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New Medical Schools, Access to Doctors and Health Outcomes: Evidence from Japan *

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Abstract

We investigate the effects of the medical school and the associated university hospital constructions in the 1970s on access to doctors and mortality, using the prefecture-level panel data of Japan and an event study design that exploits an exogenous variation in the pre-war location of medical schools. We find the long-term effect of an increase in doctors, and the effect closes the gap in the access to doctors that existed between treated and control prefectures before the policy intervention. We also find a decline in mortality for acute and intractable diseases after the establishment of the university hospital. Our results suggest that opening medical schools in rural areas are a potential policy to mitigate geographical disparities in access to doctors. Our results also indicate that the university hospital and the new medical graduates played an important role in decreasing mortality rates.

JEL Codes: I10, I14, I18, I19

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1 Introduction

Reducing regional health inequality is a long-standing challenge faced by both developing and developed countries. Numerous studies have documented that health disparities are related to spatial differences in healthcare access.[1] In response to this concern, governments have implemented supply-side interventions for healthcare access. For example, in Canada, Quebec gave financial incentives for doctors to work in rural and isolated areas, and attracted doctors from urban areas (Bolduc et al. (1996)). Moreover, for access to hospitals in rural areas, the US government provided subsidies for constructing nonprofit and local government hospitals in hospital-scarce areas after WW2 (Chung et al. (2017)).

Despite the prevalence of such policies aiming to reduce spatial inequalities in healthcare access, convincing evidence of their effects on health outcomes is surprisingly limited. This issue can be attributed to two main reasons. First, the effect of the supply-side reform on healthcare access remains unknown or ambiguous since quasi-experimental variations in access to healthcare brought by the supply-side reform are rare.[2] Second, the need for clean identification of the effect on healthcare access makes it difficult to estimate the effect of the intervention on health outcomes.[3]

This study provides new evidence on the effectiveness of a supply-side intervention by examining the impact of the medical school and the associated university hospital constructions

[1] Deaton (2003) surveys the literature and explores the relationship between income inequality and mortality through many mechanisms, including public goods provision. For studies on the relationship between regional disparities in healthcare access and health outcomes, see Dai (2010) and Nelson (2002) in the US, Fang et al. (2010) and Liu et al. (2013) in China and Gusmano et al. (2014) in France.

[2] In the case of access to doctors, this may be because there is no consensus about the effectiveness of these interventions.

[3] For some important exceptions, Iizuka and Watanabe (2016) and Gruber et al. (2014), which I turn below.

on access to doctors and health outcomes by exploring the case of Japan. In the 1970s, the Japanese government unlifted the regulation of the medical school construction, and 17 prefectures had the first medical school and the associated university hospital mainly through a unique policy, referred to as the "One Prefecture, One Medical School Policy"(OPOMS).[4]

We employ an event study design as well as difference-in-differences to show the short and long-term effects of the medical school and the university hospital constructions on access to doctors and health outcomes and find that the number of doctors increases by 20%, and the effect lasts longer than 15 years. However, the increases in the number of doctors were partially offset by reductions in the number of doctors at non-university hospitals and clinics. We also find that the mortality rate decreases after the establishment of the university hospital by 2.5%, and the effect is permanent. Finally, we examine the effects of the constructions on access to facilities, hospital capacities and utilization and present an array of evidence suggesting that the decline in mortality is driven by quality improvement and capacity expansion in healthcare service along with the opening of the university hospital and the increase in the number of doctors at non-university hospitals after the graduation of medical students.

Our research is related to several literatures. First, our research contributes to the literature that examines the relationship between access to healthcare and health outcomes. Although several papers indicate that the number of physicians per capita is negatively related to mortality rate (e.g. Finkelstein et al. (2021); Or et al. (2005); Robst (2001)), most of the papers do not analyze the causal impacts of the supply-side intervention on health

[4] Japan is composed of 47 prefectures, which form the first level of jurisdiction and administrative division. The number of medical schools and university hospitals established at 17 prefectures is equivalent to around 25% of them before the 1970s.

outcomes in rural areas. A notable exception is Gruber et al. (2014), who shows an increase in government funding to hospitals caring for the poor, and a decrease in copay lower infant mortality rate in Thailand.

To our knowledge, our research is the first paper to show the effectiveness of the educational policy on health outcomes brought by the opening of the university hospital and an increase in young doctors as a consequence of the policy. The paper most closely related to our work in this respect is Iizuka and Watanabe (2016), which shows that a change in the medical intern system in 2004 had a spin-off effect of decreasing access to hospitals and experienced doctors in rural areas, and this brought an increase in mortality rates in rural areas in Japan. Compared to their work, my research shows the direct positive consequence of medical education policy while their research shows indirect negative effects. Thus, our research can be viewed as complementary to Iizuka and Watanabe (2016).

This is also consistent with numerous other studies that examine the effect of distance to healthcare on health outcomes. Such studies show that decreasing the distance to hospitals providing high-quality care is key in decreasing the mortality rates due to acute disease.[5] These findings highlight the effectiveness of supply-side policies that establish university hospitals for mitigating regional disparities in health status.

