Medical School Closures, Market Adjustment, and Mortality in the Flexner Report Era*

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Abstract

Early twentieth century efforts to overhaul the quality of medical education in the United States (principally between 1905 and 1915 – the "Flexner Report Era") led to a steep decline in the number of medical schools and medical school graduates. In this paper, we examine the consequences of these medical school closures for county-level physicians, nurses, and midwives per capita as well as for infant and all-age mortality. To do so, we construct a school closure intensity measure for all counties in the United States, combining variation in (i) distance from closures, (ii) the historical number of graduates from closing schools, and (iii) the timing of closures. Nearby medical school closures (within 300 miles) led to reductions in physicians per capita, even after physician market adjustment through physician migration and postponed retirement. Despite not being trained in medical schools, nurses per capita increased in response to closures. Strikingly, we find that medical school closures led to lower infant and all age mortality rates, suggesting that reducing the supply of poorly trained physicians may have reduced mortality.

JEL Codes: N31, N32, I11
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"We have indeed in America medical practitioners not inferior to the best elsewhere; but there is probably no other country in the world in which there is so great a distance and so fatal a difference between the best, the average, and the worst."

- Abraham Flexner, *Medical Education in the United States and Canada*, 1910

1 Introduction

The 1910 publication of *Medical Education in the United States and Canada* (colloquially known as the 'Flexner Report') is among the most prominent reform events in the history of American medicine. Many new medical schools, often commercial and unattached to American universities, opened in the late nineteenth century. There was substantial concern about their quality – and the potential for clinical and population health harm due to the credentialing of poorly trained physicians. The Flexner Report, written by Abraham Flexner at the request of the Carnegie Foundation, evaluated the quality of every medical school in the United States. The final report recommended closing the majority of medical schools.

The Flexner Report's release was a single, albeit pinnacle, event in a larger reform effort in American medical education already underway at the time. Beginning in the late 1870s, states began establishing licensing requirements and Boards of Health. In 1901, the floundering American Medical Association underwent considerable reorganization and emerged with a new, national focus. It established the Council on Medical Education, which published minimum educational standards in 1905 and began inspecting, evaluating, and rating medical schools in 1906, leading to closures. The 1910 Flexner Report was therefore a product of this reform period rather than a cause of it. Figure 1 Panels (a) and (b) support this interpretation. They show a steep decline in the number of both medical schools and medical school graduates between 1905 and 1915 rather than a sharp decline beginning in 1910. In what follows, we refer to 1905-1915 as "the Flexner

Era." The available evidence suggests that schools which closed had lower ratings and lower pass rates on state licensing exams. Thus, the Flexner Era reforms reduced the supply of poorly trained physicians over time.

In this paper, we examine the consequences of Flexner Era medical school closures for county-level physicians per capita, nurses and midwives per capita, and infant and all-age mortality rates.[1] A priori, it is not obvious what the effect of medical school closures will be on physicians, other health care workers, or patterns of mortality in counties near closures. If there is limited market adjustment, counties near closures which historically absorbed the majority of graduates may bear the brunt of the effect, experiencing long-term reductions in physicians. If markets completely adjust, the effect of school closures will be spread equally across counties. The distribution of physicians may also adjust along a number of margins: existing physicians may migrate; older physicians may change their retirement decisions; and the location of training may change if surviving schools adjusted capacity. Other types of health care professionals, such as nurses and midwives, could also be affected if they were complements or substitutes for physicians. For population health, reducing the supply of poorly trained physicians could either decrease or increase mortality. Medical school closures could increase mortality if these poorly trained physicians provided meaningful health benefits. Alternatively, they could decrease mortality if lower-quality physicians harmed patients by spreading disease, or engaging in harmful medical practices, or if patients switched to the smaller number of higher-quality physicians that remained in practice.

Our analyses use data on medical school closures and the number of graduates from all medical schools, full count Census of Population data for 1900, 1910, 1920, and 1930, and county-level Vital Statistics data on mortality. We use the full count Census of Population data to create county-by-decennial year counts of physicians, nurses, and midwives. We also use the population censuses to generate linked samples of physi-

[1] By "per capita" we technically mean "per 1,000 population" and use this definition throughout the paper.

cians, with which we investigate where physicians attended medical school, patterns of physician migration, and the decision to exit medical practice through job change or retirement. These linked samples indicate that the median physician lived in the same county where they attended medical school, 90% lived within 300 miles, and almost all physicians lived within 500 miles. We also constructed county-level mortality data using city-level data together with newly digitized data on mortality in the rural parts of counties.

The paper uses a difference-in-difference estimation framework with continuous 'treatment,' defining treatment as school closure intensity (SCI) within a county over time, to examine the effects of closures. To construct this SCI measure, which captures how affected each county in the United States was by medical school closures between 1905 and 1915, we use data on medical school closures and the number of graduates from all medical schools between 1901 and 1904. Given evidence that new medical graduates began practice close to where they trained, we divide the number of physicians that graduated from each closing school within 300 miles of a county (prior to the Flexner Era) by the total number of physicians graduating from all schools in the United States. This proportion, which varies both across counties and over time, becomes our SCI measure. We control for SCI 300-500 miles from closures, and we also examine SCI in varying gradations of distance bins.

Our paper has two main findings. First, medical school closure intensity within 300 miles of a county was negatively associated with the number of physicians per capita in a county, with most of the effect coming through a decrease in young physicians. These physicians were under age 40 and were more directly affected by closures. In our preferred specification, a county with average closure intensity experienced a 9% reduction in young physicians and a 4% reduction in all physicians. These results are robust across a range of specifications. The effects of closures also grew over time: in a county with average closure intensity, by 1930 the decline in young physicians was 12%

and the overall decline was 5%.

Market adjustment also appears to have been significant. We show that physicians migrated to counties with higher SCI values and that physicians in counties with higher SCI values postponed retirement. Both of these responses helped to offset the decrease in new medical graduates. Existing medical schools that did not close did not increase enrollment to make-up for the lost graduates from closing schools. The small number of new medical schools that opened were generally opening in new markets and so were not offsetting closures. The lack of expansion in response to closures may have been driven by the higher costs of training medical students as standards for training rose (for example, to receive an AMA rating of 'A', medical schools needed to have full-time, instead of part-time, faculty and fully equipped laboratories, both of which were expensive).

Medical school closures within 300 miles also led to increases in nurses per capita and had no effect on midwives per capita. Nurses were trained in hospitals or on the job and so were not directly affected by medical school closures. Midwives were trained in specialty midwife schools or by assisting an experienced midwife. Increases in the number of nurses per capita suggest that they were substitutes for physician labor.

Second, strikingly, infant and total mortality declined as a result of school closures within 300 miles. A county with the average closure intensity experienced a 6% reduction in infant mortality and a 2% reduction in total mortality. The reductions were primarily driven by causes likely to be sensitive to physician quality – reductions in infectious diseases and diseases of early infancy. Other factors such as the presence of a county public health department, the number of county health department personnel, the number of hospitals and hospital beds, and city-level public health spending on sewers, water, and refuse were either unrelated or negatively related to medical school closures. Although we cannot fully isolate the role of physicians given other market adjustments in response to them, reducing the supply of poorly trained physicians

nonetheless appears to have reduced mortality.

Our paper contributes to three literatures. The first is research on the historical supply and distribution of physicians and nurses in the United States. In particular on physicians, we build on and complement the work of Moehling et al. (2020) and Andrews (2021).[2] Moehling et al. (2020) study how medical school quality affected the location decisions of physicians using data from the American Medical Directory in 1909, 1914, 1918, and 1921 for California, Mississippi, New York, and North Carolina. They find that graduates from higher quality medical schools located in more urban areas, contributing to urban-rural disparities in medical care. Andrews (2021) focuses on the Flexner Report, drawing on annual physician entry and exit data in New York State between 1903 and 1914, and finds that recent graduates of lower quality medical schools and recently relocated older physicians from lower quality schools disproportionately retired or relocated after the release of the Flexner Report. We build on this literature by studying the entire United States, documenting the effects of closures over time, and investigating margins of adjustment–including where students trained, migration of students and existing physicians, and retirement decisions of older physicians.[3] Our paper also provides new evidence on the consequences of medical school closures for nurses and midwives.

Second, our paper contributes to research on the causes of mortality decline during the first half of the twentieth century in the United States. This literature has examined a range of factors including improvements in nutrition, access to clean water and sewerage, and the development of vaccines and life saving drugs.[4] An important open question is if physicians and other health care workers contributed to improvements in health in the

[2]Miller and Weiss (2008) use survival analysis to investigate the effect of the Council of Medical Education ratings, Flexner's ratings, school characteristics, and other factors on medical school closures.

[3]Law and Kim (2005) also study historical licensing of many occupations, including physicians, and show that numbers of physicians per capita and infant mortality per capita are associated with state licensing board restrictions after 1900.

[4]On nutrition, see Fogel (1986). On water and sewerage, see Alsan and Goldin (2019); Cutler and Miller (2005); Anderson, Charles and Rees (2020). On vaccines and drugs, see Mokyr (1993); Jayachandran, Lleras-Muney and Smith (2010).

nineteenth and early twentieth centuries in the U.S.[5] Our paper provides new evidence on the contribution of Flexner Era medical school closures to declines in infant and total mortality.

Third, our paper relates to a large literature on quality regulation and disclosure. Empirical studies in this literature find that consumers are responsive to quality disclosure in a range of sectors, including education (Kane and Staiger, 2002; Jacob and Levitt, 2003), health care (Dafny and Dranove, 2008), and the food industry (Jin and Leslie, 2003). We contribute to this literature by studying a historically and socially important case of medical school closures due in part to quality concerns, showing that the removal of low-quality suppliers from the market can, under some circumstances, have important social benefits (in our case, leading to reductions in mortality).

The rest of the paper proceeds as follows. Section 2 provides background information on physicians, nurses and midwives, and mortality. Sections 3 and Section 4 describe the data and empirical strategy. Section 5 presents the results on physicians, nurses, and midwives and mortality. Section 6 presents a range of robustness checks. Section 7 concludes.

2 Historical Background

2.1 Physicians

2.1.1 Medical Education in the Nineteenth Century

The quality of medical education in the late nineteenth century was generally poor (Starr, 1982; Ludmerer, 1985; Rothstein, 1987; Miller and Weiss, 2008). Medical education ini-

[5]Haines (2001) lists stricter physician licensing laws and improved medical education as some of the public health initiatives that might have played a role in mortality improvements. Law and Kim (2005) find that changes in state-level physician licensing laws improved infant mortality, maternal mortality and mortality from appendicitis. They do not find a significant effect on overall mortality. On nurses and midwives, see Miller (2008); Moehling and Thomasson (2014); Anderson et al. (2020).

tially consisted of just two years, although by 1900 most medical schools had a four-year curriculum.[6] Most students had no undergraduate education, and some had also not completed high school because many medical schools accepted anyone who could pay. The relatively limited education of American doctors in the nineteenth century also reflected other factors, including the limited medical knowledge of the period and the fact that key scientific discoveries were occurring overseas.

Concern about the quality of medical education and the prevalence of 'quacks' dates to at least the 1870s. Illinois, which passed a licensing law in 1877, was a leader in reform efforts (Sandvick, 2009). Although all 48 states adopted licensing regulations for physicians during the second half of the nineteenth century, Baker (1984) describes regulations as generally lax and enforcement as weak.

The number of medical schools rose rapidly in the late nineteenth century.[7] The increase reflected both demand for, and supply of, medical education close to major population centers. On the demand side, traveling to distant cities or Europe for medical training was expensive and time-consuming. On the supply side, founding a medical school was relatively low cost, prestigious for the founders, and offered the possibility of profits for doctor-owned schools or donations for university-owned schools (Ludmerer, 1985; Miller and Weiss, 2008).

2.1.2 Medical Education Reform Efforts

Medical education reform efforts intensified beginning in 1905, which we consider to be the start of the Flexner Era. The AMA reorganized in 1901 with a national focus. This, together with parallel re-organization of county associations, led its membership to increase from 10,600 in 1901 to more than 70,000 by 1910 (Shafroth, 1935). The newly

[6] By the 1890s, a few schools had established high standards, including Harvard, University of Pennsylvania, University of Michigan, and Johns Hopkins.

[7] Some early medical schools were founded as part of a larger university, many others were founded by physicians and were later absorbed by universities. To avoid confusion, we will refer to medical schools by their modern affiliations.

invigorated AMA established a permanent Council on Medical Education (CME), which published educational standards in 1905, visited medical schools in 1906, and published quality ratings in 1907. Schools were graded based on ten criteria, which were worth 10 points each. Schools receiving 90-100 points were rated A, 80-89 points were rated B, 70-79 points were rated C, 60-69 were rated D, 50-59 were rated E, and below 50 were rated F. About 50% of the schools received 70 or more points, 30% received 50-69 points, and 20% received less than 50 points.

The AMA found it politically difficult to directly critique medical schools, so it turned to the Carnegie Foundation for the Advancement of Teaching (Miller and Weiss, 2008). Foundation director Henry Pritchett hired Abraham Flexner, who had a background in education but not medicine, to evaluate the quality of medical education across the United States and Canada–and to make recommendations for improving it. The AMA provided Flexner with both the results of its previous evaluations and significant behind-the-scenes assistance.

Released in 1910, *Medical Education in the United States and Canada* (i.e. the Flexner Report) recommended the closure of roughly 120 medical schools on the basis of low quality training (Flexner, 1910). In the report, Flexner argued that 31 medical schools would be sufficient to produce doctors for the entire United States. Although many schools did ultimately close, Figure 1 (a) shows that the total number of medical schools in the U.S. only fell to about 80 (from about a high of 160 in 1900) (Rothstein, 1987; Miller and Weiss, 2008). While all parts of the country experienced some closures, closures were particularly prevalent in the Midwest and parts of the South.

The Flexner Report received considerable media attention, and following its publication, AMA ratings were often discussed in local newspapers. For example, newspaper headlines about the Flexner Report included: "Poor Medical Colleges a Danger" (*El Paso Herald*, June 8, 1910); "Country Flooded with Quacks" (*Daily Capital Journal*, July 25, 1910); "Medical School Demands $100,000 of Carnegie Officials" (*Rock Island Argus*, June

11, 1910); "Carnegie Foundation Experts Unruffled by St. Louis Suit" (*New York Tribune*, June 12, 1910); and "Inferior Doctors Flood Country" (*Salt Lake Herald Republican*, June 13, 1910). Newspaper headlines in South Carolina, Vermont, and North Dakota about AMA ratings included: "Medical College Class B" (*The Herald and News*, February 28, 1913); "Medical College Needs Aid" (*Burlingon Weekly Free Press*, March 26, 1914); and "Medical College Class A" (*Grand Forks Daily Herald*, October 14, 1915).

Schools closed or merged during the Flexner Era for a variety of reasons. First, a bad rating from the AMA made it difficult for medical schools to recruit and retain students. For example, on December 5, 1912, the *Milwaukee Leader* reported that 500 medical students went on strike because the Marquette Medical School was given a C rating. Students were determined to stay in Class B medical schools, because it "gives them greater prestige on graduation" (*Milwaukee Leader*, December 5, 1912). Three hundred transferred to the Milwaukee College of Physicians and Surgeons, which had a B rating, and the other 200 moved to Chicago or St. Louis. Second, the number of applications fell after high school degrees or some college instruction became required of applicants (Miller and Weiss, 2008). Third, operating medical schools meeting higher standards was simply more expensive. Laboratories were expensive to build and maintain, and full-time faculty were generally more expensive than the part-time faculty they replaced. Fourth, state licensing boards were subjecting schools that fared poorly in the Flexner Report to increased scrutiny.[8]

Figure 2 shows cities with medical schools in 1901, prior to the Flexner Reform Era (black circles), and also shows cities that had at least one medical school that closed or merged between 1905 and 1915 (red circles). While all parts of the country experienced some closures, closures were particularly prevalent in the Midwest and parts of the South.

[8]By 1910, Baker (1984, p. 194) suggests that "Though they [state licensing boards] only began the task of education reform ... the machinery was in place so that the Flexner Report could have fairly prompt impact without further legislation."

Table 1 provides evidence that closing schools were smaller and weaker along a number of dimensions. Closing schools had a lower percentage of students passing state licensing exams. They also had lower ratings from the AMA – 73% received a "B" or "C" rating, while only 21% of schools remaining open received a "B" or "C" rating. Finally, fewer closing schools had university affiliations.

Closures impacted both the number of medical school graduates and the number of physicians per capita. Panel (b) of Figure 1 shows the flow of new medical school graduates over time. The number peaked around 1904, immediately prior to the Flexner era, and declined through World War I. The number of students began to increase again after 1919. Panel (a) of Appendix Figure A.1 plots the number of physicians and physicians per capita. Even before the Flexner report, the number of physicians was rising much more slowly than population, leading to a decline in physicians per capita. The decline in physicians per capita was particularly steep between 1910 and 1920 and continued from 1920 to 1930.[9][10] The geographic distribution of physicians per capita over time is shown in Appendix Figure A.4.

2.1.3 Physicians Services

In the early twentieth century many people could not afford doctors, so as the number of doctors per capita fell, those on the margin may have moved from seeing a doctor to not seeing a doctor. A Bureau of Labor Statistics study of the cost of living during 1918-1919 found that low income families had limited access to doctors (Bureau of Labor

[9]The Flexner report's impacts on the training of Black and Female physicians are the subject of specific subliteratures (Savitt, 2006; Miller and Weiss, 2012; Bailey, 2017; Moehling, Niemesh and Thomasson, 2019). The share of Black physicians rose between 1900 and 1930 from 1.25% to 2.5%, while the share of female physicians increased slightly from 5.35% to 5.55%. In both cases, their shares were dramatically below their share of the overall population. We explore the empirical effects on Black and female physicians in the results section.

[10]Data on physician incomes are only available at very end of our sample period. In 1929, non-salaried physicians, lawyers, and dentists had similar mean and median incomes, but physician incomes grew more rapidly over time (Weinfeld, 1951). (Two-thirds or more of individuals in these professions were non-salaried.) Between 1929 and 1949, physicians' average incomes grew 125%, while lawyers' incomes grew 50% and dentists' incomes grew 67%. One reason for this differential growth may be reductions in medical school graduates during Flexner Era reforms.

Statistics, 1924). A second large study in the 1920s found similar results (Community Health Service, 1932).

While it is impossible to directly evaluate physician quality in historical settings, contemporary evidence on quality in low-income countries suggests that low quality doctors can and do harm patients (Banerjee, Deaton and Duflo, 2004; Das, Hammer and Leonard, 2008; Das et al., 2012; Das and Hammer, 2014; Mohanan et al., 2015; Das et al., 2016). Doctor quality can be measured in a number of ways including by vignettes, through observation, or using standardized patients ("mystery shoppers" who present with a standardized pre-specified set of supposed symptoms). Das and Hammer (2014) survey studies that measure doctor quality in a range of settings including in Dehli, Tanzania, Senegal and Ghana. In Delhi, "a provider had to have above average competence to have a 50% chance of not harming their patients. Even among the top 20% of providers, the likelihood of harming the patient was more than 50% for viral diarrhea, 25% for preeclampsia (a potentially life-threatening condition of hypertension in pregnancy), and 7% for tuberculosis (Das and Hammer, 2014, p. 536)." Similar patterns are observed in other countries (Das, Hammer and Leonard, 2008; Das and Hammer, 2014).

