NBER WORKING PAPER SERIES

MEDICAL SCHOOL CLOSURES, MARKET ADJUSTMENT, AND MORTALITY IN THE FLEXNER REPORT ERA

Karen Clay
Grant Miller
Margarita Portnykh
Ethan J. Schmick

Working Paper 33937
http://www.nber.org/papers/w33937

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 2025

We thank Marcella Alsan, Leah Boustan, Dan Bogart, Lou Cain, Claudia Goldin, Lauren HoehnVelasco, Maggie Jones, Chris Karbownik, Joe Price, Elyce Rotella, Andrew Smyth, Mel Stephens, Melissa Thomasson and conference and seminar participants at Canadian Network for Economic History, Carnegie Mellon University, Emory University, Harvard University, Marquette University, the National Bureau of Economic Research, Northwestern University, University of California, Irvine, University of Michigan, University of Montreal, University of Wisconsin-Milwaukee, and Yale University for useful comments. Karen Clay gratefully acknowledges financial support from Carnegie Mellon University. Grant Miller gratefully acknowledges financial support from Stanford University. All errors are our own. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

At least one co-author has disclosed additional relationships of potential relevance for this research. Further information is available online at http://www.nber.org/papers/w33937

Medical School Closures, Market Adjustment, and Mortality in the Flexner Report Era
Karen Clay, Grant Miller, Margarita Portnykh, and Ethan J. Schmick
NBER Working Paper No. 33937
June 2025
JEL No. I11, I18, N31, N32

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 be- tween 1900 and 1930 for county-level physicians, nurses, and midwives per capita as well as for infant, non-infant, and total 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 a 4% reduction in physicians per capita, even after physician market adjustment through physician migration and postponed retirement. Strikingly, we find that medical school closures led infant mortality rates to decline by 8% and non- infant mortality rates to decline by 4%, suggesting that reducing the supply of poorly trained physicians may have reduced mortality.

Karen Clay
Carnegie Mellon University
and NBER
kclay@andrew.cmu.edu

Grant Miller
Stanford University
School of Medicine
Department of Health Policy
and NBER
ngmiller@stanford.edu

Margarita Portnykh
Carnegie Mellon University
mportnyk@andrew.cmu.edu

Ethan J. Schmick
Marquette University
ethan.schmick@marquette.edu

"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. 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 era 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 AMA ratings and lower pass rates on state licensing exams. This suggests that the Flexner Era reforms reduced the supply of poorly trained physicians.

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, non-infant, and total mortality rates.[1] A priori, it is not obvious what the effect of medical school closures will be on physicians, nurses, or midwives, or on patterns of mortality in counties near closures, which historically absorbed the majority of graduates. If there is limited market adjustment, counties near closures 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. Nurses and midwives, which were not trained in medical schools, could also be affected if they were complements or substitutes for physicians. For population health, reducing the supply of poorly trained physicians could either increase or decrease 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, the number of graduates from all medical schools, full count Census of Population data from 1900 to 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 linked census samples from the Multigenerational Longitudinal Panel (Helgertz et al.,

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

2020) to 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-differences estimation framework with a continuous, time-varying treatment that we term school closure intensity (SCI). 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 from the linked sample 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 0-300 measure. We control for SCI 300-500 miles from closures, and we also examine SCI in varying gradations of distance from closures.

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. In our preferred specification, a county with average closure intensity experienced a 4% reduction in all physicians. The effects come from a mix of decreases in young physicians per capita, the flow of which is reduced in places near closures, and old physicians per capita, who suffer reputational effects if the medical school where they trained closes. These results are robust across a range of specifications.

Market adjustment to these closures 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. Notably, 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. A county with average closure intensity experienced a 7% increase in nurses. This is notable, because nurses were trained in hospitals or on the job and so were not directly affected by medical school closures.[2] Increases in the number of nurses per capita suggest that they were substitutes for physician labor.

Second, strikingly, infant, non-infant, and total mortality declined as a result of school closures within 300 miles.[3] A county with the average closure intensity experienced a 8% reduction in infant mortality and a 4% reduction in non-infant mortality. These estimates imply that 16,000 infant lives and 38,000 non-infant lives were saved per year by closing low quality medical schools. 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 medical

[2]Midwives were trained in specialty midwife schools or by assisting an experienced midwife.

[3]Non-infant mortality is the difference between the counts of total and infant mortality. Rates are computed per 1,000 in population to ensure comparability and to avoid known issues with birth registration (Eriksson, Niemesh and Thomasson, 2018).

school closures, 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, for physicians, we build on and complement the work of Moehling et al. (2020) and Andrews (2021).[4] 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 relocated or retired 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 – migration of students and existing physicians; retirement decisions among older physicians; and the response of surviving medical schools to closures.[5] 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.[6] An important open question

[4]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.

[5]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.

[6]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).

is if physicians and other health care workers contributed to improvements in health in the U.S. during the nineteenth and early twentieth centuries.[7] Our paper provides new evidence on the contribution of Flexner Era medical school closures to declines in infant, non-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 the historically and socially important case of medical school closures due to quality concerns. Our findings suggest 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.

[7] 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 state-level 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).

2 Historical Background

2.1 Physicians

2.1.1 Medical Education in the Late 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 initially consisted of just two years, although by 1900 most medical schools had a four-year curriculum.[8] 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 also rose rapidly in the late nineteenth century.[9] This 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).

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

[9]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.

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 the AMA's membership to increase from 10,600 in 1901 to more than 70,000 by 1910 (Shafroth, 1935). The newly 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.

The AMA found it politically difficult to critique medical schools directly, so it instead 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 70 (from about a high of 160 in 1900) (Rothstein, 1987; Miller and Weiss, 2008).

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.[10]

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. The geographic distribution of physicians per capita over time is shown in

[10] 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."

Appendix Figure A.2.

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 appear to have reduced 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 1903, immediately prior to the Flexner Era, and then 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 more slowly than the general 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.[11]

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 seen doctors less often. A Bureau of Labor Statistics study of the cost of living between 1918 and 1919 found that low income families had limited access to doctors (Bureau of Labor Statistics, 1924). A second large study in the 1920s found similar results (Community Health Service, 1932).[12]

[11] 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.

[12] 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 (Two-thirds or more of individuals in these professions were non-salaried) (Weinfeld, 1951). Between 1929 and 1949, physicians' average incomes grew 125%, while lawyers' incomes

While it is impossible to directly evaluate physician quality in historical settings, contemporary evidence on quality in lower-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 in these environments 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 Delhi (India), 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 pre-eclampsia (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).

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, making more correct diagnoses, performing more appropriate procedures, doing procedures more often under hygienic conditions, and offering better advice. Having higher quality doctors may have had spillover effects beyond the patients seen as well. For example, their advice may have been repeated to family, friends, or others (Finkelstein et al., 2022).

grew 50% and dentists' incomes grew 67%. One reason for this differential growth may be reductions in medical school graduates during Flexner Era reforms.

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.

Unlike physicians, nurses were primarily trained in hospitals or on the job and so were only indirectly affected by medical school closures. 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 midwives) 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. At the turn of the century, 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 infant, non-infant, and total 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.[13]

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 state-level infant mortality rates.[14] 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.[15]

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

[13]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).

[14]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.

[15]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.

the year that schools opened, graduated its first class, closed (if applicable), and merged with or were absorbed by another school (if applicable). Appendix Table B.1 shows a list of the 79 schools that were closed, absorbed, or merged during the Flexner Era.[16] 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 experienced an immediate increase of about 30 graduates, but returned 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.[17] Appendix Figure A.3 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:

$$\text{SCI}\begin{Bmatrix} j \\ i \end{Bmatrix}_{ct} = \frac{100 * \sum_{m_{ct}} \text{Graduates}_{m_{ct}}^{1901-1904}}{\sum_k \text{Graduates}_k^{1901-1904}} \tag{1}$$

In Equation (1), c indexes counties and t indexes years. $\text{SCI}\begin{Bmatrix} j \\ i \end{Bmatrix}_{ct}$ is school closure intensity measured 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

[16]We say that a medical school was absorbed by another school if all students in that school were 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. We say that medical schools merged when two or more medical schools came together to form a school with a new name.

[17]See table notes for the full empirical specification.

1904 from *all* medical schools in the United States. SCI $\left\{ {j \atop i} \right\}_{ct}$ is bounded between 0 and 100. SCI $\left\{ {j \atop i} \right\}_{ct}$ is 0 for all counties in 1900-1904 because we only consider 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.[18] This school closure intensity measure captures the effect 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 preferred 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 second is our more granular results showing that the effects of school closures are concentrated within 300 miles (see Section 5.1 and Figure 5).

The average county had a maximum SCI $\left\{ {300 \atop 0} \right\}_{ct}$ of 5.7, indicating that schools that closed within 300 miles of a county accounted for, on average, about 5.7% of all medical school graduates in the United States. Appendix Table A.1 provides summary statistics for SCI in different distance bins that we use in our empirical analysis for the 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.[19] The total number of graduates (between 1901-1904) from these schools was 3,423, while the number of graduates from all schools in the U.S was 22,083. Thus, by 1915, SCI for Cook County within 0 to 300 miles 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

[18] In a robustness check, we examine the effect of allowing extending the SCI to span 1905-1918.

[19] These closures included seven medical schools in Chicago, four in Louisville (KY), three in Indianapolis (IN), two in Cincinnati (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).

and graduated 84 students between 1901 and 1904. Thus, SCI for Los Angeles County within 0 to 300 miles was 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, 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 from 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).[20]

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.[21] The number of nurses per capita increased steadily over time. The number of midwives per capita was initially low and fell over time.

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

[21]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.

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 censuses (e.g. between 1900 and 1910).[22]

We use the MLP to investigate where physicians attended medical school.[23] 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 where 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).[24] From 1900-1915, 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

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

[23]In the linked sample, we define an individual as likely to have been in medical school in census 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. If so, we assume this is the county they attended medical school in. 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 year t (e.g. 1910).

[24]Infant mortality data for rural parts of counties were not published for 1911-1914. Total mortality and mortality by cause are both available during this time frame.

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, non-infant mortality rates, and total mortality rates computed per 1,000 people. We only include counties in the sample if they had entered the death registration area by 1910.[25] Appendix Figure A.4 shows a map of the death registration area in 1910 alongside the maximum SCI value in these counties. Appendix Table A.1 provides summary statistics for our sample for infant, non-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 flexibly across relatively narrow geographic ranges. Specifically, we estimate:

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

In Equation (2), y_{ct} is physicians, nurses, midwives, or mortality per capita in county c in year t. 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. We calculate SCI values for 0-50, 51-100, 101-200, and 201-300 miles of county c. We control for school closure intensity between 301 and 500 miles of county c, SCI $\left\{ {500 \atop 301} \right\}_{ct}$, 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

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

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) because 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, because it does not depend on choice of measurement unit.[26] PPML can, however, also yield biased estimates in some settings (Bellégo, Benatia and Pape, 2022). In Section 6, we examine the robustness of our results to a range of alternative log, level, and PPML specifications that include or do not include zeros.

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:

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

Equation (3) is similar to Equation (2), but our school closure intensity measure now captures closures within 0 to 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 (2) and (3) reflect the effect of medical school

[26] 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.

closures assuming that there are no other shocks correlated with proximity to school closures and 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. Unfortunately, our case is not easily compatible with an event study framework because we do not study a single well-defined "event" (multiple school closures affect a given county and these closures occur at different times). Although we cannot easily test the parallel trends assumption in our setting, the large number of never-treated units in our setting suggests that parameters can be identified (Marcus and Sant'Anna, 2021).[27]

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.[28]

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 there-

[27]We have a large never treated group of counties – 315 out of 2,982 counties (11%). 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).

[28]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.

fore conduct an exercise in which we 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). Treated counties move from being not treated to being treated in the year SCI $\left\{ {}^{300}_{0} \right\}_{ct}$ crosses the Xth percentile. We perform this analysis for the median (50th percentile) and the mean ($\sim$ 60th percentile).

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 of SCI within 0-300 miles, as our main specification.

Consistent with Figure 5, Table 2 also shows that physicians per capita declined in counties within 300 miles of a closure.[29] These estimates from Equation (3) are similar across the three different samples: all counties (column 1), all counties except those with

[29]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.

closures (column 2), and all counties except those 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.[30] Panel B highlights that these 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.[31] Panel C also shows that in counties at mean SCI, older physicians (older than age 40) per capita declined by 4%.[32][33] Appendix Table A.3 shows that the declines were largely driven by closures of B & C graded schools.