Next, our research extends the understanding of health policies intended to mitigate geographical disparities in access to doctors. In this literature, there are studies that analyze the effect of policies to increase the total number of doctors on access to doctors in rural

[5]For example, Goodman et al. (1997) and Kumar et al. (2014) report that the distance to hospital is negatively correlated with mortality rate but it is insignificant. Bazzoli et al. (2012) shows that the safety net hospital closure has an inconclusive effect on the mortality rate of the disadvantaged population. McClellan (1994) shows that the proximity to high-volume hospitals decreases the mortality rate of acute myocardial infarction.

areas. For example, there is an active line of research analyzing the effect of an increase in the number of U.S. physicians brought by accepting international medical graduates (IMGs) on rural access to doctors. However, there is no consensus on the effect of these policies.[6] Although to varying degrees, most of the research shows that the effectiveness of this program was small in mitigating urban-rural disparities.

Another active line of research is the literature on physician location choice. Cooper et al. (1975), Leonardson et al. (1985) and Steele and Rimlinger (1965) document an uneven distribution of physicians across the United States and point out factors that impact physicians' choices of practice location, including place of birth and location of study. Falcettoni (2018) and Kulka and McWeeny (2019) structurally analyze physicians' location choices and point out that the opportunities for education and place of birth are more important for physicians' location choice than monetary incentives. Our research directly examines how the place of medical education contributes to the increase in access to doctors and shows that the disparity in access to doctors is mitigated at the prefecture level.

Moreover, we also show that establishing a new medical school is effective in keeping graduates in the prefecture where the medical school was built in the long run. This is partly due to the institutional setting of the career path of doctors in Japan. However, this result is also supported by the findings in the literature. Magnus and Tollan (1993) examines the effect of establishing a medical school in a rural area in northern Norway and shows that 56% of its graduates stay in rural areas. Also, rural background and exposure through

[6] Mullan (1995) and Fink et al. (2003) show international medical graduates are no more likely to practice in under-served rural areas than U.S. medical graduates and point out that increasing the number of international medical graduates does not solve the physician shortages in under-served rural areas. In contrast, Thompson et al. (2009) and Mick et al. (2000) assert that IMGs fill gaps in the primary care workforce in many rural areas while IMGs contribute to physician abundance in urban areas in some cases.

education and medical practice effectively attract doctors to rural areas and increase their retention rate.[7] In addition, Rabinowitz et al. (1999) and Matsumoto et al. (2008) shows that rural exposure through medical practice even extends doctors' retention rate in rural areas.

The rest of the paper proceeds as follows. Section 2 reviews the history of the medical school construction in the 1970s. Section 3 describes the data, and Section 4 presents the empirical strategies. Section 5 presents the results. Section 6 discusses the external validity of our research and does the cost-benefit analysis. The final section concludes.

2 Background and Source of Variations

2.1 Medical School Construction[8]

Regional inequality in access to doctors was recognized as a prevailing problem in Japan. The density of doctors was consistently high in urban areas, and especially prefectures without a medical school suffered from poor access to doctors.

Before 1970, medical school construction was prohibited and the Japanese government increased doctors' supply by expanding medical school class sizes after the introduction of National Health Insurance (NHI) in 1961. Corresponding to an increase in demand for medical services after the introduction of NHI, the government increased the class sizes of existing medical schools from 2,880 to 4,040 between 1962 and 1969.[9] However, this

[7] Hancock et al. (2009) and Ravaghi et al. (2015) particularly mention that rural background and rural exposure through both education, recreation, or upbringing are strong factors motivating doctors to practice in rural areas.

[8] The discussion of this section heavily relies on Hashimoto (2008).

[9] Kondo and Shigeoka (2013) show NHI increased health care utilization.

expansion was insufficient, and the doctor-population ratio remained low, around 1.14 per 1,000 population.

In 1970, the Ministry of Health and Welfare (MHW) planned to increase the doctor-population ratio to 1.5 per 1,000 population in 15 years and relaxed regulations for establishing medical Schools. As a result, 12 private medical schools and one public medical school were constructed between 1970 and 1972, and three prefecture established their first medical school during this period.[10]

From 1973 to 1981, the Japanese government implemented a nationwide project referred to "One Prefecture, One Medical School Policy (OPOMS)" to construct public medical schools in prefectures where no medical school had existed before.[11] As a result, this project established 15 public medical schools and 15 associated university hospitals at 15 prefectures, and every prefecture had at least one medical school in the end.

These increases are equivalent to around 25% of the number of medical schools and university hospitals each before the implementation of OPOMS.

Japanese government imposed the regulation and prohibitied the medical school construction again in 1981, and this regulation continued until 2016.

Figure 1 depicts the geographical distribution of medical schools in 1969 and in 1981. As the left panel shows, 18 prefectures did not have a medical school in 1969. The right panel shows that more than 30 medical schools were established after 1969, and every prefecture had at least one medical school in 1981.

[10] In addition, four private medical schools were established between 1973 and 1978.

[11] OPOM established one more medical school at the largest prefecture (Hokkaido) where two medical schools had already existed.

2.2 Treatment Group and Control Group

Our research exploits exogenous variations in the number of medical schools across prefectures before 1970 to estimate the effect of medical school construction. Therefore, we classify 17 prefectures where the first medical school was established after 1970 into the treatment group.[12] Among the remaining prefectures, we classify 20 prefectures in which medical schools were not newly built after 1970 into the control group. Figure 2 depicts prefectures in the treatment and control groups.