Similarly, in our setting seeing a low quality doctor may have also translated into a higher risk of mortality. For example, low quality physicians may have spread disease, offered incorrect diagnoses, performed incorrect procedures, or offered advice that did not help or even harmed patients. Conversely, higher quality doctors may have been less likely to spread disease from patient to patient by practicing good hygiene, more likely to make a correct diagnosis, more likely to perform appropriate procedures, more likely to do procedures under hygienic conditions, and more likely to offer healthful advice. Having higher quality doctors may have had have spillover effects beyond the patients seen as well. Their advice may be repeated to family, friends, or others (Finkelstein et al., 2022).

2.2 Nurses and Midwives

The numbers of nurses per capita rose rapidly in the United States after 1900, while the numbers of midwives fell. Appendix Figure A.1 Panels (b) and (c) plot the number of nurses and midwives and the number per capita. The number of nurses per capita was substantial in 1900, about half of the number of physicians per capita, and rose rapidly over time, surpassing the number physicians per capita by 1920. In contrast, the number of midwives per capita was small in 1900 – about 5% of the number of physicians per capita – and fell over time.

Hospitals found it advantageous to establish nursing schools because nursing students offered cheap labor (Dingwall, Rafferty and Webster, 2002; D'Antonio and Whelan, 2009; Egenes, 2017; Anderson et al., 2020). The number of classes offered to nurses was typically small, however, with most of the education coming from on-the-job experience. Once trained, nurses delivered health care in a wide range of settings, including homes (as private and visiting nurses), hospitals, physician offices, clinics, and settlement houses.

Midwives were trained either on the job (assisting more experienced midwife) or in specialty schools of midwifery (Rooks and Mahan, 1997). A number of schools opened in large cities during the nineteenth century. Midwives often attended the births of lower-income and immigrant women and were themselves often Black or foreign-born. By 1900, midwives were being supplanted by doctors – roughly half of births were attended by doctors (Rushing, 1994).

2.3 Mortality

Mortality declined rapidly during the first half of the twentieth century in the United States. Appendix Figure A.1 Panel (d) plots national trends in total and infant mortality. Evidence from selected cities for the nineteenth century suggests that the decline began

some time in the late 1800s (Beach, Clay and Saavedra, 2022; Anderson et al., 2022). The declines have been attributed to a range of factors, including improvements in nutrition, access to clean water and sewerage, regulation and licensing of health care professionals, and the development of vaccines and life saving drugs.[11]

An important open question is if physicians, nurses, or midwives contributed to improvements in health in the nineteenth and early twentieth centuries in the U.S. As part of their study of historical licensing of a number of occupations, Law and Kim (2005) find that between 1880 and 1930 increases in a composite index of state licensing strictness for physicians are associated with fewer physicians per capita in the state and lower infant mortality rates.[12] The literature on community and visiting nurses suggests that they improved infant and child mortality (Hamilton, 1988; Miller, 2008; Moehling and Thomasson, 2014). Anderson et al. (2020) find that midwife licensing reduced maternal mortality and may have reduced infant mortality.[13]

3 Data

3.1 Medical school data

We use data on medical schools from the 1918 American Medical Association report entitled *Medical Colleges of the United States and of Foreign Countries* (American Medical Association, 1918). This report contains a brief "biography" of every medical school that operated in the United States prior to 1918 and generally provides information about the years that schools opened, graduated their first class, closed (if applicable), and merged

[11]On nutrition, see Fogel (1986). On water and sewerage, see Alsan and Goldin (2019); Cutler and Miller (2005); Anderson, Charles and Rees (2020). On midwife licensing see Anderson et al. (2020). On vaccines and drugs, see Mokyr (1993); Jayachandran, Lleras-Muney and Smith (2010).

[12]The index sums seven criteria: initial law, state board, licensing exam, college requirement, four year requirement, internship requirement, and science requirement. There are 65 state-year observations for infant mortality and 111 state-year observations for overall mortality.

[13]Only seven states adopted midwife licensing laws between 1905 and 1915: New York (1907), Texas (1907), Utah (1907), Wisconsin (1909), Maryland (1910), Pennsylvania (1913), and Colorado (1915). Of these, Texas and Utah were not in the national death registration area before the passage of the law.

with or were absorbed by other schools (if applicable). Appendix Table B.1 shows a list of the 79 schools that were closed, absorbed, or merged during the Flexner Era.[14] We combine these data with information on the number of graduates from each medical school from annual AMA reports (JAMA, 1901-1921).

We treat medical schools that were absorbed by others as having closed, and schools that received the absorbed school's students as the same entity over time. Event study estimates indicate that recipient institutions experience an immediate increase of about 30 graduates, but return to their pre-absorption/merger level of graduates within 5-6 years. Specifically, we regress the number of graduates in the recipient institutions on a set of event-time indicators based on the year of absorption/merger, calendar year fixed effects, and school fixed effects. Appendix Figure A.2 shows these results.

Using information on medical schools that closed and the number of graduates in all medical schools prior to the Flexner Era (1901-1904), we define our annual county-level measure of school closure intensity (SCI) as follows:

$$\text{SCI}\left\{{j \atop i}\right\}_{ct} = \frac{100 * \sum_{m_{ct}} \text{Graduates}_{m_{ct}}^{1901-1904}}{\sum_{k} \text{Graduates}_{k}^{1901-1904}} \tag{1}$$

In equation (1), c indexes counties and t indexes years. $\text{SCI}\left\{{j \atop i}\right\}_{ct}$ is the school closure intensity measure within i to j miles of county c in year t. m_{ct} indexes medical schools within i to j miles of county c's centroid that had *closed* by year t. k indexes all medical schools in the United States. Thus, $\text{Graduates}_{m_{ct}}^{1901-1904}$ is the number of graduates between 1901 and 1904 from medical schools that would close within i to j miles of county c's centroid by year t. $\text{Graduates}_{k}^{1901-1904}$ is the number of physicians graduating between 1901 and 1904 from *all* medical schools in the United States. $\text{SCI}\left\{{j \atop i}\right\}_{ct}$ is bounded between 0 and 100. $\text{SCI}\left\{{j \atop i}\right\}_{ct}$ is 0 for all counties in 1900-1904 because we only consider

[14] A medical school is absorbed by another school if all students in that school are transferred to the absorbing institution and the absorbed school no longer exists. This occurred frequently during the Flexner Era, with higher-quality institutions absorbing lower quality ones. Medical schools merged when two or more medical schools came together to form a school with a new name.

school closures between 1905 and 1915. SCI $\left\{ {j \atop i} \right\}_{ct}$ reaches its maximum value in 1915 and remains at this value for the remainder of the study period. This school closure intensity measure captures the impact of medical school closures on new physician flows over time and across counties at varying distances from closures.

Based on two pieces of empirical evidence, we define our baseline school closure intensity measure within 0 to 300 miles of a county's centroid. The first is linked data on where physicians settled after medical school, suggesting that most physicians lived within 300 miles of the school they attended (the next subsection provides more detail). The other is our results showing that the effects of school closures are concentrated within 300 miles (see Section 5.1 and Figure 5).

The average county had an maximum SCI $\left\{ {300 \atop 0} \right\}_{ct}$ of 5.7, indicating that school closures within 300 miles of a county accounted for, on average, about 5.7% of all medical school graduates in the United States. Table A.1 provides summary statistics for SCI in different distance bins that we use in our empirical analysis for years 1900, 1910, 1920, and 1930.

Cook County in Illinois and Los Angeles County in California provide useful illustrations for our SCI measure. Cook County, which includes Chicago, had 27 medical schools close within 300 miles between 1905 and 1915.[15] The total number of graduates (between 1901-1904) from these schools was 3,423, while the number of graduates from all schools in the country was 22,083. Thus, by 1915, SCI within 300 miles of Cook County was 15.50 (100*3,423/22,083). By contrast, Los Angeles County had just one medical school close within 300 miles. The school, which was in Los Angeles, closed in 1909 and graduated 84 students between 1901 and 1904. Thus, SCI within 300 miles of Los Angeles County is 0.38 (100*84/22,083).

Figure 3 shows a heat-map of SCI $\left\{ {300 \atop 0} \right\}_{ct}$ for all counties in the United States in 1905,

[15] These closures included seven medical schools in Chicago, four in Louisville (KY), three in Indianapolis (IN), two in Cincinatti (OH), two in Columbus (OH), two in Detroit (MI), two in St. Louis (MO), one in Fort Wayne (IN), one in Grand Rapids (MI), one in Keokuk (IA), one in Milwaukee (WI), and one in Toledo (OH).

1910, and 1915. The Midwest had the highest SCI values and, therefore, we expect those counties to be most strongly affected by school closures. Some Mid-Atlantic and Southern states also have high SCI values.

3.2 Census Data

Full Count Samples

We use the full count Census of Population data for 1900, 1910, 1920, and 1930 to create county-decennial year counts of physicians, nurses, and midwives (Ruggles et al., 2021). Because many county boundaries changed between 1900 and 1930, we harmonize all of our data to 2010 county boundaries using crosswalks provided by Ferrara et al. (2022).[16]

Appendix Table A.1 provides summary statistics on physicians, nurses, and midwives per capita. Young physicians (under age 40) per capita fell substantially over time, while old physicians (age 40 and above) per capita increased slightly over time. The vast majority of physicians were native born White physicians, followed by foreign born physicians, female physicians, and Black physicians.[17] The number of nurses per capita increased steadily over time. The number of midwives per capita was initially low and fell over time.

Linked Samples

We use linked population census samples come from the Multigenerational Longitudinal Panel (MLP), which is available through IPUMS (Ruggles et al., 2021; Helgertz et al., 2023). This project links individual records between decennial censuses using a probabilistic method of record linking and provides links between consecutive decennial

[16]To harmonize boundaries, we use their population based (M2) measure, which accounts for heterogeneity in urbanization across boundary changes.

[17]The composition of foreign-born physicians from sending countries in the 1900 census is: 32% Canada, 21% Germany, 11% England, 7% Ireland, 4% Russia, 3% Scotland, and 3% or less from all other countries.

censuses (e.g. between 1900 and 1910).[18]

We use the MLP to investigate where physicians attended medical school.[19] Figure 4 Panels (a) and (b) show the distributions of the distances between where physicians trained and where they lived 10 years later. 58% of physicians lived in the county where they trained and so traveled 0 miles. The average location (roughly the 75th percentile) was about 100 miles from the county of training. Over 90% of physicians lived within 300 miles of the county in which they trained, and 95% lived within 500 miles. We also use the MLP to explore patterns of physician migration, changes in occupation, and retirement later in the paper.

3.3 Mortality Data

Our mortality data draws on newly digitized data for 1900-1914 from the *Mortality Statistics of the United States* and previously digitized data for 1915-1930 from the *Mortality Statistics of the United States* (Bailey et al., 2018). [20] From 1900-1915, the number of deaths were reported separately in registration cities and rural parts of counties in the registration areas. To construct county-level death counts for every county in the death registration area, we add deaths from the rural parts of counties to deaths in all cities in those counties. Similar to the construction of other variables, we harmonize county boundaries to 2010 definitions. In our analysis we use infant mortality rates and total mortality rates computed per 1,000 people.[21] We only include counties in the sample if

[18]See Helgertz et al. (2023) for more details on the exact record linking method.

[19]We define an individual as likely to have been in medical school in year t-10 if they (1) were over the age of 16, (2) reported attending school and were living in a county that contained a medical school, and (3) reported their occupation as a physician in year t. For example, in the 1900-1910 linked sample, we locate all individuals that were physicians in 1910. We then see if they were over the age of 16, reported attending school, and lived in a county with a medical school in 1900. We then calculate the distance between the centroid of the county where the physician trained during year t-10 (e.g. 1900) and the centroid of the county where the physician was living in t (e.g. 1910).

[20]Infant mortality data were not published for 1911-1914. All cause mortality and mortality by cause are both available during this time frame.

[21]Rates are computed per 1,000 in population to ensure comparability and to avoid known issues with birth registration (Eriksson, Niemesh and Thomasson, 2018).

they enter the death registration area by 1910.[22] Appendix Figure A.3 shows a map of the death registration area in 1910, and Appendix Table A.1 provides summary statistics for our sample for infant and total mortality rates.

4 Empirical Strategy

We first estimate the relationship between physicians per capita and school closure intensity (SCI) using a difference-in-differences framework with a range of distance bins, allowing us to examine the effect of school closures in relatively narrow geographic windows. Specifically, we estimate:

$$y_{ct} = \beta_1 \cdot \text{SCI}\left\{{50 \atop 0}\right\}_{ct} + \beta_2 \cdot \text{SCI}\left\{{100 \atop 51}\right\}_{ct} + \beta_3 \cdot \text{SCI}\left\{{200 \atop 101}\right\}_{ct} + \beta_4 \cdot \text{SCI}\left\{{300 \atop 201}\right\}_{ct} + \beta_5 \cdot \text{SCI}\left\{{500 \atop 301}\right\}_{ct} + \theta_c + \chi_t + Z'_{ct} * \delta + \epsilon_{ct} \tag{2}$$

In Equation (2), y_{ct} is physicians, nurses, midwives, or mortality per capita in county c in year t. $\text{SCI}\left\{{j \atop i}\right\}_{ct}$ is our school closure intensity measure, as defined in equation (1), for schools that closed within i to j miles of county c. $\text{SCI}\left\{{500 \atop 301}\right\}_{ct}$ is school closure intensity between 301 and 500 miles of county c, which we include because closures further away could also potentially affect county c. We do not control for closures further than 500 miles away because, as Section 3 explains, nearly all physicians resided within a 500 mile radius of the county in which they attended medical school. We control for county fixed effects (θ_c), year fixed effects (χ_t), and county characteristics (Z'_{ct}) including percent Black, percent urban, and manufacturing establishments per capita. We cluster our standard errors at the county-level, and to address potential correlation among nearby counties, we also compute spatial standard errors (Conley, 1999) in some specifications.

We estimate equation (2) using Poisson Pseudo Maximum Likelihood (PPML) be-

[22] We use all available data prior to 1910.

cause some of our dependent variables have a substantial number of zeros (Chen and Roth, 2023; Bellégo, Benatia and Pape, 2022). PPML provides a more natural way to include zeros than methods requiring transformations of the dependent variable, such as the inverse hyperbolic sine, because it does not depend on choice of measurement unit.[23] PPML can, however, also yield biased estimates in some settings (Bellégo, Benatia and Pape, 2022). In robustness checks, we examine alternate specifications that use: log(y), log(y+1), and inverse hyperbolic sine. If we drop zeros, the magnitudes for PPML generally fall between log(y) and log(y+1).

The results from Equation (2), which we present in the results section, lead us to conclude that most of the effects of medical school closures are concentrated within 300 miles. We therefore adopt a more parsimonious difference-in-differences framework for our subsequent analyses:

$$y_{ct} = \beta_1 \cdot \text{SCI} \left\{ {}^{300}_{0} \right\}_{ct} + \beta_2 \cdot \text{SCI} \left\{ {}^{500}_{301} \right\}_{ct} + \theta_c + \chi_t + Z'_{ct} * \delta + \epsilon_{ct} \tag{3}$$

Equation (3) is similar to Equation (2), but our school closure intensity measure now captures closures within 300 miles (rather than finer distance bins). We again cluster standard errors at the county-level and estimate the parameters in Equation (3) using PPML.

The estimates of the βs in Equations (3) and (2) reflect the effect of medical school closures provided there are no other shocks correlated with proximity to school closures and also with closure timing that are not due to the closures themselves. This implies that treatment and control counties would have had parallel trends in outcomes in the absence of medical school closures. Although we cannot easily test this assumption, the large number of never-treated units in our setting suggests that parameters can be

[23] As discussed by Chen and Roth (2023), the results of the common transformations, such as the inverse hyperbolic sine and other log-like transformations, are highly sensitive to the units of the outcome.

identified (Marcus and Sant'Anna, 2021).[24]

Nonetheless, we conduct a variety of additional analyses to explore these issues. We drop any county that had a medical school closure, and we drop any county that had a medical school closure within 50 miles. Our preferred specification omits any county that had a medical school closure itself, partly addressing concerns about the potential endogeneity of school closures, but also retaining variation in treatment intensity among counties located close to closures. We also test for the expected distance gradient of school closure effects using finer bins of distance to closures (as shown in Equation (2)), use other occupations as 'placebo' outcomes, and assess sensitivity to controlling for census region-year and census division-year fixed effects, which could have influenced both medical school closures and changes in physicians nearby.[25]

Finally, given staggered medical school closures over time, to address any potential bias that might result from treatment effects that are not constant over time and across groups, we also use the estimator proposed by Callaway and Sant'Anna (2021). This estimator is robust to treatment effect heterogeneity if the treatment is binary. We therefore classify counties based on whether they are in the Xth percentile, or above for SCI $\left\{{}^{300}_{0}\right\}_{ct}$ (i.e. treatment = 1) or if they are below the Xth percentile (i.e. treatment = 0). We conduct this analysis for the median (50th percentile) and the mean ($\sim$ 60th percentile).

[24]Data limitations preclude direct analysis of parallel trends. Many counties do not have data for 1870 and 1880, and there is no population census microdata for 1890. The mortality data has related issues, because many counties in the registration area in 1910 have a small number of pre-1910 observations. Additionally, a continuous treatment variable that changes over time does not permit a traditional event study analysis. One thing to note is that in this context, we have a large never treated group of counties – 315 out of 2,982 counties ($\tilde{1}1\%$). When the number of never treated units is "reasonably large", comparisons are between untreated and treated units rather than between early and later treated units. In this setting it is possible to identify policy-relevant parameters even "if researchers are not comfortable with a priori ruling out nonparallel pretrends" (Marcus and Sant'Anna, 2021, p. 251).

[25]There are 4 census regions: Northeast, Midwest, South, and West. There are 9 census divisions: New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain and Pacific.

5 Results

5.1 Effects of Closures on Physicians, Nurses, and Midwives

The effect of medical school closures on physicians per capita at varying distances from a closure is not *a priori* obvious. We therefore begin our analysis by estimating the effects of closures on counties at different distances using Equation (2). Figure 5 plots the resulting SCI estimates for closures within 0-50, 50-100, 100-200, 200-300, and 300-500 miles.

In general, the effects of medical school closures are negative, significant, and concentrated within 300 miles for all physicians, young physicians, and old physicians. Interestingly, the exception is counties 0-50 miles from closures, in which these effects are insignificant (and less precise given that the number of counties generally rises with distance from closures), possibly because market adjustments focused most on them. We do not observe reductions in physicians per capita beyond 300 miles, leading us to adopt Equation (3), which examines the effects SCI 0-300 miles, as our main specification.

