Occupational Regulation and Reduction in Quality: Evidence from the Medical Residency Training System in China

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April 10, 2024 ‡

Abstract

This paper examines the impact of occupational regulation on the level and quality of labor supply. For this purpose, we explore the introduction of the three-year medical residency training system in China in 2014 as a natural experiment. Using a difference-in-differences (DID) design, we show that there is a decline of over 22% in the number of candidates opting for and passing the medical licensing exam after 2014. Meanwhile, there is a significant decline in college admission scores of medical majors compared to those of non-medical majors. These findings suggest that implementing the medical residency training system reduces the labor supply of young physicians and hinders high-quality candidates from enrolling in medical schools, exacerbating the shortage of doctors in China's already strained medical system. We offer evidence that low salaries for doctors are one mechanism driving these changes.

Keywords: Occupational Regulation, Choice of College Major, Medical Residency Training, High-quality Aspirants

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‡We thank Jonah Rockoff, Sandra Black, Michael Best, Alicia Plemmons, Edward Timmons, and Devon Gorry for discussions and comments that shaped the content of this paper. We thank Qiuyan Guo and Yuhan Cao for outstanding research assistance. We also thank seminar participants at the Southeastern Micro Labor Workshop for their comments. All errors are our own.

1 Introduction

In the past few decades, occupational regulation has attracted considerable debate within academic and policy circles. Many studies warn about the negative effects of stringent occupational regulation on the level of labor supply (Law and Marks, 2009; Blair and Chung, 2018; Federman et al., 2006; Blair and Chung, 2019). Meanwhile, some studies support it as a signal of quality that shut out aspiring workers who are likely to provide low-quality service and enhance the labor market (Akerlof, 1970; Leland, 1979; Xia, 2021; Kleiner and Park, 2010; Anderson et al., 2020). However, besides possibly weeding out low-quality candidates, the high costs in time and money of fulfilling occupational requirements may deter high-quality aspirants from even trying to become licensed and lower the overall quality of the profession. High-quality aspirants are likely to have an abundance of other opportunities open to them such that the opportunity cost of meeting occupational requirements is high and deterrent. While this logic is persuasive, no credible empirical evidence has been presented to confirm the shutting out of high-quality candidates by stringent occupational regulations.

Occupational regulation is especially prevalent in the healthcare sector, where licensing is mandatory for all physicians and over 75 percent of non-physician practitioners. Healthcare professionals play a central role in providing medical care and safeguarding the health of the public. The prevalence of licensing in the healthcare sector likely stems from the goal of ensuring the delivery of quality services. However, the significant time and financial costs associated with meeting licensing requirements might deter hopefuls from entering the medical field. This issue is particularly pronounced in developing countries, where doctors are often significantly underpaid compared to professionals in other sectors (Sixth Tone, 2019). For instance, the salaries of most physicians in India are much lower compared to those of IT engineers (Pandey, 2023). Amidst such surroundings, stringent licensing requirements may dissuade highly qualified candidates from pursuing a medical career, potentially reducing the overall quality of healthcare services.

By exploring the implementation of the three-year medical residency training system in China in 2014 as a natural experiment, the present study constitutes a unique opportunity to inform our understanding of how occupational regulation affects the level and quality of medical labor supply. The Chinese medical education system follows the British system where the vast majority of medical students attend a five-year undergraduate program after high school to earn an MBBS (Bachelor of Medicine and Bachelor of Surgery). Traditionally, as in most other developing economies, Chinese medical school graduates that have passed the medical licensing exam, the National Medical Licensing Examination (NMLE), work directly as junior physicians without formal residency training. They gradually acquire practical skills and knowledge through learning from senior physicians in the same department over an indefinite number of years.

In 2014, the Chinese Ministry of Health (MOH) established a national standardized residency training program in mainland China, aiming to align with the healthcare systems in developed countries. Thereafter, all new medical school graduates looking to become physicians must first complete residency training in an accredited program. Residency programs are set at 3 years in duration regardless of specialty and must comply with training content and accreditation standards created by the MOH. Due to a severe shortage of physicians, there are no match quotas for many medical specialities. As such, residency applicants are secured placements in the program.

For this study, we use three unique administrative datasets on medical education and medical licensing exams provided by the Ministry of Education and the Ministry of Health. The first dataset provides annual reports on the number of college graduates with a medical degree in each university. The second dataset contains information on the annual count of medical graduates sitting the NMLE in each province. The third dataset include college admission numbers and scores at the university-major-year-province level for all Chinese universities.

To identify the residency program's causal effects on the quantity of medical labor supply, we estimate the changes in the number of medical graduates sitting the NMLE after the introduction of the program in 2014. The granularity of provincial-level data allows us to use the discrete nature of the residency program with significant statistical power.

We then examine whether the residency program discourages high-quality candidates from pursuing a medical career in medicine and potentially lowers the overall quality of the profession. Many studies indicate that college admission exam scores are strong predictors of later-life labor market quality (Boyd et al., 2008; Chetty et al., 2023; Jia and Li, 2021). Following the literature, we use a difference-in-differences (DID) design to compare the admission scores of non-medical majors and that of medical ones before and after the residency training reform. Similar to the education system in Republic of Korea (South Korea), Egypt, Vietnam, and Russia, the results of the standardized national exams, the National College Entrance Examination (NCEE), are the only criteria for college admission irrespective of income and other socio-demographic characteristics. Universities rank and select applicants based solely on their total NCEE score.

Using administrative examination data, we show that the number of medical graduates taking the NMLE dropped by over 20 percent and remained low following the introduction of the standardized residency training system in 2014. We also observe a significant decrease in the average admission scores of medical majors compared to those of non-medical majors after 2014, corroborating that the medical residency program dissuades high-quality aspirants from pursuing a medical career.

We address several threats to our empirical design. Our main results are robust to a wide range of alternative specifications. We also show that the coefficient estimates of the DID model are not statistically significant in placebo tests that assume the medical residency training system had been introduced 1, 2, 3 or 4 years earlier. Moreover, we conduct an event study and show that the set of pre-2014 coefficients are small in magnitude and statistically indistinguishable from zero, confirming that we are not capturing a generic growth trajectories in medical labor supply. Further, we randomly assign the treatment status of medical and non-medical majors and estimate the DID specification as placebo treatment effect. The point estimates obtained in the main regressions are significant when compared to the distribution of placebo effects, corroborating the validity of the DID approach.

There is no shortage of explanations for why the residency training program may have discouraged high-quality candidates from pursuing a medical career. A priori, we view the income mechanism as particularly plausible. Unlike in developed countries where physicians are the highest-paid professionals, doctors in many developing countries receive low pay. In particular, the average starting salary for China's junior doctors is around 4,850 yuan ($730) a month, significantly lower than the average college graduate starting salary of 6,000 yuan (Health Commission of Shenzhen Municipality, 2018). After the implementation of the national medical residency program, medical graduates have to work as residents for three years with lower wages instead of directly working as junior doctors with full salary. Merely 35% of residents nationwide receive a monthly salary exceeding RMB 3,000 (HealthInsight, 2022). This significant deterioration in income is likely to hinder high-quality candidates from enrolling in medical schools and fresh medical graduates from pursuing clinical practice.[1]

Given the levels of population, health, and medical technology involved in clinical practice, our results are directly relevant to the ongoing policy debates about the costs of medical residency training on doctors in developing countries. This is particularly pertinent in light of the critical shortage of healthcare workers in these regions today. While OECD and other developed countries have a mature 2- to 3- year medical residency program for physicians, most emerging economies lack formal or structured medical residency training. For instance, the medical licensing systems in Uganda, India, and Myanmar resemble the system in China before 2014. In these countries, medical school graduates who have passed the licensing exams can work directly as junior physicians without undergoing residency training. The findings in this paper indicate that the implementation of the medical residency program has led to a significant decrease in the labor supply of young practitioners in China, exacerbating the shortage of doctors in a public health system that is already notoriously overburdened. According to the World Health Organization, China has only 1.6 physicians per 1000 population, which is far below the OECD average of 3.2 physicians per 1000 population. Moreover, physicians play a central role in providing medical care and safeguarding the health of the public. It is essential to attract and select high-quality candidates for clinical practices. We show that the medical residency program shuts out high-quality contenders, potentially reducing the overall quality of clinical practices. Our results and methods contribute credible evidence to this important policy issue.

This study relates to a body of research on occupational regulations (Friedman and Kuznets, 1945; Kleiner, Morris M and Kudrle, 2000; Kugler and Sauer, 2005; Timmons and Thornton, 2008; Thornton and Timmons, 2013; Kleiner, 2013; Gittleman et al., 2018; Kleiner and Park, 2010). Prior studies all

[1]According to a report from the National Health Commission, in 2019, only about 60% of medical graduates took the medical licensing exams with the aim of becoming physicians (Health Commission of Shenzhen Municipality, 2018).

find large negative labor supply effects of licensing. For instance, Blair and Chung (2019) found that licensing reduces equilibrium labor supply by an average of 17%-27%. So far, most empirical studies on occupational regulations focus on developed countries, including the United States, Canada, and countries in the European Union. Little is known about the impacts of occupational licensing in emerging markets. We contribute to filling this gap in the literature by examining the impacts of residency training system on medical labor supply in China, the largest developing country in the world. More importantly, largely due to data limitations, existing studies could not identify whether the high costs of fulfilling licensing requirements may lower the overall quality of the profession. To the best of our knowledge, this study is the first one to prove that occupational regulations weed out high-quality contenders.