Figure 3 shows the time series of the total number of medical schools and the total number of class sizes of medical schools in the treatment and control groups, respectively. The left panel presents the time series of the number of medical schools. From 1960 to 2000, the number of medical schools was stable at 21 in the control group. The total number of medical schools in the treatment group was zero before 1970 and started to increase afterwards. Finally, it reached 17 and became stable. The right panel presents the time series of the class sizes. In the control group, class sizes were stable until 1962 and expanded until 1977, corresponding to the policy changes. In the treatment group, it remained at zero before 1970 and started to increase until 1980 as the medical school construction went on.

[12] OPOMS established medical schools at Hokkaido and Okinawa (Northernmost and southernmost prefectures), but we excluded them from the treatment group because Hokkaido already had two medical schools before the implementation of OPOM, and the socioeconomic environment at Okinawa was different from the other prefectures due to the occupation by the U.S. until 1972.

2.3 Timeline of Medical School and University Hospital Construction and Career Path of Doctors

Medical school and university hospital construction followed the same timeline decided by the government. First, an associated university hospital opened three to four years after the construction of a medical school. University hospitals are the best quality and high-tech hospital in each prefecture, managed by the medical school and provides medical education and training to medical school students and interns. Once the university hospital opened, there was an inflow of medical professors and doctors into new university hospitals, especially from well-established medical schools and associated university hospitals in urban areas.

Second, the first-generation students obtained a medical license six years after the medical school construction. These new graduates became medical interns at the university hospital affiliated with the medical school they graduated from. Consequently, they became the subsequent inflow of doctors into prefectures, where the first medical school was established. In Japan, the legal requirement for the length of the medical internship is at least two years.

After the medical internship, medical interns became resident doctors. They were assigned to the university hospital and general hospitals in the same prefecture in rotation and continued on-the-job training. In return for learning opportunities at the university hospital and chances to get board certification and to pursue Ph.D., university hospitals decided on resident doctors' career paths.[13] Finally, after around ten years of rotation, these doctors were considered fully trained, and they could choose work locations on their own. Figure 4

[13]Japan did not have the residency matching until 2004. Ikai (2000) describes that more than 80% of resident doctors were on career paths offered by the university hospital. university hospitals exercised power over doctors' allocation and worked as a matchmaker corresponding to demands for doctors by general hospitals in the same prefecture.

summarizes the timeline of events after the medical school construction.

3 Data

We use several data sources covering from 1960 to 1999 at the prefecture level. We newly digitized all the survey data conducted between 1960 and 1996 except for the data on social investment and population used as controls.

3.1 List of Universities

The source of information about the year of establishment of medical schools, university hospitals and class size is *Zenkoku Daigaku Ichiran* [List of Universities]. This survey is annually conducted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

The survey contains information on the year of establishment and class size of all universities and their affiliated facilities in Japan at the university level. We use the survey to identify when medical schools and university hospitals were established and the year of graduation of the first-generation students.

3.2 Doctor

3.2.1 Survey of Physicians, Dentists and Pharmacists

Data of information on doctors comes from *Ishi, Shikaishi, Yakuzaishi Chosa* [Survey of Physicians, Dentists and Pharmacists]. This survey was annually conducted by Ministry of Health, Labour and Welfare (MHLW) up to 1982 and biannually thereafter.

The survey covers the universe of doctors and contains information on the number of doctors by type of practice (Non-University hospital, Clinic, University Hospital including faculties) at the prefecture level. The survey also reports the number of doctors by their specialty from 1969 at the prefecture level. We use the survey from 1960 to 1999 and construct the prefecture panel data of doctors.[14]

3.2.2 Survey of Medical Institutions

We also use the data on doctors obtained from *Iryō Shisetsu Chosa* [Survey of Medical Institutions]. This survey is annually conducted by MHLW and contains the number of full-time doctors at hospitals at the prefecture level. We use the survey from 1960 to 1999 and construct prefecture panel data of doctors.

3.3 Health Outcomes

For health outcomes at the prefecture level, we use *Jinkou Doutai Toukei* [Vital Statistics], conducted by MHLW. Vital Statistics includes a myriad of vital events at the prefecture level, of which this research uses the number of deaths by cause (All-cause, Cancer, Stroke, Heart attack, Pneumonia, Suicide) and the number of deaths by age (Children, Middle age, Elderly).[15]

While Vital Statistics have been annually conducted since 1960, the coding system used to categorize causes of death drastically changed by introducing the 10th revision of International Classification of Diseases (ICD-10) in 1995, and it became impossible to follow

[14] Between 1982 and 1999, we linearly interpolate the observations.

[15] Children are considered to be aged from 0 to 14, middle age are considered to be aged from 50 to 64, and elderly are considered to be aged from 65.

the number of deaths by causes consistently afterward.[16] Therefore, we limit the data from 1960 to 1994 for cause-specific mortality rates.

3.4 Hospitals, Beds, Patients, and Other Medical Staffs

For information on hospitals, hospital beds, and nurses at hospitals, we use Survey of Medical Institutions. Our research covers the following variables from 1960 to 1999: the number of hospitals, the number of clinics, the number of emergency hospitals, the number of beds, and the number of nurses at the prefecture level.

For information on patients in hospitals, we use *Byōin Hōkoku* [Hospital Report], which is annually conducted by MHLW and covers the cumulative number of outpatient and inpatient at the prefecture level from 1960 to 1999.