Consistent with Figure 5, Table 2 also shows that physicians per capita declined in counties close to closures.[26] These estimates from Equation (3) are similar across the three different samples as well: all counties (column 1), all counties except counties with closures (column 2), and all counties except counties within 50 miles of closures (column 3). Our preferred specification is column 2 because excluding counties with closures helps to ensure that our results are not driven by some unobserved factor leading both to medical school closures and to changes in the number of physicians.

Panel A of Table 2 indicates that physicians per capita declined by 4% on average in counties at mean SCI within 300 miles of a closure.[27] Panels B and C highlight that these

[26]The number of observations in Table 2 is slightly different between panels because some counties always have zero for the dependent variable in Panels B, C, D, and E.

[27]Throughout the results section we interpret coefficients from column 2 evaluated at average SCI values in 1920, which accounts for all school closures. For example, average SCI in 1920 is 5.74, implying a 4% decrease in physicians after all closures occurred (5.74$*$-0.007).

reductions were concentrated among young physicians (age 40 and younger), whose training opportunities were directly influenced by school closures. For counties at mean SCI, young physicians per capita declined by 9% on average.[28] Panel C also shows that in counties at mean SCI, older physicians (older than age 40) per capita declined by 4%.[29] Appendix Table A.5 indicates that closures of *all* medical schools had little effect on the geographic distribution of Black, female, and foreign-born physicians.[30]

Although nurses and midwives were not trained by medical schools, medical school closures may have nonetheless indirectly affected them if they were substitutes or complements with physicians. Table 2 Panel D shows that medical school closures increased nurses per capita by 6% on average, suggesting that they functioned as substitutes for physicians.[31] Appendix Figure A.6 plots the resulting SCI estimates for closures within 0-50, 50-100, 100-200, 200-300, and 300-500 miles. Table 2 Panel E shows that medical school closures did not have a statistically significant effect on midwives per capita

Table 3 highlights that the effects of closures on physicians and nurses per capita grew over time. Interacting decennial census year dummies with our SCI measure and omitting 1900 as the reference group, we find that reductions among physicians per capita within 300 miles of a closure are evident as early as 1910, declining by about 2%. By 1920, physicians per capita had fallen by 4% on average, growing to 5% by 1930.[32] These reductions explain about 16% of the overall decline between 1900 and 1920 and 12% of the overall decline between 1900 and 1930.[33] For nurses, the effect of closures was

[28] 5.74∗-0.016=0.092

[29] 5.74∗-0.007=0.040

[30] The effects of the closures of all schools may have been small both because of the small numbers of physicians in these groups and because most Black and female physicians were trained in a small subset of these schools. The numbers of Black, female, and foreign-born physicians per capita were small in 1900 (0.01, 0.05, and 0.12, respectively) relative to all physicians (1.39). By 1930, these numbers were still low in both absolute and relative terms (0.02, 0.03, and 0.06 relative to 0.95 for all physicians).

[31] 5.74∗0.011=0.063

[32] The average SCI in 1910 is 3 and is 5.74 in 1920 and 1930, implying a 2% decline in all physicians in 1910 (3∗-0.0062), 4% (5.74∗-0.007) in 1920, and a 5% (5.74∗-0.0087) decline in 1930.

[33] The overall decline between 1900 and 1920 is 24% and is given by the 1920 fixed effect reported in Table 3. Thus, the school closure share of the overall decline is 16% (0.04/0.244). The overall decline between 1900 and 1930 is 40% given by the 1930 fixed effect in Table 3. Thus, the school closure share of the overall decline is 12% (0.05/0.403)

significant and negative in 1910. By 1920, however, the effect had turned positive and significant and had grown by 1930. In contrast, the effect on midwives is not significant in 1910 and 1920 and is negative and significant in 1930.

In sum, Flexner Era medical school closures had larger effects on counties near closures, but the differential effects on these counties were modest when compared to the background decline in physicians per capita throughout the early twentieth century. The effects of medical school closures spilled over to nurses, who appear to function as substitutes for physicians, despite the fact that nurses were not trained by medical schools.

5.2 Physician Market Adjustment

In this section we examine a number of potential margins along which physician markets may have adjusted after school closures: (i) expansion of existing medical schools or opening of new schools, (ii) changes in migration of existing physicians, and (iii) changes in the retirement decisions of older physicians.

Table 4 shows little evidence of county-level changes in medical school enrollment in response to Flexner-Era medical school closures. We first use county enrollment in medical schools that remained open from 1901 to 1930 as the dependent variable and re-estimate Equation (3). Panel A shows results for counties that had at least one school remain open throughout this period.[34] Panel B of Table 4 shows these results for enrollment in all medical schools that remained open between 1901 and 1930 *plus* enrollment in medical schools that opened after 1901 and remained open through 1930. In both panels, changes in SCI did not lead to statistically significant changes in the number of students. The unresponsiveness of medical school enrollment to closures may have been due to the growing cost of running a medical school given that AMA ratings scored

[34]Fourteen schools opened after 1901 and remained opened through 1930.These schools were located in Atlanta (GA), Cambridge (MA), Chicago (IL), Cincinnati (OH), Columbus (OH), Indianapolis (IN), Kansas City (KS), Kansas City (MO), Los Angeles (CA), Milwaukee (WI), Madison (WI), Norman (OK), Philadelphia (PA), and St. Louis (MO). On average, these schools had 187 students, which is between the average for schools that closed (140 students) and schools that remained open (250 student; see Table 1).

schools based on the quality of their buildings, laboratories, hospitals, libraries, and whether faculty were full time (Barzansky, 2010). The pool of possible students had also shrunk, given that ratings also depended on the number of students with one or two years of undergraduate education.

Next, we estimate a simple discrete choice model of physician location following the two-step approach used in Timmins (2007) and Sinha, Caulkins and Cropper (2018).[35] The sample is the linked population census data for individuals who reported their occupation as physicians in 1910 and 1920. The first part of Table 5 documents that moving is costly for physicians, and is more costly as distance increases. The estimates for distance bins are all negative and significant, and they increase significantly with distance, indicating that moving longer distances is more costly.

The second part of the model shows that counties with greater school closure intensity within 300 miles (SCI 0-300) were more attractive destinations for physicians, all else equal. The estimates for SCI 0-300 miles are positive and significant for all physicians, old physicians, and young physicians. It is intuitive that reductions in physicians per capita due to medical school closures created new opportunities for other physicians to move to these counties, but the estimates in Table 2 are nonetheless still negative, suggesting that physician migration did not fully offset the effect of closures.

Finally, Table 6 reports that medical school closures led to reductions in exit from medicine, primarily due to reductions in retirement. The analysis draws on linked population census samples of physicians and is estimated using Equation (3). In Panel A, the sample is individuals who reported being physicians in 1910 who are observed again in 1920. While many still report being physicians, some physician change careers or retire. The dependent variables are dummy variables for whether the person has exited being a physician (=1) or not (=0); has changed occupation (=1) or not (=0); or has retired (=1) or not (=0). Panel B reports parallel results using both the 1900-1910 and 1910-1920 linked

[35] Appendix C presents the details of this model.

samples. The first column of both Panels A and B shows that at average SCI, increases in SCI within 300 miles of a county reduced the probability that physicians exited medicine by 0.6-1.2 percentage points, a relative reduction of 4-8%.[36] Columns 2 and 3 indicate that this decline in physician exit was primarily due to reductions in retirement (rather than changes in occupation). A physician living in a county with mean SCI was 0.6-1.2 percentage points less likely to retire over the next decade, a relative decline of 12 to 24%.[37]

Overall, market adjustment in response to medical school closures appears to have played an important role in determining the ultimate impact of closures. Although school closures do not appear to have substantially influenced medical school enrollment over time, physician migration to more affected counties and reductions in exit from medicine due to postponed retirement offset some of the effect of medical school closures.

5.3 Effects of Closures on Physicians and Nurses in the Death Registration Area

We can only observe the effects of closures on mortality in a subset of the United States, the Death Registration Area (DRA).[38] In 1900, ten states and the District of Columbia were part of the DRA. Mortality data for these areas were collected, analyzed, and published. The DRA expanded over time as more states joined the DRA. In our main analysis, we restrict attention to counties that were in the DRA by 1910 when the Flexner

[36] 5.74$*$-0.001=0.006 and 5.74$*$-0.002=0.012. The average probability of exit from medicine over our study period is 16 percentage points. Thus, 0.006/.16 = 0.04 or a 4% change and 0.012/0.16=.08 or a 8% change.

[37] 5.74$*$-0.001=0.006 and 5.74$*$-0.002=0.012. The average probability of retirement over our study period is 5 percentage points. Thus, 0.006/0.05=0.12 or 12% and 0.012/0.05=0.24 or 24%.

[38] What is the Death Registration Area? In the second half of nineteenth century, there was growing interest in using mortality statistics to understand public health. The Census Bureau requested that interested states adopt a standard death certificate by January 1, 1900.

Report was released.[39] Figure A.3 shows the states that were in the DRA in 1910.

In 1910 the DRA contained roughly half of the United States population and half of all doctors and nurses. Table A.2 shows summary statistics for counties included and excluded from the DRA. Compared to counties outside the DRA, counties in the DRA had: slightly lower SCI in 1915 (5.45 vs 5.86); slightly more physicians per capita (1.39 vs 1.28); more old physicians per capita (0.75 vs 0.63); and more nurses per capita (1.59 vs 0.94). Counties in the DRA also had: higher populations (49,578 vs 21,601); a lower share of African American residents (0.01 vs 0.18); a higher share of urban residents (0.27 vs 0.12); and more manufacturing establishments per capita (4.72 vs 2.77).

An important question is if the effects of medical school closures on physicians and nurses in counties in the DRA are the same as for counties outside the DRA. To examine this, we re-estimate a fully-interacted version of Equation (3) using interactions with a dummy variable for DRA membership.

Table 7 shows that the overall effect of closures on physicians per capita (Panel A) was similar across the two groups of counties. As before, the effects are similar across columns 1-3. In the DRA, physicians per capita declined by 4% on average in counties at mean SCI.[40] Estimates for young and old physicians in Panels B and C, however, differ across the two groups of counties. In the DRA, there was no effect on young physicians and a large negative effect on old physicians.[41] Outside the DRA, there was a large negative effect on young physicians and a more modest negative effect on old physicians. The differences in effects on nurses in Panel D are not statistically significant, but are large, suggesting that the spillover to nurses was larger in the DRA. The differences in the effects on old and young physicians across the two groups of counties may reflect the

[39] Restricting attention to counties that enter in 1900 provides more temporal variation at the cost of a smaller sample size. Temporal variation in SCI ends in 1915, so adding counties that entered the DRA in 1915 or later does not contribute to identification. Focusing on counties that entered by 1910 balances sample size and temporal variation.

[40] Average SCI in the DRA 1920 is 5.45, implying a 4% decrease in physicians after all closures occurred (5.45$*$-0.007).

[41] The effects by distance bins estimated for the DRA sample only are shown in Appendix Figure A.7.

fact that the registration area was a more urban and manufacturing intensive part of the country. Thus, there may have been a stronger incentive for young physicians to migrate for positions that might previously have been filled by graduates of closing schools, and also a stronger reputational penalty for older physicians who graduated from closing schools.

The results for the DRA imply that counties in the DRA with higher SCI may have experienced more rapid improvement in physician quality than counties with lower SCI for two reasons. First, counties in the DRA with higher SCI had substantial declines in older physicians. Older physicians were likely to have been of lower quality on average simply because their training had occurred longer ago. In a study of New York state, Andrews (2021) found differential retirement of low-quality older physicians following the Flexner Report. Reductions in the numbers of older physicians were thus likely to increase average physician quality.[42] Second, while school closure did not change the number of young physicians, their average quality likely increased in locations with higher SCI (because prior to school closures, areas that would have high SCI presumably had relatively low quality young physicians). Thus, closures should increase the average quality of young physicians as well.[43]

The effects of closures on mortality will depend on the relative importance of physician quantity, physician quality, and nurse quantity. Physician quality in counties with high SCI likely increased relative to counties with low SCI, but physician quantity decreased. Nurse quantity increased in counties with high SCI. While our discussion below will focus on physicians, it is important to note that the effects of school closures on mortality may reflect changes in the quantity and quality of doctors and the quantity of nurses. We do not use school closures to instrument for physicians per capita to study

[42]Later in the sample period, young physicians impacted by closures were now older physicians. Thus older physicians may have been increasing in quality through this channel as well.

[43]It is also possible that the quality of young physicians may have risen differentially near closure if non-closing medical schools closer to closing schools were more focused on improvement than non-closing medical schools further from closing schools.

their effect on mortality for this reason. In fact, the statistically significant effects that we find on nurses per capita constitute a violation of the exclusion restriction assumption required in doing so.

5.4 Effects of Closures on Mortality

Table 8 shows that medical school closures led to declines in infant and total mortality. The table reports estimates from Equation 3 for infant mortality and total mortality. As before, Column 2 is our preferred specification. Panels A and C present results for census years, and so are directly comparable to the results in Table 7. Panels B and D utilize annual variation in SCI and the fact that the mortality data are also available annually.

In a DRA county with the average SCI, infant mortality fell 6-8% and total mortality fell 2-3%.[44] The effects by distance bins are shown in Appendix Figure A.8. The declines in infant mortality and all age mortality were largest within 50 miles of closures, but mortality declines were observed at distances of up to 200 miles.

Appendix Table A.11 shows that these mortality effects grew over time. Notably the effects for infant mortality were substantial in 1910 and 1920, although they would continue to grow between 1920 and 1930. This suggests that the results were not driven by later programs, such as the Sheppard-Towner Act, which was passed in 1921 (Moehling and Thomasson, 2014).

These magnitudes can be compared to other studies of infant mortality during this time period. Anderson et al. (2022) find that municipal water filtration reduced infant mortality by 11-12 percent in 25 cities between 1900 and 1940. Alsan and Goldin (2019) find that the introduction of water and sewerage in the Boston Area between 1880-1920 reduced infant mortality by 23 percent. During a slightly later period, 1933-1939, Jacks, Pendakur and Shigeoka (2021) find that the repeal of Prohibition increased infant

[44] For infant mortality, 0.055 = 0.0101*5.45 and 0.077 = 0.0141*5.45. For total mortality, 0.024 = 0.0044*5.45 and 0.034 = 0.0062*5.45

mortality by 4.0-4.7%.

In Table 9, we also examine the impact of medical school closures on deaths by cause. Three limitations of the analysis in Table 9 are worth noting. First, data on deaths by county by cause are not available after 1915, so these results only captures the early impact of closures. Second, the classification of deaths by cause during this period is limited by the fact that many individuals did not die in hospitals or under doctors care. In these cases, causes of death were assigned after the fact based on descriptions provided by family, friends, or others (Humphreys, 2001). Third, the classification of deaths changed over time due revisions in classification systems and increased specificity of cause of death on death certificates (Van Buren, 1917).

In Table 9, medical school closures reduced infectious disease deaths and deaths in early infancy, had no effect on a range of other types of mortality for which limited types of treatment were available, and were associated with increases in mortality from non-infectious diseases and cancer (likely as a result of competing risks). These effects of medical school closures are consistent with contemporary medical knowledge at the time. Doctors knowledge and skills were more suited to addressing infectious diseases and diseases of early infancy (for which advice about basic hygiene, isolation, rest, hydration, and breastfeeding could make a difference) than to addressing complex chronic diseases such as diabetes or cancer.

A final potential concern is that mortality effects are coming in part through other channels, such as county responses to medical school closures. Table 10 shows that medical school closures are unrelated or negatively related to county health departments, city health-related expenditures, and county hospital infrastructure (Hoehn-Velasco, 2021; Cain and Rotella, 2022).[45] Specifically, Panel A shows that medical school closures did not affect county health departments as measured by total personnel per capita, medical officers per capita, or budgets per capita. Panel B shows that medical school closures

[45]Melissa Thomasson and Peter Nencka graciously shared the county hospital data with us.

did not affect city sewer or refuse expenditures per capita. Medical school closures seem to have *decreased* water expenditures per capita. Importantly, cities did not respond to closures by investing more in water infrastructure per capita. This is consistent with the evidence in Table 9, which showed that medical school closures had no effect on typhoid.[46] Panel C shows that medical school closures did not affect hospital infrastructure as measured by the number of medical institutions per capita, the number of hospitals per capita or the number of hospital beds per capita.

6 Robustness

In this section, we consider the robustness of our results in five ways: (i) using alternative measures for SCI or if we weight by population, (ii) using other occupations that should not reasonably respond to closures as 'placebo' outcomes for physicians, (iii) testing for confounding region-year and division-year effects, (iv) evaluating the consequences of using spatially-clustered standard errors, and (v) evaluating the extent of any bias due to the use of two-way fixed effects estimation with staggered treatment timing.[47] In the interest of parsimony, in this subsection we only report robustness results for physicians and for mortality.[48]

First, Appendix Tables A.4 and A.7 shows that the results are generally similar if we use alternative measures of SCI or if we weight each county-year observation by the population of the county. In Appendix Table A.4 we include closures through 1918; estimate the effects separately for earlier and later closures; estimate the effects using a

[46]Typhoid is often spread through contaminated water, so investments in water infrastructure typically decrease typhoid rates.

[47]Using a difference-in-difference estimation framework with staggered treatment timing, it is also ordinarily customary to assess if treatment timing is correlated with pre-existing differences in outcome trends. However, our case is not easily compatible with an event study framework both because we do not study a single well-defined "event" (multiple school closures affect a given county).

[48]The full set of robustness checks were also run for nurses, midwives, and physicians in the Death Registration Area. The results are similar to the reported results and are available upon request.

polynomial of SCI. The effects are similar to our main results in Tables 2.[49] In Appendix Table A.7 Weighting reduces the magnitude of the effects on all physicians and young physicians somewhat.

Second, we show that the physician estimates in Table 2 and Figure 5 do not simply reflect broader occupational changes correlated with medical school closures. Specifically, we use occupations reported in the population censuses to create five mutually-exclusive occupation categories: physicians, white collar workers outside of medical care, skilled blue collar workers, unskilled workers, and agricultural workers.[50] We also generate a sixth category of all workers outside of medical care. We then re-estimate Equation 2 using these other occupation categories as 'placebo' outcomes. Appendix Figure A.5 shows these results. In contrast to our results for physicians, the estimates for other occupations in Appendix Figure A.5 are generally statistically insignificant (or in a few cases, are positive), suggesting that the effect of medical school closures on physicians does not simply reflect broader occupational changes over time.

Third, we show that secular region-level and division-level changes do not explain the effects of medical school closures on physicians per capita or mortality. Appendix Tables A.8 and A.12 present results from re-estimating Equation 3 controlling for alternative fixed effects, including region-year fixed effects, region-time trends, division-year fixed effects, and division-time trends. These estimates are similar to the results in Tables 2 and 8.

Fourth, we show that our results are robust to using spatially-clustered standard

[49]The sample of Black and Women's medical schools is small, as are the number of Black and female physicians. This is likely contributing to the null effect on female physicians. It is unclear why the effect of closures on Black physicians is positive and significant.

