Because *Midwives* is equal to zero in many states prior to the adoption of licensing requirements, we take the quartic root of the dependent variable and report marginal effects in brackets.⁴⁶

The results, which are reported in Table 7, suggest that the adoption of licensing requirements led to a substantial increase in the supply of professional midwives. Specifically, we find that licensing is associated with an increase of 23.4 to 27.8 midwives per 100,000 women ages 15-45, relative to a mean of 22.3. Estimates of the effect of licensing requirements on the supply of foreign-born and black midwives are generally larger, but are not statistically significant at conventional levels.

8. CONCLUSION

Previous studies provide strong evidence that holders of occupational licenses earn between 11 and 18 percent more than their unlicensed counterparts, presumably because it restricts the supply of labor (Kleiner and Krueger 2010; 2013). This premium is of similar magnitude to estimates of the union-nonunion wage gap (Lewis 1986; Blanchflower and Bryson 2003). However, occupational licensing rules are rarely, if ever, portrayed by advocates as a vehicle for increasing the

⁴⁵ The variables included in \mathbf{X} are % of population less than 18 years of age, % 18-65 years of age, % white, % black, % living in an urban area, % female, % foreign born, physician educational requirements, a department of health indicator, a department of child hygiene indicator, a women's suffrage indicator and Sheppard-Towner spending.

⁴⁶ For instance, *Midwives* is zero for 14 states (AZ, CO, DE, ME, MA, NE, NH, ND, RI, SD, VT, WA, WV and WY) in 1900. Of these states, only Wyoming required midwives to be licensed in order to practice.

earnings of licensees. Instead, rules obligating practitioners to pass an exam, receive training, or obtain letters of reference are justified on the grounds that they improve safety and public health (Kleiner 2000; Gittleman and Kleiner 2016). Yet, there is scant empirical evidence on whether this is so.

The current study draws on U.S. Census Bureau data from the period 1900-1940 to estimate the effects of midwifery licensing requirements on maternal mortality. During most of this period, puerperal fever was the leading cause of maternal mortality, accounting for approximately half of all deaths related to childbirth (Woodbury 1924; Loudon 2000a, 2000b). Doctors and public health officials argued that the unsanitary practices of midwives were to blame for the high rates of puerperal fever (Cody 1913; Plecker 1915; Edgar 1916; Frizzelle 1917; Terry 1917; Stedman 1920; Howe 1921; Rude 1922), and recommended licensing as the solution (Edgar 1916; Hardin 1925).

In response, 22 states (and at least a dozen municipalities) passed midwifery laws, bringing educational requirements and oversight to a previously unregulated market. Under these laws, a license could often be obtained by simply receiving basic instruction from a public health nurse or county health officer. In other states, applicants were required to graduate from a recognized school of midwifery and pass an examination administered by their State Board of Medical Examiners. Exploiting geographical and temporal variation in the adoption of requirements such as these, we find that the licensing of midwives led to a 6 percent reduction in maternal mortality. We also find evidence, albeit more tentative, that requiring a license reduced the nonwhite infant mortality rate.

These basic results, however, mask important heterogeneity. For instance, the relationship between midwifery laws and maternal mortality appears to have been more pronounced in states that required applicants to pass an exam or graduate from a recognized school of midwifery. Moreover, this relationship was strongest in urban areas, a result that is consistent with anecdotal evidence that enforcement of midwifery laws was less strict in the countryside and small towns

(Borst 1995, pp. 55-60; Molina 2006, p. 105). When we distinguish between maternal mortality due to puerperal fever and maternal mortality from other causes, we find that requiring a license is associated with a nearly 7 percent reduction in maternal mortality due to puerperal fever, suggesting that the focus on antiseptic technique and non-intervention was effective. Requiring a license also led to a 5 percent reduction in maternal mortality from other causes, suggesting that licensed midwives could, at a minimum, identify birth complications and when to ask for assistance from a physician.

Our results are relevant for ongoing policy debates and also address outstanding theoretical issues. A majority of births in many developing countries are still attended by Traditional Birth Attendants (TBAs) with no formal education or training (UNFPA 2011). Experts contend that replacing TBAs with trained and licensed midwives would substantially reduce infant and maternal mortality (WHO 2005, pp. 68-72; Thompson et al. 2011; UNFPA 2011, pp. 2-7), but the evidence in support of this contention is largely anecdotal. In the United States, lay midwives are, in many states, required to pass an exam or graduate from an accredited program, but are essentially unregulated in others (Rooks 1997; Rausch 2008; Reaves 2010; Rini 2015).

Economic theory offers no clear guidance as to the direction of the relationship between licensing and the quality of services received by consumers (Kleiner 2000), yet licensing requirements have become commonplace in the United States and other developed countries (Gittleman and Kleiner 2016). Our results provide strong evidence that the adoption of licensing requirements between 1900 and 1940 reduced maternal mortality, most likely through an increase in the supply of trained midwives. To our knowledge, our study is the first to provide econometric evidence that the adoption of licensing requirements leads to an improvement in consumer health. Whether requiring doctors, dentists and other health professionals to be licensed also leads to better health outcomes is an open, but crucial, question that deserves the attention of future researchers.