The results of this paper also expand the literature on the determinants of the choice of college major. Previous studies have examined the role of predicted future earnings (Dahl et al., 2023; Wiswall and Zafar, 2015; Mukherjee et al., 2017; Manski, 1993), perceived ability (Kirkeboen et al., 2016; Stinebrickner and Stinebrickner, 2013; Zafar, 2011), the salience of occupational risk (Bo et al., 2020), exposure to academic fields (Fricke et al., 2018), and non-pecuniary factors enjoyed at school (Delavande and Zafar, 2019). In this paper, we show that occupational regulation is a significant factor that influences the choice of college major.

The remainder of the paper is organized as follows. Section 2 gives a brief introduction to the medical system in China and the main policy changes of interest. Section 3 describes the main features of data sets used in the empirical analysis. Next, in Section 4, we introduce the main empirical specifications. Section 5 presents the main findings about changes in the number of NMLE examinees and college admission scores in response to the introduction of the national standardized residency training system. Section 6 performs robustness tests. Sections 7 and 8 conclude this work.

2 Background

Medical Education in China

Like many other countries such as India, Japan, and Egypt, the Chinese medical education system follows the British system where the vast majority of medical students attend a five-year undergraduate program after high school to earn an MBBS (Bachelor of Medicine and Bachelor of Surgery). Medical students study humanities, medical ethics, basic science, and basic medical courses such as medical history, biochemistry, anatomy, immunology, and physiology in the first two years. In the next two years, students take clinical courses in specialties, including surgery, internal medicine, obstetrics and gynecology, pediatrics, psychiatry, family medicine, emergency medicine, and traditional Chinese medicine. In their fifth year of study, students complete a 1-year clinical training in local hospitals, followed by a 2-part final examination that evaluates basic clinical knowledge and clinical skills. MBBS graduates can continue to pursue a 3-year Master of Medicine (MM) degree. In addition, physicians often pursue a 3-year PhD of Medicine in their later career years.

Medical school graduates that would like to pursue clinical practice can register for and take the NMLE exams. They will obtain a license to practice medicine in China after passing all exams of the NMLE sequence. The NMLE has been conducted in China since 1998 by the National Medical Examination Center (NMEC), an affiliate unit of the National Health Commission (NHC) of China (Guangzhou Red Cross Hospital, 2019). The NMLE consists of two separate exams, clinical skill exam and comprehensive medical knowledge exam. The NMLE exams are delivered according to a standardized syllabus designed by official NHC directives. The clinical skill examination assesses the ability of clinical reasoning, physical examination, and basic clinical operation. The comprehensive medical knowledge examination consists of 600 multiple-choice questions, assessing knowledge on basic sciences, clinical medicine, medical humanism, and preventive medicine. The clinical skill exam is administered nationwide every July, and the comprehensive medical knowledge examination is held nationwide every September. The questions are the same for all examinees, irrespective of the province in which they sit for the exams. The examination syllabi have remain the same from 2009 to 2019. This feature facilitates our empirical analysis as the difficulty level of the exam remains largely consistent throughout our study period.

Medical Residency Training in China

Traditionally, Chinese medical school graduates that have passed the medical licensing exams work directly as junior physicians without formal residency training. With theoretical knowledge and clinical clerkships obtained in medical school, junior physicians' practical skills and knowledge were gradually acquired through an apprenticeship model, learning from senior physicians in the same department over an indefinite number of years. The training experience is variable in terms of length and quality, as there is no standardization or oversight.

The year 2014 marked the formal establishment of a national standardized residency training program in mainland China. The central government led this effort to advance medical education and align with the healthcare systems of OECD countries. All new medical school graduates looking to become physicians must first complete residency training in an accredited program offered by public hospitals. Residency programs are set at 3 years in duration regardless of specialty and must comply with training content and accreditation standards created by the National Health Commission (NHC). Residents need to pass all exams of the NMLE sequence before finishing their residency training.

Due to a severe shortage of physicians in China, with the exceptions of certain medical specialities such as urology and dermatology, there are no residency match quotas for general practitioner, pediatrics, obstetrics and gynecology, and anesthesiology (Health Commission of Shenzhen Municipality, 2018). As such, residency applicants consistently secure placements in the program.

Medical residencies are mainly funded through the central government. Subsidies from the NHC covers training costs and regional salary up to RMB 24000 ($3000) per resident per year. NHC funding for each resident remained the same between 2014 and 2023 (Sixth Tone, 2019). Remaining funds for resident salary come from state matching funds and hospitals (China Business News, 2023). While residents in richer provinces, higher-ranked hospitals, and with graduate medical degrees earn higher salaries, the average salary for a medical resident is only RMB 3476.80 per year, significantly lower than the average starting salary for college graduates, which stands at 6,000 yuan. Moreover, merely 35% of residents nationwide receive a monthly salary exceeding RMB 3,000 (Sichuan Medical Doctor Association, 2021). Multiple news reports have highlighted individuals quitting medical residency training due to low pay that could not make ends meet (Sichuan Medical Doctor Association, 2021).

The Chinese College Admission System

The college admissions process in China consists of two steps. First, every year on June 7 and 8, high school graduates aspiring for college take the standardized national exams (the National College Entrance Examination, NCEE). Following this, hopefuls can apply to up to 5 different universities with their list of preferred majors by submitting an application form along with their NCEE results.

The Chinese college admission system has four features that facilitate our empirical analysis. First, each Chinese university allocates quotas for each major at the provincial level. As college degrees are highly valued in the Chinese labor market, universities have minimal trouble filling the assigned quotas of each major. The quota assignments remain largely unchanged over time, showing little responsiveness to fluctuations in local population or economic development. The consistency and resilience of these quota values help alleviate concerns over changes in cohort-specific medical degree enrollments.

Second, similar to the education system in Republic of Korea (South Korea), Egypt, Vietnam, and Russia, the NEEC results are the only criteria for college admission irrespective of income and other socio-demographic characteristics. Universities do not have a right to set up their own admissions procedures. They rank and select applicants based solely on their total NCEE score and major preference.

Third, most Chinese universities are state-subsidized public institutions. Their tuition fees are merely around RMB 5000-8000, which is significantly lower than the average annual income per capita of RMB 33036 (Bo et al., 2020). Besides, students from financially disadvantaged families are eligible for government financial aid. Therefore, tuition fees are unlikely to be a concern for students when they apply to college or choose a major.

Fourth, college students in Mainland China cannot transfer between universities. Besides, only a very small percentage of students, typically less than 5%, are allowed to transfer to a different major if they meet specific requirements set by their college and department. As a result, the number of applicants admitted to medical majors closely approximates the number of medical graduates at each university.

3 Data

In this section, we present the main features of the datasets used in our empirical analyses. We examine the impact of the national standardized medical residency training system on the number of NMLE examinees and the caliber of medical candidates using four datasets: the number of college graduates with a medical degree from each university, the annual count of medical graduates taking the NMLE at the provincial level, college admission numbers and scores at the university-major-year-province level for all Chinese universities, and data on province-level demographic and socioeconomic characteristics.

The NMLE Examinee Data

The Ministry of Health (MOH) provides yearly NMLE examinee data from 2004 to 2020, which includes information on the number of medical graduates taking NMLE exams in each province each year. As shown in Figure 1, the number of NMLE examinees nearly doubled from 2004 to 2013. However, following the implementation of the medical residency training system, the number of NMLE test-takers immediately decreased by approximately 22 percent and continued to decline from 2014 to 2020. Correspondingly, the percentage of practicing doctors in the country aged between 25 and 34 abruptly dropped from 27% to 21% (Figure B.1.).

Medical School Graduates

Data on yearly medical school graduates from 2004 to 2020 is provided by the Ministry of Education (MOE). It includes information on the number of students graduating with an MBBS degree from each