[50]We define white collar workers outside of medical care as having an occupation code of between 0 and 99 according to OCC1950 in IPUMS (Ruggles et al., 2021), but not being a medical worker (i.e. not codes 32 [dentists], 58 [nurses, professional], 59 [nurses, students professional], 70 [optometrists], 71 [osteopaths], 73 [pharmacists], 75 [physicians and surgeons], or 97 [therapists and healers]) Skilled blue collar workers have occupation codes 500-690 [e.g. blacksmits, machinists, brakemen, etc.]. Unskilled workers have occupation codes 700-790 or 910-970 [e.g. bartenders, janitors, laborers, etc.]. Finally, agricultural workers have occupation codes 100 [farmer], 123 [farm manager], and 810-840 [farm laborers].

errors (Conley, 1999).[51] For spatial standard errors, we use a natural log transformation rather than Poisson Pseudo Maximum Likelihood (PPML), because, to our knowledge, spatial standard errors cannot be computed using PPML. Appendix Tables A.9 and A.13 show that these results are similar in sign and statistical significance to those in Tables 2 and 8. Standard errors increase slightly in columns 2-5 as we move from no spatial standard errors to allowing spatial correlation within 100, 150, and 200 kilometers.[52]

Finally, we show that our estimates are robust to correcting for the use of conventional two-way fixed effects estimation (which can be biased if treatment timing is staggered and the treatment effect evolves over time). Because this literature focuses on dichotomous rather than continuous treatments, we first classify counties using dichotomous as above/below the median and the mean ($\sim$ 60th percentile) in the SCI distribution (i.e. SCI $\left\{{}^{300}_{0}\right\}_{ct}$ =1). We then re-estimate Specification 3 using these dichotomous school closure intensity measures. Column 1 of Appendix Table A.10 shows conventional two-way fixed effects estimates for physicians, and column 2 shows estimates Callaway and Sant'Anna (2021). In general, the Callaway and Sant'Anna (2021) estimates are comparable to or slightly larger than the standard two-way fixed effects estimates. This is unsurprising because biases in two-way fixed effects estimates tend to be lower in settings with larger numbers of never-treated units (Marcus and Sant'Anna, 2021). In our sample 315 out of 2,982 counties had no school closures within 300 miles.

Appendix Table A.18 presents the TWFE and Callaway, Goodman-Bacon and Sant'Anna (2024) estimates for mortality. The magnitudes of the coefficients are similar across TWFE, Callaway, Goodman-Bacon and Sant'Anna (2024), and our main mortality estimates in Table 8. For example, our main mortality estimates for infant mortality in column 2, Panel B at the mean are -0.077 (-0.0141 x 5.45), which is similar to -0.089 from column 2 in the TWFE estimates where the break point is the mean. These es-

[51] Our specification parametrically accounts for the fact that counties closer to medical school closures are more 'treated' than counties further away, but the standard errors may not.

[52] We use log(1+y), because it is not feasible, to our knowledge, to compute Conley standard errors using PPML.

timates are slightly smaller than the Callaway, Goodman-Bacon and Sant'Anna (2024) estimate of -0.146. We would expect this estimate to be higher because the comparisons are "cleaner".

In sum, our results for physicians are robust to (i) using other measures of SCI or if we weight by population, (ii) using other occupations that should not reasonably respond to closures as 'placebo' outcomes, (iii) controlling for a variety of secular trends and shocks, (iv) using spatially-clustered standard errors, and (v) using the Callaway and Sant'Anna (2021) estimator.

7 Conclusion

The Flexner Era was one of the most substantial reform periods in the history of American medical education and practice. Between 1905 and 1915, over 40% of medical schools in the United States closed or were absorbed by other institutions. These schools accounted for over 35% of all new medical graduates at the turn of the century. Concerns about low quality medical education and practice motivated these closures, and many scholars have written about their consequences, suggesting that physicians quality might have improved after the closures, but at the cost of fewer physicians. In this paper, we present new quantitative evidence on the impact of Flexner Era medical school closures between 1900 and 1930.

We find that areas close to medical school closures (within 300 miles) were predominantly affected, and that there were also meaningful market adjustments to these closures. On average, school closures within 300 miles of a county reduced the number of young physicians (40 and under) per capita by 9% and physicians of any age by 4%. The effects grew over time. These reductions in physicians occurred despite partial market equilibration, including migration of physicians to affected areas and the postponement of retirement among older physicians. The effects of closures were not confined to physi-

cians. Despite not begin trained in medical schools, school closures within 300 miles of a county increased the number of nurses per capita.

Ultimately, a central concern with these changes in the physician and nurse workforce is how they influenced population health and mortality. On one hand, if lower quality physicians nonetheless provided beneficial medical care, medical school closures could have have increased mortality. On the other hand, if lower quality physicians harmed patients, or if patients previously served by them sought care from higher quality physicians after these closures, mortality could have declined. Empirically, we find that closing lower quality medical schools reduced infant mortality by 6% and reduced total mortality by 3%, suggesting that at least on average, Flexner Era reforms improved population health.

A full evaluation of all social costs and benefits of Flexner Era reforms to medical education are beyond the scope of this paper. For example, it is difficult to estimate the effect of these closures on minority and female physicians because the numbers of minority and female physicians were very small during the early twentieth century. We are also unaware of suitable data on health outcomes by gender and race for most states during this period. It is certainly possible that historical reductions in physician supply may have raised the price of physician care, with uncertain welfare effects.[53] However, our paper suggests that in addition to the substantial social benefits of public policy reforms during the Progressive Era, private reforms produced important social benefits as well.

[53]Evidence on physician fees and incomes is sparse during this period. For a review of some evidence, see Tomes (2001) and Goebel (1996). In the period starting in 1929, when more evidence is available, see (Weinfeld, 1951).

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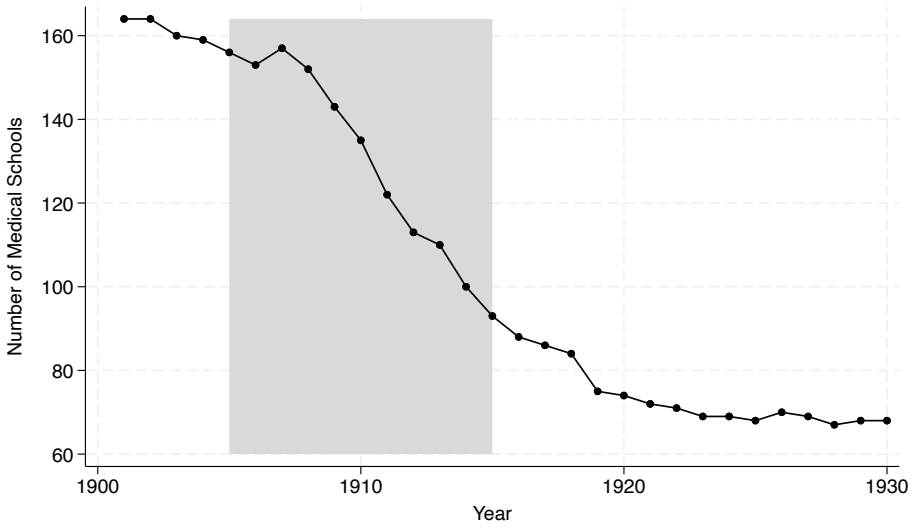
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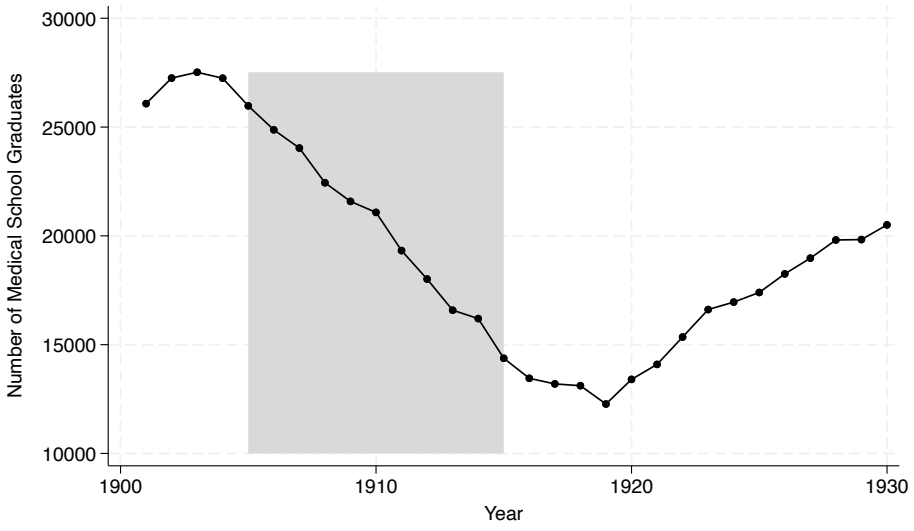
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Figure 1: National trends in medical schools and medical school graduates per 1,000

(a) Number of Medical Schools

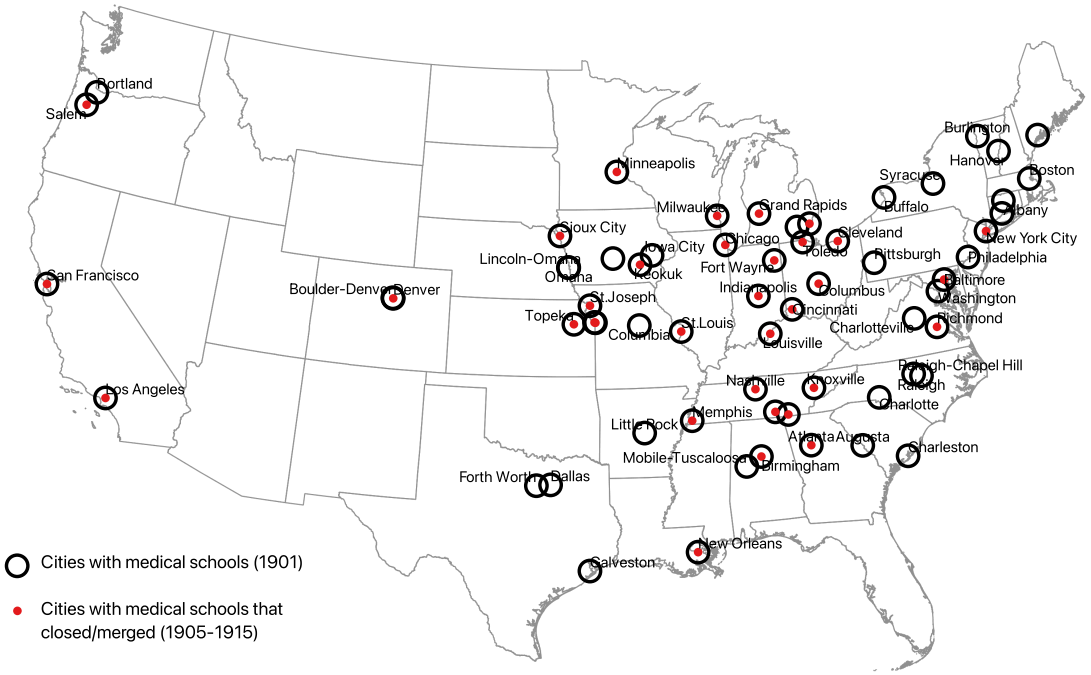


(b) Number of Medical School Students



Notes: These figures show trends in the number of medical schools and medical school graduates per 1,000. The shaded area represents what we define as the "Flexner Era", which ran from 1905-1915.

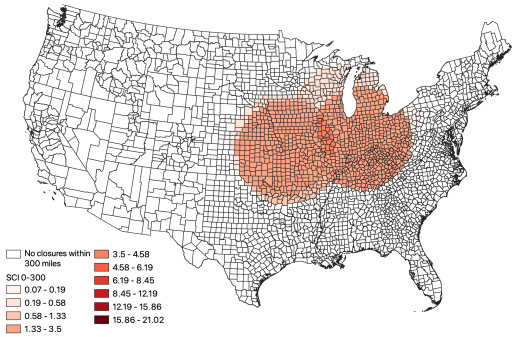
Figure 2: Cities with medical schools and medical school closures



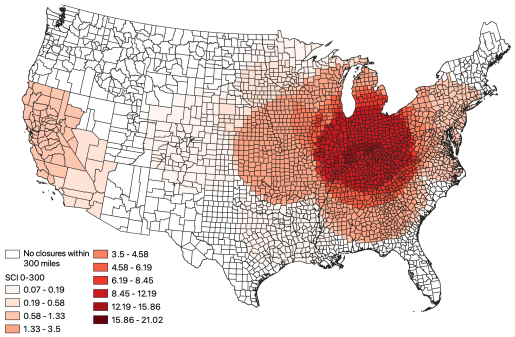
Notes: This figure displays a map of all cities that had a medical school in 1901. The red circles represent cities that had a medical school that closed or merged with another medical school between 1905 and 1915.

Figure 3: School Closure Intensity within 300 miles

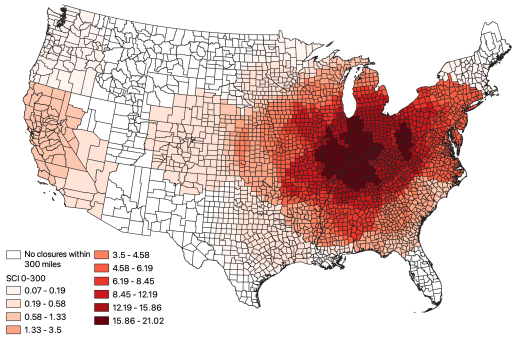
(a) 1905



(b) 1910



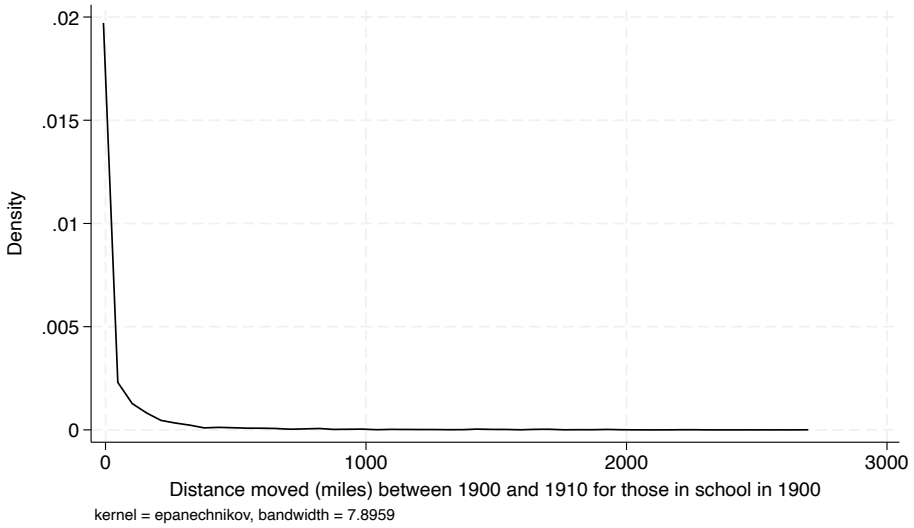
(c) 1915



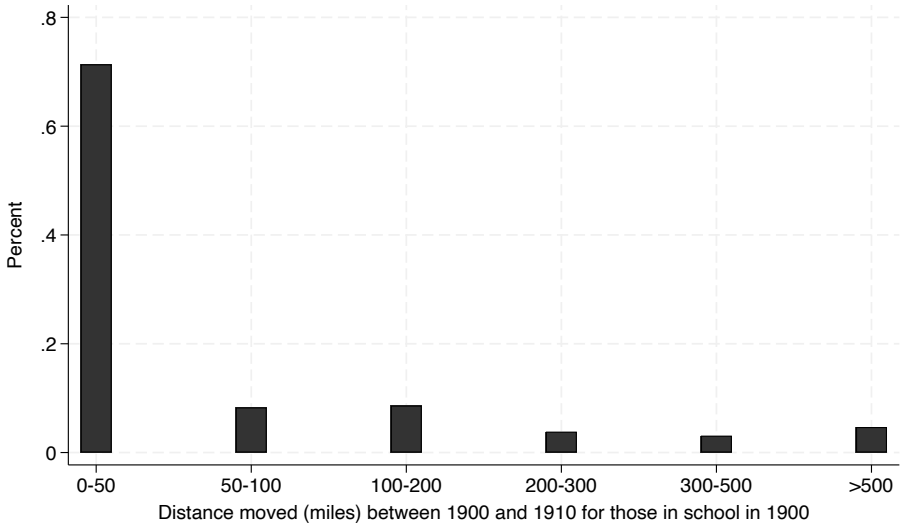
Notes: This map displays our measure of school closure intensity (SCI) within 300 miles of each county, as specified in Equation (1).

Figure 4: Distance Moved Between Medical School and Practice Location 10 Years Later

(a) Kernel Density

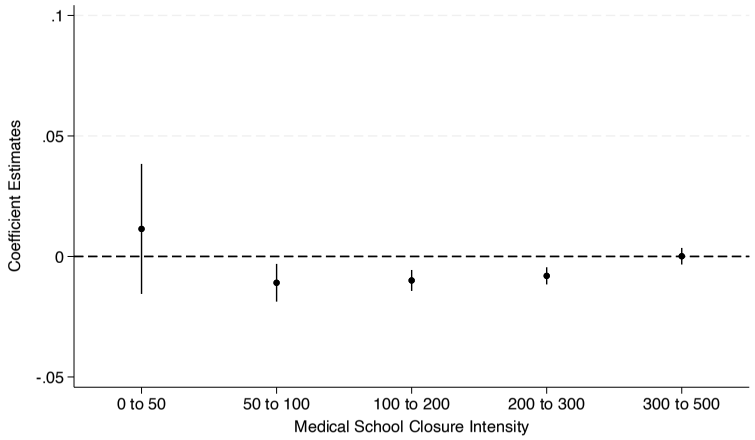


(b) Histogram

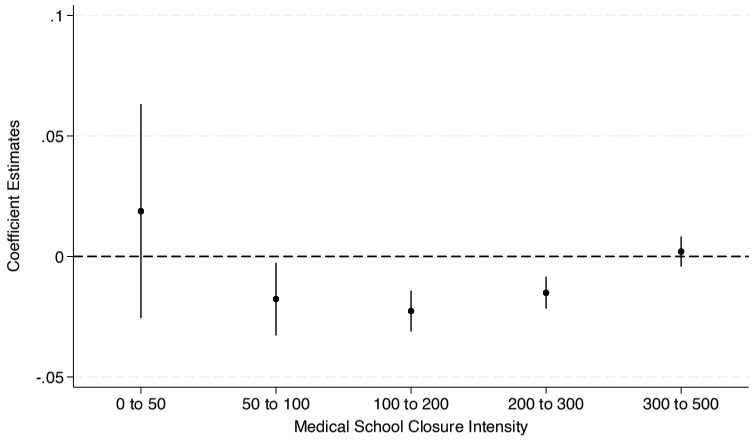


Notes: Panel A displays a kernel density estimate of the distance that recent medical school graduates were living from the county they were likely trained in. Panel B displays the histogram equivalent of Panel A. To construct this, we used the IPUMS Multigenerational Longitudinal Panel (Helgertz et al., 2020), which links individuals between decadal censuses. We used the 1900 to 1910 linked sample. To be included, an individual must have reported being a student in 1900 in a county containing a medical school, reported being a physician in 1910, and was over the age of 16 in 1900. We assume that these individuals were likely in medical school in 1900.