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 7% on average, suggesting that they functioned as substitutes for physicians.[34] Table 2 Panel E shows that medical school closures did not have a statistically significant effect on midwives per capita. Appendix Figure A.5 plots SCI estimates for closures on nurses and midwives within 0-50, 50-100, 100-200, 200-300, and 300-500 miles.

[30] 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).

[31] 5.74$*$-0.016=0.092

[32] 5.74$*$-0.007=0.040

[33] Appendix Table A.2 indicates that closures of *all* medical schools had little effect on the geographic distribution of Black, female, and foreign-born physicians.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).

[34] 5.74$*$0.011=0.063

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.[35] These reductions explain about 16% of the overall decline between 1900 and 1920 and 12% of the overall decline between 1900 and 1930.[36] For nurses, the effect of closures was 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, medical school closures within 300 miles led to reductions in physicians per capita. 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. In column 1 we examine enrollment using Equation (3) for counties that had a medical school remain open throughout

[35] 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.

[36] 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)

the period. In column 2, we examine enrollment for counties had a medical school remain open throughout the period *plus* enrollment in medical schools that opened after 1901 and remained open through 1930.[37] In both columns, 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 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 considerably when medical schools began requiring one or two years of undergraduate education prior to attending medical school.

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) (Appendix C presents the details of this model). 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 in magnitude with distance, indicating that moving longer distances is more costly.

The second part of Table 5 shows that counties with greater school closure intensity within 300 miles were attractive destinations for physicians. Recall, however, that the estimates in Table 2 are nonetheless still negative, suggesting that physician migration did not fully offset the effect of closures. Specifically, the estimates for SCI 0-300 miles in Table 5 are positive and significant for all physicians, old physicians, and young physicians. Reductions in physicians per capita due to medical school closures appear

[37]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).

to have created opportunities for other physicians to move to these counties.

Finally, Table 6 shows 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), but with different fixed effects since our unit of analysis is now an individual (see table notes for more details on the specification). 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 physicians change careers or retire. The dependent variables are dummy variables for whether the person quit being a physician (=1) or not (=0); changed occupation (=1) or not (=0); or retired (=1) or not (=0). Panel B reports parallel results dropping physicians who were initially (in 1910) living in a county that experienced a medical school closure between 1905 and 1915. The first column of both Panels A and B shows that physicians in counties with an average SCI had a 0.6 percentage point reduction in the probability that they exited medicine, a relative reduction of 4%.[38] 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 percentage points less likely to retire over the next decade, a relative decline of 12%.[39]

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.

[38] $5.74 * -0.001 = 0.006$. The average probability of exit from medicine over our study period is 16 percentage points. Thus, 0.006/0.16 = 0.04 or a 4% change.

[39] $5.74 * -0.001 = 0.006$. The average probability of retirement over our study period is 5 percentage points. Thus, 0.006/0.05=0.12 or 12%.

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).[40] In 1900, ten states and the District of Columbia were part of the DRA. Mortality data for these areas were collected and published by the Census. The DRA then expanded over time as more states joined. In our analysis, we restrict attention to counties that were in the DRA by 1910, when the Flexner Report was released.[41] By 1910, the DRA contained roughly half of the United States population and half of all doctors and nurses.

Appendix Table A.4 shows summary statistics for counties included and excluded from the DRA in 1910. 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: larger 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).

Appendix Table A.4 suggests that counties in the DRA in 1910 are significantly different from counties outside the DRA along a number of dimensions. Therefore, 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 in the DRA

[40] 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. States that adopted the standard death certificate formed the DRA.

[41] 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.

(Panel A) is similar to the effects of closures on physicians per capita in Table 2 for the U.S. as a whole.[42] 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.[43] In Panels B and C, in the DRA, there was no effect on young physicians and a large negative effect on old physicians.[44] Outside the DRA, there was a large negative effect on young physicians and a more modest negative effect on old physicians. The differences in the effects on old and young physicians across the two groups of counties may reflect the 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. In Panels D and E, counties in the DRA with high SCI experienced significant increases in nurses per capita and no change in midwives per capita. The average county in the DRA had an 8% increase in nurses per capita.

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 lower quality, on average, simply because their training 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.[45] 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 presum-

[42] Appendix Table A.5 shows that the declines were largely driven by B & C graded schools.

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

[44] The effects by distance bins estimated for the DRA sample only are shown in Appendix Figure A.6.

[45] 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.

ably had relatively lower quality young physicians). Thus, closures should increase the average quality of young physicians as well.[46]

The overall effects of medical school 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 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, non-infant, and total mortality. The table reports estimates from Equation (3) for infant mortality, non-infant, and total mortality. As before, Column 2 is our preferred specification. The analysis utilizes annual variation in SCI and the fact that the mortality data are also available annually. For the years with infant mortality, it is possible to subtract counts of infant mortality from counts total mortality to get counts of non-infant mortality and then convert this to a rate. This allows us to investigate the extent to which changes in total mortality are driven by changes in infant mortality.

In a DRA county with the average SCI, infant mortality fell 8%, non-infant mortality fell 4%, and total mortality (excluding 1911-1914) fell 5%.[47] Results are shown for total

[46] 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.

[47] For infant mortality, 0.077 = 0.0141*5.45. For non-infant mortality, 0.041 = 0.0075*5.45. For total mortality, 0.045 = 0.0082*5.45

mortality (excluding 1911-1914), which matches the samples for infant and non-infant mortality, and for total mortality (including 1911-1914). The number of observations differs across specification, because data on infant and non-infant mortality are available up to 1910 and from 1915 onward, while data on total mortality is available for the entire period. The effects for infant mortality and total mortality by distance bins are shown in Appendix Figure A.7. The declines in infant mortality, non-infant, and total mortality were largest within 50 miles of closures, but mortality declines were observed at distances of up to 200 miles. Applying the estimated decrease in infant and non-infant mortality from Table 8 to the 1910 mortality rate suggests that Flexner Era medical school reforms may have averted about 16,000 infant deaths and 38,000 non-infant deaths per year.[48]

Appendix Table A.6 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 and provided funding for maternal and infant care educational initiatives (Moehling and Thomasson, 2014). Moehling and Thomasson (2014) find that home visits by public health nurses played an important role in reducing infant mortality.

Appendix Table A.7 suggests that closure of B & C graded medical schools was likely driving the decline in mortality. This is consistent with Appendix Table A.5, which showed that declines in physicians per capita were driven by the closure of B & C graded schools.

The magnitude for infant mortality can be compared to other studies of infant mortality during this time period. Alsan and Goldin (2019) find that the introduction of water

[48]Applying our estimate of a 8% reduction in infant mortality to the 1910 infant mortality rate (2.18 infant deaths per 1,000 people with 92,200,000 people living in the United States) yields 16,080 infant lives saved. Applying our estimate of a 4% reduction in non-infant mortality to the 1910 non-infant mortality rate (10.23 deaths per 1,000 people with 92,200,000 people living in the United States) yields 37,728 non-infant lives saved.

and sewerage in the Boston Area between 1880-1920 reduced infant mortality by 23 percent. Anderson et al. (2022) find that municipal water filtration reduced infant mortality by 11-12 percent in 25 cities between 1900 and 1940. During a slightly later period, 1933-1939, Jacks, Pendakur and Shigeoka (2021) find that the repeal of Prohibition increased infant mortality by 4-5%. Thus, the magnitudes of the effects of medical school closures on infant mortality (8%) fall between the effects of the repeal of Prohibition (4-5%) and the effects of water filtration (11-12%).

In Table 9, we 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 and by cause are not available after 1915, so these results only capture 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 to 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 (Tomes, 1999). 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 issue is that these mortality effects might have operated through other channels, such as county responses to medical school closures. Table 10 shows that medical school closures are unrelated or negatively related to the size of county health departments, city health-related expenditures, and county hospital infrastructure (Hoehn-Velasco, 2021; Cain and Rotella, 2022).[49] 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 did not affect city sewer or refuse expenditures per capita (and in fact, medical school closures seem to have *decreased* water expenditures per capita). The fact that cities did not respond to closures by investing more in water infrastructure per capita is also consistent with the evidence in Table 9, which showed that medical school closures had no effect on typhoid fever mortality.[50] 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 perform a variety of tests on our results: (i) using alternative log, level, and PPML specifications with and without zeros, (ii) using alternative measures of SCI, (iii) using other occupations that should not reasonably respond to closures as 'placebo' outcomes for physicians, (iv) testing for confounding region-year and division-year effects, (v) evaluating the consequences of using spatially-clustered standard errors, and (vi) evaluating the extent of any bias due to the use of two-way fixed effects (TWFE) estimation with staggered treatment timing.[51] In the interest of parsimony, in this sub-

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

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

[51]Using a difference-in-differences 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 because we do not study a single well-defined "event" (multiple school closures affect a given county and these closures occur at different times).

section we only report robustness results for physicians and mortality.[52]

First, we show that the physician and mortality results are robust to a number of alternative methods for addressing dependent variable values of zero. The literature on estimation with dependent variable values of zero (Chen and Roth, 2023; Bellégo, Benatia and Pape, 2022) has shown that the sign and magnitudes of effects can vary across log, level, and PPML specifications and with the magnitude of the constant term that is added to the dependent variable for log transformed dependent variables. Appendix Tables A.8 and A.9 show results from re-estimating Equation (3) using these different approaches: excluding observations that have zero for the dependent variable, using log transformations of the dependent variable and estimating using OLS, and using no transformation of the dependent variable and estimating using OLS. Our primary estimates reported in Table 2 use PPML, as shown in column 1 of both tables. All estimates in the tables are negative and statistically significant. Consistent with the literature on estimation with dependent variable values of zero (Chen and Roth, 2023; Bellégo, Benatia and Pape, 2022), the magnitudes of the estimates vary across approaches and with the magnitude of the constant term that is added to the dependent variable in the case of log transformed dependent variables.

Second, we show that the physician and mortality results are generally similar using alternative measures of SCI. These alternative measures include extending the window of closures through 1918 (which captures nearly all the closures; see Figure 1) and estimating effects separately for earlier (1905-1910) and later (1911-1915) closures. These estimates, shown in Appendix Tables A.10 and A.11, are similar to our primary results in Tables 2 and 8. The one exception is that closures had different effects among older physicians in the earlier and later periods.[53]

[52]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.

[53]Appendix Table A.10 also includes estimates for Black and Women's medical school closures. The sample of Black and Women's medical schools is small, as are the number of Black and female physicians, leading to noisy estimates Black and Female physicians. It is unclear why the estimate for Black physicians is otherwise positive and significant.

Third, 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.[54] We also generate a sixth category of all workers outside of medical care, which combines the five occupational categories. We then re-estimate Equation (2) using these other occupation categories as 'placebo' outcomes. Appendix Figure A.8 shows that in contrast to our results for physicians, the estimates for other occupations are generally 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 during the Flexner Era.

Fourth, we show that secular region- and division-level changes do not explain the relationship between medical school closures and either physicians or mortality per capita. Appendix Tables A.12 and A.13 present results from re-estimating Equation (3) controlling for alternative fixed effects and time trends, including region time trends, region-year fixed effects, division time trends, and division-year fixed effects. The estimates are similar in sign, significance, and magnitude to our primary results.

Fifth, we show that our results are robust to using spatially-clustered standard errors (Conley, 1999).[55] For spatial standard errors, we use a natural log transformation of the dependent variable rather than PPML because to our knowledge, spatial standard errors cannot be computed using PPML.[56] Appendix Tables A.14 and A.15 show that these results are similar in sign and statistical significance to those in Tables 2 and 8. The

[54]We define white collar workers outside of medical care as having an occupation code 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. blacksmiths, 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).

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

[56]To be precise, we use the transformation $log(1 + y)$.

standard errors increase somewhat in columns 2-5 as we move from no spatial standard errors to allowing spatial correlation within 100, 150, and 200 kilometers.

Finally, we show that our estimates are robust to correcting for the use of conventional TWFE 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 classify counties dichotomously based on whether they are above/below the median and the mean ($\sim$ 60th percentile) in the SCI distribution. We turn this treatment variable on the first year a county is above the dichotomous cutoff (median or mean depending on specification) and re-estimate Equation (3).