3.5 Control Variables

We include several variables to control for potentially confounding factors, which might affect both independent and dependent variables. To control for financial ability and public investment, we use the prefecture level GNP and prefecture level real social investment. Both of them are obtained from Annual Report on Prefecture Account and Social Capital Investment Estimation surveyed by Cabinet Office.

We also control demographic information at the prefecture-level using the total and age-based population from Population Estimation conducted by the Ministry of Internal Affairs and Communications.

[16] MHLW examined the number of cause-specific deaths referred to ICD-9 and ICD-10 using the same data and showed death by Pneumonia dropped by 22.2%, and death by Cerebrovascular disease increased by 13.0%.

3.6 Descriptive Statistics

Table 1 presents prefecture-level descriptive statistics by the treatment status. The first three columns correspond to values in 1965, and the following three columns correspond to values in 1990. The third and sixth columns show p-value of two-sample t-test.

Panel A presents descriptive statistics related to the number of doctors. It shows a difference in the mean number of overall doctors between the treatment and control groups in 1965. This difference mainly comes from the disparity in the number of doctors at university hospitals between these two groups since there was no medical school at prefectures in the treatment group. This gap became insignificant in 1990 after the medical school construction.

Panels B-D present descriptive statistics of mortality rates, utilization and facilities, and controls. As shown, these variables are similar between the treatment and control groups, and mortality rates went down in both groups from 1969 to 1990, while the utilization and access to facilities increased.

4 Empirical Strategy

We estimate an event study specification that exploits the variation in the prefecture-level distribution of medical schools before the deregulation period to estimate the effect of medical school construction on access to healthcare services and health outcomes. Our baseline specification is the following:

$$y_{it} = \alpha_i + \delta_t + \sum_{\substack{k\neq -1 \\ k=-10}}^{k=19} \beta_k \mathbb{1}(t = t_i^* + k) \times Est_i + X_{it}'\gamma + \epsilon_{it}, \tag{1}$$

where subscript i and t indicate prefecture and year respectively. y_{it} denotes the log-transformed outcome, and our two main outcomes of interest are the number of doctors and mortality. Est_i is the dummy which takes 1 if no medical school existed before the deregulation period at prefecture i and $\mathbb{1}(t = t_i^* + k)$ is a set of dummies which takes 1 if k periods have passed relative to the year of the establishment of a medical school at prefecture i. This event study type approach can flexibly show the estimated pattern over time, leading up to the event and test for the presence of differential trends from the run-up to the establishment of a medical school. The absence of pre-existing differential trends suggests that the change of dependent variables can be attributed to the establishment of a medical school. We set the baseline period at $k = -1$, meaning that our coefficients of interest show the effects of the years relative to the year of a medical school construction compared to two years prior to its occurrence. Since the data covers mainly from 1960 to 1999, I choose $k = -10$ to 19 so that it can examine the long-term effects of the medical school construction on outcomes.

We control for a number of time-varying observable demographic variables, such as real social investment, real GDP, elderly rate and total population, and denote them by X_{it}. δ_t are time fixed effects that control for time-specific components in the outcome variables common across prefectures. α_i are prefecture fixed effects and control for unobservable time invariant components of outcomes for each prefecture. Finally, ϵ_{it} is a time-varying error at the prefecture level. We cluster standard error at the prefecture level.

To allow for heterogeneity in treatment effects across time and treated units and deal with concerns about the consistency of TWFE for staggered adoption research design discussed in Goodman-Bacon (2021), we replicate our results using the robust estimators introduced in (Sun and Abraham (2021);Gardner (2022);Callaway and Sant'Anna (2021))[17].

We also use the following specification to estimate the average treatment effect on the treated (ATT) of the medical school construction:

$$y_{it} = \alpha_i + \delta_t + \beta Est_{it} + X_{it}'\gamma + \epsilon_{it}, \tag{2}$$

where y_{it} denotes the log-transformed outcome, Est_{it} is the dummy which takes 1 if prefecture i constructed a medical school before t, δ_t and α_i are time and prefecture fixed effects each, X_{it} are the same controls used in Equation (1), and ϵ_{it} is a time-varying error at the prefecture level. We cluster standard error at the prefecture level.

In addition to TWFE estimatr, we report the robust estiamtors of β based on Sun and Abraham (2021), Gardner (2022) and Callaway and Sant'Anna (2021).

5 Results

5.1 Results: Access to Doctors

In this section, we assess the causal effect of the medical school construction on access to doctors. Figures 5 and 6 present estimates of β_k from Equation (1) taking the log of the number of doctors by practice and specialty as outcome variables. Panel (a) in Figure 5 presents estimates of β_k from Equation (1), taking the log of the total number of doctors as an outcome variable. As shown, the estimates of the years preceding the medical school construction on the log of the total number of doctors are sometimes positive and statistically

[17]Due to the multicoliniarity, we can not get estimators based on Borusyak et al. (2022) and de Chaisemartin and D'Haultfœuille (2020).

significant from zero for several estimators, but the estimators move in the negative direction over time. The estimates start to increase rapidly after the medical school construction, keep increasing over time and become stable after t = 10. Regarding the magnitude of this impact, we show that ten years after the medical school construction, the number of doctors is around 15 to 20 % more relative to the year prior to the medical school construction. Considering the mean number of doctors prior to the medical school construction is 1322.23, the estimates indicates that around 198 to 265 more doctors increased by the medical school construction. The dynamics of coefficients after the medical school construction is also corresponding to the timeline summarized by Figure 4: There is a jump in coefficients at t=3 corresponding to the establishment of the university hospital, and coefficients become steeper after t=6 when medical students become doctors and start to work.