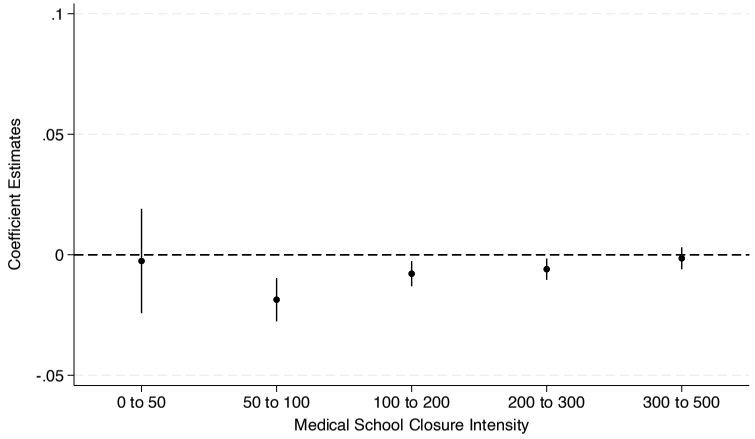
Figure 5: Impact of School Closures on Physicians per 1,000 - Distance Bins



(a) Physicians



(b) Young Physicians



(c) Old Physicians (over 40)

Notes: This figure displays estimates from equation (2) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level. 95% confidence intervals are displayed.

Table 1: Comparison of Closed Medical Schools and Schools that Remained Open

	Remained open	Closed between 1905-1915	Difference
Number of students enrolled	249.824	140.487	109.336***
	238	277	(7.819)
Percent passing state licensing exam	0.878	0.743	0.135***
	230	242	(7.222)
School was regular (allopathic)	0.867	0.778	0.089**
	240	288	(2.649)
Required 1-year of pre-med	0.062	0.000	0.062***
	240	288	(4.373)
Rated A by AMA	0.783	0.270	0.513***
	240	252	(13.256)
Rated B by AMA	0.183	0.429	-0.245***
	240	252	(-6.091)
Rated C by AMA	0.033	0.302	-0.268***
	240	252	(-8.442)
University Affiliated	0.750	0.403	0.347***
	240	288	(8.523)
Flexner recommended closing	0.617	0.986	-0.369***
	240	288	(-12.445)
Number of schools:	60	72	

Notes: This table displays results from a difference in means test (t-test). The unit of observation is a medical school. Column (1) displays averages from 1901-1904 for schools that were open in 1901 and remained open through 1920. Column (2) displays averages from 1901-1904 for schools that were open in 1901, but closed by 1915. Column (3) displays the difference in means between columns (1) and (2). The number under the averages in columns (1) and (2) is the number of observations used to compute the average. The number under the difference in column (3) is the t-statistic.

Table 2: Impact of School Closures on Physicians, Nurses, and Midwives Per 1,000, 1900-1930

	(1)	(2)	(3)
	Panel A: Physicians		
SCI 0-300 miles	-0.0072***	-0.0075***	-0.0070***
	(0.0011)	(0.0011)	(0.0012)
Observations	11926	11782	9964
	Panel B: Young physicians		
SCI 0-300 miles	-0.0157***	-0.0161***	-0.0151***
	(0.0020)	(0.0020)	(0.0023)
Observations	11910	11766	9948
	Panel C: Old physicians		
SCI 0-300 miles	-0.0069***	-0.0072***	-0.0074***
	(0.0013)	(0.0013)	(0.0015)
Observations	11918	11774	9956
	Panel D: Nurses		
SCI 0-300 miles	0.0108***	0.0114***	0.0102**
	(0.0032)	(0.0033)	(0.0041)
Observations	11846	11702	9888
	Panel E: Midwives		
SCI 0-300 miles	-0.0056	-0.0062	0.0035
	(0.0088)	(0.0091)	(0.0107)
Observations	7654	7510	6328
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	X
Excluding counties within 50 miles of a closure			X

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses.
$* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table 3: Impact of School Closures by Decade on Physicians, Nurses, and Midwives Per 1,000

	Physicians	Young physicians	Old physicians	Nurses	Midwives
	(1)	(2)	(3)	(4)	(5)
SCI 0-300 miles in 1910	-0.0062***	-0.0133***	-0.0008	-0.0106**	-0.0089
	(0.0014)	(0.0025)	(0.0019)	(0.0043)	(0.0157)
SCI 0-300 miles in 1920	-0.0070***	-0.0144***	-0.0069***	0.0075**	0.0092
	(0.0012)	(0.0024)	(0.0015)	(0.0034)	(0.0100)
SCI 0-300 miles in 1930	-0.0087***	-0.0220***	-0.0097***	0.0164***	-0.0236**
	(0.0013)	(0.0030)	(0.0015)	(0.0033)	(0.0110)
1910	-0.0578***	-0.1049***	-0.0184	0.5201***	-0.6095***
	(0.0165)	(0.0300)	(0.0210)	(0.0239)	(0.0870)
1920	-0.2443***	-0.6525***	0.0891***	0.6916***	-1.0056***
	(0.0238)	(0.0490)	(0.0311)	(0.0354)	(0.1266)
1930	-0.4029***	-1.1674***	0.1167***	0.8684***	-0.8453***
	(0.0263)	(0.0521)	(0.0329)	(0.0407)	(0.1406)
Observations	11782	11766	11774	11702	7510

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table 4: Medical School Enrollment and School Closures

	Number of students	
	(1)	(2)
SCI 0-300 miles	-0.043	-0.035
	(0.036)	(0.035)
Observations	955	1154
	Schools open throughout period	Include new schools

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. The dependent variable is the number of students enrolled in medical schools. Column (1) includes only counties that had a medical school that remained opened from 1901 to 1930. Column (2) adds counties that had a medical school open after 1901 and remain opened through 1930. PPML is used for the estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level.

Table 5: Physician Migration, 1910-1920

	(1)	(2)	(3)
	All physicians	Young physicians	Old physicians
First Stage			
d300	-10.962***	-11.837***	-10.882***
	(0.403)	(0.708)	(0.271)
d500	-14.232***	-15.344***	-13.97***
	(0.515)	(0.841)	(0.356)
Second Stage			
SCI 0-300 miles	16.384**	24.089***	16.759***
	(3.307)	(4.491)	(3.111)

Notes: This table uses a linked sample of physicians to estimate the discrete model of physician location choice described in Appendix B. $d300$ is one if the distance between the initial and current counties is less than 300 miles and 0 otherwise, and $d500$ is one if the distance between counties is more than 300 miles, but less than 500 miles and 0 otherwise. SCI 300-500, share urban, share Black, and manufacturing establishments per capita are included in the second stage.
For computational purposes, the model in column 1 is estimated using a 10 percent random sample of linked physicians and keeping 30 percent of not chosen locations at random for each individual, and the models in columns 2 and 3 are estimated using a 20 percent random sample of linked physicians and keeping 30 percent of not chosen locations at random for each individual. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table 6: Exit Being a Physician

	Pr(Exit physician=1) (1)	Pr(Change occ.=1) (2)	Pr(Retire=1) (3)
	Panel A: 1910-1920		
SCI 0-300 miles	-0.0013***	-0.0004	-0.0009***
	(0.0004)	(0.0003)	(0.0002)
Observations	59436	59436	59436
	Panel B: 1900-1910 and 1910-1920 stacked		
SCI 0-300 miles	-0.0024*	-0.0007	-0.0017**
	(0.0012)	(0.0009)	(0.0008)
Observations	106282	106282	106282

Notes: The unit of observation is an individual. The table uses a linked sample of physicians. In particular, we linked individuals who were physicians in 1900 to the 1910 census and individuals who were physicians in 1910 to the 1920 census. We observe whether these individuals remain physicians, switch occupations, or retire. Panel A uses just the 1910 to 1920 linked sample. Panel B stacks the 1900 to 1910 linked sample and the 1910 to 1920 linked sample. SCI is standardized to have a mean of zero and a standard deviation of one. SCI is based on the initial county (either 1900 or 1910) SCI value in the later census (either 1910 or 1920). Panel A controls for SCI 300-500 miles and age fixed effects. Panel B control for SCI 300-500 miles, census year fixed effects, initial county of residence fixed effects, and fixed effects for an individual's age. Standard errors are clustered at the initial county (either 1900 or 1910) level. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table 7: Impact of School Closures on Physicians, Nurses and Midwives in the Death Registration Area, 1900-1930

	(1)	(2)	(3)
	Panel A: Physicians		
SCI 0-300 miles - DRA	-0.0064***	-0.0069***	-0.0070***
	(0.0020)	(0.0020)	(0.0026)
SCI 0-300 miles * Non-DRA	0.0017	0.0020	0.0029
	(0.0023)	(0.0024)	(0.0029)
Observations	11434	11299	9582
	Panel B: Young physicians		
SCI 0-300 miles - DRA	0.0039	0.0035	0.0055
	(0.0039)	(0.0039)	(0.0051)
SCI 0-300 miles * Non-DRA	-0.0181***	-0.0180***	-0.0194***
	(0.0045)	(0.0046)	(0.0057)
Observations	11406	11271	9556
	Panel C: Old physicians		
SCI 0-300 miles - DRA	-0.0180***	-0.0185***	-0.0208***
	(0.0023)	(0.0024)	(0.0028)
SCI 0-300 miles * Non-DRA	0.0145***	0.0148***	0.0178***
	(0.0029)	(0.0029)	(0.0034)
Observations	11423	11288	9571
	Panel D: Nurses		
SCI 0-300 miles - DRA	0.0145***	0.0148***	0.0119*
	(0.0049)	(0.0050)	(0.0061)
SCI 0-300 miles * Non-DRA	-0.0102	-0.0100	-0.0061
	(0.0065)	(0.0067)	(0.0082)
Observations	11351	11216	9503
	Panel E: Midwives		
SCI 0-300 miles - DRA	0.0226	0.0257	0.0468
	(0.0261)	(0.0276)	(0.0306)
SCI 0-300 miles * Non-DRA	-0.0400	-0.0440	-0.0553*
	(0.0279)	(0.0294)	(0.0327)
Observations	7086	6953	5878
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	X
Excluding counties within 50 miles of a closure			X

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: SCI 300-500 miles and it's interaction with a dummy variable if a county is in the death registration area, county and year fixed effects and their interaction with a dummy variable if a county is in the death registration area, and share urban, share Black, and manufacturing establishments per capita and their interac-

Table 8: The Impact of School Closures on Mortality, 1900-1930

	(1)	(2)	(3)
Panel A: Infant mortality, Census Years			
SCI 0-300 miles	-0.0106***	-0.0101***	-0.0111***
	(0.0027)	(0.0026)	(0.0030)
Observations	2893	2846	2281
Panel B: Infant mortality, All years			
SCI 0-300 miles	-0.0150***	-0.0141***	-0.0103***
	(0.0027)	(0.0026)	(0.0029)
Observations	18593	18336	15152
Panel C: Total mortality, Census years			
SCI 0-300 miles	-0.0050***	-0.0044***	-0.0040**
	(0.0016)	(0.0016)	(0.0018)
Observations	2896	2849	2284
Panel D: Total mortality, All years			
SCI 0-300 miles	-0.0067***	-0.0062***	-0.0033*
	(0.0016)	(0.0015)	(0.0019)
Observations	22217	21907	18085
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	
Excluding closure within 50 miles			X

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. PPML is used for the estimation. The dependent variables in Panels A and B are the number of deaths under one year of age per 1000 people. The dependent variables in Panels C and D are the number of all deaths per 1000 people. Panels A and C present results for census years. Panels B and D present results using the annual data. Infant mortality is not available for 1911-1914, so these years are omitted from in Panel B. All estimates include SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table 9: The Impact of School Closures on Mortality by Causes, 1900-1915

	(1)	(2)	(3)
	Total	Infectious	Noninfectious
SCI 0-300 miles	-0.0035**	-0.0046*	0.0064***
	(0.0015)	(0.0024)	(0.0019)
Observations	10219	10219	10219
	Maternal	Early infancy	Typhoid
SCI 0-300 miles	0.0044	-0.0125**	0.0011
	(0.0048)	(0.0051)	(0.0044)
Observations	9993	10191	10169
	Smallpox	Cancer	Diabetes
SCI 0-300 miles	0.0268	0.0051**	0.0044
	(0.0362)	(0.0023)	(0.0034)
Observations	6436	10209	10072
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures	X	X	X

Notes: The unit of observation is a county-year. PPML is used for estimation. Infectious diseases are typhoid, malaria, smallpox, measles, scarlet fever, whooping cough, diphtheria, influenza, meningitis, pneumonia, and TB. Noninfectious are cancer, diabetes, and brights. Counties containing medical school closures are excluded from the estimating sample. All estimates include SCI 300-500 miles, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses.

Table 10: The Impact of School Closures on Mortality - Alternative Explanations

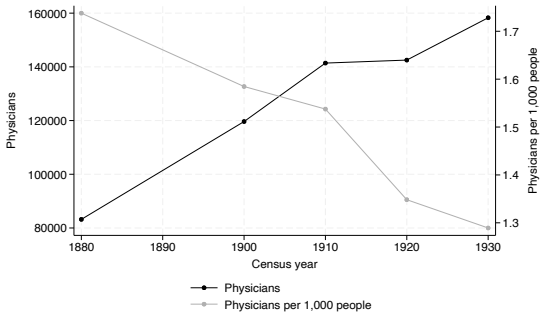
	(1)	(2)	(3)
	Total Personnel PC	Medical Officers PC	Budget PC
Panel A: County health departments			
SCI 0-300 miles	1.6694	0.7704	0.7599
	(1.0604)	(0.8550)	(0.6772)
Observations	10144	10104	10124
	(4)	(5)	(6)
	Sewers PC	Water PC	Refuse PC
Panel B: Expenditures			
SCI 0-300 miles	-0.0101	-0.0322**	0.0272
	(0.0214)	(0.0150)	(0.0187)
Observations	2323	2023	2063
	(7)	(8)	(9)
	Med Institutions PC	Hospitals PC	Hospital Beds PC
Panel C: Hospitals			
SCI 0-300 miles	-0.0030	0.0010	-0.0289
	(0.0073)	(0.0083)	(0.0227)
Observations	30131	28213	27950

Notes: The unit of observation is a county-year. PPML is used for estimation. All estimates include SCI 300-500 miles, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. Data on county health departments cover the period 1911-1930 and are from Hoehn-Velasco (2021). Data on expenditures cover the period 1900-1929 and are from Cain and Rotella (2022). Data on hospitals cover the period 1900-1930 were graciously provided by Melissa Thomasson and Peter Nencka.

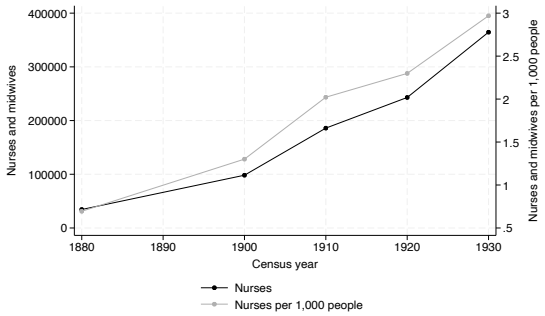
Appendix A: Supplemental Figures and Tables

Figure A.1: National trends in physicians, midwives, nurses, and mortality

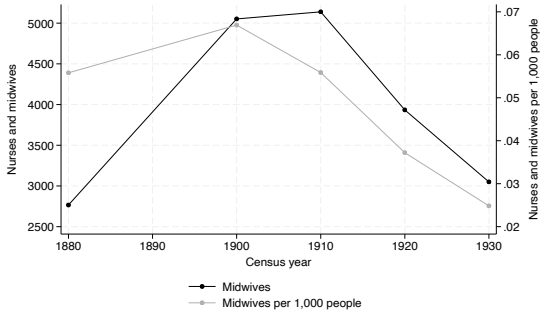
(a) Physicians



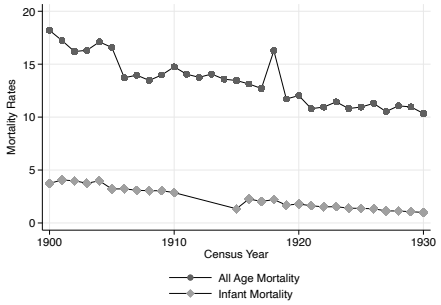
(b) Nurses



(c) Midwives

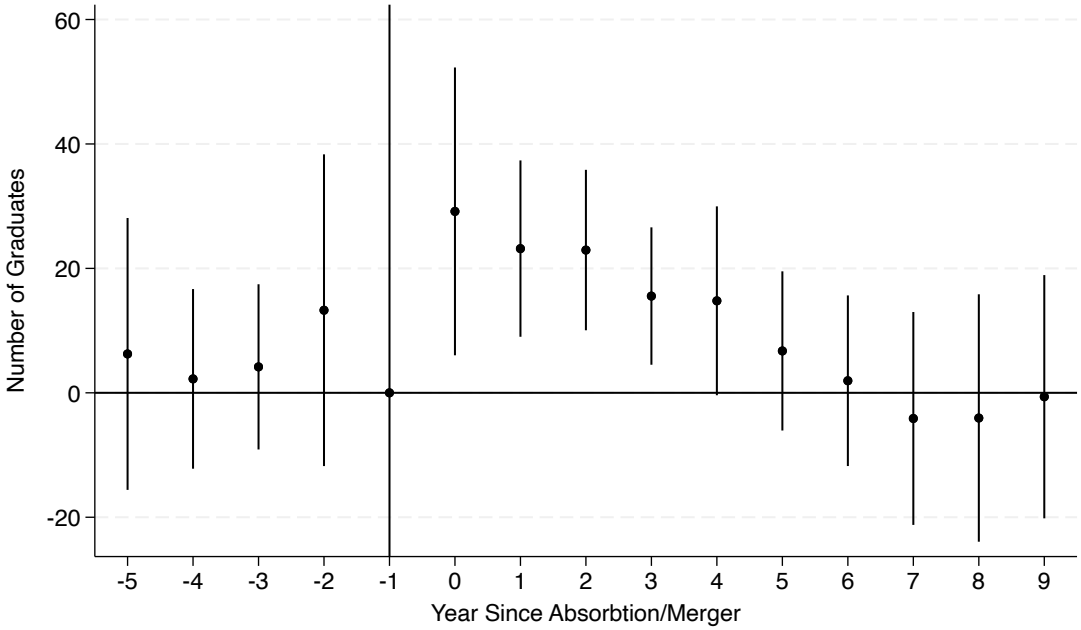


(d) Mortality rates



Notes: These figures show trends in physicians, nurses, midwives, and mortality.