Appendix Tables A.16 and A.17 show TWFE estimates using this approach alongside Callaway and Sant'Anna (2021) estimates for physicians and mortality. In Appendix Table A.16, the Callaway and Sant'Anna (2021) estimates are comparable to or larger than the standard TWFE estimates. Although the Callaway and Sant'Anna (2021) estimates are noisier than the TWFE estimates in Appendix Table A.17, the magnitudes of the coefficients are larger than the TWFE estimates, and they are similar to our primary mortality estimates in Table 8. For example, our main mortality estimate for infant mortality in Panel B, column 2 of Table 8 evaluated at the mean is -0.08 (-0.0141 x 5.45). This is similar to the estimates in Panel A, columns 3 and 4 of Appendix Table A.17.

In sum, we showed that our results are robust to: (i) using alternative log, level, or PPML specifications with and without zeros, (ii) using other measures of SCI, (iii) using other occupations that should not reasonably respond to closures as 'placebo' outcomes, (iv) controlling for a variety of secular trends and shocks, (v) using spatially-clustered standard errors, and (vi) 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 physician 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 on physician supply and mortality between 1900 and 1930.

We find that areas close to medical school closures (within 300 miles) were the most heavily 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 physicians by 4%. The effects also grew over time 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 physicians either; despite not begin trained in medical schools, school closures within 300 miles of a county increased the number of nurses per capita as well.

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 closures, mortality could have declined. Empirically, we find that closing lower quality medical schools reduced infant mortality by 8% and non-infant mortality by 4%, suggesting that, at least on average, Flexner Era reforms improved population health.

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. Relative to the mortality rate in 1910, our results suggest that Flexner Era medical school reforms may have averted 16,000 infant deaths and 38,000 non-infant deaths per year. Flexner Era medical school closures undoubtedly also changed the cost of, and access to, healthcare services – and women and minorities may have been disproportionately affected by these changes (we are unfortunately, unaware of data on health outcomes by gender and race for most states during this time) (Harley, 2006; Hunt, 1993; Laws, 2021; Miller and Weiss, 2012). Thus, although the welfare implications of Flexner Era reforms are uncertain, any reasonable value of a statistical life suggests that the benefits were very large.

References

Alsan, Marcella, and Claudia Goldin. 2019. "Watersheds in child mortality: The role of effective water and sewerage infrastructure, 1880–1920." *Journal of Political Economy*, 127(2): 586–638.

American Medical Association. 1918. "Medical Colleges of the United States and of Foreign Countries." American Medical Association.

Anderson, D Mark, Kerwin Kofi Charles, and Daniel I Rees. 2020. "Re-examining the contribution of public health efforts to the decline in urban mortality." *American Economic Journal: Applied Economics*, 143–75.

Anderson, D Mark, Kerwin Kofi Charles, Michael McKelligott, and Daniel I Rees. 2022. "Safeguarding Consumers Through Minimum Quality Standards: Milk Inspections and Urban Mortality, 1880-1910." National Bureau of Economic Research.

Anderson, D Mark, Ryan Brown, Kerwin Kofi Charles, and Daniel I Rees. 2020. "Occupational licensing and maternal health: Evidence from early midwifery laws." *Journal of Political Economy*, 128(11): 4337–4383.

Andrews, Brendon Patrick. 2021. "Reporting versus Reputation: Physician Quality and the Flexner Report of 1910." *Working Paper*.

Bailey, Martha, Karen Clay, Price Fishback, Michael Haines, Shawn Kantor, Edson Severnini, and Anna Wentz. 2018. "Inter-university Consortium for Political & Social Research ICPSR. 2018."US County-Level Natality and Mortality Data, 1915-2007." Inter-university Consortium for Political and Social Research." *Ann Arbor, MI*.

Bailey, Moya. 2017. "The Flexner report: standardizing medical students through region-, gender-, and race-based hierarchies." *American journal of law & medicine*, 43(2-3): 209–223.

Baker, Samuel L. 1984. "Physician licensure laws in the United States, 1865–1915." *Journal of the History of Medicine and Allied Sciences*, 39(2): 173–197.

Banerjee, Abhijit, Angus Deaton, and Esther Duflo. 2004. "Health, health care, and economic development: Wealth, health, and health services in rural Rajasthan." *The American economic review*, 94(2): 326.

Barzansky, Barbara. 2010. "Abraham Flexner and the era of medical education reform." *Academic Medicine*, 85(9): S19–S25.

Beach, Brian, Karen Clay, and Martin Saavedra. 2022. "The 1918 influenza pandemic and its lessons for COVID-19." *Journal of Economic Literature*, 60(1): 41–84.

Bellégo, Christophe, David Benatia, and Louis Pape. 2022. "Dealing with logs and zeros in regression models." *arXiv preprint arXiv:2203.11820*.

Bureau of Labor Statistics. 1924. "Cost of Living in the United States, Bulletin No. 357." U.S. Department of Labor.

Burlingon Weekly Free Press. March 26, 1914. "Medical College Needs Aid." *Burlingon Weekly Free Press*.

Cain, Louis P, and Elyce J Rotella. 2022. "Urbanization, sanitation, and mortality in the progressive era, 1899–1929." In *Standard of Living: Essays on Economics, History, and Religion in Honor of John E. Murray*1–17. Springer.

Callaway, Brantly, and Pedro HC Sant'Anna. 2021. "Difference-in-differences with multiple time periods." *Journal of Econometrics*, 225(2): 200–230.

Chen, Jiafeng, and Jonathan Roth. 2023. "Logs with Zeros? Some Problems and Solutions*." *The Quarterly Journal of Economics*, 139(2): 891–936.

Community Health Service. 1932. *Medical Care for the American People: The Final Report of the Committee on the Costs of Medical Care, Adopted October 31, 1932.* US Department of Health, Education, and Welfare, Public Health Service.

Conley, Timothy G. 1999. "GMM estimation with cross sectional dependence." *Journal of econometrics*, 92(1): 1–45.

Cutler, David, and Grant Miller. 2005. "The role of public health improvements in health advances: the twentieth-century United States." *Demography*, 42(1): 1–22.

Dafny, Leemore, and David Dranove. 2008. "Do report cards tell consumers anything they don't already know? The case of Medicare HMOs." *The Rand journal of economics*, 39(3): 790–821.

Daily Capital Journal. July 25, 1910. "Country Flooded with Quacks." *Daily Capital Journal; Salem, Oregon*.

Das, Jishnu, Alaka Holla, Aakash Mohpal, and Karthik Muralidharan. 2016. "Quality and accountability in health care delivery: audit-study evidence from primary care in India." *American Economic Review*, 106(12): 3765–99.

Das, Jishnu, Alaka Holla, Veena Das, Manoj Mohanan, Diana Tabak, and Brian Chan. 2012. "In urban and rural India, a standardized patient study showed low levels of provider training and huge quality gaps." *Health affairs*, 31(12): 2774–2784.

Das, Jishnu, and Jeffrey Hammer. 2014. "Quality of primary care in low-income countries: facts and economics." *Annu. Rev. Econ.*, 6(1): 525–553.

Das, Jishnu, Jeffrey Hammer, and Kenneth Leonard. 2008. "The quality of medical advice in low-income countries." *Journal of Economic perspectives*, 22(2): 93–114.

Dingwall, Robert, Anne Marie Rafferty, and Charles Webster. 2002. *An introduction to the social history of nursing.* Routledge.

D'Antonio, Patricia, and Jean C Whelan. 2009. "Counting nurses: the power of historical census data." *Journal of Clinical Nursing*, 18(19): 2717–2724.

Egenes, Karen J. 2017. "History of nursing." *Issues and trends in nursing: Essential knowledge for today and tomorrow*, 1–26.

El Paso Herald. June 8, 1910. "Poor Medical Colleges a Danger." *El Paso Herald*.

Eriksson, Katherine, Gregory T Niemesh, and Melissa Thomasson. 2018. "Revising infant mortality rates for the early twentieth century United States." *Demography*, 55(6): 2001–2024.

Ferrara, Andreas, Patrick A Testa, Liyang Zhou, et al. 2022. "New area-and population-based geographic crosswalks for US counties and congressional districts, 1790-2020." Social Science Research Network (SSRN).

Finkelstein, Amy, Petra Persson, Maria Polyakova, and Jesse M Shapiro. 2022. "A taste of their own medicine: guideline adherence and access to expertise." *American Economic Review: Insights*, 4(4): 507–526.

Flexner, Abraham. 1910. "Medical Education in the United States and Canada." The Carnegie Foundation for the Advancement of Teaching.

Fogel, Robert W. 1986. "Nutrition and the decline in mortality since 1700: some preliminary findings." In *Long-term factors in American economic growth*439–556. University of Chicago Press.

Grand Forks Daily Herald. October 14, 1915. "Medical College Class A." *Grand Forks Daily Herald*.

Haines, Michael R. 2001. "The urban mortality transition in the United States, 1800-1940." 33–64, Belin.

Hamilton, Diane. 1988. "Clinical Excellence, but too High a Cost: The Metropolitan Life Insurance Company Visiting Nurse Service (1909-1953)." *Public Health Nursing*, 5(4): 235–240.

Harley, Earl H. 2006. "The forgotten history of defunct black medical schools in the 19th and 20th centuries and the impact of the Flexner Report." *Journal of the National Medical Association*, 98(9): 1425.

Helgertz, Jonas, Steven Ruggles, John Robert Warren, Catherine A. Fitch, Ronald Goeken, J. David Hack, Matt A. Nelson, Joseph P. Price, Evan Roberts, and Matthew Sobek. 2020. "IPUMS Multigenerational Longitudinal Panel: Version 1.0 [dataset]." IPUMS.

Helgertz, Jonas, Steven Ruggles, John Robert Warren, Catherine Fitch, J David Hacker, Matt Nelson, Joseph Price, Evan Roberts, and Matthew Sobek. 2023. "IPUMS Multigenerational Longitudinal Panel: Version 1.1 [dataset]."

Hoehn-Velasco, Lauren. 2021. "The long-term impact of preventative public health programs." *The Economic Journal*, 131(634): 797–826.

Humphreys, Margaret. 2001. *Malaria: poverty, race, and public health in the United States.* JHU Press.

Hunt, Susan. 1993. "The Flexner Report and black academic medicine: an assignment of place." *Journal of the National Medical Association*, 85(2): 151.

Jacks, David S, Krishna Pendakur, and Hitoshi Shigeoka. 2021. "Infant mortality and the repeal of federal prohibition." *The Economic Journal*, 131(639): 2955–2983.

Jacob, Brian A, and Steven D Levitt. 2003. "Rotten apples: An investigation of the prevalence and predictors of teacher cheating." *The Quarterly Journal of Economics*, 118(3): 843–877.

JAMA. 1901-1921. "Statistics of medical colleges in the United States and Canada." The Journal of the American Medical Association.

Jayachandran, Seema, Adriana Lleras-Muney, and Kimberly V Smith. 2010. "Modern medicine and the twentieth century decline in mortality: Evidence on the impact of sulfa drugs." *American Economic Journal: Applied Economics*, 2(2): 118–46.

Jin, Ginger Zhe, and Phillip Leslie. 2003. "The effect of information on product quality: Evidence from restaurant hygiene grade cards." *The Quarterly Journal of Economics*, 118(2): 409–451.

Kane, Thomas J, and Douglas O Staiger. 2002. "The promise and pitfalls of using imprecise school accountability measures." *Journal of Economic perspectives*, 16(4): 91–114.

Law, Marc T, and Sukkoo Kim. 2005. "Specialization and regulation: The rise of professionals and the emergence of occupational licensing regulation." *The Journal of Economic History*, 65(3): 723–756.

Laws, Terri. 2021. "How should we respond to racist legacies in health professions education originating in the Flexner report?" *AMA Journal of Ethics*, 23(3): 271–275.

Ludmerer, Kenneth M. 1985. "Learning to heal: the development of American medical education."

Marcus, Michelle, and Pedro H. C. Sant'Anna. 2021. "The Role of Parallel Trends in Event Study Settings: An Application to Environmental Economics." *Journal of the Association of Environmental and Resource Economists*, 8(2): 235–275.

Miller, Grant. 2008. "Women's suffrage, political responsiveness, and child survival in American history." *The Quarterly Journal of Economics*, 123(3): 1287–1327.

Miller, Lynn E, and Richard M Weiss. 2008. "Medical Education Reform Efforts and Failures of US Medical Schools, 1870–1930." *Journal of the History of Medicine and Allied Sciences*, 63(3): 348–387.

Miller, Lynn E, and Richard M Weiss. 2012. "Revisiting Black medical school extinctions in the Flexner era." *Journal of the history of medicine and allied sciences*, 67(2): 217–243.