Panel (b) to (d) in Figure 5 show the effects on the growth of the number of doctors by types of practice. Panel (b) in Figure 5 presents the effect on the number of doctors at non-university hospitals. The panel shows that there is a negative growth in the number of doctors after the medical school construction, but this trend reverses after t=6. This provides an indication of a crowd-out effect of the medical school construction while there is a non-significant pre-trend. Moreover, the reversal is consistent with the timing when medical students start to work.

Panel (c) in Figure 5 presents the effect on the number of doctors at clinics. The panel shows that there is a negative growth in the number of doctors after the medical school construction, and the magnitude becomes larger over time. This indicates that there is also a crowd-out effect of the medical school construction for doctors at clinics while there is a non-significant pre-trend.

Panel (d) in Figure 5 presents the effect on the number of doctors at university hospitals. The panel shows that there is a positive growth in the number of university hospitals after the medical school construction, and the spike in the estimate is consistent with the timing of the establishment of the university hospital. The estimate becomes stable after t=6.

Figure 6 examines the effect of the medical school construction on the number of doctors of popular specialties. Except for cardiologists, there is a jump in the growth of the number of doctors when the medical school is established, and the effects become stable after t=10.

Finally, Figure 12 presents estimates of β from Equation (2) taking the log of the number of doctors by practice and specialty as outcome variables. Point estimates are positive and significant except for those of non-university hospital, clinic and cardiologist and confirm the results of the event studies.

Overall, the estimates suggest that the medical school construction increases the number of doctors for many specialties, and this increase is a long-term effect and is mainly driven by doctors working at the university hospital. Also, the estimates indicate the crowd-out effects at non-university hospitals and clinics after the medical school construction. However, the inflow of new medical graduates compensates for the crowd-out effect at non-university hospitals.

5.2 Results: Mortality

In this section, we assess the causal effect of the medical school construction on mortality. Figures 7, 8 and 9 present estimates of β_k from Equation (1) taking the log of the mortality by causes of death and age categories. Panel (a) in Figure 7 presents estimates of β_k

from Equation (1), taking the log of all-cause mortality as an outcome variable. It shows the estimates of the years preceding the medical school construction are close to zero and exhibit no discernible pre-trends. The estimates start to decrease after the establishment of the university hospital at t=3, keep decreasing over time and become stable after t = 10. Regarding the magnitude of this impact, we show that ten years after the medical school construction, the number of death is around 2.5% less relative to the year prior to the medical school construction. Considering the mean number of deaths prior to the medical school construction is 10225.12, the estimates indicates that around 256 more people were saved by the medical school construction.

Panel (b) to (d) in Figure 7 and Panel (a) to (c) in Figure 8 present the effects on the leading causes of death. Some estimates are noisy and not statistically significant, but we find the medical school construction and the establishment of the university hospital affect cancer, heart attack and stroke mortalities.

Figure 9 decomposes the deaths by ages and shows the estimates for infant, children, middle age and elderly. This decomposition indicates that the decline in mortality rate by the medical school and the establishment of the university hospital is mainly driven by the change in the number of deaths for elderly people. Panel (d) of 9 shows that the mortality rate of elderly people start to decline after the establishment of the university hospital and become almost stable after t=10.

Finally, Figure 13 presents estimates of β from Equation (2) taking the log of the mortality by causes of death and age categories. Most of point estimates for all-cause mortality are negative and significant, and the other point estimates are consistent with results of event studies.

Overall, the estimates suggest that the medical school construction and the establishment of the university hospital decrease the mortality rate. It is mainly driven by the decline in acute and intractable disease deaths, which is treatable at the university hospital, and by the decline in deaths of elderly people.

5.3 Results: Utilization and Access to Facilities

So far, our research has focused on the number of doctors and mortality as dependent variables. To clarify the paths through which the medical school construction had an effect on health outcomes, we analyze the effect of the medical school construction on access to facilities, capacity and utilization, which may affect health outcomes, rather than the access to doctors. For this purpose, we analyze the effect of the medical school construction on hospital access, clinic access, hospital capacity, healthcare workers, and utilization using the number of hospitals, the number of clinics, the number of emergency hospitals, the number of beds, the number of nurses, and the number of inpatient and outpatient outcomes, respectively.

Panel (a) to (c) in Figure 10 show the effects on the growth of the number of facilities. Panel (a) shows that some estimators increase after the medical school construction, but the effects fade out, and all coefficients are statistically not significant. Panel (b) shows that there is a negative growth in the number of clinics after the medical school construction, but this trend is reversed after t=15 and becomes close to zero. All coefficients are statistically not significant. Panel (c) shows that the medical school construction does not affect the number of emrgency hospitals.

Panel (a) to (d) in Figure 11 show the effects on hospital capacity and utilization. Panel (a), (b) and (c) show the estimate on the growth in the number of beds, nurses and inpatients each. The estimates start to increase after the establishment of the university hospital at t=3 and become stable after t=5. Panel (d) shows the estimate on the growth in the number of outpatients. The estimates start to increase at t=3 when the university hospital is established, but the change is not clear compared to the growth of inpatients, and the estimates are not statistically significant for whole periods.