Figure A.2: Number of graduates in absorbing institutions



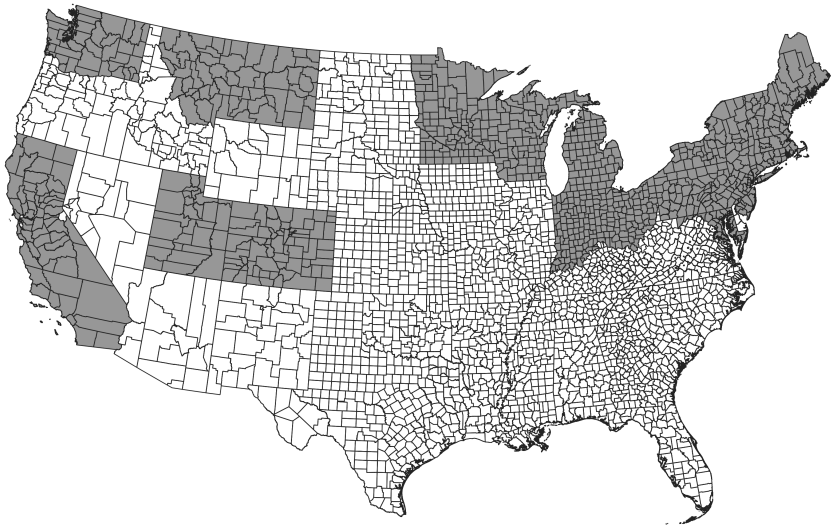
Notes: This figure presents event study estimates of the number of graduates in schools that absorbed or merged with another institution. The estimating specification is:

$$y_{st} = \sum_{k=-6}^{10} \beta_k * \mathbb{I}\left[(\text{Year of Absorption-Year}) = k\right]_{st} + \theta_s + \chi_t + \epsilon_{st}$$

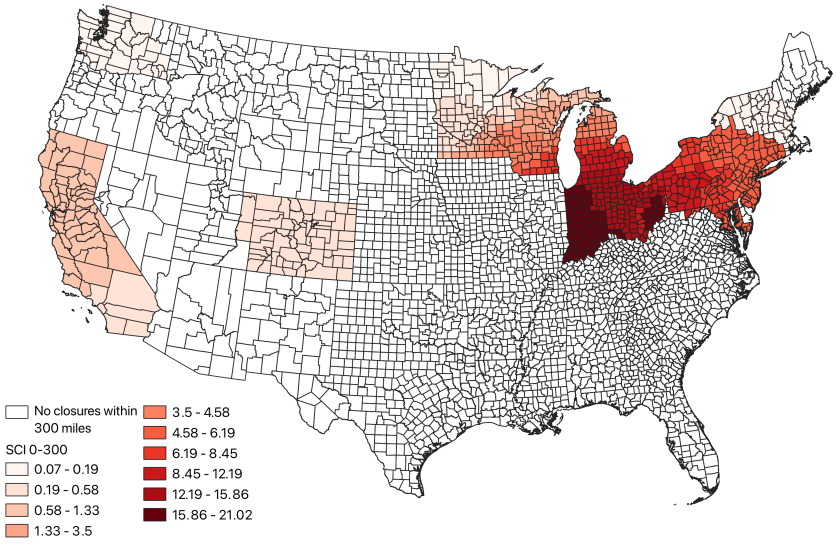
Where y_{st} is the number of students in school s in year t. Only schools that absorbed another school or merged with another school are included in the estimation. θ_s is a school fixed effect and χ_t is a year fixed effect. Event years less than or equal to -6 and greater than or equal to 10 were binned into the "-6" and "10" event-time dummies, which are not displayed. Robust standard errors were calculated and 95% confidence intervals are displayed.

Figure A.3: Death Registration Area and School Closure Intensity

(a) Death Registration Area in 1910



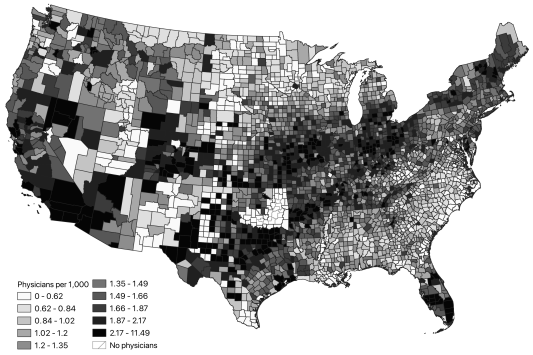
(b) SCI in Death Registration Area



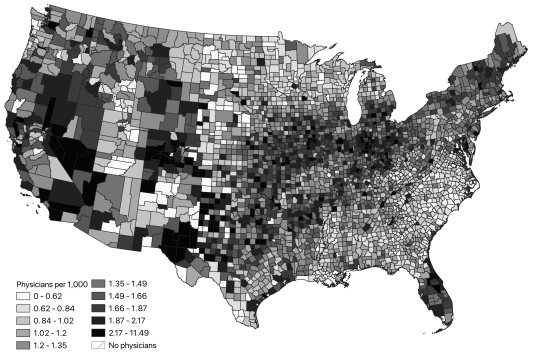
Notes: Panel A shows the counties that were in the death registration area in 1910. Panel B shows the maximum value of school closure intensity (SCI) for the counties in the death registration area in 1910.

Figure A.4: Physicians per 1,000 by County

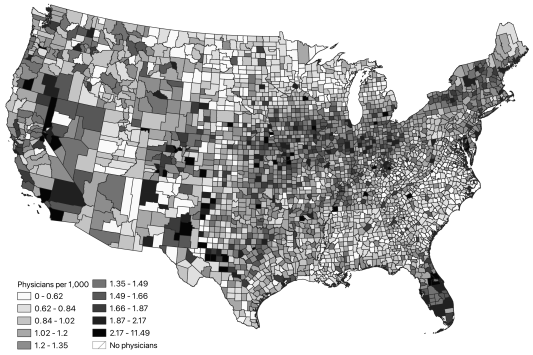
(a) 1900



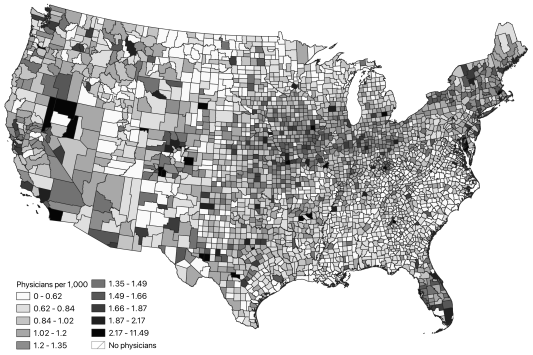
(b) 1910



(c) 1920

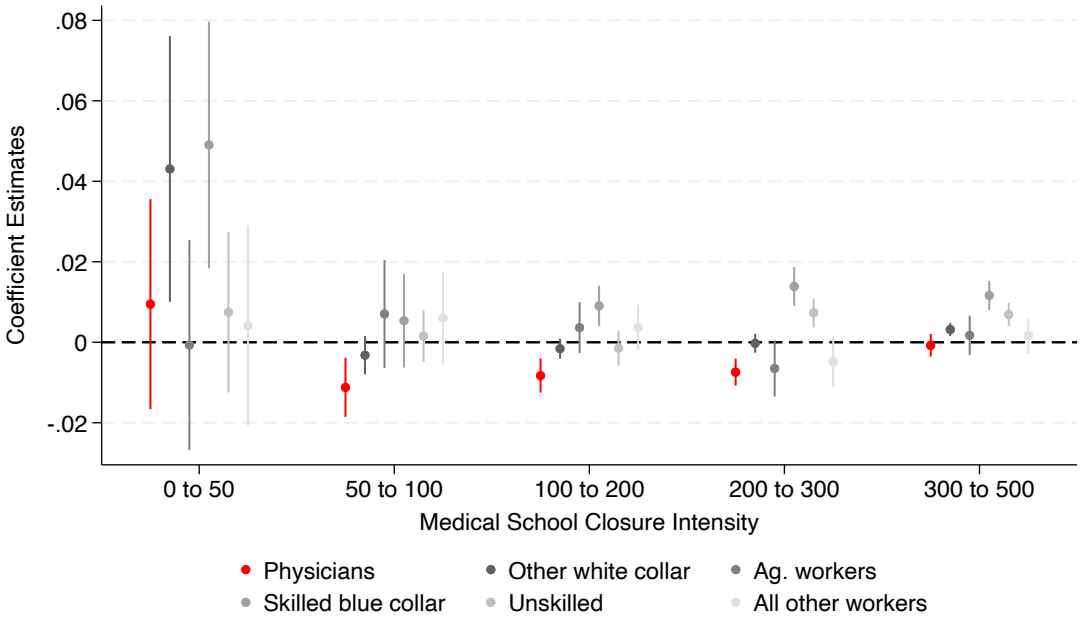


(d) 1930



Notes: These figures show the number of physicians per 1,000 in each county for the census years 1900-1930.

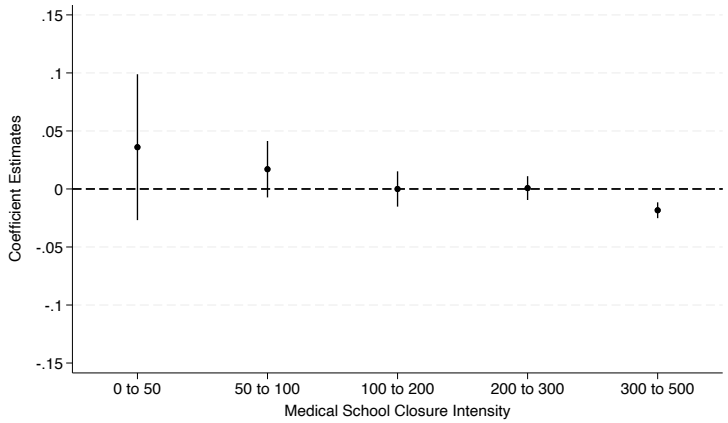
Figure A.5: Other Occupational Categories and School Closures



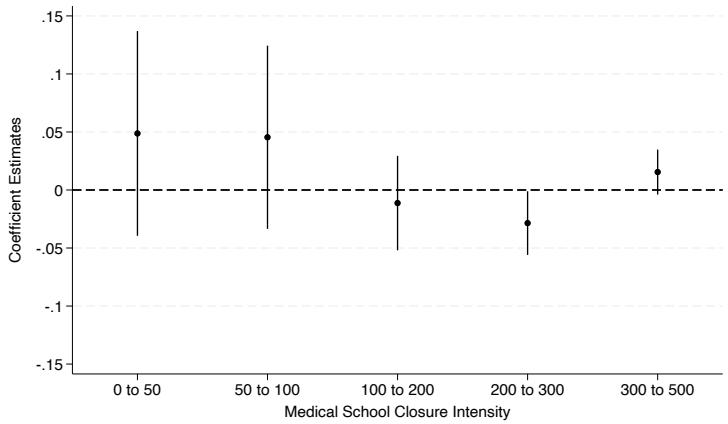
Notes: This figure displays estimates from equation (2) in the text. The unit of observation is a county-year. All estimates include: county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. All dependent variables are per 1,000 people and PPML is used for the estimation. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level. 95% confidence intervals are displayed.

Figure A.6: Impact of School Closures on Nurses and Midwives - Distance Bins

(a) All Nurses

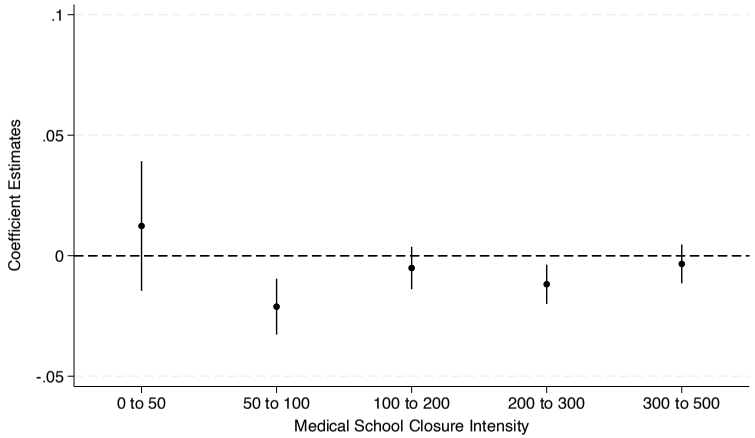


(b) Midwives

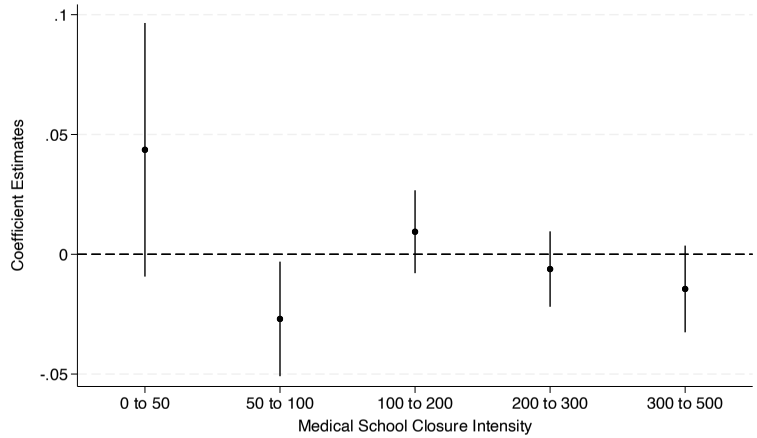


Notes: This figure displays estimates from equation ((2)) in the text. The unit of observation is a county-year. All estimates include: county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. All dependent variables are per 1,000 people and PPML is used for the estimation. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level. 95% confidence intervals are displayed.

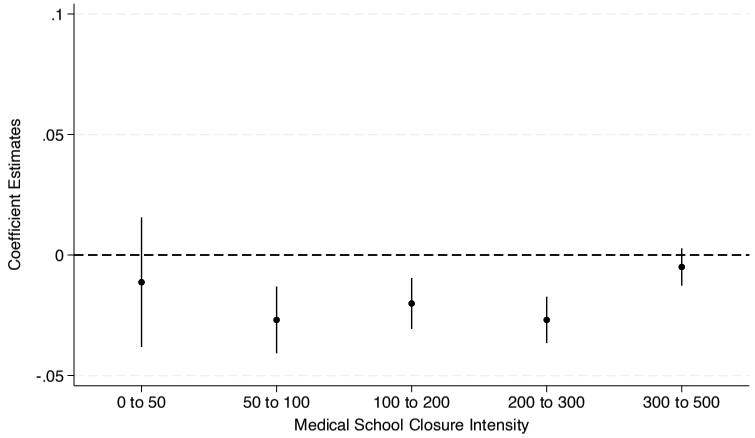
Figure A.7: Effect of medical school closures in distance bins on physicians - Mortality sample



(a) Physicians



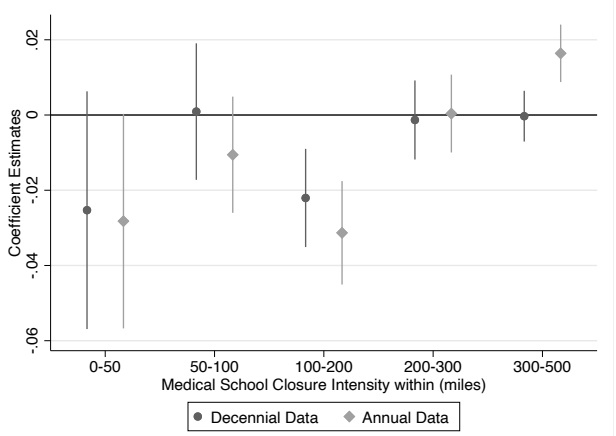
(b) Young Physicians



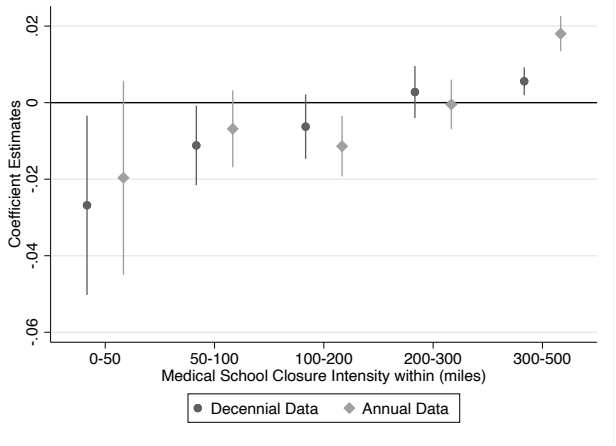
(c) Old Physicians (over 40)

Notes: This figure displays estimates from equation ((2)) in the text. The unit of observation is a county-year. All estimates include: county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. All dependent variables are per 1,000 people and PPML is used for the estimation. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Estimates are not weighted by county population. Standard errors are clustered at the county-level. 95% confidence intervals are displayed.

Figure A.8: Effect of medical school closures in distance bins on mortality



(a) Infant Mortality



(b) All age mortality

Notes: This figure displays estimates from equation ((2)) in the text. The unit of observation is a county-year. All estimates include: county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. All dependent variables are per 1,000 people and PPML is used for the estimation. All regressions control for county fixed effects, year fixed effects, share urban, share black, and manufacturing establishments per 1,000. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level. 95% confidence intervals are displayed.

Table A.1: Summary statistics

	1900 (1)	1910 (2)	1920 (3)	1930 (4)
SCI 0-300 miles	0.00	3.00	5.74	5.74
SCI 300-500 miles	0.00	3.99	7.62	7.62
SCI 0-300 miles - through 1918	0.00	3.00	6.35	6.35
SCI 300-500 miles - through 1918	0.00	3.99	8.40	8.40
SCI 1905-1910 Closures	0.00	3.00	3.00	3.00
SCI 1911-1915 Closures	0.00	0.00	2.74	2.74
SCI 0-300 miles - Black schools	0.00	1.09	2.29	2.29
SCI 0-300 miles - Women schools	0.00	1.23	1.23	1.23
SCI 0-50 miles	0.00	0.10	0.20	0.20
SCI 50-100 miles	0.00	0.29	0.56	0.56
SCI 100-200 miles	0.00	1.07	2.02	2.02
SCI 200-300 miles	0.00	1.53	2.95	2.95
SCI 300-500 miles	0.00	3.99	7.62	7.62
Physicians per 1,000 people	1.39	1.32	1.10	0.95
Young physicians per 1,000 people	0.70	0.65	0.39	0.24
Old physicians per 1,000 people	0.69	0.67	0.71	0.71
Native white physicians per 1,000 people	1.25	1.20	1.01	0.88
Black physicians per 1,000 people	0.01	0.02	0.02	0.02
Female physicians per 1,000 people	0.05	0.05	0.04	0.03
Foreign-born physicians per 1,000 people	0.12	0.10	0.07	0.06
Nurses per 1,000 people	0.73	1.14	1.34	1.71
Midwives per 1,000 people	0.06	0.03	0.03	0.02
Observations	2983	2983	2983	2983
Infant mortality	2.81	2.19	1.72	1.13
Total mortality	15.11	12.44	12.52	11.25
Observations	322	906	761	907

Notes: This table displays summary statistics for our main dependent and independent variables.