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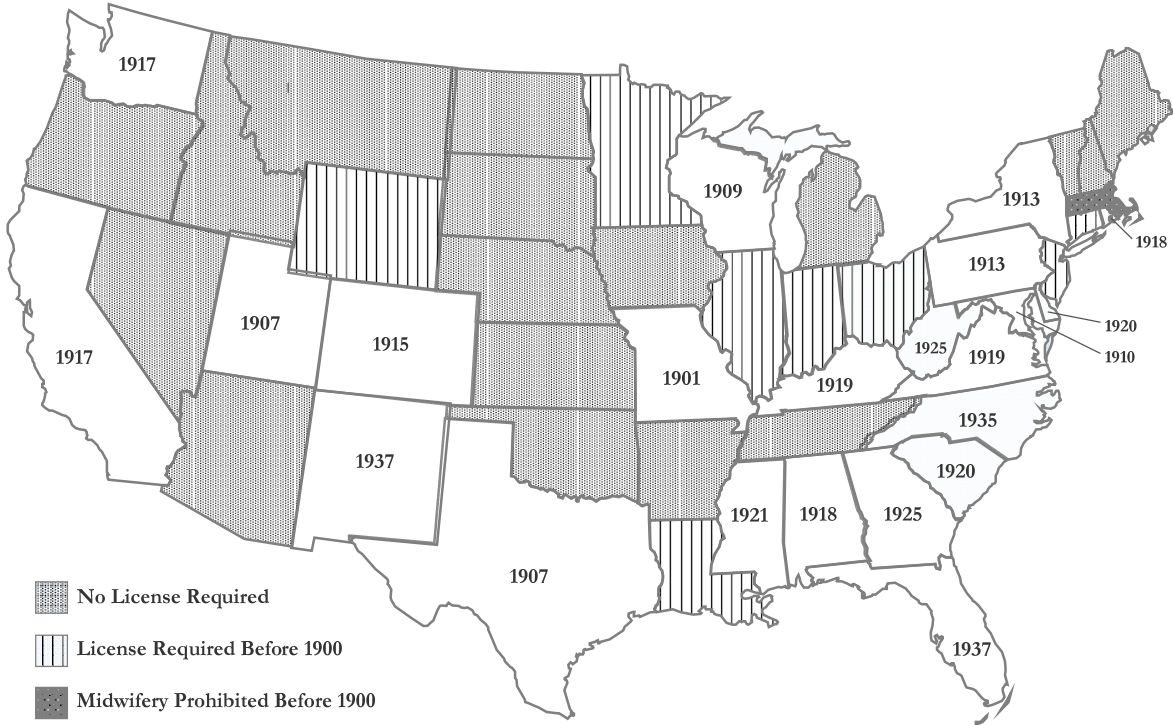
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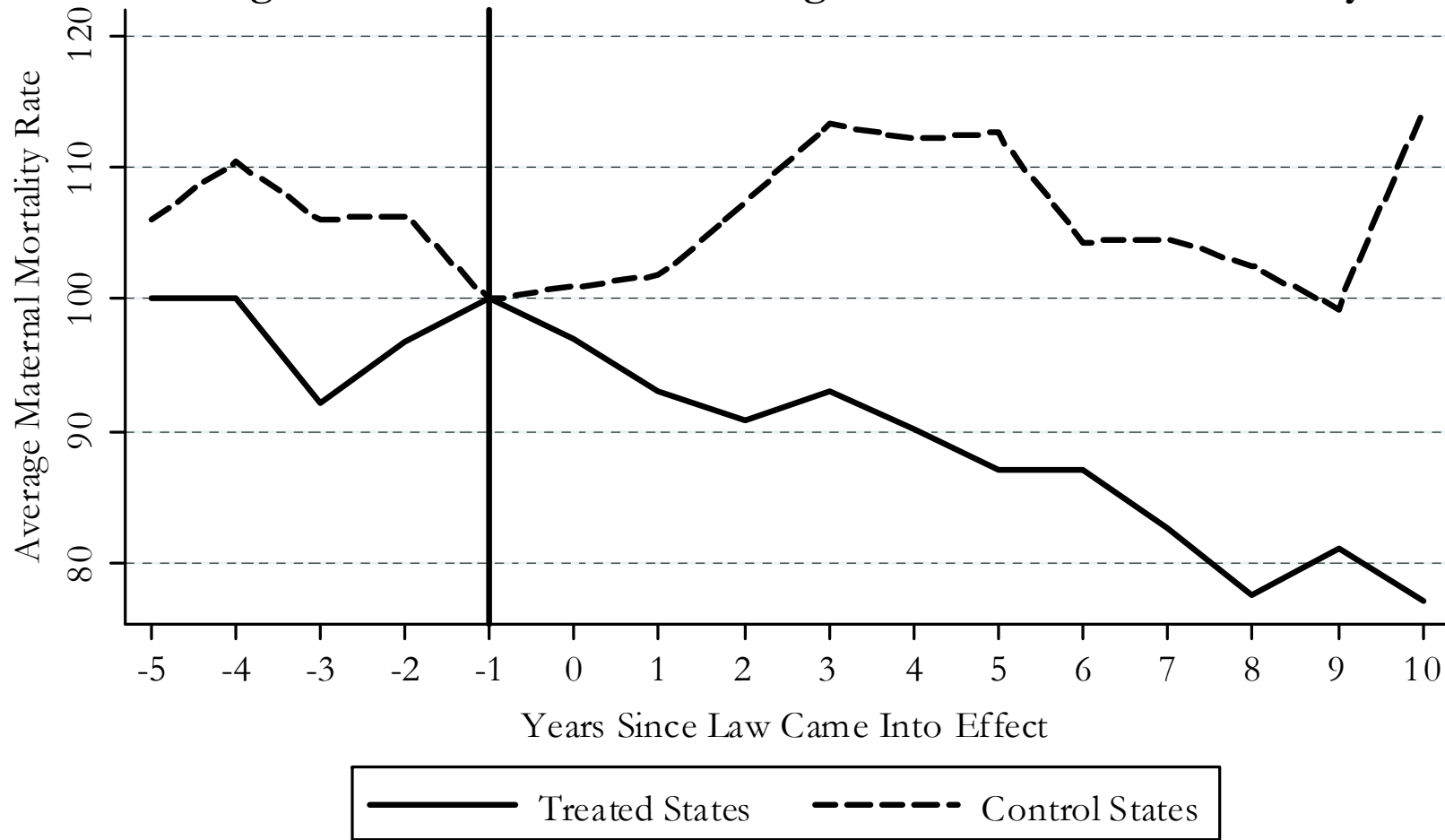
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Figure 1. Passage of Midwife Licensing Requirements



Notes: Years are for when midwives were first required to be licensed. Sources are provided in Appendix Table 1. The District of Columbia required midwives to be licensed in 1896. An ordinance adopted in 1907 required midwives practicing in New York City to be licensed.

Figure 2. Pre- and Post-Licensing Trends in Maternal Mortality



Based on annual data from *Mortality Statistics*, published by the U.S. Census Bureau. On the horizontal axis, 0 represents the year in which midwifery became a licensed profession. It was randomly assigned to states with unregulated midwifery during the period under study. Maternal mortality rates are expressed relative to year -1.