Finally, Figure 14 presents estimates of β from Equation (2) taking the log of the number of non-university hospitals, clinics, emergency hospitals, beds, nurses, inpatients and outpatients as outcome variables. Point estimates are positive except for those of clinics, but most of them are insignificant. This confirms the results of the event studies.

Overall, the analysis in this section suggests that hospital capacity and utilization were moderately improved by the increase in the number of beds and the number of inpatients associated therewith by the establishment of the university hospital. Based on the analyses of Section 5, we conclude that the decrease in mortality rate is likely brought about by quality improvement and capacity expansion in healthcare service along with the opening of the university hospital and the increase in the number of doctors at non-university hospitals after the graduation of medical students.

6 Discussions

6.1 External Validity

As we show in Section 5.1, the medical school construction increases access to doctors and this effect is perpetuated more than 15 years after the establishment of a medical school. However, as this type of policy might rarely be implemented, one might question whether the results were driven by the particularities of Japan's institutional setting; the strong influence of the university hospital on the career of medical graduates may have caused the high retention rate of doctors in doctor-scarce areas. In this section, we address the issues of external validity of this research.

First, educational policies to establish medical schools in rural areas are relatively common. Simoens and Hurst (2006) report several Scandinavian countries established medical schools in rural areas, with the aim of bringing more local students into medical schools and increasing the number of doctors in rural areas. Indeed, Magnus and Tollan (1993) shows that 56% of the graduates remained in rural areas after such policies were implemented in northern Norway. Also, Hancock et al. (2009) and Ravaghi et al. (2015) mention that rural background and rural exposure through education may be factors behind doctors staying in rural areas.

Second, regulation of doctors in terms of regional mobility is common. For example, doctors are licensed at the state level in the U.S. and Canada, and obtaining licenses for different states involves high administrative costs, which prevents doctors from moving so easily. Overall, the prevalence of this type of policy and the cost associated with moving to a different region (e.g., state) mitigates some potential concerns regarding the external validity of this research.

6.2 Cost Benefit Analysis

In this section, we analyze the social cost of medical school construction and compare it to the social benefits. We consider that the social cost of the medical school construction is brought by the establishment of medical schools and university hospitals and by an increase in health care consumption. As the social benefit factors of the medical school construction, We consider health benefits composed of a decrease in the mortality rate. Due to a limitation of access to health data, we can not include improvements in morbidity rates in social benefit. This implies that this analysis estimates the lower bound of social benefit by the medical school construction. Next, we estimate each component of social cost and benefit.

The establishment of medical schools and university hospitals imposes two types of costs. First, there is the cost of constructing and equipping medical schools and university hospitals and labour costs. Unfortunately, there is no historical data on both the construction and equipment cost and labour cost in the 1970s. Instead, for the construction and equipment cost, we use the current cost of construction and equipment of about 500 million dollars. For labour cost, we use the current labour cost for a medical university and a university hospital, about 116 million dollars per year.[18]

Second, there may exist an increased healthcare spending due to the improvement in access to hospitals through the establishment of university hospitals. To calculate the change in health care spending brought by opening university hospitals, we estimate the effect of

[18] m3.com (2010) mentions the cost of construction and equipment. For labour costs, we refer to a financial report 2019 of Hamamatsu University School Hamamatsu University School of Medicine (2019).

medical school construction on amounts of payment by national health insurance at the prefecture level. However, because an estimate is negative and insignificant, we suppose that the increased healthcare spending did not exist. Therefore, given that the depreciation period for a medical university and a university hospital is for 20 years and the marginal cost of funds for 1.3, the annual cost for the establishment of a medical school and university hospital is 32.5 million dollars, and the total cost becomes 148.5 million dollars per year.

As the social benefit, we consider the reduction in mortality rate brought by the medical school construction. Our central estimate of the mortality impact of the medical school construction is a decrease in mortality rate by 12 per 100,000 persons. Given the value of statistical life per person is 9.7 million dollars[19], and the average population of a prefecture in the treatment group is 1.4 million, the establishment of a medical school and a university hospital makes social benefit by 1629.6 million dollars per year.

Although this analysis is somewhat speculative and simple, it shows that social benefits brought by medical school construction are larger than social costs.

7 Conclusion

This paper finds evidence that the establishment of a medical school and a university hospital increases the total number of doctors, mainly driven by doctors working at the university hospital, and this effect has been perpetuated for more than 15 years. The medical school construction could bring the crowd-out effects at non-university hospitals and clinics, but the inflow of new medical graduates compensates for the crowd-out effect at

[19] Viscusi and Aldy (2003) mentions the value of statistical life per person in Japan.

non-university hospitals.

We also find that the medical school construction and the establishment of the university hospital decrease the mortality rate. It is mainly driven by the decline in acute and intractable disease deaths, which is treatable at the university hospital, and by the decline in deaths of elderly people. Our research suggests that the quality improvement and capacity expansion in healthcare service, along with the opening of the university hospital and the increase in the number of doctors at non-university hospitals after the graduation of medical students, contribute to the decline in mortality.

Based on our results, we suggest that the medical school and the university hospital constructions are potentially cost-effective means of improving access to care as well as improving health outcomes.