Table A.2: Summary statistics - DRA versus Non-DRA counties in 1910

	Non-DRA counties (1)	DRA counties (2)	Difference: (1)-(2) (3)
SCI 0-300 miles in 1915	5.86	5.45	0.41*
SCI 300-500 miles in 1915	8.12	6.49	1.62***
Physicians per 1,000 people	1.28	1.39	-0.11***
Young physicians per 1,000 people	0.65	0.65	0.00
Old physicians per 1,000 people	0.63	0.75	-0.11***
Nurses per 1,000 people	0.94	1.59	-0.64***
Midwives per 1,000 people	0.04	0.03	0.01***
Population	21601	49578	-27977***
Percent Black	0.18	0.01	0.17***
Percent Urban	0.12	0.27	-0.15***
Manu. estab. per 1,000	2.77	4.72	-1.95***
Observations	2077	906	

Notes: Columns (1) and (2) display summary statistics comparing counties in the death registration area in 1910 to those not in the death registration area in 1910. Column (3) displays the difference between columns (1) and (2).
$* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.3: Impact of School Closures on Physicians Per 1,000, 1900-1930 - SCI specific to school grade

	(1)	(2)	(3)
	Panel A: Physicians		
SCI 0-300 miles - A grade schools	0.0065*	0.0062*	0.0055
	(0.0037)	(0.0037)	(0.0039)
SCI 0-300 miles - B & C grade schools	-0.0184***	-0.0187***	-0.0167***
	(0.0017)	(0.0017)	(0.0018)
Observations	11926	11782	9964
	Panel B: Young physicians		
SCI 0-300 miles - A grade schools	0.0362***	0.0363***	0.0319***
	(0.0074)	(0.0075)	(0.0082)
SCI 0-300 miles - B & C grade schools	-0.0438***	-0.0452***	-0.0418***
	(0.0032)	(0.0032)	(0.0035)
Observations	11910	11766	9948
	Panel C: Old physicians		
SCI 0-300 miles - A grade schools	-0.0096**	-0.0098**	-0.0083*
	(0.0043)	(0.0043)	(0.0046)
SCI 0-300 miles - B & C grade schools	-0.0115***	-0.0114***	-0.0104***
	(0.0021)	(0.0021)	(0.0024)
Observations	11918	11774	9956
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	X
Excluding counties within 50 miles of a closure			X

Notes: This table presents estimates from the following specification:

$$y_{ct} = \beta_1 \cdot \text{SCI - A } \{^{300}_{0}\}_{ct} + \beta_2 \cdot \text{SCI - A } \{^{500}_{301}\}_{ct} + \beta_3 \cdot \text{SCI - B \& C } \{^{300}_{0}\}_{ct} + \beta_4 \cdot \text{SCI - B \& C } \{^{500}_{301}\}_{ct} + \beta_5 \cdot \text{SCI - not graded } \{^{300}_{0}\}_{ct} + \beta_6 \cdot \text{SCI - not graded } \{^{500}_{301}\}_{ct} + \theta_c + \chi_t + Z'_{ct} * \delta + \epsilon_{ct}$$

The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. The coefficients β_5 and β_6 are not reported. Some schools in the sample did not receive a grade because they closed between 1905 and 1907 prior to the AMA first assigning grades in 1907. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses.

The independent variables are constructed as described in the text. Information on medical school closures comes from *Medical Colleges of the United States and of Foreign Countries* which was published by the American Medical Association American Medical Association (1918). Information on the number of graduates from medical schools that closed comes from annual reports in the Journal of the American Medical Association.

$* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.4: Alternative Measures of SCI

	Physicians	Young physicians	Old physicians
	(1)	(2)	(3)
	Panel A: SCI through 1918		
SCI 0-300 miles	-0.0058***	-0.0131***	-0.0063***
	(0.0010)	(0.0019)	(0.0013)
Observations	11782	11766	11774
	Panel B: SCI for earlier and later closures		
SCI 1905-1910 Closures	-0.0077***	-0.0174***	-0.0028
	(0.0013)	(0.0024)	(0.0018)
SCI 1911-1915 Closures	-0.0070***	-0.0129***	-0.0148***
	(0.0023)	(0.0049)	(0.0028)
Observations	11782	11766	11774
	Panel C: SCI squared		
SCI 0-300 miles	0.0029	0.0082*	0.0039
	(0.0025)	(0.0046)	(0.0031)
SCI 0-300 miles squared	-0.0006***	-0.0015***	-0.0006***
	(0.0001)	(0.0003)	(0.0002)
Observations	11782	11766	11774
	Panel D: SCI for Black and women schools		
	Black physicians	Female physicians	
SCI 0-300 miles - Black schools	0.0382**		
	(0.0149)		
SCI 0-300 miles - Women schools		0.0020	
		(0.0154)	
Observations	5030	9170	

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.5: Impact of School Closures on Physician Demographic Groups Per 1,000, 1900-1930

	(1)	(2)	(3)
	Panel A: Black physicians		
SCI 0-300 miles	0.0064	0.0043	0.0082
	(0.0068)	(0.0071)	(0.0079)
Observations	5170	5030	3968
	Panel B: Female physicians		
SCI 0-300 miles	-0.0004	-0.0019	-0.0008
	(0.0064)	(0.0067)	(0.0074)
Observations	9314	9170	7688
	Panel C: Foreign-born physicians		
SCI 0-300 miles	-0.0037	-0.0051	-0.0032
	(0.0048)	(0.0049)	(0.0060)
Observations	9346	9202	7784
	Panel D: Native-born white physicians		
SCI 0-300 miles	-0.0086***	-0.0088***	-0.0085***
	(0.0011)	(0.0011)	(0.0012)
Observations	11922	11778	9960
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	X
Excluding counties within 50 miles of a closure			X

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.6: Zero issue

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Panel A: Physicians				
SCI 0-300 miles	-0.0104***	-0.0054***	-0.0059***	-0.0104***	-0.0124***	-0.0122***	-0.0131***	-0.0068***	-0.0075***
	(0.0012)	(0.0005)	(0.0006)	(0.0010)	(0.0013)	(0.0014)	(0.0014)	(0.0010)	(0.0011)
Observations	11689	11689	11786	11786	11786	11689	11786	11689	11782
					Panel B: Young physicians				
SCI 0-300 miles	-0.0245***	-0.0056***	-0.0061***	-0.0189***	-0.0281***	-0.0080***	-0.0084***	-0.0152***	-0.0161***
	(0.0032)	(0.0006)	(0.0006)	(0.0017)	(0.0028)	(0.0011)	(0.0011)	(0.0019)	(0.0020)
Observations	11188	11188	11786	11786	11786	11188	11786	11188	11766
					Panel C: Old physicians				
SCI 0-300 miles	-0.0109***	-0.0026***	-0.0033***	-0.0097***	-0.0146***	-0.0037***	-0.0047***	-0.0054***	-0.0072***
	(0.0019)	(0.0005)	(0.0005)	(0.0013)	(0.0020)	(0.0010)	(0.0010)	(0.0013)	(0.0013)
Observations	11543	11543	11786	11786	11786	11543	11786	11543	11774
					Panel D: Nurses				
SCI 0-300 miles	0.0049	0.0013	0.0004	0.0034	0.0015	-0.0055*	-0.0059**	0.0130***	0.0114***
	(0.0052)	(0.0011)	(0.0011)	(0.0028)	(0.0047)	(0.0028)	(0.0027)	(0.0032)	(0.0033)
Observations	11028	11028	11786	11786	11786	11028	11786	11028	11702
					Panel E: Midwives				
SCI 0-300 miles	0.0135	0.0022***	0.0012***	0.0043***	0.0062	0.0030***	0.0017***	0.0069	-0.0062
	(0.0198)	(0.0006)	(0.0003)	(0.0013)	(0.0038)	(0.0008)	(0.0003)	(0.0091)	(0.0091)
Observations	3789	3789	11786	11786	11786	3789	11786	3789	7510
	Log(y)	Log(y+1) excluding zeroes	Log(y+1)	Log(y+0.1)	Log(y+0.01)	y excluding zeroes	y	PPML excluding zeroes	PPML

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses.
$* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.7: Impact of School Closures on Physicians Per 1,000, 1900-1930 - Weighted

	(1)	(2)	(3)
	Panel A: Physicians		
SCI 0-300 miles	-0.0032**	-0.0055***	-0.0061***
	(0.0016)	(0.0016)	(0.0016)
Observations	11924	11780	9964
	Panel B: Young physicians		
SCI 0-300 miles	-0.0071***	-0.0074**	-0.0099***
	(0.0026)	(0.0032)	(0.0029)
Observations	11908	11764	9948
	Panel C: Old physicians		
SCI 0-300 miles	-0.0026	-0.0071***	-0.0071***
	(0.0022)	(0.0016)	(0.0016)
Observations	11916	11772	9956
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	X
Excluding counties within 50 miles of a closure			X

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.8: Impact of School Closures on Physicians Per 1,000, 1900-1930 - Adding Region-year and Division-year Fixed Effects and Time Trends

	Physicians	Young physicians	Old physicians
	(1)	(2)	(3)
	Panel A: Region-year FE		
SCI 0-300 miles	-0.0083***	-0.0169***	-0.0079***
	(0.0012)	(0.0023)	(0.0015)
Observations	11758	11758	11758
	Panel B: Region-year TT		
SCI 0-300 miles	-0.0083***	-0.0160***	-0.0081***
	(0.0012)	(0.0023)	(0.0014)
Observations	11758	11758	11758
	Panel C: Division-year FE		
SCI 0-300 miles	-0.0122***	-0.0261***	-0.0102***
	(0.0013)	(0.0024)	(0.0018)
Observations	11758	11758	11758
	Panel D: Division-year TT		
SCI 0-300 miles	-0.0097***	-0.0200***	-0.0079***
	(0.0012)	(0.0022)	(0.0016)
Observations	11758	11758	11758

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people and PPML is used for the estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.9: Impact of School Closures on Physicians Per 1,000, 1900-1930 - Spatial SE

	(1)	(2)	(3)	(4)	(5)
			Panel A: Physicians		
SCI 0-300 miles	-0.0075***	-0.0059***	-0.0059***	-0.0059***	-0.0059***
	(0.0011)	(0.0006)	(0.0011)	(0.0014)	(0.0017)
Observations	11758	11758	11758	11758	11758
			Panel B: Young physicians		
SCI 0-300 miles	-0.0162***	-0.0061***	-0.0061***	-0.0061***	-0.0061***
	(0.0020)	(0.0006)	(0.0012)	(0.0015)	(0.0018)
Observations	11758	11758	11758	11758	11758
			Panel C: Old physicians		
SCI 0-300 miles	-0.0072***	-0.0033***	-0.0033***	-0.0033***	-0.0033***
	(0.0013)	(0.0005)	(0.0009)	(0.0011)	(0.0012)
Observations	11758	11758	11758	11758	11758
Method	PPML	Log(1+y)	Spatial HAC: 100 km band-width	Spatial HAC: 150 km band-width	Spatial HAC: 200 km band-width

Notes: This table presents estimates from equation (3) in the text. The unit of observation is a county-year. All dependent variables are per 1,000 people. PPML is used for estimation in column (1). We log transform the dependent variables for columns (2)-(5) using $log(y + 1)$ and use OLS for estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.10: Alternative DiD estimators

	Physicians	
	(1)	(2)
	Panel A: 50th percentile	
High SCI 0-300 miles	-0.0223***	-0.0411***
	(0.0055)	(0.0062)
Observations	11756	11756
	Panel B: Mean ($\sim$ 60th percentile)	
High SCI 0-300 miles	-0.0522***	-0.0628***
	(0.0055)	(0.0061)
Observations	11756	11756
Estimator:	TWFE	Callaway & Sant'Anna (2021)

Notes: The unit of observation is a county-year. The dependent variable is the log of physicians per 1,000 people (i.e. $log(y+1)$). Column (1) uses two-way fixed effects using county and year fixed effects. Column (2) uses the estimator proposed by Callaway and Sant'Anna (2021). The independent variable is an indicator taking a value of one if SCI $\left\{{}^{300}_{0}\right\}_{ct}$ is at or above the 50th percentile (Panel A) or mean ($\sim$ 60th percentile) (Panel B). All estimates control for: SCI 300-500 miles, share urban, share Black, and manufacturing establishments per capita. Column 1 includes county and year fixed effects. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level in columns 1 and 3. 95% confidence intervals are displayed in parentheses.

Table A.11: Impact of School Closures on Mortality by Decade, 1900-1930

	(1)	(2)	(3)
Panel A: Infant mortality			
SCI 0-300 miles in 1910	-0.0074**	-0.0070**	-0.0093**
	(0.0033)	(0.0033)	(0.0041)
SCI 0-300 miles in 1920	-0.0099***	-0.0094***	-0.0096***
	(0.0028)	(0.0028)	(0.0031)
SCI 0-300 miles in 1930	-0.0136***	-0.0132***	-0.0138***
	(0.0032)	(0.0032)	(0.0036)
Observations	2893	2846	2281
Panel B: Total mortality			
SCI 0-300 miles in 1910	-0.0040**	-0.0035**	-0.0040*
	(0.0017)	(0.0017)	(0.0020)
SCI 0-300 miles in 1920	-0.0050***	-0.0042***	-0.0036*
	(0.0017)	(0.0016)	(0.0019)
SCI 0-300 miles in 1930	-0.0054***	-0.0049***	-0.0044**
	(0.0018)	(0.0018)	(0.0020)
Observations	2893	2846	2281
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	
Excluding closure within 50 miles			X

Notes: This table presents estimates from specification (3) in the text. The unit of observation is a county-year. PPML is used for the estimation. The dependent variables in all columns are the number of deaths under one year of age per 1000 people. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses.

Table A.12: The Impact of School Closures on Mortality, 1900-1930 - Alternative Fixed Effects

	(1)	(2)	(3)	(4)	(5)
Panel A: Infant mortality, Census Years					
SCI 0-300 miles	-0.0101***	-0.0101***	-0.0060*	-0.0094***	-0.0047
	(0.0026)	(0.0026)	(0.0033)	(0.0028)	(0.0037)
Observations	2846	2846	2846	2846	2846
Panel B: Infant mortality, All years					
SCI 0-300 miles	-0.0141***	-0.0135***	-0.0074***	-0.0089***	-0.0010
	(0.0026)	(0.0027)	(0.0028)	(0.0027)	(0.0028)
Observations	18336	18336	18336	18336	18336
Panel C: Total mortality, Census years					
SCI 0-300 miles	-0.0044***	-0.0055***	-0.0043**	-0.0080***	-0.0074***
	(0.0016)	(0.0016)	(0.0021)	(0.0016)	(0.0024)
Observations	2849	2849	2849	2849	2849
Panel D: Total mortality, All years					
SCI 0-300 miles	-0.0062***	-0.0077***	-0.0077***	-0.0067***	-0.0039*
	(0.0015)	(0.0017)	(0.0022)	(0.0015)	(0.0020)
Observations	21907	21907	21907	21907	21907
County FE	X	X	X	X	X
Year FE	X	X	X	X	X
Excluding counties with closures	X	X	X	X	X
Region-Trend		X			
Region-by-Year FE			X		
Division-Trend				X	
Division-by-Year FE					X

Notes: This table presents estimates from specification (3) in the text. Counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 8). The unit of observation is a county-year. PPML is used for the estimation. The dependent variables in Panels A and B are the number of deaths under one year of age per 1000 people. The dependent variables in Panels C and D are the number of all deaths per 1000 people. Panels A and C present results for census years. Panels B and D present results using the annual data. Infant mortality is not available for 1911-1914, so these years are omitted from in Panel B. All estimates include SCI 300-500 miles, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses.

Table A.13: The Impact of School Closures on Mortality, 1900-1930 - Spatial SE

	(1)	(2)	(3)	(4)	(5)
Panel A: Infant mortality, Census Years					
SCI 0-300 miles	-0.0101***	-0.0085**	-0.0108***	-0.0108**	-0.0108**
	(0.0026)	(0.0039)	(0.0042)	(0.0047)	(0.0051)
Observations	2846	2817	2831	2831	2831
Panel B: Infant mortality, All years					
SCI 0-300 miles	-0.0141***	-0.0114*	-0.0222***	-0.0222**	-0.0222**
	(0.0026)	(0.0065)	(0.0083)	(0.0094)	(0.0102)
Observations	18336	17296	17298	17298	17298
Panel C: Total mortality, Census years					
SCI 0-300 miles	-0.0044***	-0.0077***	-0.0044	-0.0044	-0.0044
	(0.0016)	(0.0022)	(0.0029)	(0.0034)	(0.0034)
Observations	2849	2846	2852	2852	2852
Panel D: Total mortality, All years					
SCI 0-300 miles	-0.0062***	-0.0113*	-0.0120*	-0.0120*	-0.0120
	(0.0015)	(0.0059)	(0.0061)	(0.0069)	(0.0075)
Observations	21907	21539	21541	21541	21541
Method	PPML	log(y)	Spatial HAC: 100 km	Spatial HAC: 150 km	Spatial HAC: 200 km

Notes: This table presents estimates from specification 3 in the text. The unit of observation is a county-year. PPML is used for estimation in column (1). We log transform the dependent variables for columns (2)-(5) using log(y) and use OLS for estimation. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). 95% confidence intervals are displayed in parentheses.