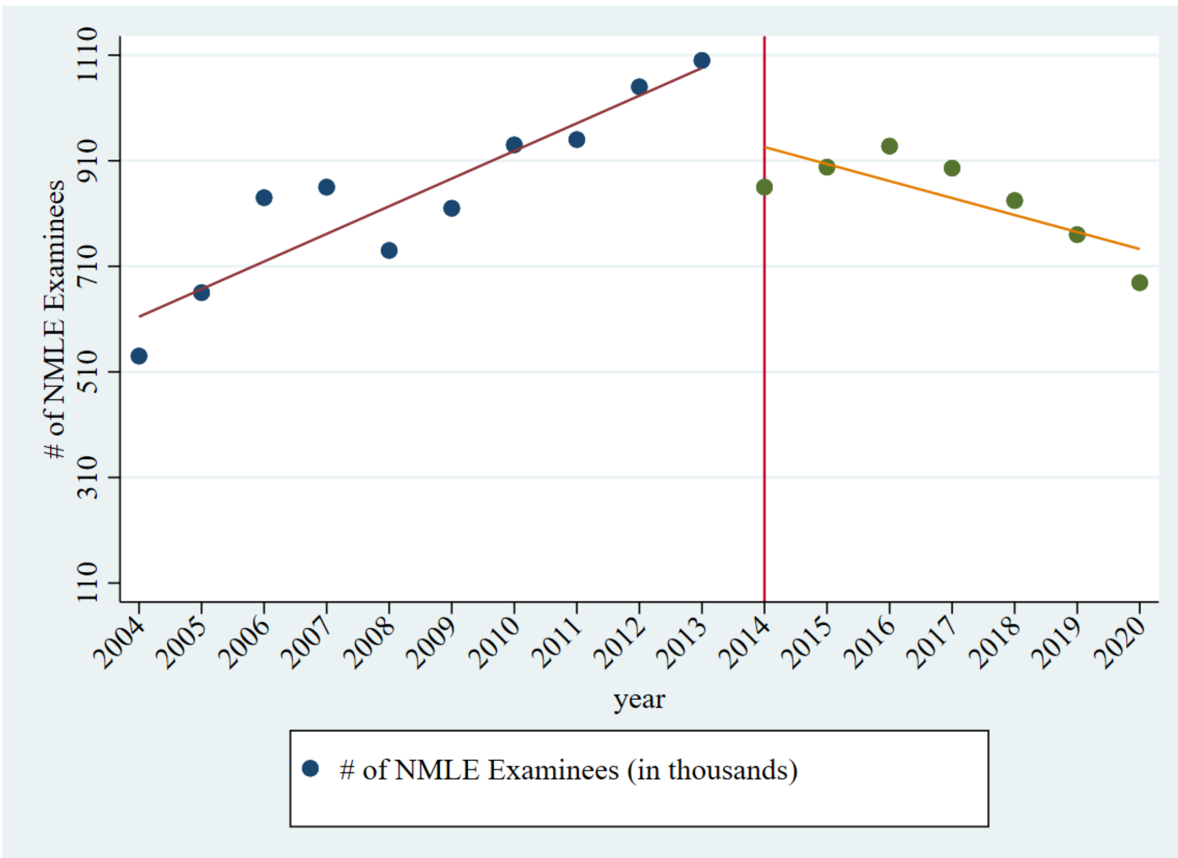

FIGURE 1

The Number of NMLE Examinees (2004-2020)

Notes: Figure 1 plots the number of medical graduates taking NMLE exams in each province each year. The NMLE examinee data are provided by the Ministry of Education.

Chinese university.

Figure 2 displays the annual count of individuals taking the NMLE, along with the number of medical graduates, from 2004 to 2019. Before the implementation of the national medical residency training system in 2014, both the number of medical school graduates and the number of NMLE examinees had been increasing every year and following parallel trends. This growth in medical education was largely due to the rapid economic growth and expansion of the higher education industry in China in the first decade of the twenty-first century. As medical school courses focus on the particular ailments of individual patients, most medical graduates were likely to take the NMLE exams and become licensed physicians so that their education and experience could yield gratifying work. However, after the introduction of the medical residency program, the number of people sitting the NMLE exams dropped by nearly 22 percent and remained low, while the number of medical graduates continued to increase from 2014 to 2019. Meanwhile, as shown in Figure 3, the pass rate significantly declined after 2014.

National College Entrance Examination (NCEE) Scores

The administrative dataset on college admission results includes information on the number of students admitted and their NCEE scores at the university-major-year-province level.

Figure 4 shows the average admission scores of medical and non-medical majors in each university from 2009 to 2019. As can be seen, admission scores for medical majors were significantly higher than those for non-medical majors and showed no heterogeneous preexisting time trends from 2009 to 2013. These parallel pre-trends motivate our choice of the DID model as the primary empirical specification. After the introduction of the medical residency training system in 2014, admission scores for medical majors decreased relative to those for non-medical majors and continued to decline from 2014 to 2019.

Table B.1. presents summary statistics of NECC scores for students admitted to medical (Panel A) and non-medical (Panel B) majors at the university-major-year-province level. Column 1 reports the average NECC scores for medical and non-medical majors during the baseline period (2009–2013). Standard errors are included in the parentheses. Column 2 displays the average NECC scores after

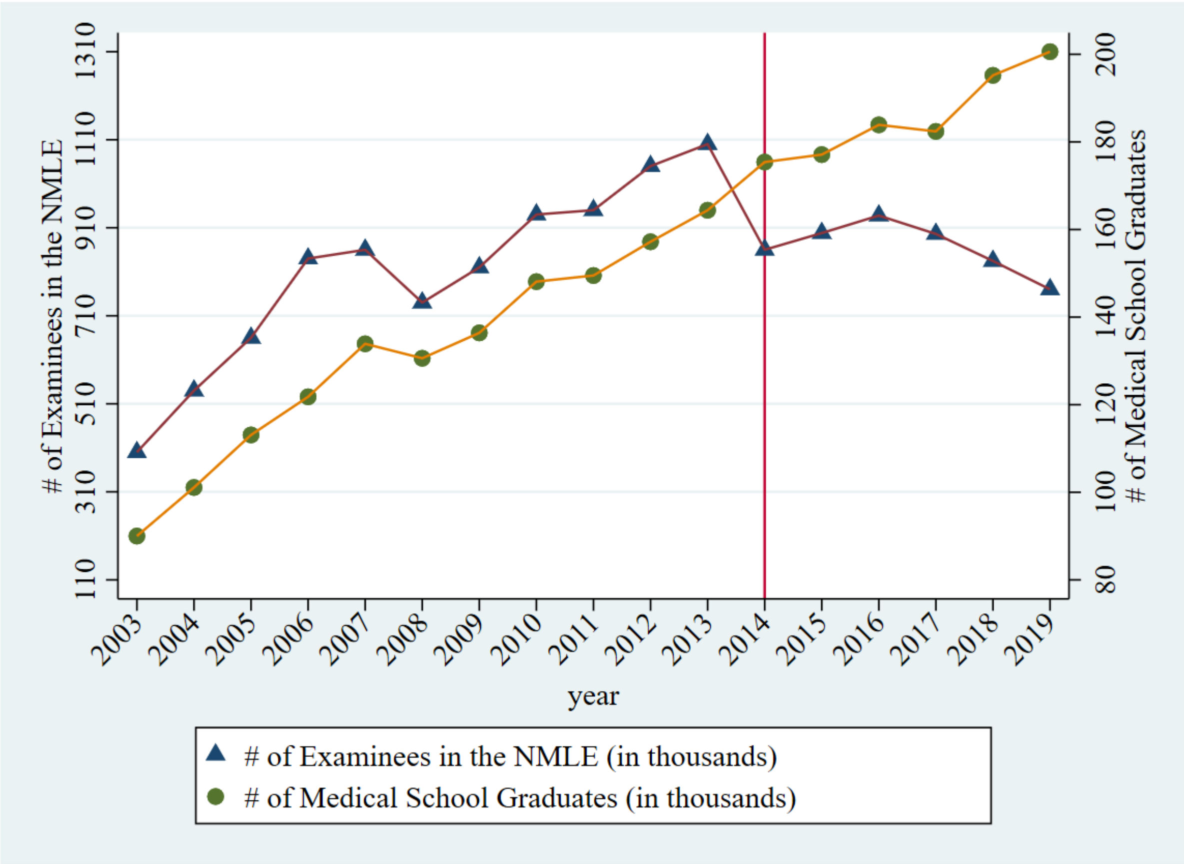

FIGURE 2

The Number of NMLE Examinees and Medical Graduates (2004-2019)

Notes: Figure 2 plots the annual count of individuals taking the NMLE, along with the number of medical graduates, from 2004 to 2019. The Ministry of Education provides the data on NMLE Examinees and medical school graduates.

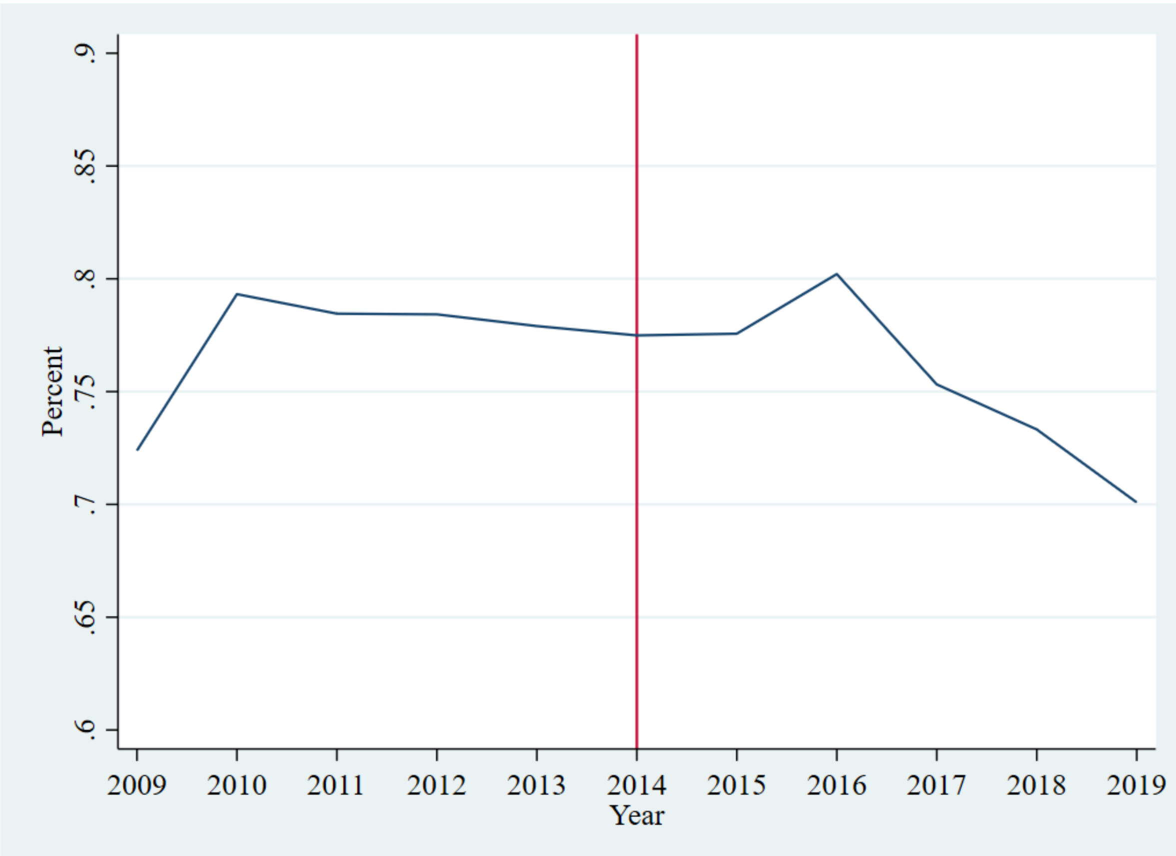

FIGURE 3

NMLE Pass Rates (2009-2019)