Table 1. Descriptive Statistics for State-Level Maternal Mortality Analysis, 1900-1940

	Full sample	<i>Midwifery License</i> <i>Required = 1</i>	<i>Midwifery License</i> <i>Required = 0</i>	Description
<i>Maternal Mortality</i>	27.9 (11.1) N = 1,296	26.7 (10.1) N = 711	29.3 (12.0) N = 585	Maternal mortality per 100,000 female population
<i>% Pop < 18</i>	.351 (.045)	.352 (.046)	.350 (.043)	Percent of population less than 18 years of age
<i>% Pop 18-65</i>	.598 (.037)	.600 (.038)	.597 (.036)	Percent of population that was 18-65 years of age
<i>% White</i>	.899 (.134)	.882 (.141)	.919 (.121)	Percent of population that was white
<i>% Black</i>	.079 (.128)	.101 (.142)	.052 (.102)	Percent of population that was black
<i>% Urban</i>	.482 (.183)	.523 (.186)	.431 (.166)	Percent of population that lived in an urban area
<i>% Female</i>	.489 (.018)	.493 (.014)	.485 (.022)	Percent of population that was female
<i>% Foreign</i>	.116 (.091)	.107 (.090)	.126 (.091)	Percent of population that was foreign born
<i>Physicians per Capita</i>	131.8 (45.5)	129.4 (41.3)	134.6 (49.9)	Physicians per 100,000 population
<i>Physician Diploma</i>	.962 (.191)	.982 (.134)	.938 (.241)	= 1 if state required physicians to have a diploma
<i>Physician Education</i>	.952 (.214)	.989 (.106)	.908 (.290)	= 1 if state medical boards could set preliminary education requirements
<i>Dept. of Child Hygiene</i>	.726 (.446)	.820 (.384)	.612 (.488)	= 1 if state had a division of child hygiene
<i>Suffrage</i>	.767 (.423)	.823 (.382)	.699 (.459)	= 1 if women were allowed to vote
<i>ST Act</i>	4.15 (10.2)	5.26 (12.2)	2.80 (6.84)	For 1930, sum of Sheppard-Towner spending for 1922-1929 (\$1,000)
<i>Typhoid</i>	8.87 (9.30)	7.75 (8.29)	10.2 (10.2)	Typhoid mortality per 100,000 population
<i>Non-pulmonary TB</i>	11.1 (7.04)	10.1 (5.93)	12.4 (8.01)	Non-pulmonary tuberculosis mortality per 100,000 population

Notes: Unweighted means with standard deviations in parentheses.

Table 2. Maternal Mortality and Midwifery Laws: State-Level Analysis, 1900-1940

	(1)	(2)	(3)	(4)	(5)
<i>Year Prior to Midwifery License Required</i>	...	...	...	...	-.006 (.019)
<i>Midwifery License Required</i>	-.062** (.025)	-.064** (.026)	-.062** (.027)	-.062** (.024)	-.063** (.024)
Mean	27.9	27.9	27.9	27.9	27.9
N	1,296	1,296	1,296	1,296	1,296
R ²	.953	.955	.956	.965	.965
Policy controls	no	yes	yes	yes	yes
Typhoid and non-pulmonary TB	no	no	yes	yes	yes
State-specific linear trends	no	no	no	yes	yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics*, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the maternal mortality rate per 100,000 females in state s and year t . Controls include % of population less than 18 years of age, % 18-65 years of age, % white, % black, % living in an urban area, % female, % foreign born, physicians per capita, state fixed effects and year fixed effects. Regressions are weighted by female population. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 3. Falsification Outcomes and Midwifery Laws: State-Level Analysis, 1900-1940

	<i>Pulmonary Tuberculosis</i>		<i>Malaria</i>		<i>Influenza</i>		<i>Diabetes</i>	
<i>Midwifery License Required</i>	.036 (.023)	.018 (.017)	.042 (.033) [.391]	.039 (.042) [.357]	.019 (.059)	.077 (.051)	.055* (.031)	.008 (.017)
Mean	81.6	81.6	3.05	3.05	37.2	37.2	17.8	17.8
N	1,296	1,296	1,296	1,296	1,296	1,296	1,296	1,296
Typhoid and non-pulmonary TB	no	yes	no	yes	no	yes	no	yes
State-specific linear trends	no	yes	no	yes	no	yes	no	yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics*, published by the U.S. Census Bureau. Each cell represents the results from a separate OLS regression. The dependent variable is equal to the natural log (or, in the case of malaria, the quartic root) of the specified mortality rate per 100,000 population in state s and year t . Controls include % of population less than 18 years of age, % 18-65 years of age, % white, % black, % living in an urban area, % female, % foreign born physician, physicians per capita, physician educational requirements, a department of child hygiene indicator, a women's suffrage indicator, Sheppard-Towner spending, state fixed effects and year fixed effects. Regressions are weighted by state population. Standard errors, corrected for clustering at the state level, are in parentheses and marginal effects are in brackets.

Table 4. Heterogeneous Effects and Midwifery Laws: State-Level Analysis, 1900-1940

	<i>Maternal Mortality</i>	<i>Urban Maternal Mortality</i>	<i>Rural Maternal Mortality</i>	<i>Maternal Mortality due to Puerperal Fever</i>	<i>Maternal Mortality due to Other Causes</i>
<i>Midwifery License Required</i>	-.036*** (.013)	-.109*** (.040)	-.027 (.026)	-.072* (.037)	-.055** (.023)
<i>Midwifery License Required * Exam Sufficient</i>	-.026 (.034)	...	...	...	...
<i>Midwifery License Required * Graduation Necessary</i>	-.052 (.054)	...	...	...	...
Mean	27.9	17.7	11.6	10.5	17.5
N	1,296	1,296	1,296	1,296	1,296

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics*, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the specified mortality rate per 100,000 of the relevant population in state s and year t . Controls include % of population less than 18 years of age, % 18-65 years of age, % white, % black, % living in an urban area, % female, % foreign born, physicians per capita, physician educational requirements, a department of child hygiene indicator, a women's suffrage indicator, Sheppard-Towner spending, the typhoid mortality rate, the non-pulmonary tuberculosis mortality rate, state fixed effects, year fixed effects and state-specific linear time trends. Regressions are weighted by the relevant female population. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 5. Maternal Mortality and Midwifery Laws: Municipal-Level Analysis, 1900-1917