Table A.14: The Impact of School Closures on Mortality, 1900-1930 - SCI specific to school grade

	(1)	(2)	(3)
Panel A: Infant mortality, Census Years			
SCI 0-300 miles - A grade schools	-0.0522***	-0.0463***	-0.0311*
	(0.0165)	(0.0158)	(0.0169)
SCI 0-300 miles -B and C grade schools	0.0007	0.0002	-0.0002
	(0.0045)	(0.0044)	(0.0053)
Observations	2893	2846	2281
Panel B: Infant mortality, All years			
SCI 0-300 miles - A grade schools	-0.0015	0.0078	0.0069
	(0.0132)	(0.0109)	(0.0115)
SCI 0-300 miles -B and C grade schools	-0.0121***	-0.0145***	-0.0165***
	(0.0036)	(0.0033)	(0.0039)
Observations	18593	18336	15152
Panel C: Total mortality, Census years			
SCI 0-300 miles - A grade schools	-0.0199**	-0.0140*	-0.0072
	(0.0093)	(0.0075)	(0.0076)
SCI 0-300 miles -B and C grade schools	0.0005	0.0001	-0.0023
	(0.0027)	(0.0027)	(0.0034)
Observations	2896	2849	2284
Panel D: Total mortality, All years			
SCI 0-300 miles - A grade schools	-0.0017	0.0027	-0.0007
	(0.0091)	(0.0082)	(0.0086)
SCI 0-300 miles -B and C grade schools	-0.0068***	-0.0079***	-0.0077***
	(0.0024)	(0.0023)	(0.0028)
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	
Excluding closure within 50 miles			X
Observations	22217	21907	18085

Notes: This table presents estimates from the following specification:
$y_{ct} = \beta_1 \cdot \text{SCI - A} \left\{ {}^{300}_{0} \right\}_{ct} + \beta_2 \cdot \text{SCI - A} \left\{ {}^{500}_{301} \right\}_{ct} + \beta_3 \cdot \text{SCI - B \& C} \left\{ {}^{300}_{0} \right\}_{ct} + \beta_4 \cdot \text{SCI - B \& C} \left\{ {}^{500}_{301} \right\}_{ct} + \beta_5 \cdot \text{SCI - not graded} \left\{ {}^{300}_{0} \right\}_{ct} + \beta_6 \cdot \text{SCI - not graded} \left\{ {}^{500}_{301} \right\}_{ct} + \theta_c + \chi_t + Z'_{ct} * \delta + \epsilon_{ct}$, where θ_c and χ_t are county and year fixed effects, Z_{ct} are share urban, share Black, and manufacturing establishments per capita. The unit of observation is a county-year. The coefficients β_1 and β_3 are reported. All dependent variables are per 1,000 people and PPML is used for the estimation. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. The independent variables are constructed as described in the text. Information on medical school closures comes from *Medical Colleges of the United States and of Foreign Countries* which was published by the American Medical Association American Medical Association (1918). Information on the number of graduates from medical schools that closed comes from annual reports in the Journal of the American Medical Association.
$* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.15: The Impact of School Closures on Mortality by Old physicians fraction in 1900

	(1)	(2)	(3)
Panel A: Infant mortality, All Years			
SCI 0-300 miles	-0.0141***	-0.0201***	-0.0057
	(0.0026)	(0.0028)	(0.0052)
Observations	18336	9734	8602
Panel B: Total mortality, All Years			
SCI 0-300 miles	-0.0062***	-0.0082***	-0.0018
	(0.0015)	(0.0017)	(0.0036)
Observations	21907	11517	10390
Sample	All	Fraction Old High	Fraction Old Low
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures	X	X	X
Excluding closure within 50 miles			

Notes: This table presents estimates from specification (3) in the text. PPML is used for the estimation. Counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 8). The unit of observation is a county-year. In column (1), all data is used. Column (2) restricts the sample to counties with an above median fraction of old physicians in 1900, while column (3) restricts it to counties with a below median fraction of old physicians in 1900.
The dependent variables in Panel A are the number of deaths under one year of age per 1000 people. The dependent variables in Panel B are the number of all deaths per 1000 people. Infant mortality is not available for 1911-1914, so these years are omitted in Panel A. All estimates include SCI 300-500 miles, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses.

Table A.16: The Impact of School Closures on Mortality by Old physicians fraction in 1900

	(1)	(2)	(3)
Panel A: Infant mortality, All Years			
SCI 0-300 miles	-0.0141***	-0.0201***	-0.0057
	(0.0026)	(0.0028)	(0.0052)
Observations	18336	9734	8602
Panel B: Infant mortality, Census years			
SCI 0-300 miles	-0.0101***	-0.0120***	-0.0133**
	(0.0026)	(0.0034)	(0.0054)
Observations	2846	1495	1351
Panel C: Total mortality, All years			
SCI 0-300 miles	-0.0062***	-0.0082***	-0.0018
	(0.0015)	(0.0017)	(0.0036)
Observations	21907	11517	10390
Panel D: Total mortality, Census years			
SCI 0-300 miles	-0.0044***	-0.0054***	-0.0057*
	(0.0016)	(0.0016)	(0.0033)
Observations	2849	1498	1351
Sample	All	Fraction Old High	Fraction Old Low
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures	X	X	X
Excluding closure within 50 miles			
Observations	2849	1498	1351

Notes: This table presents estimates from specification (3) in the text. PPML is used for the estimation. Counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 8). The unit of observation is a county-year. In column (1), all data is used. Column (2) restricts the sample to counties with an above median fraction of old physicians in 1900, while column (3) restricts it to counties with a below median fraction of old physicians in 1900.
The dependent variables in Panels A and B are the number of deaths under one year of age per 1000 people. The dependent variables in Panels C and D are the number of all deaths per 1000 people. Infant mortality is not available for 1911-1914, so these years are omitted in Panel A. All estimates include SCI 300-500 miles, share urban, share Black, and manufacturing establishments per capita. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses.

Table A.17: The Impact of School Closures on Mortality by Old physicians fraction in 1900

	(1)	(2)	(3)
Panel A: Infant mortality, Census Years			
SCI 0-300 miles	-0.0181***	-0.0175***	-0.0191***
	(0.0055)	(0.0054)	(0.0062)
SCI A 0-300 miles * High Fraction	0.0090	0.0086	0.0090
	(0.0060)	(0.0059)	(0.0070)
Observations	2893	2846	2281
Panel B: Infant mortality, All years			
SCI 0-300 miles	-0.0143**	-0.0114**	-0.0059
	(0.0058)	(0.0052)	(0.0056)
SCI A 0-300 miles * High Fraction	-0.0013	-0.0045	-0.0076
	(0.0061)	(0.0052)	(0.0060)
Observations	18593	18336	15152
Panel C: Total mortality, Census years			
SCI 0-300 miles	-0.0086**	-0.0071**	-0.0058*
	(0.0036)	(0.0032)	(0.0031)
SCI A 0-300 miles * High Fraction	0.0037	0.0022	0.0012
	(0.0038)	(0.0034)	(0.0036)
Observations	2896	2849	2284
Panel D: Total mortality, All years			
SCI 0-300 miles	-0.0052	-0.0034	0.0016
	(0.0036)	(0.0034)	(0.0040)
SCI A 0-300 miles * High Fraction	-0.0020	-0.0038	-0.0064
	(0.0038)	(0.0035)	(0.0043)
Observations	22217	21907	18085
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	
Excluding closure within 50 miles			X

Notes: ADD

Table A.18: The Impact of School Closures on Mortality, 1900-1930 - Alternative DiD estimators

	(1)	(2)	(3)	(4)
Panel A: Infant mortality, All years				
High SCI 0-300 miles	-0.121**	-0.223	-0.090***	-0.149
	(0.056)	(0.281)	(0.027)	(0.166)
Observations	14000	14000	20310	20310
Panel B: Total mortality, All years				
High SCI 0-300 miles	-0.089*	-0.146	-0.062**	-0.113
	(0.052)	(0.235)	(0.028)	(0.165)
Observations	14930	14930	20394	20394
Method	TWFE	Callaway Sant'Anna (2021)	TWFE	Callaway Sant'Anna (2021)
	50th percentile	50th percentile	Mean 60th percentile	Mean 60th percentile

Notes: The unit of observation is a county-year. The dependent variable is the log of physicians per 1,000 people (i.e. $log(y)$). Columns (1) and (3) uses two-way fixed effects using county and year fixed effects. Columns (2) and (4) uses the estimator proposed by Callaway and Sant'Anna (2021). The independent variable is an indicator taking a value of one if SCI $\{^{300}_{0}\}_{ct}$ is at or above the 50th percentile or the 75th percentile. All estimates control for: SCI 300-500 miles, share urban, share Black, and manufacturing establishments per capita. Columns (1) and (3) includes county and year fixed effects. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 2). Standard errors are clustered at the county-level in columns(1) and (3). 95% confidence intervals are displayed in parentheses.

Appendix B: Medical School Closures and Mergers Between 1905 and 1915

The following table contains information on all medical school closures, absorptions, and mergers that occurred in the United States between 1905 and 1915. Information on these closures, absorptions, and mergers comes from *Medical Colleges of the United States and of Foreign Countries* which was published by the American Medical Association American Medical Association (1918).

Table B.1: Schools that Closed or Merged Between 1905 and 1915

	Closed	Merged	Absorbed	Year	Absorbing school name/merged name
1. American Medical Missionary College, Chicago, IL			X	1910	College of Physicians and Surgeons
2. Atlanta College of Physicians and Surgeons, Atlanta, GA				1915	Emory University (name change)
3. Atlanta School of Medicine, Atlanta, GA			X	1913	Atlanta College of Physicians and Surgeons
4. Atlantic Medical College, Baltimore, MD	X			1910	
5. Baltimore Medical College, Baltimore, MD			X	1913	University of Maryland School of Medicine
6. Baltimore University School of Medicine, Baltimore, MD	X			1907	
7. Barnes Medical College, St. Louis, MO			X	1911	National University of Arts and Sciences
8. Bennett Medical College, Chicago, IL			X	1915	Loyola University School of Medicine
9. Birmingham Medical School, Birmingham, AL	X			1915	
10. California Eclectic Medical College, Los Angeles, CA	X			1915	
11. Central College of Physicians and Surgeons, Indianapolis, IN		X		1905	Indiana Medical College, School of Medicine of Purdue University
12. Central Medical College of St. Joseph, St. Joseph, MO			X	1905	Ensworth Medical College
13. Chattanooga Medical College, Chattanooga, TN	X			1910	
14. Cleveland College of Physicians and Surgeons, Cleveland, OH			X	1910	Western Reserve University Medical Department
15. Cleveland-Pulte Medical College, Cleveland, OH	X			1914	

(Table B.1 continued)

	Closed	Merged	Absorbed	Year	Absorbing school/merged name
16. College of Medicine and Surgery (Physio-Medical), Chicago, IL			X	1911	Chicago College of Medicine and Surgery
17. College of Physicians and Surgeons, Little Rock, AR			X	1911	University of Arkansas Medical Department
18. College of Physicians and Surgeons, Baltimore, MD			X	1915	University of Maryland School of Medicine
19. College of Physicians and Surgeons, Dallas, TX	X			1910	
20. College of Physicians and Surgeons, Memphis, TN			X	1911	University of Tennessee College of Medicine
21. College of Physicians and Surgeons (Medical Department of Kansas City University), Kansas City, KS			X	1905	University of Kansas School of Medicine
22. Cooper Medical College, San Francisco, CA			X	1908	Leland Stanford Junior University
23. Dearborn Medical College, Chicago, IL	X			1907	
24. Denver College of Physicians and Surgeons, Denver, CO	X			1909	
25. Denver and Gross College of Medicine, Denever, CO			X	1911	University of Colorado School of Medicine
26. Detroit Homeopathic College, Detroit, MI	X			1912	
27. Drake University College of Medicine, Des Moines, IA			X	1913	State University of Iowa College of Medicine
28. Eclectic Medical College of Indiana, Indianapolis, IN	X			1908	
29. Eclectic Medical College of the City of New York, New York, NY	X			1913	
30. Ensworth Medical College, St. Joseph, MO	X			1914	

(Table B.1 continued)

	Closed	Merged	Absorbed	Year	Absorbing school/merged name
31. Epworth College of Medicine, Oklahoma City, OK	X			1910	
32. Flint Medical College of New Orleans University, New Orleans, LA	X			1911	
33. Fort Wayne College of Medicine, Fort Wayne, IN		X		1905	Indiana Medical College, School of Medicine of Purdue University
34. Gate City Medical College, Texarkana, TX	X			1908	
35. Grand Rapids Medical College, Grand Rapids, MI	X			1907	
36. Hahnemann Medical College, San Francisco, CA			X	1915	University of California Medical School
37. Harvey Medical College, Chicago, IL	X			1905	
38. Hering Medical University, Chicago, IL	X			1913	
39. Homeopathic Medical College of Missouri, St. Louis, MO	X			1909	
40. Hospital College of Medicine (Medical Department Central University of Kentucky),Louisville, KY		X		1907	Louisville and Hospital Medical College 1907
41. Hospital Medical College, Eclectic, Atlanta, GA	X			1911	
42. Kansas City Medical College, Kansas City, MO			X	1905	School of Medicine of the University of Kansas
43. Kansas Medical College, Topeka, KS			X	1913	University of Kansas School of Medicine
44. Kentucky School of Medicine, Louisville, KY			X	1908	Medical Department of the University of Louisville
45. Kentucky University Medical Department, Louisville, KY			X	1907	Medical Department of the University of Louisville

(Table B.1 continued)

	Closed	Merged	Absorbed	Year	Absorbing school/merged name
46. Keokuk Medical College (College of Physicians and Surgeons), Keokuk, IA			X	1908	Drake University College of Medicine
47. Knoxville Medical College, Knoxville, TN	X			1910	
48. Lincoln Memorial University Medical Department, Knoxville, TN			X	1914	University of Tennessee College of Medicine
49. Louisville Medical College, Louisville, KY		X		1907	Louisville and Hospital Medical College
50. Louisville National Medical College (Medical Department State University), Louisville, KY	X			1912	
51. Maryland Medical College, Baltimore, MD	X			1913	
52. Medical College of Indiana, Indianapolis, IN		X		1905	Indiana Medical College, School of Medicine of Purdue University
53. Medical College of Ohio, Cincinatti, OH		X		1909	Ohio-Miami Medical College of the University of Cincinatti
54. Medico-Chirurgical College of Kansas City, Kansas City, MO			X	1905	School of Medicine of the University of Kansas
55. Memphis Hospital Medical College, Memphis, TN			X	1913	University of Tennessee College of Medicine
56. Miami Medical College, Cincinatti, OH		X		1909	Ohio-Miami Medical College of the University of Cincinatti
57. Michigan College of Medicine and Surgery, Detroit, MI	X			1907	
58. Mississippi Medical College, Meridian, MS	X			1907	
59. National Medical University, Chicago, IL	X			1909	
60. Ohio Medical University, Colubus, OH		X		1907	Starling-Ohio Medical College

(Table B.1 continued)

	Closed	Merged	Absorbed	Year	Absorbing school/merged name
61. Ohio-Miami Medical College of the University of Cincinatti, Cincinatti, OH				1911	University of Cincinatti College of Medicine (name change)
62. Physio-Medical College of Indiana, Indianapolis, IN	X			1909	
63. Physio-Medical College of Texas, Dalla, TX		X		1908	College of Medicine and Surgery, Physio-Medical, Chicago
64. Pulte Medical College, Cincinatti, OH			X	1910	Cleveland-Pulte Medical College
65. Reliance Medical College, Chicago, IL			X	1911	Bennett Medical College
66. Sioux City College of Medicine, Sioux City, IA	X			1909	
67. Southern Methodist University Medical Department, Dallas, TX	X			1915	
68. Southwestern Homeopathic Medical College and Hospital, Louisville, KY	X			1910	
69. Starling-Ohio Medical College, Cincinatti, OH				1914	Ohio State University College of Medicine (name change)
70. Toldeo Medical College, Toledo, OH	X			1914	

(Table B.1 continued)

	Closed	Merged	Absorbed	Year	Absorbing school/merged name
71. University College of Medicine, Richomnd, VA			X	1913	Medical College of Virginia
72. University Medical College of Kansas City, Kansas City, MO	X			1913	
73. University of Minnesota College of Homeopathic Medicine and Surgery, Minneapolis, MN	X			1909	
74. University of Nashville Medical Department, Nashville, TN	X			1911	
75. University of Southern California College of Medicine, Los Angeles, CA			X	1909	University of California Medical School
76. University of the South Medical Department (Sewanee Medical College), Sewanee, TN	X			1909	
77. Willamette University Medical Department, Salem, OR			X	1913	University of Oregon Medical Department
78. Wisconsin College of Physicians and Surgeons, Milwaukee, WI				1913	Marquette University School of Medicine (property transfer)
79. Woman's Medical College of Baltimore, Baltimore, MD	X			1910	

Notes: This table lists all medical schools that closed, were absorbed, or merged with another medical school during the Flexner Era, which we define to be from 1905-1915.

Appendix C: Discrete model of physician location choice

To see how medical school closures affected physician's migration decision, we estimate a model of residential location choice.

Assume a country, populated by I individuals (physicians), is divided into J locations (counties), which differ in medical school closure intensity, as well as economic characteristics. Let $b(i)$ be the initial location for an individual i.

The utility that an individual i receives in location j is a function of the moving costs $(f(d_{b(i),j}))$ that the individual would have to pay to live in a location j, given she was in location $b(i)$ in the previous period, vectors of local attributes (c_j), an unobserved (to the econometrician) set of county attributes ϵ_j, and an idiosyncratic shock $\nu_{i,j}$. Specifically, the utility individual i receives from living in location j is given by:

$$U_{i,j} = \alpha_d f(d_{b(i),j}) + \alpha_c g(c_j) + \epsilon_j + \nu_{i,j} \tag{C.1}$$

We consider the following moving cost function:

$$f(d_{i,j}) = \gamma_1 d1_{i,j} + \gamma_2 d2_{i,j} + \gamma_3 d3_{i,j}, \tag{C.2}$$

where $d1$ is a dummy variable which is equal to 1 if a person would have to move less than 50 miles to get to location j and 0 otherwise, $d2$ is a dummy variable which is equal to 1 if a person would have to move more than 50 miles, but less than 300 miles and 0 otherwise, and $d3$ is a dummy variable which is equal to 1 if a person would have to move more than 300 miles, but less than 500 miles and 0 otherwise.

Assuming that an individual specific shock $\nu_{i,j}$ is distributed i.i.d. Type-I extreme, the probability that an individual i will choose to live in location j is given by:

$$P_{i,j}(d, c; \alpha) = Pr(lnV_{i,j} \geq lnV_{i,l}, \forall j \neq l) = \frac{exp(\alpha_c g(c_j) + \alpha_d f(d_{b(i),j}) + \epsilon_j)}{\sum_{l=1}^{J} exp(\alpha_c g(c_l) + \alpha_d f(d_{b(i),l}) + \epsilon_l)} \tag{C.3}$$

Replacing all variables that vary only by location j with a location specific fixed effect θ_j, we can rewrite migration equation (C.3) as:

$$P_{i,j}(d; \alpha, \theta) = \frac{exp(\alpha_d f(d_{b(i),j}) + \theta_j)}{\sum_{l=1}^{J} exp(\alpha_d f(d_{b(i),l}) + \theta_l)} \tag{C.4}$$

where

$$\theta_j(c_j; \alpha) = \alpha_c g(c_j) + \epsilon_j \tag{C.5}$$

The estimation proceeds in two steps. In the first step we estimate how moving costs affect individual's decision to move by estimating the likelihood function presented in equation (C.4). In the second step we regress location specific fixed effect $\widehat{\theta_j}$, estimated in the first step, which can be thought of as average/mean utility of a given location net of moving costs effects, on county-level characteristics, such as percent black, percent urban, manufacturing establishments per 1,000, as well as our measure of the school

closure intensity (SCI 0-300 miles).

In particular, we estimate the following equation:

$$\widehat{\theta_j(c_j;\alpha)} = \alpha_j^{SCI} SCI_j + \alpha_j^{Black} pctBlack_j + \alpha_j^{Urban} pctUrban_j + \alpha_j^{Manuf} ManufEst_j + \epsilon_j \quad \text{(C.6)}$$