Tables

Table 1: Summary Statistics

	1969			1990		
	Treatment (1)	Control (2)	p-value (1)-(2)	Treatment (4)	Control (5)	p-value (4)-(5)
Panel A. Doctors (per 1,000)						
Total	0.963	1.201	0.000	1.645	1.744	0.350
	(0.203)	(0.157)		(0.203)	(0.203)	
Hospital	0.335	0.339	0.865	0.760	0.766	0.925
	(0.079)	(0.059)		(0.189)	(0.145)	
Clinic	0.582	0.619	0.223	0.557	0.626	0.061
	(0.081)	(0.100)		(0.094)	(0.121)	
University Hospital	0.003	0.154	0.000	0.267	0.320	0.661
	(0.007)	(0.058)		(0.077)	(0.124)	
Internalist	0.494	0.566	0.019	0.682	0.754	0.189
	(0.073)	(0.104)		(0.153)	(0.173)	
Cardiologist	0.063	0.068	0.509	0.132	0.135	0.887
	(0.027)	(0.019)		(0.056)	(0.054)	
Surgeon	0.210	0.248	0.002	0.269	0.286	0.401
	(0.032)	(0.039)		(0.059)	(0.063)	
Neurosurgeon	0.009	0.015	0.002	0.047	0.044	0.426
	(0.003)	(0.006)		(0.011)	(0.013)	
Panel B. Mortality (per 100,000)						
All-cause	800.483	776.925	0.435	763.636	750.445	0.695
	(99.941)	(77.547)		(107.995)	(92.065)	
Cancer	132.982	119.315	0.347	193.977	192.720	0.879
	(14.232)	(16.080)		(27.017)	(21.984)	
Heart attack	95.859	93.860	0.607	153.306	152.630	0.926
	(11.855)	(11.441)		(22.638)	(21.249)	
Stroke	219.277	210.080	0.438	121.559	119.280	0.729
	(37.514)	(33.043)		(20.363)	(18.979)	
Accident	49.347	46.435	0.229	32.624	29.530	0.069
	(6.693)	(7.779)		(5.491)	(4.270)	
Pneumoia	27.253	28.300	0.467	64.712	61.215	0.459
	(2.932)	(5.509)		(14.801)	(13.369)	
Infant	1620.465	1569.945	0.443	506.224	455.085	0.064
	(207.620)	(183.764)		(93.075)	(61.315)	
Children	165.547	163.258	0.603	49.377	46.348	0.052
	(13.930)	(12.274)		(4.512)	(4.633)	
Middle age	1070.975	1073.616	0.907	618.540	620.485	0.883
	(66.727)	(69.186)		(35.722)	(44.100)	
Elderly	6071.109	6056.814	0.858	4069.090	4073.016	0.930
	(231.629)	(249.884)		(97.281)	(168.571)	
Panel C. Utilization and Facilities (per 1,000)						
Hospital	0.088	0.082	0.515	0.101	0.091	0.401
	(0.033)	(0.023)		(0.042)	(0.033)	
Clinic	0.615	0.655	0.257	0.610	0.674	0.081
	(0.101)	(0.111)		(0.100)	(0.117)	
Emergency Hospital	0.025	0.025	0.929	0.042	0.039	0.513
	(0.013)	(0.09)		(0.014)	(0.011)	
Nurse	2.021	2.182	0.340	5.157	5.212	0.900
	(0.552)	(0.440)		(1.347)	(1.173)	
Bed	10.529	10.787	0.612	14.906	14.715	0.885
	(2.822)	(1.707)		(4.270)	(3.610)	
Inpatient	3082.277	3214.353	0.612	4640.593	4588.003	0.910
	(911.518)	(589.597)		(1476.447)	(1304.842)	
Outpatient	3242.906	3212.925	0.612	5209.802	4911.379	0.395
	(1049.089)	(567.729)		(1290.696)	(643.058)	
Panel D. Controls						
Population (thousand)	1366.765	1675.950	0.215	1693.412	1969.450	0.513
	(835.506)	(606.872)		(1438.986)	(1016.975)	
GNP (per 1,000)	479.027	483.528	0.872	3073.222	2950.367	0.404
	(73.066)	(95.176)		(495.407)	(364.636)	
Social Investment (per 1,000)	97.407	94.437	0.582	246.586	226.435	0.196
	(14.081)	(18.423)		(53.463)	(35.555)	
Elderly Rate	0.085	0.081	0.430	0.144	0.140	0.650
	(0.014)	(0.011)		(0.024)	(0.019)	
Number of Prefectures	17	20		17	20	

This table presents prefecture-level summary statistics by the treatment status in 1969 (before the treatment) and in 1990 (after the treatment). The table presents the mean and standard deviation of outcomes and controls.