	(1)	(2)	(3)	(4)
<i>Midwifery License Required</i>	-.093*** (.028) [-2.98]	-.082*** (.025) [-2.63]	-.029 (.023) [-.925]	-.020 (.019) [-.649]
Mean	16.0	16.0	16.0	16.0
N	6,365	6,365	6,365	6,365
R ²	.321	.335	.350	.434
Typhoid and non-pulmonary TB	no	yes	yes	yes
State-specific linear trends	no	no	yes	no
Municipality-specific linear trends	no	no	no	yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics*, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the quartic root of the maternal mortality rate per 100,000 population in municipality m and year t . Controls include physician educational requirements, a department of health indicator, a department of child hygiene indicator, a women's suffrage indicator, municipality fixed effects and year fixed effects. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses and marginal effects are in brackets.

Table 6. Infant Mortality and Midwifery Laws

	State-level analysis, 1900-1940				Municipal-level analysis, 1900-1917					
	<i>Infant Mortality</i>	<i>White Infant Mortality</i>	<i>Nonwhite Infant Mortality</i>		<i>Infant Mortality</i>	<i>Infant Mortality</i>	<i>Diarrhea Under Age 2</i>	<i>Diarrhea Under Age 2</i>	<i>Diarrhea Ages 2+</i>	<i>Diarrhea Ages 2+</i>
<i>Midwifery</i>	.005	.002	-.049*	<i>Midwifery</i>	-.035	.007	-.080*	-.024*	-.045	-.003
<i>License Required</i>	(.016)	(.024)	(.027) [-12.4]	<i>License Required</i>	(.044)	(.014)	(.047) [-9.25]	(.014) [-2.83]	(.030) [-1.62]	(.016) [-.119]
Mean	164.3	139.4	248.9	Mean	306.2	306.2	89.2	89.2	18.7	18.7
N	1,296	1,114	1,114	N	6,365	6,365	6,365	6,365	3,747	3,747
R ²	.990	.989	.940	R ²	.818	.854	.814	.851	.571	.636
				State-specific linear trends	yes	no	yes	no	yes	no
				Municipality-specific linear trends	no	yes	no	yes	no	yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics*, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. **State-level analysis:** The dependent variable is equal to the natural log (or, in the case of nonwhite infant mortality, the quartic root) of the specified mortality rate per 100,000 of the relevant population in state s and year t . Controls include % of population less than 18 years of age, % 18-65 years of age, % white, % black, % living in an urban area, % female, % foreign born, physicians per capita, physician educational requirements, a department of child hygiene indicator, a women's suffrage indicator, Sheppard-Towner spending, the typhoid mortality rate, the non-pulmonary tuberculosis mortality rate, state fixed effects, year fixed effects and state-specific linear time trends. Regressions are weighted by the relevant state population. Standard errors, corrected for clustering at the state level, are in parentheses and marginal effects are in brackets. **Municipal-level analysis:** The dependent variable is equal to the natural log (or, in the case of diarrhea, the quartic root) of the specified mortality rate per 100,000 population in municipality m and year t . Controls include physician educational requirements, a department of health indicator, a department of child hygiene indicator, a women's suffrage indicator, the typhoid mortality rate, the non-pulmonary tuberculosis mortality rate, municipality fixed effects and year fixed effects. Regressions are weighted by municipality population. Standard errors, corrected for clustering at the state level, are in parentheses and marginal effects are in brackets.

Table 7. Licensing and the Supply of Midwives: Evidence from Census Years, 1870-1930

	<i>Total Midwives</i>		<i>Black Midwives</i>		<i>Foreign-Born Midwives</i>	
<i>Midwifery License Required</i>	.569*** (.206) [23.4]	.677*** (.243) [27.8]	.526 (.506) [19.7]	.869 (.773) [32.6]	.453 (.340) [45.0]	.319 (.401) [31.7]
Mean	22.3	22.3	19.7	19.7	72.4	72.4
N	286	286	258	258	286	286
R ²	.605	.721	.564	.647	.644	.728
State-specific linear trends	no	yes	no	yes	no	yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on Decennial U.S. Census data at the state level. Each column represents the results from a separate OLS regression. The dependent variable is equal to the quartic root of the specified midwife rate per 100,000 females ages 15-45 from the relevant population in state s and year t . Controls include % of population less than 18 years of age, % 18-65 years of age, % white, % black, % living in an urban area, % female, % foreign born, physician educational requirements, a department of health indicator, a department of child hygiene indicator, a women's suffrage indicator, Sheppard-Towner spending, state fixed effects and year fixed effects. Regressions are weighted by the relevant female population, ages 15-45. Standard errors, corrected for clustering at the state level, are in parentheses and marginal effects are in brackets.