Notes: Figure 3 plots the NMLE pass rates from 2009 to 2019. The Ministry of Health provides the data on NMLE pass rates.

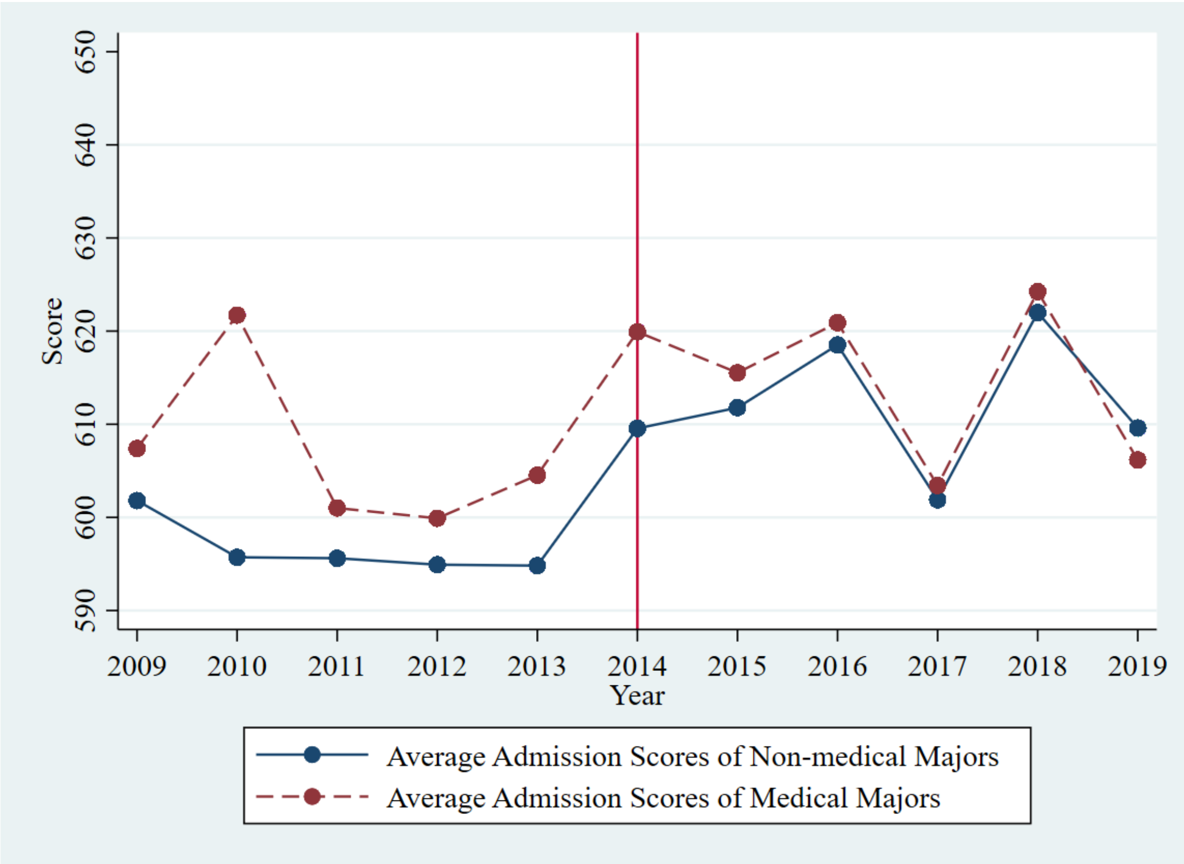

FIGURE 4

Admission Scores of Medical and Non-medical majors (2009-2019)

Notes: Figure 4 plots the average NECC scores of medical and non-medical majors from 2009 to 2019. The Ministry of Education provides the NECC data at the university-major-year-province level.

the implementation of the medical residency training system (2014–2019). Column 3 calculates the difference in means between the pre- and post- periods (Columns 1 and 2), respectively. In line with Figure 4, the mean value of NECC scores for students admitted to medical majors is 638.8 in the post-residency period and systematically different from the mean value of NECC scores for students admitted to medical majors, 628.6, before the medical residency program was implemented. In contrast, the mean value of NECC scores for students admitted to non-medical majors is 631.2 in the post-residency period, while the mean value of NECC scores for students admitted to non-medical majors was 631.2 before the introduction of the medical residency program.

Provincial Demographic and Socioeconomic Data

We utilize data from the China Statistical Yearbook (CSY) to obtain the annual median household income, poverty rate, and unemployment rate for each province. The CSY is a large-scale yearbook of statistical information comprehensively reflecting the economic and social development of the People's Republic of China. Provincial socioeconomic data are then matched to the NMLE records and NECC scores for heterogeneity analysis.

4 Empirical Methodology

Equation 1 displays the empirical model we use to estimate the residency program's causal effects on the quantity of medical labor supply.

$$Y_{cb} = \alpha + \beta Post + X_{cb} + \gamma_c + \mu_b + \epsilon_{cb}, \tag{1}$$

In the equation, Y_{cb} is the natural logarithm of the number of NMLE examinees in province c and year b. $Post$ is a post-residency indicator. The estimates of the coefficient β reflect the effect of the medical residency program. In addition, X_{cb} includes a set of provincial characteristics. In particular, We use the number of medical school graduates as one of the control variables because only graduates from accredited medical schools are eligible to take the NMLE exams and become licensed physicians for clinical practice. Province fixed effects, γ_c, absorb time-invariant location-specific factors that could affect college admission scores. The cohort fixed effects, μ_b, control for secular changes that are common to all provinces in a given year. ϵ_{cb} represents the regression error, with all standard errors clustered at the province-year level throughout the analysis.

Difference-in-Differences Specification

Equation 2 below presents our baseline DID model, comparing the NECC scores of students admitted to medical majors with those admitted to non-medical majors before and after 2014, the year the medical residency program was implemented:

$$Y_{iucb} = \alpha + \beta Medical * Post + X_{cb} + \gamma_c + \mu_b + \delta_{cb} + \epsilon_{ucb}, \tag{2}$$

In the equation, Y_{iucb} is the natural logarithm of NCEE scores for major i in university u, province c, and year b. $Medical$ is an indicator for medical majors; $Post$ is the post-residency indicator; The estimates of the coefficient β reflect the effect of the medical residency program. In addition, X_{cb} includes a set of provincial characteristics, such as population, income per capita, and urbanization rate. Province fixed effects, γ_c, absorb time-invariant location-specific factors that could affect college admission scores. The cohort fixed effects, μ_b, control for secular changes that are common to all provinces in a given year. Local, time-varying shocks to college admission scores that affect all individuals are absorbed by province-by-birth-year fixed effects, δ_{cb}. ϵ_{ucb} represents the regression error, with all standard errors clustered at the province-year level throughout the analysis.[2]

[2] In our robustness checks in Appendix Table **??**, we cluster standard errors at the province-year-university level, allowing arbitrary correlation in error terms for a given province-year-university pair. The results show that the effect of the medical residency program remains highly similar when clustering standard errors at the province-year-university level.

Internal Validity

The central requirement for identification in our DID strategy is the parallel-trend assumption, wherein in the absence of the residency program, the average NECC scores for students admitted to the medical majors would have followed the same trend as those for students admitted to the non-medical majors. While the counterfactual is certainly unobservable, we perform a series of robustness tests to support the parallel-trend assumption. We conduct an event study by interacting the major dummies in equation 2 with year dummies. The relatively flat line on the left end of each graph (i.e., before 2014) provides evidence for the parallel-trends assumption, supporting the validity of the DID strategy.

To better address concerns about differential cohort trends, we assumed that the medical residency program had been introduced 1, 2, 3, or 4 years earlier than the actual arrival year and then replicated the main regressions in Appendix Tables B.2. and B.3.. We consistently find no effect of the medical residency program on NECC scores or the number of NMLE examinees in these "placebo" settings, lending further credence to the DID approach. Besides, our estimates are robust to various empirical specifications that relax the classical DID assumption and allow differential growth trajectories for different college majors, addressing concerns that NECC scores for different majors may have different growth paths (Gobillon and Magnac, 2016).