Milwaukee Leader. December 5, 1912. "Medical Students Walk Out of Classes." *Milwaukee Leader*.

Moehling, Carolyn M, and Melissa A Thomasson. 2014. "Saving babies: the impact of public education programs on infant mortality." *Demography*, 51(2): 367–386.

Moehling, Carolyn M, Gregory T Niemesh, and Melissa A Thomasson. 2019. "Shut Down and Shut Out: Women Physicians in the Era of Medical Education Reform." *Draft Manuscript. Version: April*.

Moehling, Carolyn M, Gregory T Niemesh, Melissa A Thomasson, and Jaret Treber. 2020. "Medical education reforms and the origins of the rural physician shortage." *Cliometrica*, 14(2): 181–225.

Mohanan, Manoj, Marcos Vera-Hernández, Veena Das, Soledad Giardili, Jeremy D Goldhaber-Fiebert, Tracy L Rabin, Sunil S Raj, Jeremy I Schwartz, and Aparna Seth. 2015. "The know-do gap in quality of health care for childhood diarrhea and pneumonia in rural India." *JAMA pediatrics*, 169(4): 349–357.

Mokyr, Joel. 1993. "Technological progress and the decline of European mortality." *The American Economic Review*, 83(2): 324–330.

New York Tribune. June 12, 1910. "Carnegie Foundation Experts Unruffled by St. Louis Suit." *New York Tribune*.

Rock Island Argus. June 11, 1910. "Medical School Demands $100,000 of Carnegie Officials." *Rock Island Argus*.

Rooks, Judith Pence, and Charles S Mahan. 1997. "Midwifery and childbirth in America."

Rothstein, William G. 1987. *American medical schools and the practice of medicine: A history.* Oxford University Press.

Ruggles, Steven, Catherine A. Fitch, Ronald Goeken, J. David Hacker, Matt A. Nelson, Evan Roberts, Megan Schouweiler, and Matthew Sobek. 2021. "IPUMS Ancestry Full Count Data: Version 3.0 [dataset]." IPUMS.

Rushing, Beth. 1994. "Turn-of-the-Century Midwifery Practice among North." *Ethnic Women: A Multiple Status Reality*, 104.

Salt Lake Herald Republican. June 13, 1910. "Inferior Doctors Flood Country." *Salt Lake Herald Republican*.

Sandvick, Clinton. 2009. "Enforcing Medical Licensing in Illinois: 1877-1890." *The Yale Journal of Biology and Medicine*, 82(2): 67.

Savitt, Todd. 2006. "Abraham Flexner and the black medical schools. 1992." *Journal of the National Medical Association*, 98(9): 1415.

Shafroth, Will. 1935. "How the Doctors Solved the Coordination Problem: An Account of the Reorganization and Present Constitution of the American Medical Association." *American Bar Association Journal*, 21(4): 221–223.

Sinha, Paramita, Martha L Caulkins, and Maureen L Cropper. 2018. "Household location decisions and the value of climate amenities." *Journal of Environmental Economics and Management*, 92: 608–637.

Starr, Paul. 1982. *The Social Transformation of American Medicine: The Rise of a Sovereign Profession and the Making of a Vast Industry.* Basic Books.

The Herald and News. February 28, 1913. "Medical College Class B." *The Herald and News; Newberry, South Carolina*.

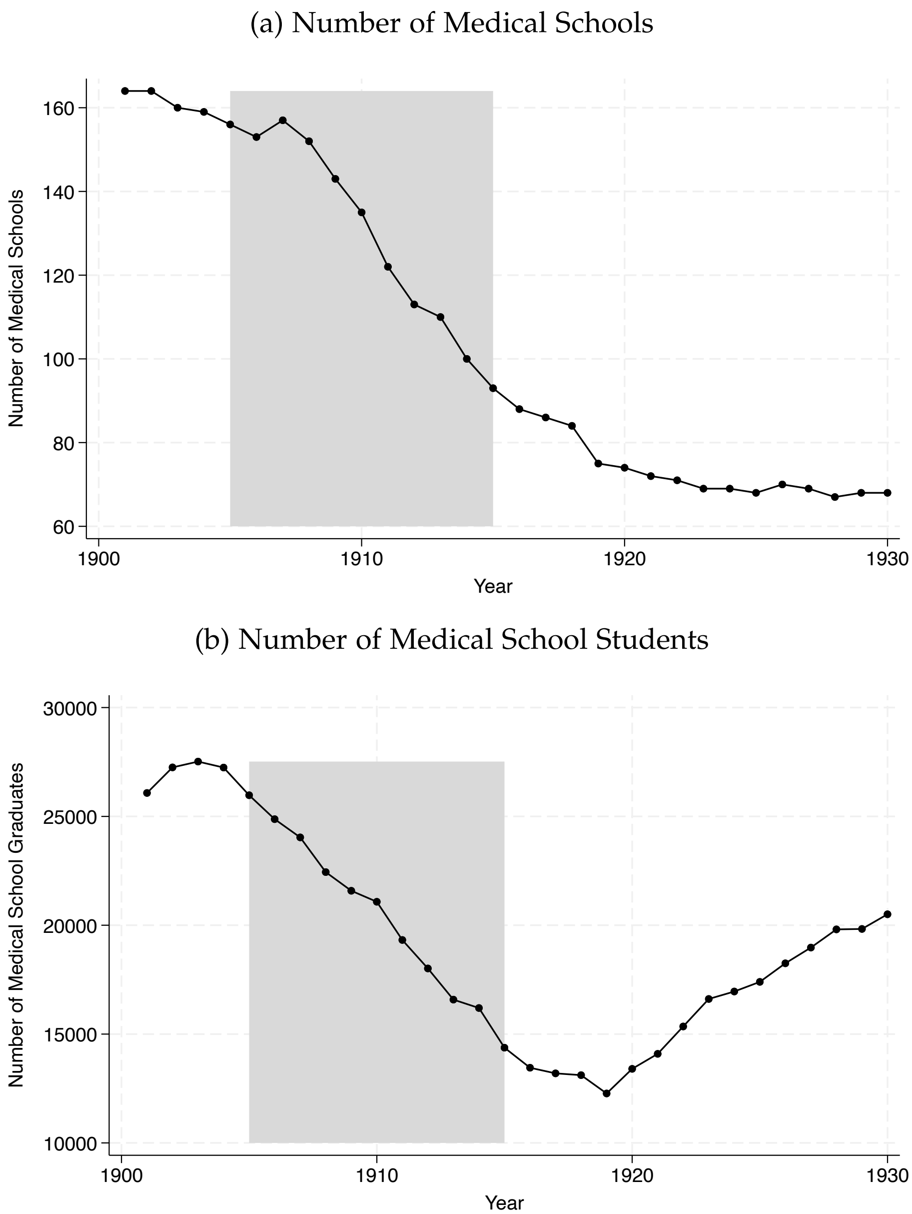
Timmins, Christopher. 2007. "If You Cannot Take the Heat, Get Out of the Cerrado & Recovering the Equilibrium Amenity Cost of Nonmarginal Climate Change in Brazil." *Urban Economics & Regional Studies*.

Tomes, Nancy. 1999. *The Gospel of Germs: Men, Women, and the Microbe in American Life.* Harvard University Press.

Van Buren, George H. 1917. "COMPARABILITY—THE WILL-O'-THE-WISP OF CAUSE OF DEATH STATISTICS?" *American Journal of Public Health*, 7(12): 1016–1026.

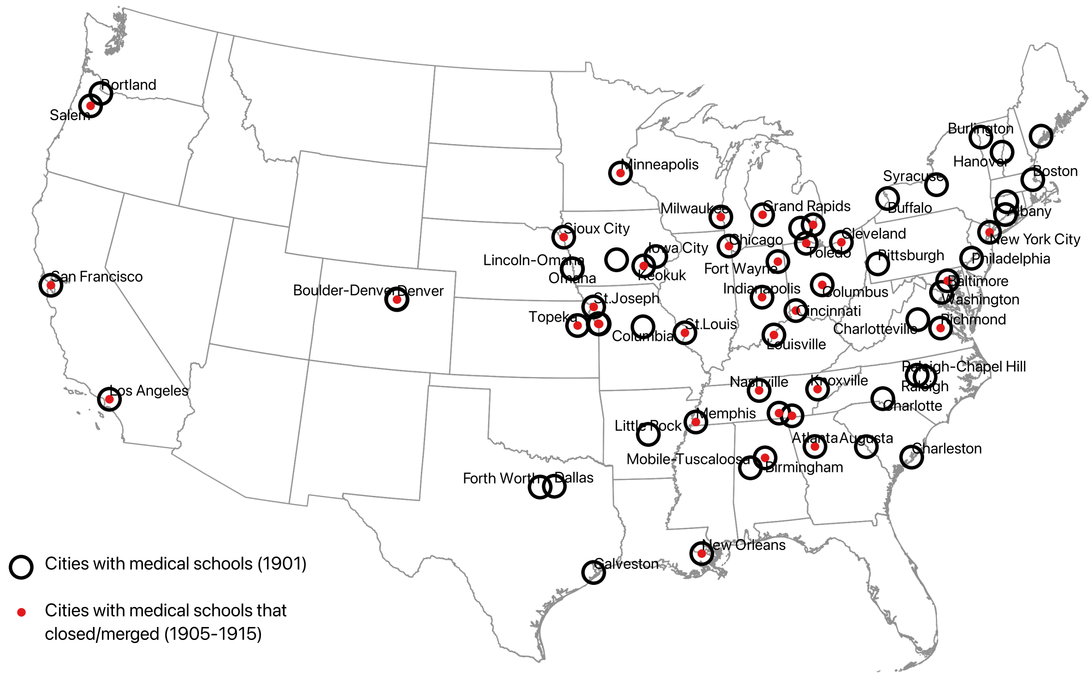
Weinfeld, William. 1951. "Income of physicians, 1929-49."

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



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.

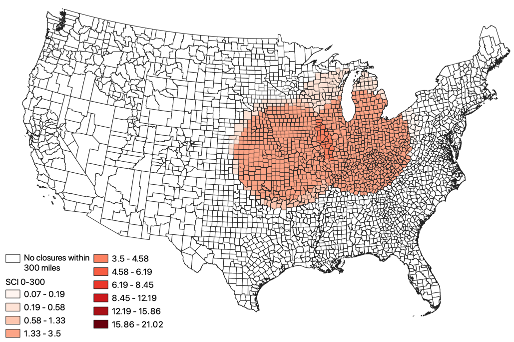
Figure 2: Cities with medical schools and medical school closures



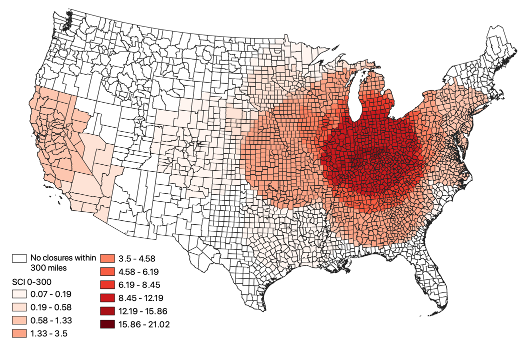
Notes: This figure displays a map of all cities that had a medical school in 1901 (the black circles). The red circles represent cities that had a medical school that closed or was absorbed/merged with another medical school between 1905 and 1915.