Appendix Table 1. State Midwifery Laws, 1870-1940

State	Licensing Requirement	Year of Passage	Description
Alabama	Yes	1918	Midwives were required to pass an examination and register with the Alabama State Board of Health. According to Tovino (2004, p. 72), “Although thousands of women practiced as lay midwives in Alabama, only a few completed the required training.” In response to the passage of the law, the Tuskegee Institute developed a four-week course “of intensive training in midwifery” (Kennedy 1921).
Arizona	No		A 1903 law stipulated that the practice of midwifery be unrestricted (van Blarcom 1913).
Arkansas	No		A 1904 law stipulated that the practice of midwifery be unrestricted (van Blarcom 1913).
California	Yes	1917	The law came into effect on July 27, 1917. It required that midwives receive instruction in anatomy, hygiene and sanitation, obstetrics and physiology from a legally chartered school approved by the Board of Medical Examiners. Applicants also had to pass an examination in these subjects. Persons practicing midwifery without a license were subject to a fine of not more than \$600 and/or imprisonment for up to 180 days. The full text of the law is available in Henning and Hyatt (1921).
Colorado	Yes	1915	The law required that applicants be examined by the State Board of Medical Examiners. Persons practicing midwifery without a license were subject to a fine of not more than \$300 or imprisonment for up to 30 days. See Colorado (1915) for the full text of the law. Also see Stone (1918).
Connecticut	Yes	1893	The law came into effect in October 1893. Applicants had to pass an exam administered by a committee appointed by the State Board of Health. Persons practicing midwifery without a license were subject to a fine of not more than \$300 or imprisonment for up to 90 days. See Connecticut (1893) for the full text of the law.
Delaware	Yes	1920	License to be issued by the State Board of Health upon a signed statement from a licensed physician that the applicant is qualified. See the National Committee for the Prevention of Blindness (1920) for more details.
Florida	Yes	1931	The law required that applicants be at least 21 years of age, sponsored by two practicing physicians, be able to read “the Manual for Midwives intelligently” and show evidence “of habits of cleanliness.” Applicants were required to have attended 15 deliveries under the supervision of a licensed physician or to have graduated from a school for midwives recognized by the State Health Officer. See Hanson (1931) for the full text of the law.
Georgia	Yes	1925	Midwives were required to receive basic instruction from public health nurses in order to be certified. Beginning in 1956, applicants had to be

			of “good character and sound mind.” Under the new requirements, applicants who were not previously certified had to complete a course of instruction approved by the Georgia Department of Public Health and were required to pass an examination. Previously certified midwives were required to receive “periodic instruction made available to them each year in order to maintain eligibility for certification.” See Georgia Department of Public Health (1928), Cadwallader (1957), Georgia (1957), Pennell and Stewert (1968) and Warsh (2010, pp. 108-109) for details.
Idaho	No		A 1908 law stipulated that the practice of midwifery be unrestricted (van Blarcom 1913).
Illinois	Yes	1877	The law came into effect on July 1, 1877. It created the State Board of Health, which was empowered to examine midwives (and physicians) who had not graduated from a medical institution “in good standing.” Persons practicing midwifery without a license were subject to a fine of not more than \$500 and/or imprisonment for up to 365 days. See Illinois State Board of Health (1884), Egan (1910) and Sandvick (2009) for more details.
Indiana	Yes	1897	The law came into effect on April 14, 1897. It required applicants to have graduated from a recognized school of midwifery or pass an examination given by the Board of Medical Registration and Examination. Persons practicing midwifery without a license were subject to a fine of not less than \$25 and not more than \$500 (Egan 1910; van Blarcom 1913; Burns 1914, pp. 142-144; Pennell and Stewart 1968).
Iowa	No		The practice of midwifery was unregulated until 1978, when it was prohibited AG’s opinion (Egan 1910; Pennell and Stewart 1968; Butter and Kay 1988).
Kansas	No		Under a 1911 law, midwives were required to register with the local registrar of vital statistics (van Blarcom 1913).
Kentucky	Yes	1919	Established in 1919, the Bureau of Child Hygiene was tasked with instructing, examining and licensing midwives “through county health officers.” See Kentucky (1922) for the full text of the law.
Louisiana	Yes	1894	The law required examination by the Board of Medical Examiners, but exempted the “so-called midwife of the rural districts and plantation practice, who, in the sense of this act, are not considered as practicing midwifery as a profession.” Persons practicing midwifery without a license were subject to a fine of up to \$100 (Louisiana 1904; Duffy 1962, p. 409; Pennell and Stewart 1968).
Maine	No		A 1903 law stipulated that the practice of midwifery be unrestricted (van Blarcom 1913).
Maryland	Yes	1910	The law came into effect on July 1, 1910. It required examination by the State Board of Health. Applicants were also required to provide a “certificate from a legal practitioner of medicine...that he or she has attended at least 5 cases of childbirth” and had to provide certificates from three “reputable citizens” attesting that the applicant was of good moral character. See Maryland (1914) for the full text of the law.

Massachusetts	No		The practice of midwifery was prohibited by the Medical Practice Act of 1894 (Declercq 1994).
Michigan	No		The practice of midwifery was (and remains) unregulated (Egan 1910; Pennell and Stewart 1968; Butter and Kay 1988; Gray 2015).
Minnesota	Yes	1891	The law came into effect on April 20, 1891. It required applicants to have graduated from a recognized school of midwifery or pass an examination administered by the Board of Medical Examiners. Practicing midwifery without a license was subject to a fine of up to \$50 or imprisonment of up to 30 days. See Minnesota (1891) for the full text of the law. Also see Egan (1910).
Mississippi	Yes	1921	Beginning in 1921, the Bureau of Child Welfare provided instruction to midwives and required them to be certified. Applicants were judged based on character, cleanliness, intelligence and “reputation for calling a doctor in difficult or abnormal cases.” See Mississippi Board of Health (1921) for more details.
Missouri	Yes	1901	Applicants had to pass an examination administered by the State Board of Health. Women who did not practice midwifery as a profession and did not charge for their services were not required to obtain a license. Persons practicing midwifery as a profession without a license were subject to a fine of not more than \$50 or imprisonment for up to two months. See Missouri (1909) for the full text of the law. Also see Perry (1983).
Montana	No		The practice of midwifery was unregulated until 1978, when it was prohibited AG’s opinion (Egan 1910; Pennell and Stewart 1968; Butter and Kay 1988).
Nebraska	No		The practice of midwifery was unregulated (Egan 1910; van Blarcom 1913; Pennell and Stewart 1968; Butter and Kay 1988).
Nevada	No		The practice of midwifery was unregulated (Egan 1910; van Blarcom 1913; Pennell and Stewart 1968; Butter and Kay 1988).
New Hampshire	No		The practice of midwifery was unregulated (Egan 1910; van Blarcom 1913; Pennell and Stewart 1968; Butter and Kay 1988).
New Jersey	Yes	1892	Under the law, applicants were required to have 6 months of training from a legally incorporated school of midwifery and pass an examination given by the Board of Medical Examiners. Practicing midwifery without a license was punishable by a fine of not more than \$50 and/or imprisonment for up to 30 days (New Jersey State Board of Medical Examiners 1902). In 1910, the law was amended to require two years of training (van Blarcom 1913; Levy 1921).
New Mexico	Yes	1937	A 1901 law stipulated that the practice of midwifery be unrestricted (van Blarcom 1913). The 1937 law provided for licensure by examination and set penalties for practicing midwifery without a license (Pennell and Stewart 1968).
New York	Yes	1913	Applicants had to be at least 21 years of age, be able to read and write and be of “good moral character.” These requirements came into effect on November 16, 1914 except in New York City and Rochester (New York Department of Health 1915; Williams 1915). As of January 1, 1915, applicants were required to show evidence of “habits of