Finally, we conduct the randomization inference procedure as suggested by Bertrand et al. (2004), and present the results in Appendix Figure B.2.. We randomly assign the treatment status of medical school to other college majors and estimate the DID specification as placebo treatment effect. This procedure is repeated 1000 times to form a distribution of placebo treatment effects. The point estimates obtained in the main regressions are significant compared with the distribution of placebo effects, thus corroborating the validity of the DID approach.[3]

[3]Please see Section C in the Appendix for more detail.

5 Results

This section has three subsections. The first subsection summarizes the main results of the DID estimates. The spatial distribution of the provincial level DID estimates are presented in the second subsection. The final subsection performs validation tests to check the robustness of the DID estimates.

The Impact of the National Residency Training System on the Number of NMLE Examinees

TABLE 1

Effect of the Medical Residency Training System on the Number of NMLE Examinees

	Ln(NMLE Examinees)			
	(1)	(2)	(3)	(4)
Post	-0.229***	-0.257***	-0.228***	-0.230***
	(0.053)	(0.057)	(0.096)	(0.075)
Observations	600	600	600	600
R-squared	0.899	0.999	0.916	0.973
Controls	Yes	Yes	Yes	Yes
Province FE		Yes		Yes
Year FE			Yes	Yes

Table 1 presents results for the effect of the residency training system on the number of people sitting NMLE exams, using different control variables in each specification. The model in Column 1 controls for the province fixed effects. The results show that the introduction of the national residency training system caused a significant decrease of 22.9% in the number of NMLE examinees.

If the NMLE exam registration patterns are different across different years or if medical graduates in different provinces have different preferences of career choices, any variations in the time or location of data collection could affect the regression results. To account for this possibility, the specification in Column 2 includes year fixed effects while the specification in column 3 includes year fixed effects and province fixed effects. As with the other control variables, the inclusion of these fixed effects has little impact on the estimated effect of the medical residency training system.

The granularity of provincial-level data enables us to estimate the impacts of the policy in different regions. We observe substantial variations in average treatment effect across provinces.

The Effect of the National Residency Training System on the NECC Scores of Students in Medical and Non-medical Majors

TABLE 2*Effect of the Medical Residency Training System on NECC Scores*

	Ln(NECC Scores)			
	(1)	(2)	(3)	(4)
Treat*post	-4.707***	-4.652***	-4.016***	-4.012***
	(1.901)	(1.741)	(1.523)	(1.413)
Observations	1152	1152	1152	1152
R-squared	0.076	0.560	0.637	0.727
Year FE	YES	YES	YES	YES
University FE		YES	YES	YES
Province FE			YES	YES
Province-Year FE				YES

Table 2 presents results on the NECC scores of students admitted to medical and non-medical majors, with each specification using different control variables. The model in Column 1 controls for the year fixed effects. The results show that the introduction of the national residency training system caused a significant decrease of 4.7 points in NECC scores for medical majors compared to non-medical majors after the implementation of the national medical residency training system.

We make several adjustments to the DID specification to ensure the robustness of these results. In particular, our specifications in Columns 2-4 build on the model in Column 1 by adding university fixed effects, province fixed effects, and province-year fixed effects. The estimates obtained are highly similar, thus bolstering confidence in our baseline model.

6 Validation Tests

In this section, we perform several validation tests to check the robustness of our estimates.

Time Window Selections

We capture the sensitivity of the estimates on NMLE examinees relative to sample selection by analyzing two sub-samples of the original time window (2004 to 2020): 2009 to 2018 (5 years before and after the policy change) and 2011 to 2016 (3 years before and after the policy change). Table B.7. and Table B.8. summarize the estimates for these two time windows.

These estimates are consistent with those of the original time window (2004 to 2020). Meanwhile, we note that as the time window narrows, the estimates decrease in magnitude, indicating a smaller reduction in the number of NMLE examinees. This diminishing effect is logical, as medical school graduates from years closer to the implementation of the national standardized residency training system have less opportunity to alter or adapt their career paths..

Event-study Estimates

To further test the parallel trends assumption, we next provide event-study estimates of the effect of the medical residency program. We use the same specification as in our main analysis but add the interactions of the major indicator with year dummies. The relatively flat line on the left end of each graph (i.e., before 2014) provides evidence for the parallel-trends assumption, supporting the validity of the DID strategy.

Placebo Exposure Tests: Assume earlier introduction of the Medical Residency Program

To better address concerns about differential cohort trends, we assumed that the medical residency program had been introduced 1, 2, 3, or 4 years earlier than the actual arrival year and then replicated the main regressions in Appendix Tables B.2. and B.3.. We consistently find no effect of the medical residency program on NECC scores or the number of NMLE examinees in these "placebo" settings, lending further credence to the DID approach. Besides, our estimates are robust to various empirical specifications that relax the classical DID assumption and allow differential growth trajectories for

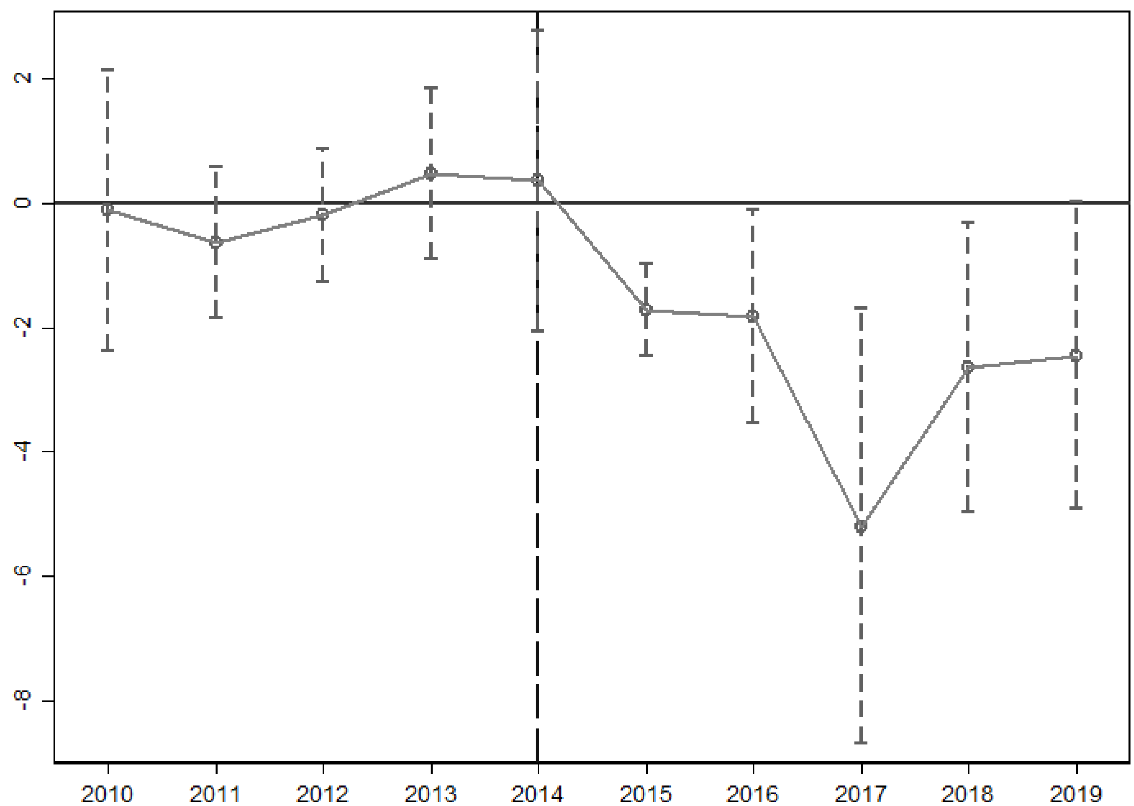

FIGURE 5

Effect of the Medical Residency Program on NECC Scores: Event Study Plot different college majors, addressing concerns that NECC scores for different majors may have different growth paths (Gobillon and Magnac, 2016).

Randomization Inference Procedure

As an additional robustness check, we conduct the randomization inference procedure, as suggested by Bertrand et al. (2004). We randomly assign the treatment status of medical majors to non-medical majors and estimate the DID specification to derive the corresponding placebo treatment effect. We repeat this process 1000 times to generate a distribution of placebo treatment effects, against which we compare the treatment effect observed in the actual treatment assignment. This allows us to obtain p-values and tests of statistical significance. In Appendix Figure B.2., we present the probability density function of placebo treatment effects for adult earnings. In particular, we show that the point estimates obtained in the main regressions are clearly significant compared with the distribution of placebo effects, thus confirming the validity of the DID approach.

7 Mechanisms

Among all possible explanations for why the residency training program may have discouraged medical school graduates from becoming doctors, the income mechanism is particularly plausible. As shown in Figures A.1.-A.4., unlike in developed countries where physicians are the highest-paid professionals, doctors in many developing countries receive low pay. In particular, the average starting salary for China's junior doctors is around 4,850 yuan ($730) a month, significantly lower than the average college graduate starting salary of 6,000 yuan. After the implementation of the national medical residency program, medical graduates have to work as residents for three years with lower wages instead of directly working as junior doctors with full salary. The average salary for a medical resident is only RMB 3476 per month with merely 35% of residents nationwide receive a monthly salary exceeding RMB 3,000. This significant deterioration in income is likely to hinder high-quality candidates from enrolling in medical schools and fresh medical graduates from pursuing clinical practice.