Figure 3: School Closure Intensity (SCI) within 300 miles of a county

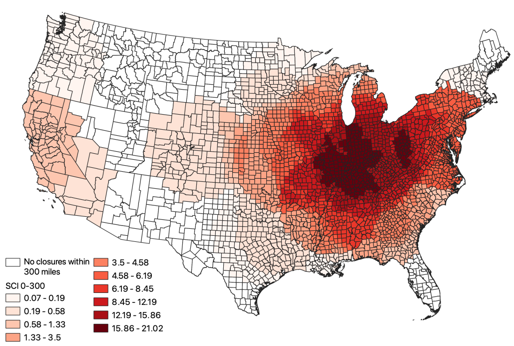
(a) 1905



(b) 1910



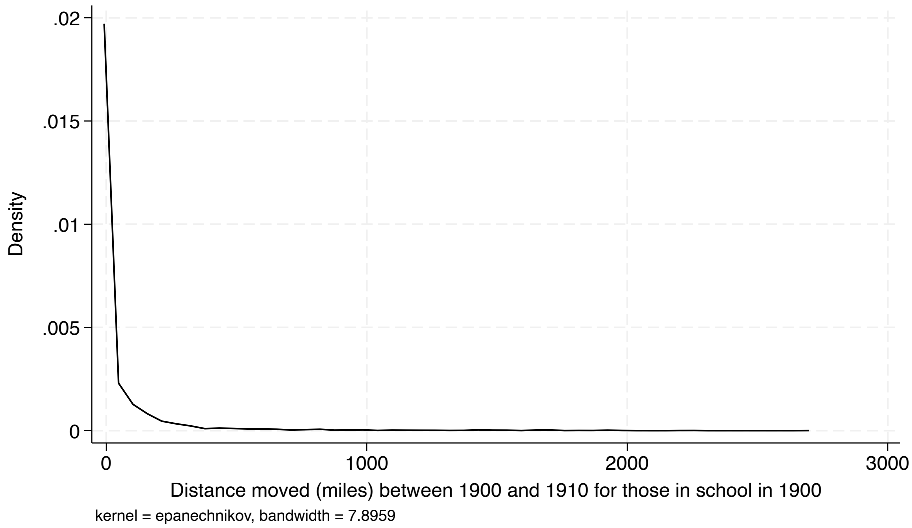
(c) 1915



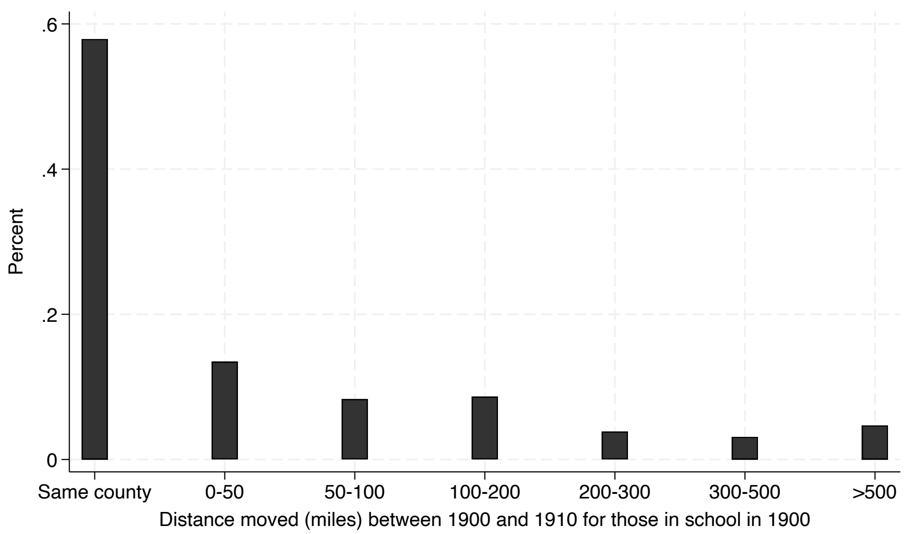
Notes: This map displays our measure of school closure intensity (SCI) within 300 miles of each county, as specified in Equation (1).

Figure 4: Distance moved between medical school and practice location 10 years later

(a) Kernel Density

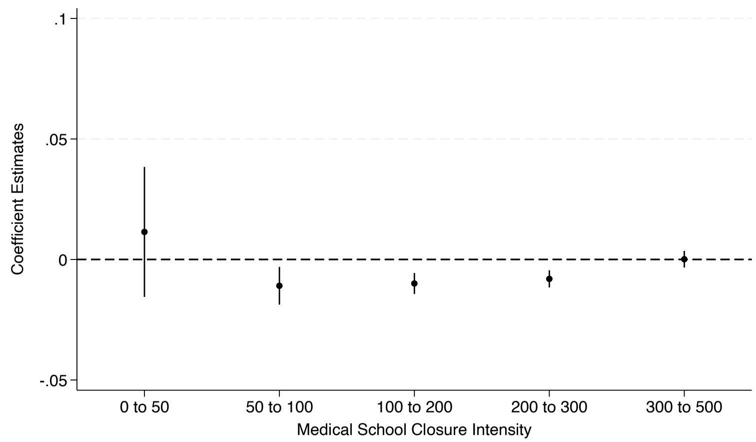


(b) Histogram

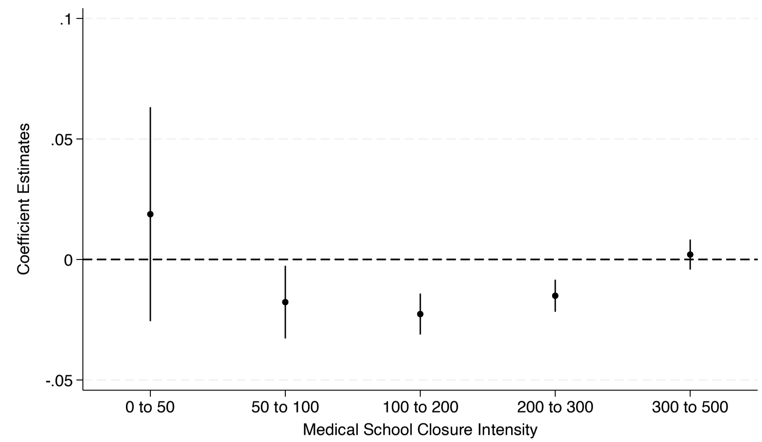


Notes: Panel A displays a kernel density estimate of the distance that recent medical school graduates were living from the county they were likely trained in. Panel B displays the histogram equivalent of Panel A. To construct this, we used the IPUMS Multigenerational Longitudinal Panel (Helgertz et al., 2020), which links individuals between decadal censuses. We used the 1900 to 1910 linked sample. To be included in our sample, 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 when we observe them in 1900.

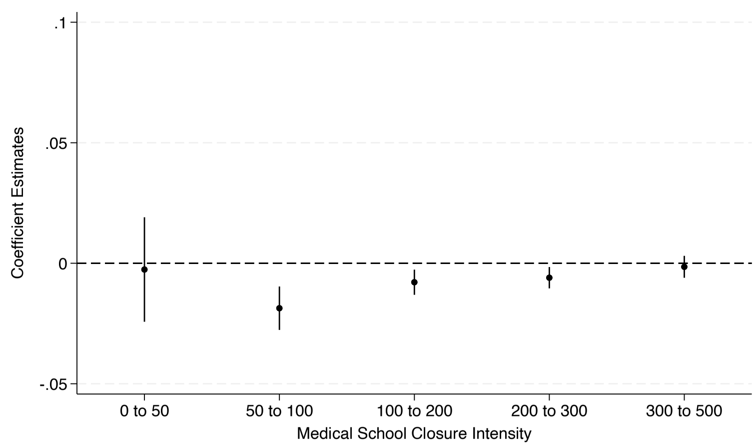
Figure 5: Impact of school closures on physicians per 1,000 - distance bins



(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 medical schools that closed to those that remained open

	Remained open	Closed between 1905-1915	Difference
Number of students enrolled	249.824	140.487	109.336***
			(7.819)
Percent passing state licensing exam	0.878	0.743	0.135***
			(7.222)
School was regular (allopathic)	0.867	0.778	0.089**
			(2.649)
Required 1-year of pre-med	0.062	0.000	0.062***
			(4.373)
Rated A by AMA	0.783	0.270	0.513***
			(13.256)
Rated B by AMA	0.183	0.429	-0.245***
			(-6.091)
Rated C by AMA	0.033	0.302	-0.268***
			(-8.442)
University Affiliated	0.750	0.403	0.347***
			(8.523)
Flexner recommended closing	0.617	0.986	-0.369***
			(-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 difference in column (3) is the t-statistic. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

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	11924	11780	9964
	Panel B: Young physicians		
SCI 0-300 miles	-0.0157***	-0.0161***	-0.0151***
	(0.0020)	(0.0020)	(0.0023)
Observations	11908	11764	9948
	Panel C: Old physicians		
SCI 0-300 miles	-0.0069***	-0.0072***	-0.0074***
	(0.0013)	(0.0013)	(0.0015)
Observations	11916	11772	9956
	Panel D: Nurses		
SCI 0-300 miles	0.0108***	0.0114***	0.0102**
	(0.0032)	(0.0033)	(0.0041)
Observations	11844	11700	9888
	Panel E: Midwives		
SCI 0-300 miles	-0.0056	-0.0062	0.0035
	(0.0088)	(0.0091)	(0.0107)
Observations	7652	7508	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 and the dependent variable is number of students enrolled in these schools (students enrolled in schools that closed are not included). 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			
0-300 miles	-10.962***	-11.837***	-10.882***
	(0.403)	(0.708)	(0.271)
300-500 miles	-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)	Pr(Change occ.=1)	Pr(Retire=1)
	(1)	(2)	(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: 1910-1920; only physicians in counties without closures		
SCI 0-300 miles	-0.0011***	-0.0004	-0.0008***
	(0.0004)	(0.0004)	(0.0002)
Observations	48311	48311	48311

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 1910 to the 1920 census. We observe whether these individuals remain physicians, switch occupations, or retire. Panel A uses all successfully linked individuals who were a physician in 1910. Panel B uses all successfully linked individuals who were a physician in 1910 and living in a county that did not experience a medical school closure between 1905 and 1915. SCI is based on the initial county's (1910) SCI value in the second census (1920). Both panels control for SCI 300-500 miles and age fixed effects. Standard errors are clustered at the initial county (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	-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	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	-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	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	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 not in the death registration area, county and year fixed effects and their interaction with a dummy variable if a county is not in the death registration area, and share urban, share Black, and manufacturing establishments per capita and their interaction with a dummy variable if a county is not in the death registration area. 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 8: The impact of school closures on mortality, 1900-1930

	(1)	(2)	(3)
Panel A: Infant mortality			
SCI 0-300 miles	-0.0150***	-0.0141***	-0.0103***
	(0.0027)	(0.0026)	(0.0029)
Observations	18593	18336	15152
Panel B: Non-infant mortality			
SCI 0-300 miles	-0.0079***	-0.0075***	-0.0038*
	(0.0018)	(0.0017)	(0.0020)
Observations	18593	18336	15152
Panel C: Total mortality (excluding 1911-1914)			
SCI 0-300 miles	-0.0087***	-0.0082***	-0.0045**
	(0.0019)	(0.0018)	(0.0021)
Observations	18593	18336	15152
Panel D: Total mortality			
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 are the number of deaths under one year of age per 1000 people, in Panel B are the number of deaths over one year of age per 1000 people, and in Panel C and Panel D are the number of all deaths per 1000 people. Infant mortality is not available for 1911-1914, so these years are omitted in Panels A, B and C. 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 cause, 1900-1915

	(1) Total	(2) Infectious	(3) 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 county health departments, sewer & water expenditures, and hospitals

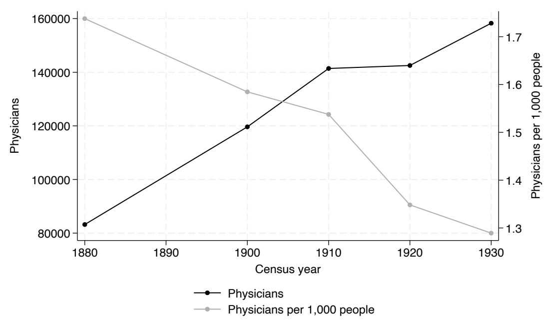
	(1) Total Personnel PC	(2) Medical Officers PC	(3) Budget PC
Panel A: County health departments			
SCI 0-300 miles	1.6694	0.7704	0.7599
	(1.0604)	(0.8550)	(0.6772)
Observations	10144	10104	10124
	(4) Sewers PC	(5) Water PC	(6) Refuse PC
Panel B: Expenditures			
SCI 0-300 miles	-0.0101	-0.0322**	0.0272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

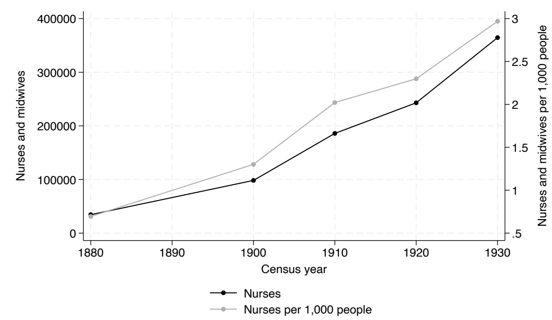
Appendix A: Supplemental Figures and Tables