			cleanliness” and to have graduated from a recognized midwifery program or provide a statement from a licensed physician attesting that the applicant had attended and received instruction in at least 15 deliveries (Williams 1915).
North Carolina	Yes	1935	The practice of midwifery was unregulated until a 1908 law required midwives to wash hands before touching a patient and banned women who were addicted to drugs or alcohol from the practice of midwifery (van Blarcom 1913). In 1917, midwives were required to register with the Board of Health (North Carolina 1920). In April of 1935, midwives were required to obtain a permit from the Board of Health, “under rules and regulations which it shall adopt with respect thereto...” Practicing midwifery without a permit was punishable by a fine of not more than \$50 or imprisonment for up to 30 days. See North Carolina (1935) for the full text of the law.
North Dakota	No		The practice of midwifery was unregulated (Egan 1910; van Blarcom 1913; Pennell and Stewart 1968; Butter and Kay 1988).
Ohio	Yes	1896	Applicants were required to pass an examination administered by the State Board of Medical Registration and Examination. Practicing midwifery without a license was punishable by a fine of not less than \$25 and not more than \$100. See Laning (1896), Ohio (1905) and Egan (1910).
Oklahoma	No		The practice of midwifery was unregulated (Egan 1910; van Blarcom 1913; Pennell and Stewart 1968; Butter and Kay 1988).
Oregon	No		The practice of midwifery was unregulated (Egan 1910; van Blarcom 1913; Pennell and Stewart 1968; Butter and Kay 1988).
Pennsylvania	Yes	1913	Beginning in 1914, applicants were required to pass an examination administered by the Bureau of Medical Education and Licensure and penalties for practicing midwifery without a license came into effect (van Blarcom 1913; Pennsylvania State Department of Health 1913, pp. 8-9; Stevens 1914, p. 404; Miller and Baker 1916, p. 1000).
Rhode Island	Yes	1918	The law came into effect on July 1, 1918. It required applicants to be examined by the State Board of Health and stipulated penalties for practicing midwifery without a license. Persons practicing midwifery without a license were subject to a fine of up to \$100 and/or imprisonment for up to 6 months. See Rhode Island (1918) for the full text of the law.
South Carolina	Yes	1920	Midwives were required to receive basic instruction from public health nurses in order to obtain a permit. Beginning in the early 1940s, midwives were required to be able to read and write, “see well, have average intelligence and be in good general health.” New midwives were required to attend a two-week course of instruction “at an annual State or district midwife institute” before receiving a certificate “at the discretion” of the county health officer. Certified midwives were required to attend “a two weeks institute every four years.” See Dodd (1920), South Carolina (1960) and Hill (2012) for details.
South Dakota	No		The practice of midwifery was unregulated (Egan 1910; van Blarcom 1913; Pennell and Stewart 1968; Butter and Kay 1988).

Tennessee	No		The practice of midwifery was unregulated (Egan 1910; van Blarcom 1913; Pennell and Stewart 1968; Butter and Kay 1988).
Texas	Yes	1907	The Medical Practice Act required applicants to be 21 years of age, of good moral character and to have graduated from a “bon fide, reputable” medical school. Applicants were examined by the Board of Medical Examiners in obstetrics, but the law did “not apply to those who do not follow obstetrics as a profession, and who do not advertise themselves as obstetricians or midwives.” Persons practicing obstetrics without a license were subject to a fine of up to \$500 and/or imprisonment for up to 6 months. See Daniel (1910), Egan (1910) and Texas (1916) for more details.
Utah	Yes	1907	The law required a license to practice obstetrics, but permitted the practice of obstetrics “in case of emergency” and in communities “where there are no licensed practitioners.” Applicants were required to pass an examination administered by the Board of Medical Examiners. See Egan (1910) for more details.
Vermont	No		A 1906 law stipulated that the practice of midwifery be unrestricted (van Blarcom 1913).
Virginia	Yes	1919	The law required that midwives register with the local registrar and “obey the sanitary rules of the State Board of Health.” Persons convicted of practicing the profession of midwifery without a permit were subject to a fine in “a sum not less than ten dollars and not more than fifty dollars.” See Virginia (1918) and Pennell and Stewart (1968).
Washington	Yes	1917	The law required that applicants receive 14 months of training from a “legally incorporated school on midwifery in good standing” and pass an examination administered by the Board of Medical Examiners. Any person practicing midwifery without a license “shall be deemed guilty of a misdemeanor.” For details see Washington (1919), Smith (2005, pp. 55-56) and Varney and Thompson (2016, p. 143).
West Virginia	Yes	1925	The law into effect on January 11, 1926. Applicants for licensure had to be at least 21 years of age, able to read and write, show habits of cleanliness and have good moral character. A diploma from a school of midwifery or a physician’s statement verifying that the applicant had attended at least five births was required. See Bickley (1990) for more details.
Wisconsin	Yes	1909	The law came into effect in December, 1909. It required applicants to have graduated from a reputable midwifery school, pass an examination administered by the Medical Board of Examiners and furnish evidence of “good moral and professional character.” To be considered reputable, a school had to offer at least 12 months of instruction and practical experience in at least 20 “cases of confinement.” See Wisconsin (1909) for the full text of the law.
Wyoming	Yes	1899	Examination and licensure by the State Board of Medical Examiner (van Blarcom 1913; Pennell and Stewart 1968). The law allowed the practice of obstetrics or midwifery without a license “in cases of emergency.” See Wyoming (1899) for the full text of the law.