To delve into the income mechanism, we use data from the China Family Panel Studies (CFPS) 2010-2018 to assess the impact of the medical residency training system on the earnings of doctors compared to non-doctors. The CFPS is a large-scale, nationally representative, longitudinal survey conducted by the Social Science Survey Institute at Peking University. The survey covers 25 out of 31 provinces and autonomous regions throughout China. Each wave of the survey records personal monthly income (measured in thousands of RMB), which we use as the main income variable. To limit the influence of potential outliers in the income data, we winsorize 0.5% from each tail of the income distribution for the baseline sample.[4]

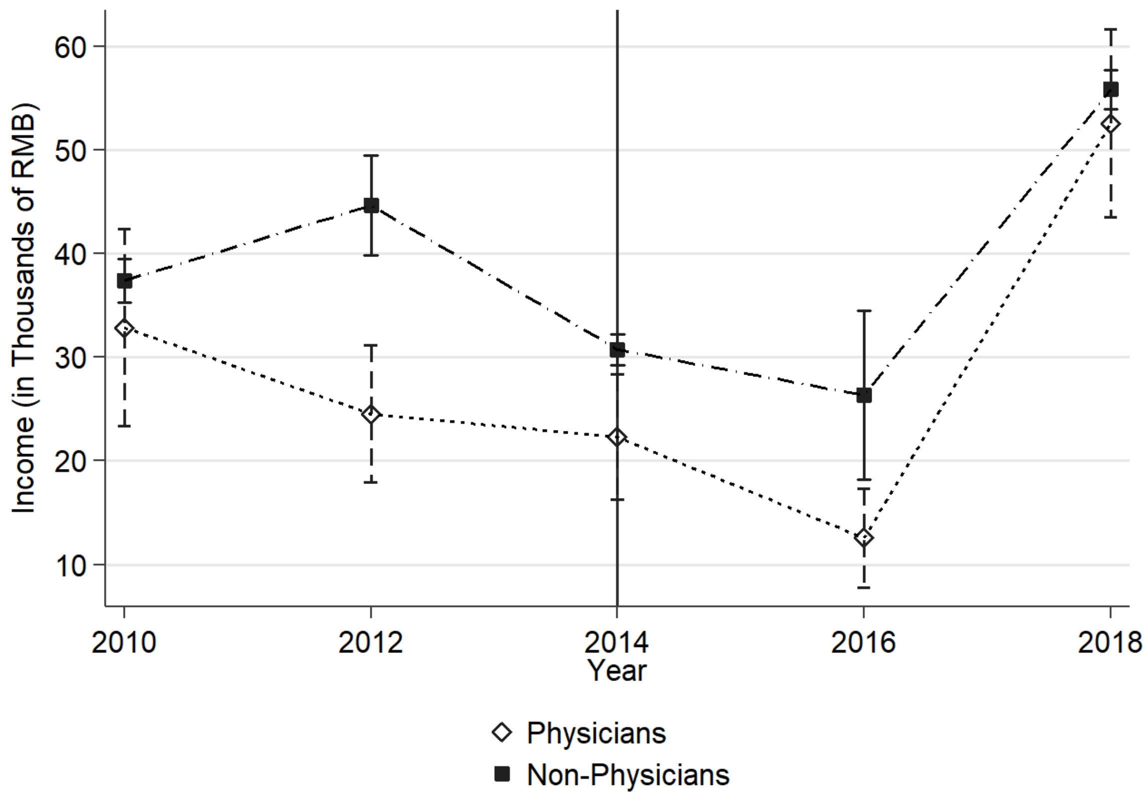

FIGURE 6
Physician vs. Non-physician Salary (2010-2018)

Figure 6 plots the monthly incomes of doctors compared to non-doctors among college graduates with 95% confidence intervals. In line with Figures A.1.-A.4., the average salary for doctors in China is

[4]For the 0.5% winsorization, we replace values above the 99.5th percentile by the value at the 99.5th percentile and values below the 0.5th percentile by the value at the 0.5th percentile.

significantly lower than the average salary of college graduates. This wage disparity persists even after the introduction of the medical residency training system, supporting the income mechanism.

8 Discussions and Conclusions

Using a variety of survey and administrative data, this paper examines the impacts of occupational regulation on medical labor supply in China, the largest developing country in the world. Specifically, we examine the causal role of the national standardized medical residency training system on the level and quality of labor supply of young doctors in China. We adopt a causal inference approach, a difference-in-difference (DID) model, to address potential estimation biases.

Using the DID model, Our results show that the implementation of the medical residency program results in a 22% decrease in the number of candidates opting for and passing the medical licensing exam as well as a significant decline in college admission scores of medical school compared to those of non-medical ones, suggesting that the medical residency program diminish the overall labor supply of young physicians and deter high-quality contenders from pursuing a medical career. The granularity of provincial-level data enables us to estimate the impacts of the policy in different regions. We observe substantial variation in average treatment effect across provinces.

Among all possible explanations for why the residency training program may have discouraged medical school graduates from becoming doctors, the income mechanism is particularly plausible. Unlike in developed countries where physicians are the highest-paid professionals, doctors in many developing countries receive low pay. In particular, the average starting salary for China's junior doctors is around 4,850 yuan ($730) a month, significantly lower than the average college graduate starting salary of 6,000 yuan. After the implementation of the national medical residency program, medical graduates have to work as residents for three years with lower wages instead of directly working as junior doctors with full salary. This significant deterioration in income is likely to hinder high-quality candidates from enrolling in medical schools and fresh medical graduates from pursuing clinical practice.

This study relates to a body of research that shows occupational regulations can be a barrier to entry that restricts labor supply. So far, most empirical studies on occupational regulations focus on developed countries, such as the United States, Canada, and countries in the European Union. Little is known about the impacts of occupational licensing in emerging markets. We contribute to filling this gap in the literature by examining the impacts of residency training system on medical labor supply in China, the largest developing country in the world.

Besides, our results are directly relevant to ongoing policy debates about the merits of residency training system on doctors in developing countries today. OECD and other developed countries have a mature 2- to 3- year national residency training system for physicians. In contrast, many emerging economies have no or very informal medical residency training programs. For instance, the medical licensing systems in Uganda, India, and Myanmar are similar to the one in China before 2014, where medical school graduates that have passed the medical licensing exams work directly as junior physicians without residency training. The findings in this paper indicate that the implementation of national residency training system caused a significant decline in labor supply of young practitioners in China, exacerbating the shortage of doctors in the public health system of developing countries. Moreover, physicians play a central role in providing medical care and safeguarding the health of the public. It is essential to attract and select high-quality candidates. We show that the medical residency program shuts out high-quality contenders. Our results and methods contribute credible evidence to this important policy issue.

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Appendix A:

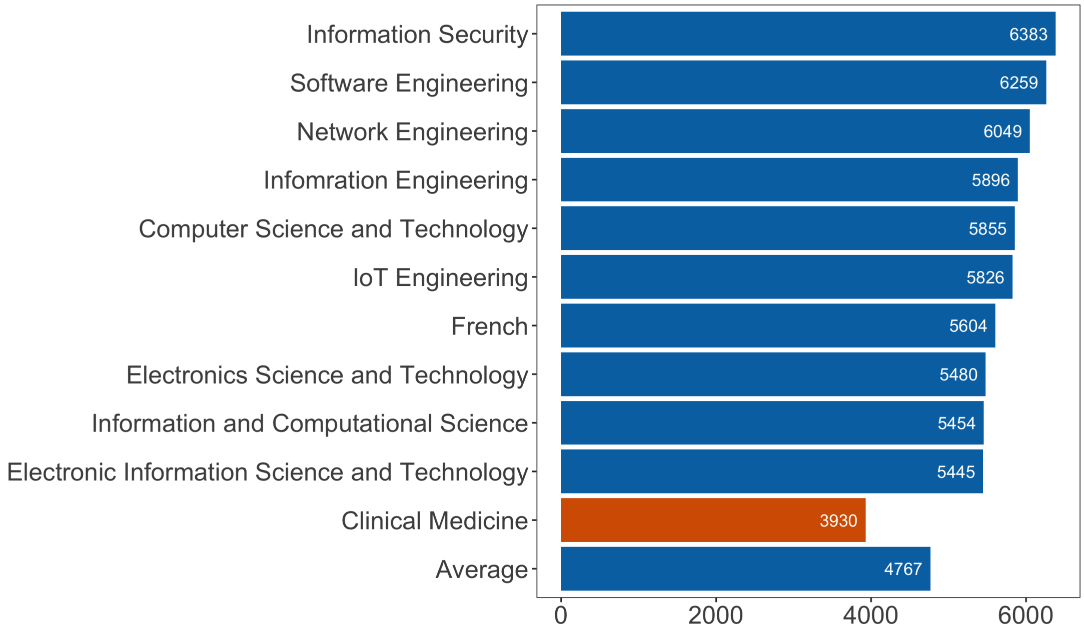

FIGURE A.1.
Top 10 Highest-Paying Jobs in China

Notes: Figure A.1. lists the top 10 highest-paying jobs in China

FIGURE A.2.
Top 10 Highest-Paying Jobs in the US

Notes: Figure A.2. lists the top 10 highest-paying jobs in the US.