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

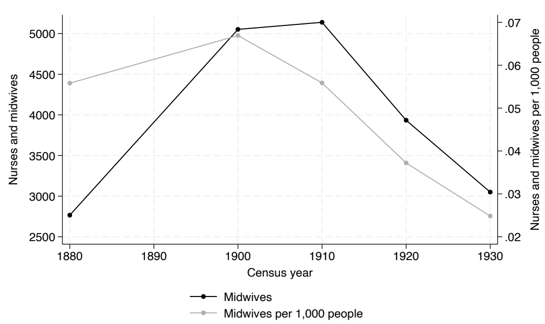
(a) Physicians



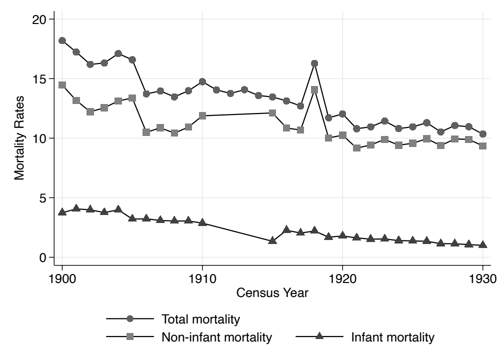
(b) Nurses



(c) Midwives



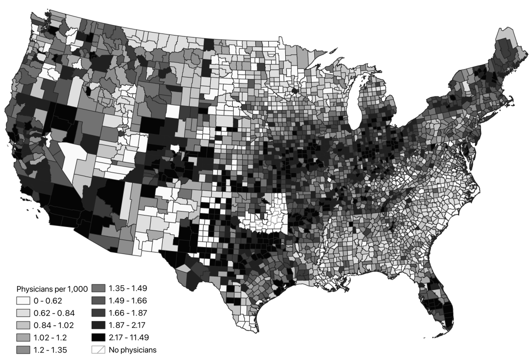
(d) Mortality rates



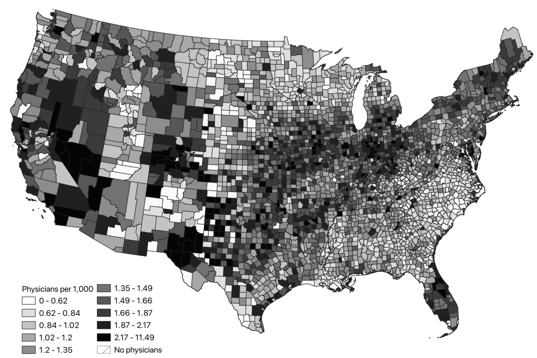
Notes: These figures show trends in physicians, nurses, midwives, and mortality. Infant mortality data for 1911-1914 are not available because data for rural parts of counties were not published for that period.

Figure A.2: Physicians per 1,000 by County

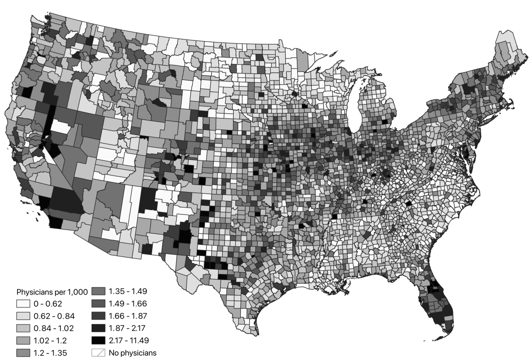
(a) 1900



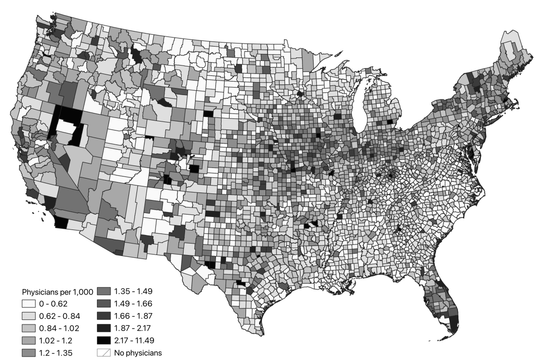
(b) 1910



(c) 1920

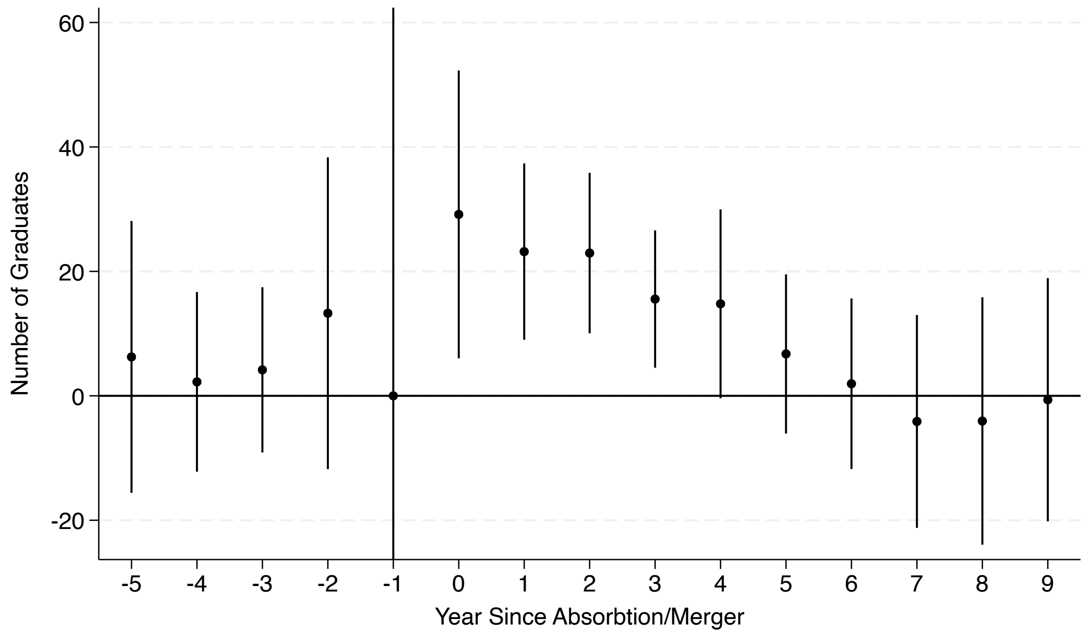


(d) 1930



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

Figure A.3: Number of graduates in absorbing institutions



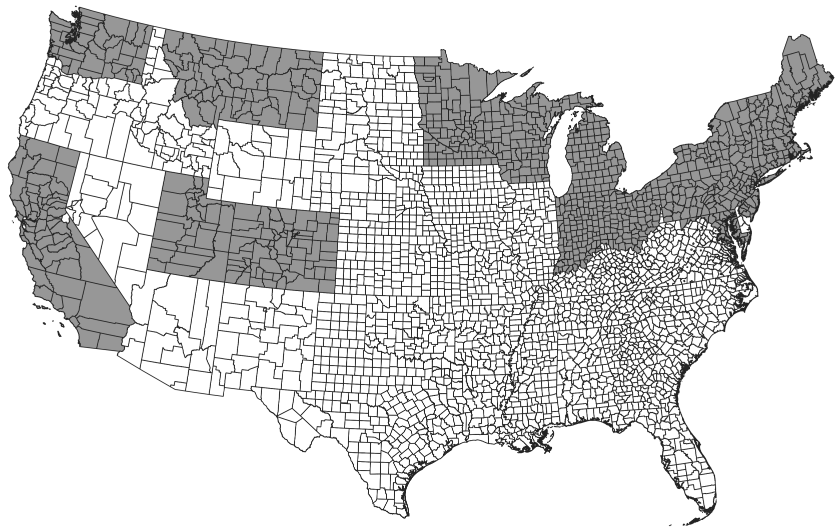
Notes: This figure presents event study estimates of the number of graduates in schools that absorbed or merged with another institution. The estimating specification is:

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

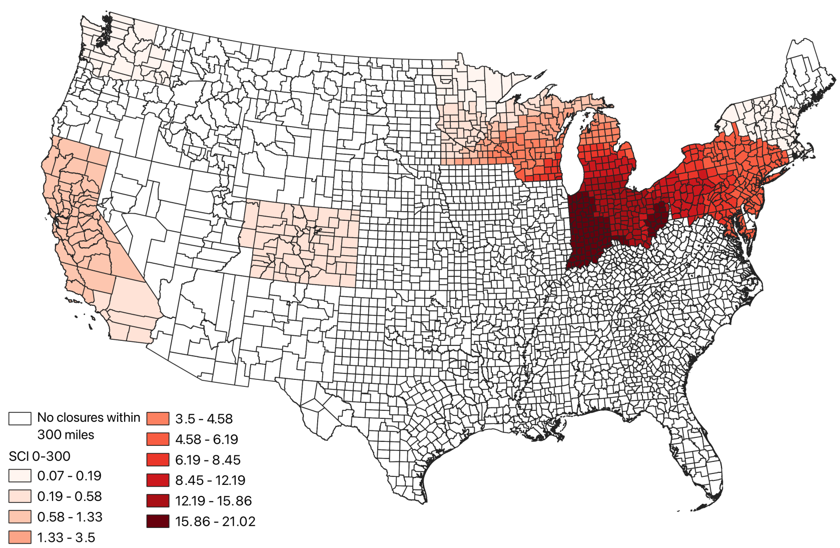
Where y_{st} is the number of graduates in medical school s in year t. Only schools that absorbed another school or merged with another school are included in the estimation. For schools that absorbed another institution, the dependent variable is the number of graduates in the absorbing institution. For schools that merged with another institution, the dependent variable is the number of graduates in both schools prior to the merger. For schools that absorbed multiple institutions or merged multiple times, $k = 0$ corresponds to the first time they absorbed or merged with another school. 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. 95% confidence intervals based on robust standard errors are displayed.

Figure A.4: Death Registration Area and School Closure Intensity

(a) Death Registration Area in 1910



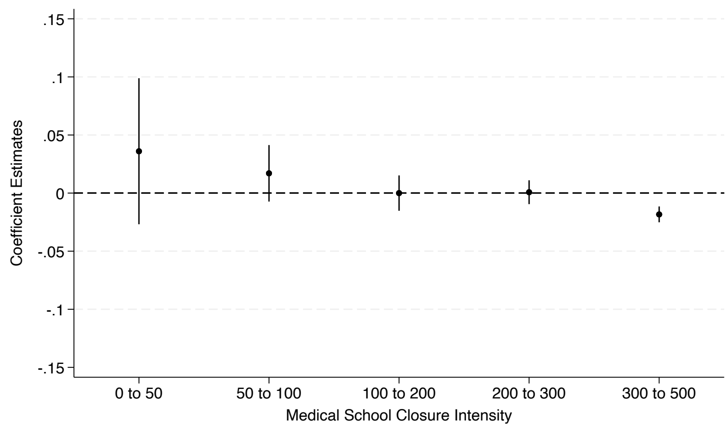
(b) SCI in Death Registration Area



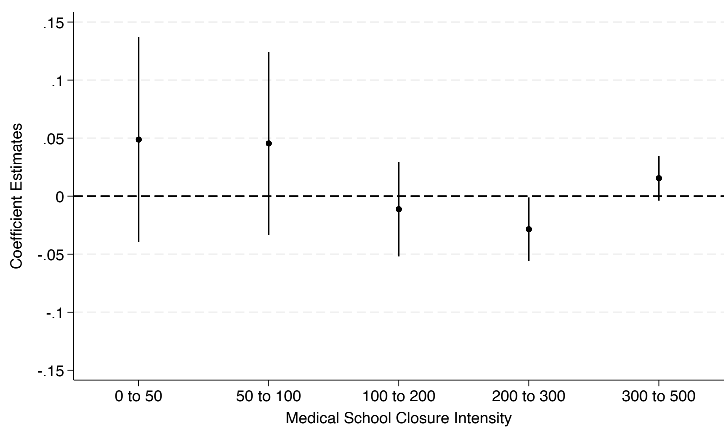
Notes: Panel A shows the counties that were in the Death Registration Area in 1910. Panel B shows the maximum value of school closure intensity (SCI) for the counties in the Death Registration Area.