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Appendix Table 2. States and Years Covered in State-Level Analysis, 1900-1940

State	Years Covered	State	Years Covered
Alabama	1925-1940	Nebraska	1920-1940
Arizona	1926-1940	Nevada	1929-1940
Arkansas	1927-1940	New Hampshire	1900-1940
<i>California</i>	1906-1940	New Jersey	1900-1940
<i>Colorado</i>	1906-1940	<i>New Mexico</i>	1929-1940
Connecticut	1900-1940	<i>New York</i>	1900-1940
<i>Delaware</i>	1919-1940	<i>North Carolina</i>	1916-1940
<i>Florida</i>	1919-1940	North Dakota	1924-1940
<i>Georgia</i>	1922-1924, 1928-1940	Ohio	1909-1940
Idaho	1922-1940	Oklahoma	1928-1940
Illinois	1918-1940	Oregon	1918-1940
Indiana	1900-1940	<i>Pennsylvania</i>	1906-1940
Iowa	1923-1940	<i>Rhode Island</i>	1900-1940
Kansas	1914-1940	<i>South Carolina</i>	1916-1940
<i>Kentucky</i>	1911-1940	South Dakota	1906-1909, 1930-1940
Louisiana	1918-1940	Tennessee	1917-1940
Maine	1900-1940	Texas	1933-1940
<i>Maryland</i>	1906-1940	Utah	1910-1940
Massachusetts	1900-1940	Vermont	1900-1940
Michigan	1900-1940	<i>Virginia</i>	1913-1940
Minnesota	1910-1940	<i>Washington</i>	1908-1940
<i>Mississippi</i>	1919-1940	<i>West Virginia</i>	1925-1940
Missouri	1911-1940	<i>Wisconsin</i>	1908-1940
Montana	1910-1940	Wyoming	1922-1940

Notes: States that contributed data before and after a midwifery law was passed are denoted in italics.

**Appendix Table 3. Maternal Mortality and Leads and Lags of Midwifery Laws:
State-Level Analysis, 1900-1940**

	(1)	(2)	(3)	(4)
<i>5 to 6 Years Prior to Midwifery License Required</i>	.035 (.038)	.034 (.044)	...	...
<i>3 to 4 Years Prior to Midwifery License Required</i>	-.049 (.036)	-.055 (.046)	...	...
<i>1 to 2 Years Prior to Midwifery License Required</i>	-.055 (.040)	-.048 (.052)	...	...
<i>Midwifery License Required</i>	-.090** (.044)	-.096* (.051)	...	...
<i>Year of Law Change</i>	...	...	-.035 (.021)	-.026 (.018)
<i>1 to 2 Years After Midwifery License Required</i>	...	...	-.056** (.023)	-.059** (.023)
<i>3 to 4 Years After Midwifery License Required</i>	...	...	-.078** (.032)	-.083*** (.030)
<i>5+ Years After Midwifery License Required</i>	...	...	-.067* (.035)	-.093** (.037)
Mean	27.9	27.9	27.9	27.9
N	1,296	1,296	1,296	1,296
R ²	.956	.966	.956	.966
State-specific linear trends	no	yes	no	yes

*Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Based on annual data from *Mortality Statistics*, published by the U.S. Census Bureau. Each column represents the results from a separate OLS regression. The dependent variable is equal to the natural log of the maternal mortality rate per 100,000 females in state s and year t . Controls include % of population less than 18 years of age, % 18-65 years of age, % white, % black, % living in an urban area, % female, % foreign born, physicians per capita, physician educational requirements, a department of child hygiene indicator, a women's suffrage indicator, Sheppard-Towner spending, the typhoid mortality rate, the non-pulmonary tuberculosis mortality rate, state fixed effects and year fixed effects. Regressions are weighted by female population. Standard errors, corrected for clustering at the state level, are in parentheses.

**Appendix Table 4. Examination in Midwifery Administered by the
Wisconsin Medical Board of Examiners, 1926**

1. Describe the female organs of generation.
 2. Give the symptoms of pregnancy during the first three months.
 3. When you examine a woman in labor, how do you determine if the position is normal?
 4. What would you do for the severe case of hemorrhage during labor until a physician could be called?
 5. What are the symptoms of kidney trouble in the pregnant woman?
 6. Describe the preparation of the woman in the beginning of labor. Also how do you prepare yourself?
 7. How do you take care of the cord and the baby's eyes? Describe after care of the mother with especial reference to the nipples and genitals.
 8. How do you deliver the placenta? In case a severe hemorrhage follows delivery of the placenta, what would you do?
 9. If the baby does not breathe well or cry lustily, what do you do?
 10. How do you feed a baby for the first three or four days? What do you use?
 11. What would lead you to suspect a parturient woman would be likely to develop convulsions?
 12. What benefit may be derived from your making a report of a birth? Why is it necessary so to report?
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Notes: The original copy of this exam is available at http://ebling.library.wisc.edu/historical/wi-women/exam_questions.pdf.

Appendix Table 5. Municipality Midwifery Ordinances, 1900-1917

City and State	Year Ordinance Adopted	Description
Alexandria, Virginia	1912	Adopted on July 23, 1912. Applicants were examined by the health officer of the city. Persons found guilty of practicing midwifery without a license were subject to a fine of “not less than \$5 nor more than \$100.”
Jacksonville, Florida	1913	Effective April 1, 1914. Applicants had to pass an examination administered by the city board of health. The city board of health, in turn, was required to provide instruction free of charge. “No test of the literacy or the education of the applicants shall form part of the examination.” Any person “to assist for a compensation of any kind a woman in normal childbirth” was subject to the ordinance. Violation of the ordinance was punishable by a fine of not more than \$25 or imprisonment for up to 30 days.
Los Angeles, California	1910	Applicants were required to pass an examination administered by board of health. The board of health was also tasked with investigating the applicant and refusing permits to those with a criminal history and to those found to have committed immoral acts. Practicing midwifery without a permit was punishable by a fine of up to \$500 and/or imprisonment for up to 6 months.
Marquette, Michigan	1915	Applicants had to be 21 years of age, able to read and write and pass an examination administered by the city health officer. Based on the results of the examination, her qualifications and her “experience as a midwife”, the city health officer was authorized to certify the applicant. Violation of the ordinance was punishable by a fine of up to \$50 or imprisonment for up to 90 days.
Memphis, Tennessee	1910	Effective August 9, 1910. Applicants were required to pass an examination administered by the superintendent of health. In addition, applications for a permit had to be signed by at least three “reputable citizens and taxpayers of the city of Memphis, who certify to the good character of the applicant.” Practicing midwifery without a permit was punishable by a fine of not less than \$5 but not more than \$50. Anyone acting as a midwife for “hire or compensation” was subject to the ordinance.
New York, New York	1907	As of November 6, 1907, midwives were required to obtain a permit issued by the New York City Board of Health (Bell 1914). According to rules adopted by the Board of Health, applicants were required to have attended at least 20 deliveries under the supervision of a