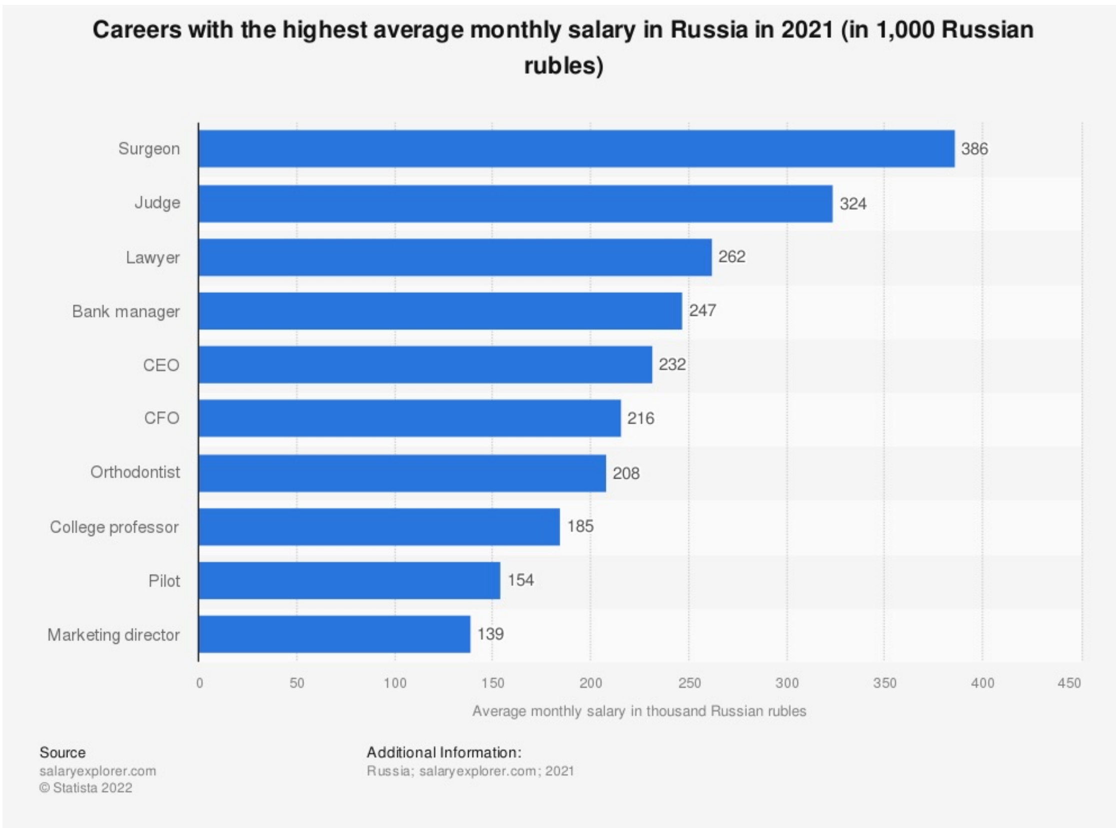

FIGURE A.3.
Top 10 Highest-Paying Jobs in Russia

Notes: Figure A.3. lists the top 10 highest-paying jobs in Russia

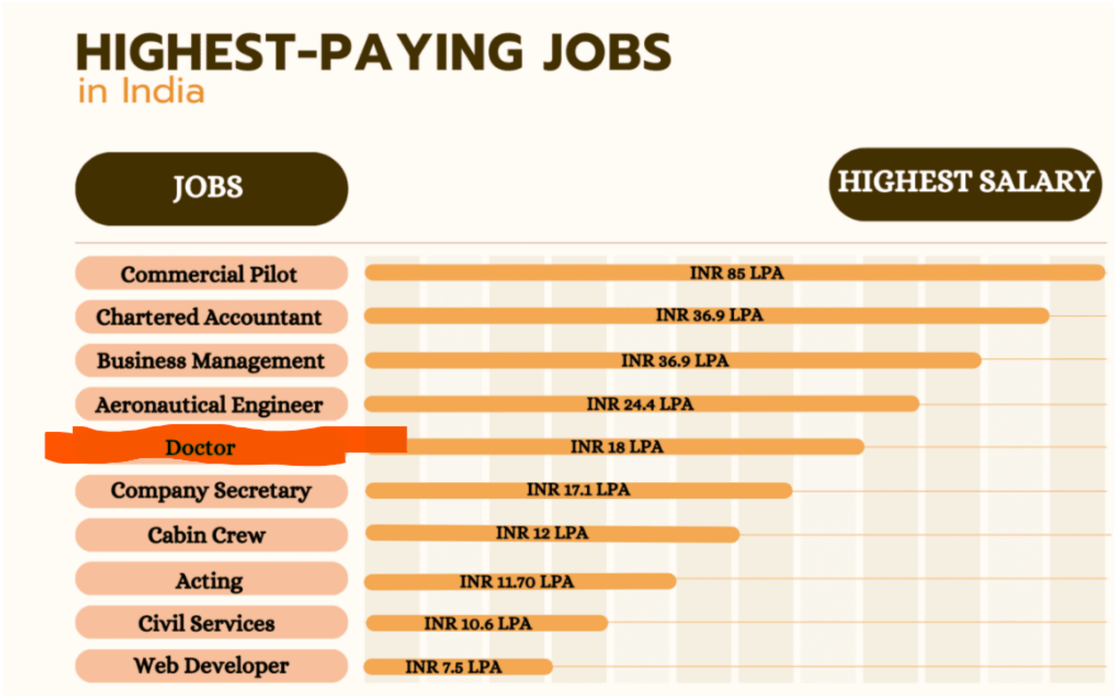

FIGURE A.4.
Top 10 Highest-Paying Jobs in India

Notes: Figure A.4. lists the top 10 highest-paying jobs in India

Appendix B:

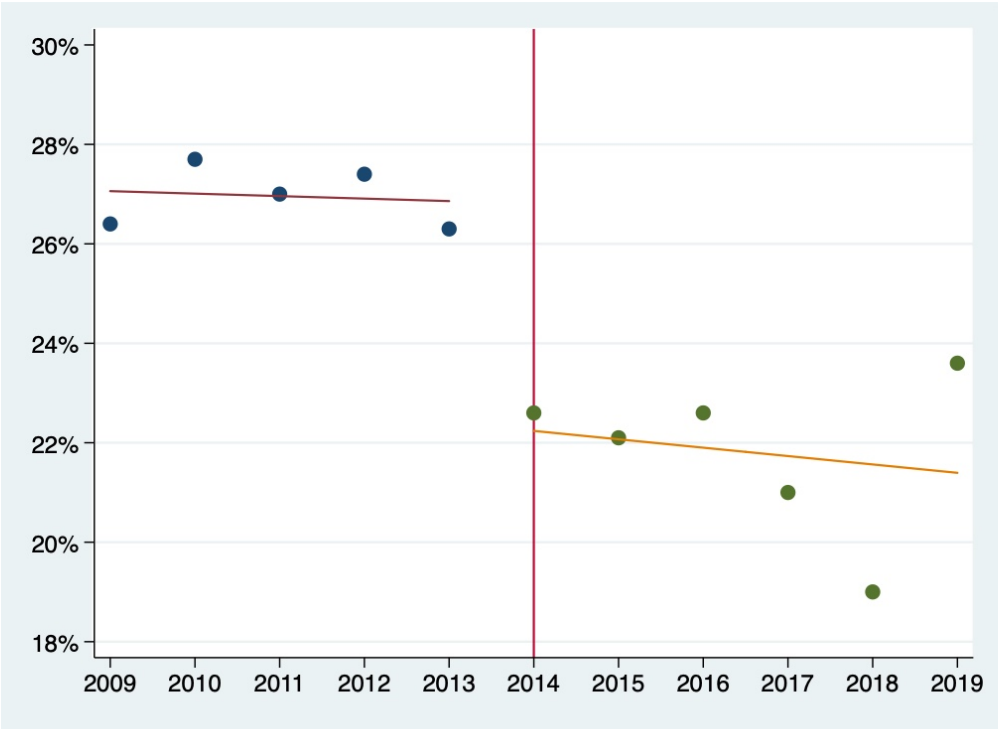

FIGURE B.1.
Percentage of Licensed Doctors Aged 25 to 34 (2009-2019)

Notes: Figure B.1. plots the percentage of licensed doctors aged 25 to 34 from 2009 to 2019

TABLE B.1.
Summary Statistics: NECC Scores for Medical and Non-medical Majors

	Panel A: medical_average		
	(1)	(2)	(3)
	Mean	Mean	Diff
	(2009-2013)	(2014-2019)	
Score	628.6	638.8	10.2***
	(2.086)	(2.360)	(3.283)
YOY Score(%)	-0.333	1.024	1.357***
	(0.403)	(0.322)	(0.531)
	Panel B: non_medical_average		
	(1)	(2)	(3)
	Mean	Mean	Diff
	(2009-2013)	(2014-2019)	
Score	631.2	643.5	12.3***
	(2.086)	(1.993)	(2.941)
YOY Score(%)	-0.418	0.869	1.287***
	(0.258)	(0.194)	(0.326)

The sample is obtained from the Ministry of Education to identify college admission scores of medical and non-medical majors. Panel A only includes medical majors, while panel B includes non-medical majors. The unit of observation is collapsed to the university-major-year-province level. Columns 1 and 2 show the mean of selected variables in each subsample. YOY values represent the year to year change in the average admission scores at the university-major-year-province level; Columns 1-3 show the annual average value of relevant variables in 2009-2013, the annual average value of relevant variables in 2014-2019, and the difference in means between the pre- and post- periods (Columns 1 and 2), respectively. Standard error are in parenthesis. *** Significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level.