Figure A.5: Impact of school closures on nurses and midwives - distance bins

(a) Nurses

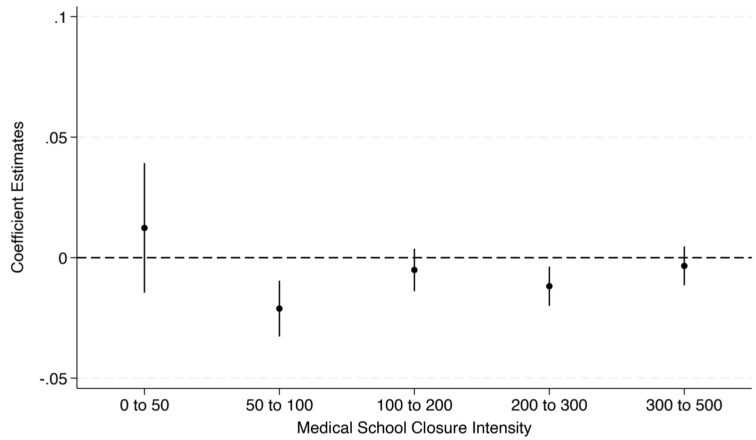


(b) Midwives

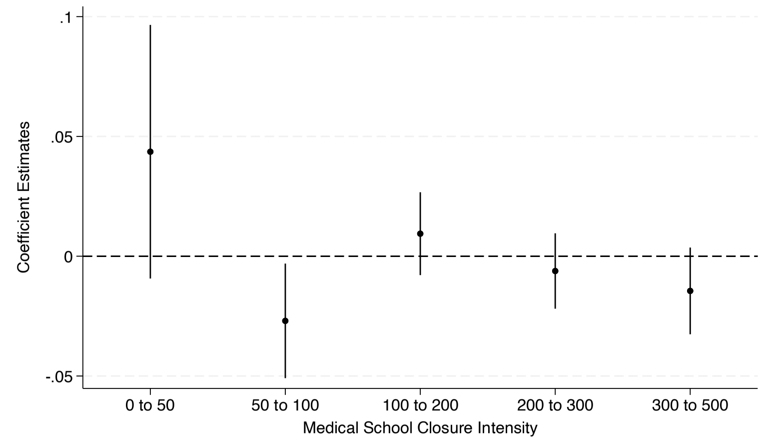


Notes: This figure displays estimates from Equation (2) in the text. The unit of observation is a county-year. All estimates include: county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. All dependent variables are per 1,000 people and PPML is used for 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.

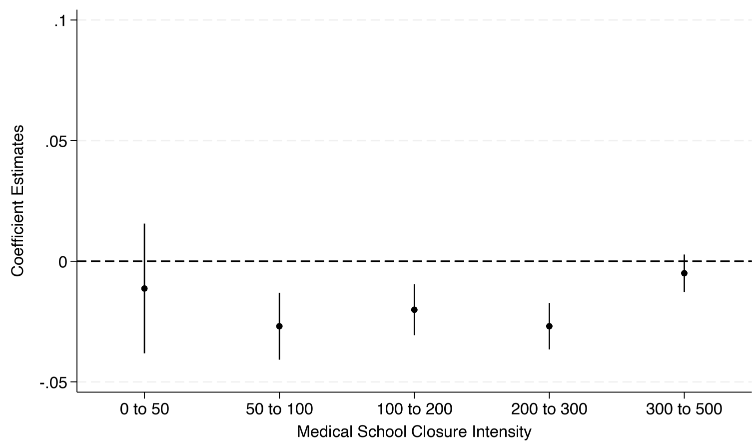
Figure A.6: Effect of medical school closures in distance bins on physicians - Death Registration Area in 1910



(a) Physicians



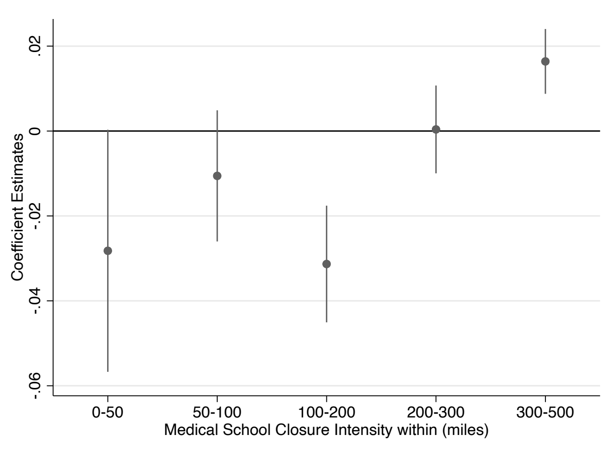
(b) Young Physicians



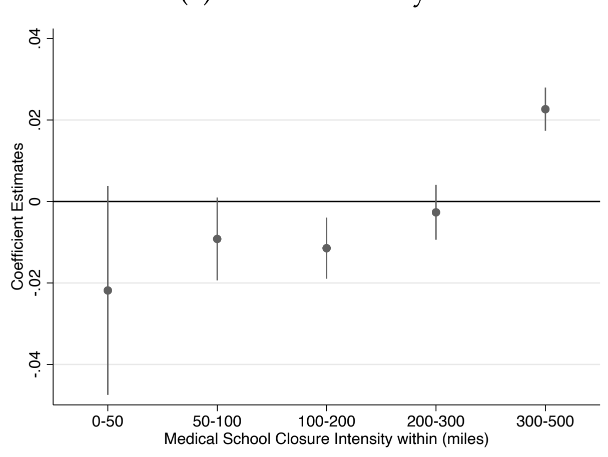
(c) Old Physicians (over 40)

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). Standard errors are clustered at the county-level. 95% confidence intervals are displayed.

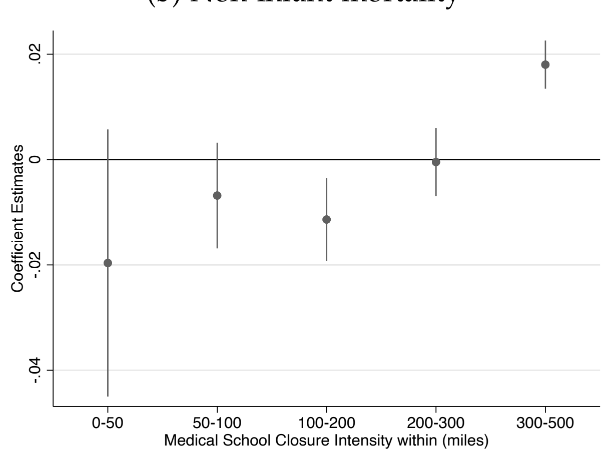
Figure A.7: Effect of medical school closures in distance bins on mortality



(a) Infant Mortality



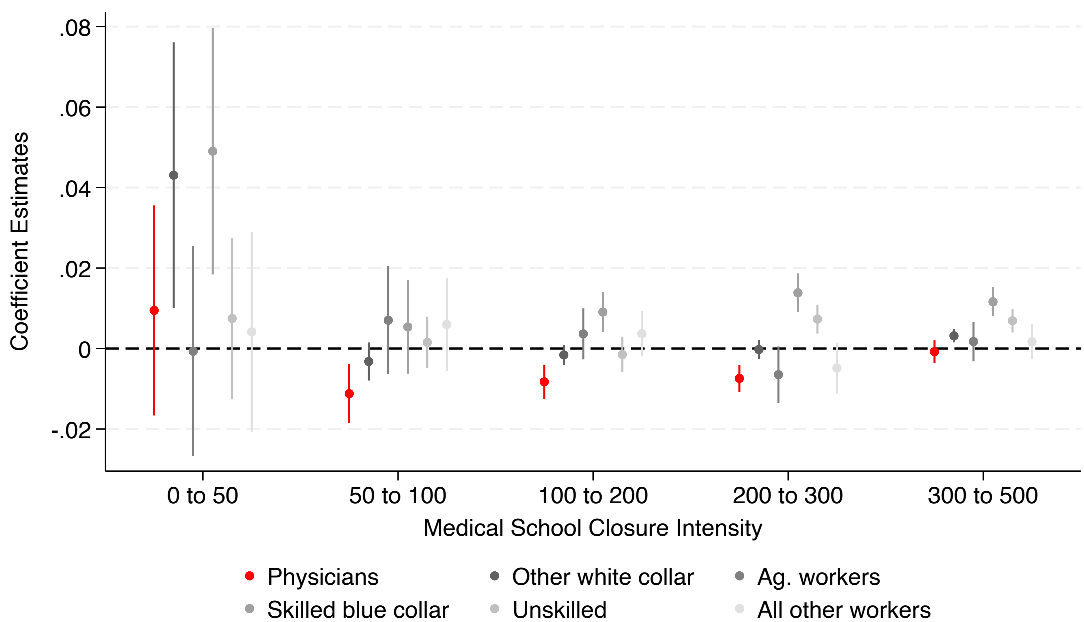
(b) Non-infant mortality



(c) Total 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.

Figure A.8: Other occupational categories and school closures



Notes: This figure displays estimates from Eequation (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.

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	2.18	1.71	1.13
Non-infant mortality	12.30	10.23	10.80	10.12
Total mortality	15.11	12.41	12.51	11.25
Observations	322	894	747	892

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

Table A.2: 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	5168	5028	3968
		Panel B: Female physicians	
SCI 0-300 miles	-0.0004	-0.0019	-0.0008
	(0.0064)	(0.0067)	(0.0074)
Observations	9312	9168	7688
		Panel C: Foreign-born physicians	
SCI 0-300 miles	-0.0038	-0.0052	-0.0032
	(0.0048)	(0.0049)	(0.0060)
Observations	9344	9200	7784
		Panel D: Native-born white physicians	
SCI 0-300 miles	-0.0086***	-0.0088***	-0.0085***
	(0.0011)	(0.0011)	(0.0012)
Observations	11920	11776	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.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***	-0.0186***	-0.0167***
	(0.0017)	(0.0017)	(0.0018)
Linear combination:	0.0249***	0.0249***	0.0222***
SCI A - (SCI B & C)	(0.0043)	(0.0043)	(0.0044)
Observations	11924	11780	9964
	Panel B: Young physicians		
SCI 0-300 miles - A grade schools	0.0361***	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)
Linear combination:	0.0799***	0.0815***	0.0737***
SCI A - (SCI B & C)	(0.0088)	(0.0088)	(0.0097)
Observations	11908	11764	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)
Linear combination:	0.0019	0.0016	0.0021
SCI A - (SCI B & C)	(0.0048)	(0.0048)	(0.0051)
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 the following specification:

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

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

Table A.4: 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 that were 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.5: Impact of school closures on physicians per 1,000, 1900-1930 - SCI specific to school grade in the Death Registration Area

	(1)	(2)	(3)
		Panel A: Physicians	
SCI 0-300 miles - A grade schools	0.0058	0.0021	-0.0040
	(0.0122)	(0.0121)	(0.0122)
SCI 0-300 miles - B & C grade schools	-0.0204***	-0.0207***	-0.0198***
	(0.0041)	(0.0042)	(0.0048)
Linear combination:	0.0262**	0.0228*	0.0158
SCI A - (SCI B & C)	(0.0131)	(0.0129)	(0.0126)
Observations	2894	2845	2248
		Panel B: Young physicians	
SCI 0-300 miles - A grade schools	0.0290	0.0256	0.0065
	(0.0258)	(0.0263)	(0.0263)
SCI 0-300 miles - B & C grade schools	-0.0307***	-0.0318***	-0.0232**
	(0.0080)	(0.0082)	(0.0099)
Linear combination:	0.0596**	0.0574**	0.0297
SCI A - (SCI B & C)	(0.0280)	(0.0286)	(0.0285)
Observations	2884	2835	2240
		Panel C: Old physicians	
SCI 0-300 miles - A grade schools	-0.0291**	-0.0332***	-0.0322***
	(0.0120)	(0.0117)	(0.0123)
SCI 0-300 miles - B & C grade schools	-0.0247***	-0.0250***	-0.0285***
	(0.0046)	(0.0047)	(0.0055)
Linear combination:	-0.0044	-0.0081	-0.0037
SCI A - (SCI B & C)	(0.0119)	(0.0116)	(0.0122)
Observations	2891	2842	2245
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:

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

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: 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.