physician. In addition, applicants had to be 21 years of age, of “moral character”, able to read and write and “show evidences...of habits of cleanliness.” The homes and equipment of midwives had to be available for inspection “at all times.” New rules took effect on April 1, 1914. Under the new rules, applicants were required to have graduated from a registered school of midwifery. See New York Department of Health (1909), Bell (1914), New York Bureau of Child Hygiene (1915) and New York Department of Health (1915) for more details.

Norfolk, Virginia	1912	Adopted July 16, 1912. Applicants were required to receive a permit from the city health commissioner who was empowered to “refuse such permit in any case where in his judgement it is not advisable to grant the same.” Violations of the ordinance were punishable by a fine of up to \$20.
Raleigh, North Carolina	1912	Adopted on July 19, 1912. Midwives were required to register in the office of the board of health and provide the name and location of the “college or school or other institution from which such person received a diploma, certificate or license.” Neglecting to register was punishable with a fine of \$10 per day.
Syracuse, New York	1913	Effective April 7, 1913. Midwives were examined and licensed by the Board of Examiners in Midwifery, appointed by the mayor. Applicants had to be 21 years of age. The board was empowered to exam applicants “as to their moral character and qualifications to practice midwifery.” Violation of the law was punishable by a fine not less than \$50 but not more than \$100. According to the New York Department of Health (1915), the city of Syracuse “has not exercised any systematic supervision of the midwives licensed.”

Sources for Appendix Table 5

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Source: Public Health Reports (1896-1970), 28(8): 372-375. Available at:

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Raleigh, NC. 1912. "Board of Health—Organization, Powers, and Duties." Chapter XX, Ordinance July 19, 1912. Source: Municipal Ordinances, Rules, and Regulations Pertaining to Public Health Adopted from July 1, 1911 to December 31, 1911 by Cities of the United States Having a Population of over 10,000 in 1910 (1913). Washington, DC: Government Printing Office.

Syracuse Midwifery Act, Chapter 227. Source: Charter of the City of Syracuse Consisting of Second Class Cities Law and Special Statutes Together with General Ordinances, and Rules and Regulations of the Boards, Bureaus, Offices and Departments of the City of Syracuse (1915).

Appendix Table 6. States and Years Covered in Municipal-Level Analysis, 1900-1917

State	Number of Cities in Sample	Years Covered	State	Number of Cities in Sample	Years Covered
Alabama	3	1900-1917	Nebraska	2	1900-1917
Arizona	0	...	Nevada	0	...
Arkansas	0	...	New Hampshire	7	1900-1917
<i>California</i>	11	1900-1917	New Jersey	27	1900-1917
<i>Colorado</i>	4	1900-1917	New Mexico	0	...
Connecticut	20	1900-1917	<i>New York</i>	45	1900-1917
Delaware	1	1900-1917	North Carolina	2	1900-1917
<i>Florida</i>	2	1900-1917	North Dakota	0	...
Georgia	2	1900-1917	Ohio	21	1900-1917
Idaho	0	...	Oklahoma	0	...
Illinois	9	1900-1917	Oregon	1	1900-1917
Indiana	21	1900-1917	<i>Pennsylvania</i>	51	1900-1917
Iowa	4	1900-1905	Rhode Island	9	1900-1917
Kansas	3	1900-1917	South Carolina	1	1900-1917
Kentucky	4	1900-1917	South Dakota	0	...
Louisiana	1	1900-1917	Tennessee	2	1900-1915, 1917
Maine	8	1900-1917	<i>Texas</i>	2	1900-1917
<i>Maryland</i>	4	1900-1917	<i>Utah</i>	2	1900-1917
Massachusetts	52	1900-1917	Vermont	3	1900-1917
Michigan	23	1900-1917	Virginia	6	1900-1917
Minnesota	5	1900-1917	<i>Washington</i>	4	1900-1917
Mississippi	0	...	West Virginia	1	1900-1917
<i>Missouri</i>	3	1900-1917	<i>Wisconsin</i>	18	1900-1917
Montana	0	...	Wyoming	0	...

Notes: States with cities that contributed data before and after a midwifery law was passed are denoted in italics.

Appendix Table 7. Descriptive Statistics for Municipal-Level Maternal Mortality Analysis, 1900-1917

	Full sample	<i>Midwifery License Required = 1</i>	<i>Midwifery License Required = 0</i>	Description
<i>Maternal Mortality</i>	16.0 (11.0) N = 6,365	16.2 (11.1) N = 2,635	15.8 (11.0) N = 3,730	Maternal mortality per 100,000 population
<i>Physician Diploma</i>	.825 (.380)	.980 (.139)	.715 (.451)	= 1 if state required physicians to have a diploma
<i>Physician Education</i>	.741 (.438)	.912 (.283)	.620 (.485)	= 1 if state medical boards could set preliminary education requirements
<i>Dept. of Public Health</i>	.998 (.045)	1.00 (0.00)	.997 (.059)	= 1 if state had a public health department
<i>Dept. of Child Hygiene</i>	.079 (.269)	.128 (.334)	.043 (.204)	= 1 if state had a division of child hygiene
<i>Suffrage</i>	.049 (.217)	.052 (.221)	.048 (.214)	= 1 if women were allowed to vote
<i>Typhoid</i>	27.9 (28.5)	25.5 (24.9)	29.5 (30.8)	Typhoid mortality per 100,000 population
<i>Non-pulmonary TB</i>	22.5 (13.4)	22.5 (13.3)	22.5 (13.5)	Non-pulmonary tuberculosis mortality per 100,000 population

Notes: Unweighted means with standard deviations in parentheses.