TABLE B.2.

Placebo Exposure Tests: Assume earlier introduction of the Medical Residency Program

	Ln(NECC Scores)			
	(1)	(2)	(3)	(4)
	2010	2011	2012	2013
Treat*post	-2.153	-2.711	-1.951	-3.247
	(1.376)	(1.639)	(1.606)	(3.173)
Observations	482	482	482	482
R-squared	0.799	0.799	0.798	0.798
Year FE	YES	YES	YES	YES
University FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES

Notes: The sample is obtained from the Ministry of Education to identify college admission scores of medical and non-medical majors. The unit of observation is collapsed to the university-major-year-province level. The main specification in each column includes year, university, province, and province-by-year fixed effects. Standard error are in parenthesis. *** Significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level.

TABLE B.3.

Placebo Exposure Tests: Assume earlier introduction of the Medical Residency Program

	Ln(NMLE Examinees)			
	(1)	(2)	(3)	(4)
	2010	2011	2012	2013
Treat*post	-0.232	0.274	-0.241	-0.118
	(0.192)	(0.326)	(0.188)	(0.139)
Observations	30	30	30	30
R-squared	0.923	0.929	0.927	0.923
Province FE	YES	YES	YES	YES
Province-Year FE	YES	YES	YES	YES

Notes: The sample is obtained from the Ministry of Education to identify college admission scores of medical and non-medical majors. The unit of observation is collapsed to the university-major-year-province level. The main specification in each column includes year, province, and province-by-year fixed effects. Standard error are in parenthesis. *** Significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level.

TABLE B.4.

Effect of Residency Training System on the Number of NLPE Examinees

Variable	# of Examinees		
	N	N	N
Treat*Pass	401.21***	391.35***	404.11***
	(2.12)	(2.81)	(0.59)
Year FE	No	Yes	Yes
Province FE	No	No	Yes
Observations	76	76	52
R^2	0.981	0.991	0.985

Outcome variable: the number of NLPE examinees on an annual basis from 2005 to 2020 (in thousands). The sample is obtained from the Ministry of Education. Standard error are in parenthesis. *** Significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level. Robust standard errors in parentheses.

TABLE B.5.
Effect of Residency Training System on the Proportion of Licensed Doctors aged 25-34

Variable	% of Doctors Aged 25-34		
	%	%	%
Pass*Treat	-0.05***	-0.05***	-0.05***
	(-99.74)	(-67.21)	(-40.89)
Year FE	No	Yes	Yes
Province FE	No	No	Yes
Observations	271	271	271
R^2	0.986	1.000	0.988

Outcome variable: the proportion of licensed doctors aged 25-34. The sample is obtained from the Ministry of Education. The model in Column 1 controls for the year fixed effects. The specifications in Columns 2-4 build on the model in Column 1 by adding university fixed effects, province fixed effects, and province-year fixed effects, respectively. Standard error are in parenthesis. *** Significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level.

TABLE B.6.

Summary Statistics: NMLE Examinees and Medical Graduates

Panel A: NMLE Examinees			
	(1)	(2)	(3)
	Mean	Mean	Diff
	(2009-2013)	(2014-2019)	
Score	28740.73	26560.03	-2180.70
	(2278.91)	(1401.7)	(2675.48)
YOY Score(%)	4.758	2.051	-2.707
	(7.340)	(4.024)	(7.918)

Panel B: Medical Graduates			
	(1)	(2)	(3)
	Mean	Mean	Diff
	(2009-2013)	(2014-2019)	
Score	17134.36	22037.12	4902.76
	(4838.70)	(5526.56)	(7655.11)
YOY Score(%)	3.655	6.268	2.613**
	(1.540)	(0.749)	(1.536)

The sample is obtained from the Ministry of Education to determine the number of NMLE examinees and medical graduates. Panel A presents the annual number of NMLE examinees, while Panel B displays the yearly count of medical graduates in each province. Columns 1 and 2 show the mean of selected variables in each sub-sample. YOY values represent the year to year change in selected variables in each sub-sample; Columns 1-3 show the annual average value of relevant variables in 2009-2013, the annual average value of relevant variables in 2014-2019, and the difference in means between the pre- and post- periods (Columns 1 and 2), respectively. Standard error are in parenthesis. *** Significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level.

TABLE B.7.

Effect of Residency Training System on the Number of NMLE Examinees from 2009 to 2018

Variable	# of Examinees		
	N	N	N
Pass	-0.217***	-0.215***	-0.217***
	(12.12)	(13.81)	(11.59)
Year FE	No	Yes	Yes
Province FE	No	No	Yes
Observations	451	451	451
R^2	0.981	0.991	0.985

Outcome variable: the number of NMLE examinees on an annual basis from 2009 to 2018 (in thousands). Robust standard errors in parentheses. The sample is obtained from the Ministry of Education. The model in Column 1 controls for the year fixed effects. The specifications in Columns 2-3 build on the model in Column 1 by adding province fixed effects, and province-year fixed effects, respectively. Standard error are in parenthesis. *** Significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level.

TABLE B.8.

Effect of Residency Training System on the Number of NMLE Examinees from 2011 to 2016

Variable	# of Examinees		
	N	N	N
Pass	-0.209***	-0.212***	-0.205***
	(11.12)	(13.81)	(11.09)
Year FE	No	Yes	Yes
Province FE	No	No	Yes
Observations	300	300	300
R^2	0.981	0.991	0.985

Outcome variable: the number of NMLE examinees on an annual basis from 2011 to 2016 (in thousands). Robust standard errors in parentheses. The sample is obtained from the Ministry of Education. The model in Column 1 controls for the year fixed effects. The specifications in Columns 2-3 build on the model in Column 1 by adding province fixed effects, and province-year fixed effects, respectively. Standard error are in parenthesis. *** Significant at the 1 percent level; ** significant at the 5 percent level; * significant at the 10 percent level.

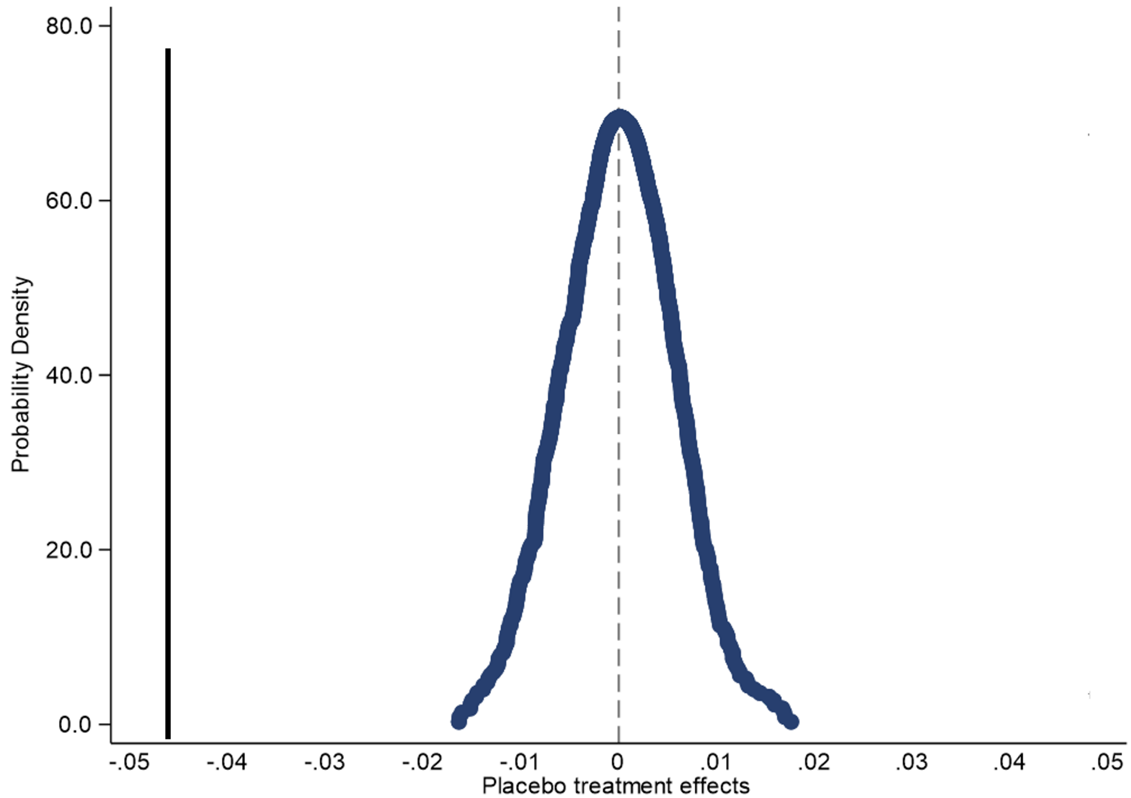

FIGURE B.2.
Random inference distribution