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

Table A.6: 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: Non-infant mortality			
SCI 0-300 miles in 1910	-0.0034*	-0.0030*	-0.0029
	(0.0018)	(0.0018)	(0.0022)
SCI 0-300 miles in 1920	-0.0044**	-0.0036**	-0.0028
	(0.0018)	(0.0017)	(0.0020)
SCI 0-300 miles in 1930	-0.0051***	-0.0046***	-0.0037*
	(0.0018)	(0.0018)	(0.0020)
Observations	2896	2849	2284
Panel C: 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)
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures		X	
Excluding closure within 50 miles			X
Observations	2896	2849	2284

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. 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.7: The impact of school closures on mortality, 1900-1930 - SCI specific to school grade

	(1)	(2)	(3)
Panel A: Infant mortality			
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 B: Non-infant mortality			
SCI 0-300 miles - A grade schools	0.0004	0.0040	-0.0023
	(0.0101)	(0.0096)	(0.0101)
SCI 0-300 miles -B and C grade schools	-0.0095***	-0.0105***	-0.0096***
	(0.0025)	(0.0025)	(0.0029)
Observations	18593	18336	15152
Panel C: Total mortality			
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)
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 the following specification:
$y_{ct} = \beta_1 \cdot \text{SCI - A} \left\{ {300 \atop 0} \right\}_{ct} + \beta_2 \cdot \text{SCI - A} \left\{ {500 \atop 301} \right\}_{ct} + \beta_3 \cdot \text{SCI - B \& C} \left\{ {300 \atop 0} \right\}_{ct} + \beta_4 \cdot \text{SCI - B \& C} \left\{ {500 \atop 301} \right\}_{ct} + \beta_5 \cdot \text{SCI - not graded} \left\{ {300 \atop 0} \right\}_{ct} + \beta_6 \cdot \text{SCI - not graded} \left\{ {500 \atop 301} \right\}_{ct} + \theta_c + \chi_t + Z'_{ct} * \delta + \epsilon_{ct}$, 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. Infant mortality is not available for 1911-1914, so these years are omitted in Panels A and B. 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.8: Investigating sensitivity to zero as the dependent variables - physicians

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Panel A: Physicians				
SCI 0-300 miles	-0.0075***	-0.0068***	-0.0104***	-0.0054***	-0.0059***	-0.0104***	-0.0124***	-0.0122***	-0.0131***
	(0.0011)	(0.0010)	(0.0012)	(0.0005)	(0.0006)	(0.0010)	(0.0013)	(0.0014)	(0.0014)
Observations	11780	11687	11687	11687	11784	11784	11784	11687	11784
					Panel B: Young physicians				
SCI 0-300 miles	-0.0161***	-0.0152***	-0.0245***	-0.0056***	-0.0061***	-0.0189***	-0.0281***	-0.0080***	-0.0084***
	(0.0020)	(0.0019)	(0.0032)	(0.0006)	(0.0006)	(0.0017)	(0.0028)	(0.0011)	(0.0011)
Observations	11764	11186	11186	11186	11784	11784	11784	11186	11784
					Panel C: Old physicians				
SCI 0-300 miles	-0.0072***	-0.0054***	-0.0109***	-0.0026***	-0.0033***	-0.0097***	-0.0146***	-0.0037***	-0.0047***
	(0.0013)	(0.0013)	(0.0019)	(0.0005)	(0.0005)	(0.0013)	(0.0020)	(0.0010)	(0.0010)
Observations	11772	11541	11541	11541	11784	11784	11784	11541	11784
	PPML	PPML excluding zeroes	Log(y)	Log(y+1) excluding zeroes	Log(y+1)	Log(y+0.1)	Log(y+0.01)	y excluding zeroes	y

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. 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.9: Investigating sensitivity to zero as the dependent variables - mortality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Infant mortality									
SCI 0-300 miles	-0.0141***	-0.0079***	-0.0222***	-0.0140***	-0.0068	-0.0212***	-0.0353***	-0.0126**	-0.0252***
	(0.0026)	(0.0020)	(0.0051)	(0.0030)	(0.0047)	(0.0069)	(0.0091)	(0.0052)	(0.0059)
Observations	18336	17296	17296	17296	21989	21989	21989	17296	18406
Panel B: Non-infant mortality									
SCI 0-300 miles	-0.0075***	-0.0017	-0.0117***	-0.0097***	-0.0280***	-0.0414***	-0.0536***	-0.0146	-0.0620***
	(0.0017)	(0.0013)	(0.0039)	(0.0033)	(0.0057)	(0.0079)	(0.0101)	(0.0146)	(0.0171)
Observations	18336	17296	21538	17296	21989	21989	21989	17296	18406
Panel C: Total mortality									
SCI 0-300 miles	-0.0062***	-0.0023*	-0.0120***	-0.0106***	-0.0295***	-0.0428***	-0.0550***	-0.0272	-0.0662***
	(0.0015)	(0.0013)	(0.0039)	(0.0035)	(0.0059)	(0.0082)	(0.0103)	(0.0172)	(0.0184)
Observations	21907	17296	21539	17296	21989	21989	21989	17296	21989
	PPML	PPML excluding zeroes	Log(y)	Log(y+1) excluding zeroes	Log(y+1)	Log(y+0.1)	Log(y+0.01)	y excluding zeroes	y

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. Infant mortality is not available for 1911-1914, so these years are omitted in Panels A and 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.

Table A.10: Alternative measures of SCI - physicians

	Physicians (1)	Young physicians (2)	Old physicians (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 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.11: Alternative measures of SCI - mortality

	(1) Infant mortality	(2) Non-infant mortality	(3) Total mortality
Panel A: SCI through 1918			
SCI 0-300 miles	-0.0183***	-0.0102***	-0.0085***
	(0.0027)	(0.0016)	(0.0015)
Observations	18593	18593	22217
Panel B: SCI for earlier and later closures			
SCI 1905-1910 Closures	-0.0181***	-0.0040**	-0.0091***
	(0.0027)	(0.0016)	(0.0016)
SCI 1911-1915 Closures	-0.0148***	-0.0081***	-0.0067***
	(0.0028)	(0.0018)	(0.0016)
Observations	18593	18593	22217
County FE	X	X	X
Year FE	X	X	X
Excluding counties with closures	X	X	X
Excluding closure within 50 miles			
Observations	18593	18593	22217

Notes: This table presents estimates from Equation (3) in the text. The unit of observation is a county-year. All estimates include: SCI 300-500 miles, county and year fixed effects, share urban, share Black, and manufacturing establishments per capita. Infant mortality is not available for 1911-1914, so these years are omitted in Panels A and B.The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 8). 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.12: Impact of school closures on physicians per 1,000, 1900-1930 - adding region-year and division-year fixed effects and time trends

	(1)	(2)	(3)	(4)	(5)
			Panel A: Physicians		
SCI 0-300 miles	-0.0075***	-0.0082***	-0.0083***	-0.0097***	-0.0122***
	(0.0011)	(0.0012)	(0.0012)	(0.0012)	(0.0013)
Observations	11780	11780	11780	11780	11780
			Panel B: Young physicians		
SCI 0-300 miles	-0.0161***	-0.0159***	-0.0168***	-0.0199***	-0.0261***
	(0.0020)	(0.0023)	(0.0023)	(0.0022)	(0.0024)
Observations	11764	11764	11764	11764	11764
			Panel C: Old physicians		
SCI 0-300 miles	-0.0072***	-0.0081***	-0.0079***	-0.0080***	-0.0101***
	(0.0013)	(0.0014)	(0.0015)	(0.0016)	(0.0018)
Observations	11772	11772	11772	11772	11772
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 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.13: Impact of school closures on mortality, 1900-1930 - adding region-year and division-year fixed effects and time trends

	(1)	(2)	(3)	(4)	(5)
Panel A: Infant mortality					
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 B: Non-infant mortality					
SCI 0-300 miles	-0.0075***	-0.0107***	-0.0106***	-0.0099***	-0.0073***
	(0.0017)	(0.0019)	(0.0023)	(0.0017)	(0.0021)
Observations	18336	18336	18336	18336	18336
Panel C: Total mortality					
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 are the number of deaths under one year of age per 1000 people, in Panel B are the number of deaths over one year of age per 1000 people, and in Panel C are the number of all deaths per 1000 people. Infant mortality is not available for 1911-1914, so these years are omitted from in Panels A and 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.14: 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 bandwidth	Spatial HAC: 150 km bandwidth	Spatial HAC: 200 km bandwidth

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 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.15: The impact of school closures on mortality, 1900-1930 - spatial SE

	(1)	(2)	(3)	(4)	(5)
Panel A: Infant mortality, All Years					
SCI 0-300 miles	-0.0141***	-0.0222***	-0.0222***	-0.0222**	-0.0222**
	(0.0026)	(0.0051)	(0.0083)	(0.0094)	(0.0102)
Method			100	150	200
Observations	18336	17296	17298	17298	17298
Panel B: Infant mortality, Census years					
SCI 0-300 miles	-0.0075***	-0.0117***	-0.0117*	-0.0117*	-0.0117
	(0.0017)	(0.0039)	(0.0061)	(0.0068)	(0.0074)
Method			100	150	200
Observations	18336	21538	21540	21540	21540
Panel C: Total mortality, All years					
SCI 0-300 miles	-0.0062***	-0.0120***	-0.0120*	-0.0120*	-0.0120
	(0.0015)	(0.0039)	(0.0061)	(0.0069)	(0.0075)
Method			100	150	200
Observations	21907	21539	21541	21541	21541

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. Infant mortality is not available for 1911-1914, so these years are omitted in Panels A and B. The 36 counties containing medical school closures are excluded from the estimating sample (i.e. the estimating sample is from column 2 of Table 8). 95% confidence intervals are displayed in parentheses.

Table A.16: Alternative DiD estimators - physicians

	Physicians			
	(1)	(2)	(3)	(4)
High SCI 0-300 miles	-0.0223***	-0.0411***	-0.0522***	-0.0628***
	(0.0055)	(0.0062)	(0.0055)	(0.0061)
Observations	11756	11756	11756	11756
Estimator:	TWFE	Callaway & Sant'Anna (2021)	TWFE	Callaway & Sant'Anna (2021)
High SCI definition:	50th pct.	50th pct.	Mean (60th pct.)	Mean (60th pct.)

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) and (3) use two-way fixed effects using county and year fixed effects. Column (2) and (4) use 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 (columns 1 and 2) or mean ($\sim$ 60th percentile) (columns 3 and 4). All estimates control for: SCI 300-500 miles, share urban, share Black, and manufacturing establishments per capita. Columns (1) and (3) include 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.
$* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

Table A.17: Alternative DiD estimators - mortality

	(1)	(2)	(3)	(4)
Panel A: Infant mortality				
SCI 0-300 miles	-0.1590***	-0.2232	-0.1191***	-0.1457
	(0.0391)	(0.2809)	(0.0394)	(0.2353)
Observations	17296	14000	17296	14930
Panel B: Non-infant mortality				
SCI 0-300 miles	-0.1163***	-0.2683	-0.0928**	-0.1784
	(0.0357)	(0.2679)	(0.0369)	(0.2302)
Observations	17968	14562	17968	15515
Panel C: Total mortality				
SCI 0-300 miles	-0.0809***	-0.1490	-0.0528*	-0.1129
	(0.0262)	(0.1655)	(0.0273)	(0.1647)
Observations	21539	20310	21539	20394
Estimator:	TWFE	Callaway & Sant'Anna (2021)	TWFE	Callaway & Sant'Anna (2021)
High SCI definition:	50th pct.	50th pct.	Mean (60th pct.)	Mean (60th pct.)

Notes: The unit of observation is a county-year. The dependent variable is the log of infant mortality per 1000 people, log of non-infant mortality per 1000 people, and log of total mortality per 1000 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 60th 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 8). Standard errors are clustered at the county-level in columns(1) and (3). 95% confidence intervals are displayed in parentheses.

Table A.18: The impact of school closures on mortality: 1900-1930 vs 1900-1917

	(1) 1900-1930	(2) 1900-1917
Panel A: Infant mortality		
SCI 0-300 miles	-0.0141***	-0.0078***
	(0.0026)	(0.0027)
Observations	18336	7725
Panel B: Non-infant mortality		
SCI 0-300 miles	-0.0075***	-0.0033*
	(0.0017)	(0.0017)
Observations	18336	7725
Panel C: Total mortality		
SCI 0-300 miles	-0.0062***	-0.0034**
	(0.0015)	(0.0015)
Observations	21907	11296
County FE	X	X
Year FE	X	X
Excluding counties with closures	X	X
Excluding closure within 50 miles	X	X

Notes: This table presents estimates from Equation (3) in the text. The unit of observation is a county-year. 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 8). Infant mortality is not available for 1911-1914, so these years are omitted in Panels A and B. Standard errors are clustered at the county-level. 95% confidence intervals are displayed in parentheses. $* = p < 0.10$, $** = p < 0.05$, $*** = p < 0.01$

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:

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

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:

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