Figures

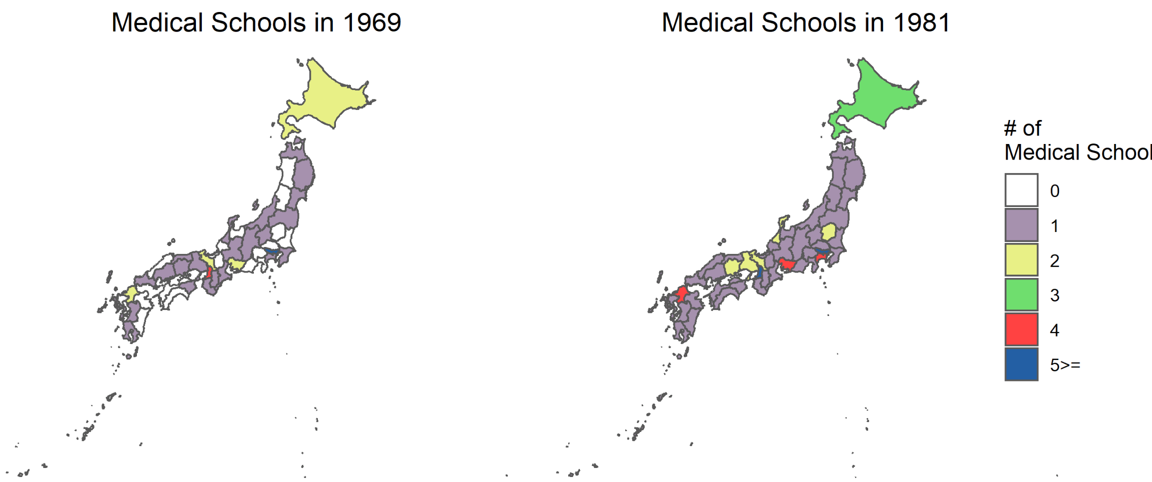


Figure 1: Distribution of Medical Schools

Note: This figures show the distribution of medical schools in Japan in 1969 and 1981. There existed 11 medical schools and 13 medical schools in Tokyo in 1969 and 1981 each. In 1969, 18 prefectures did not have a medical school. In 1981, all prefectures had at least one medical school.

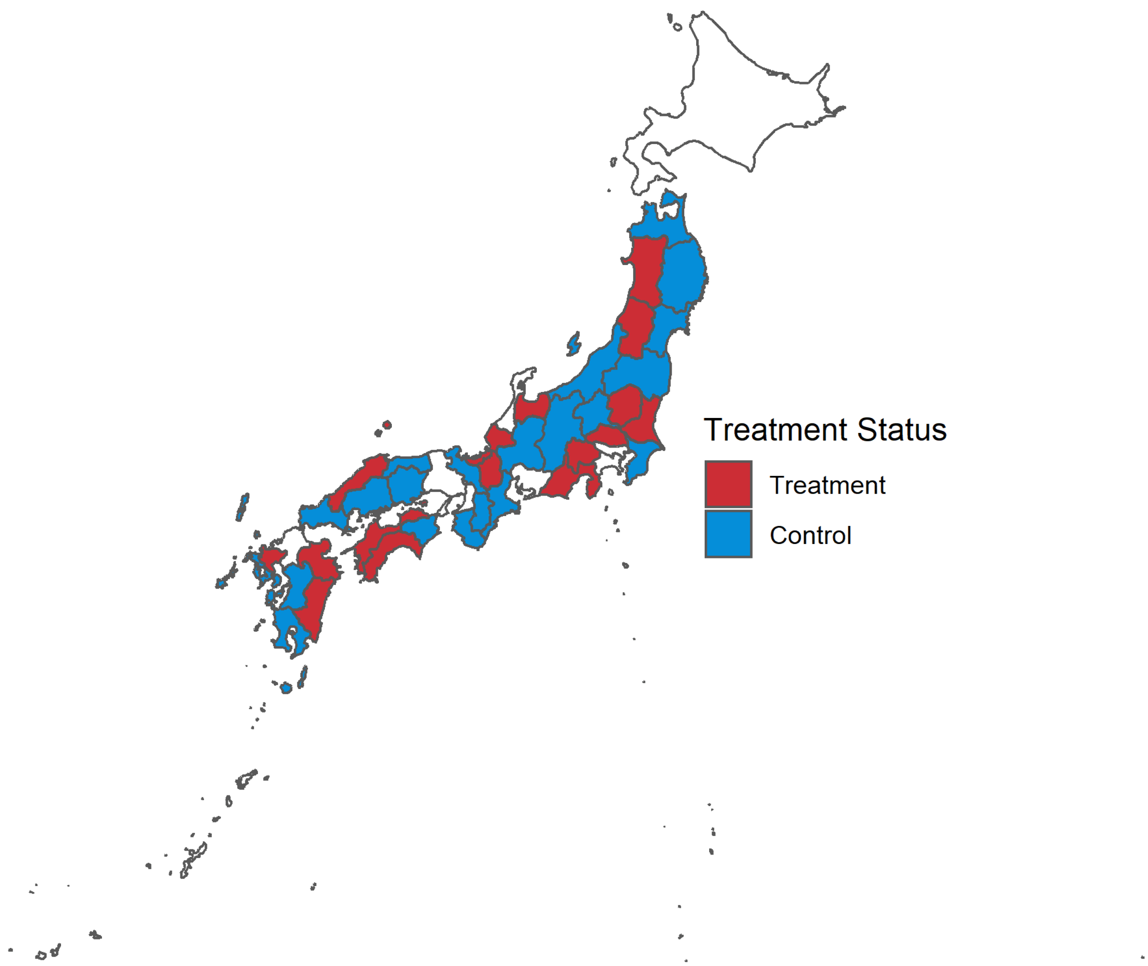


Figure 2: Treatment and Control Groups

Note: This figure shows prefectures in the treatment and the control groups. The treatment group includes prefectures at which the first medical school was constructed between 1970 and 1980, and the control group includes prefectures at which no medical school was newly constructed after 1970.

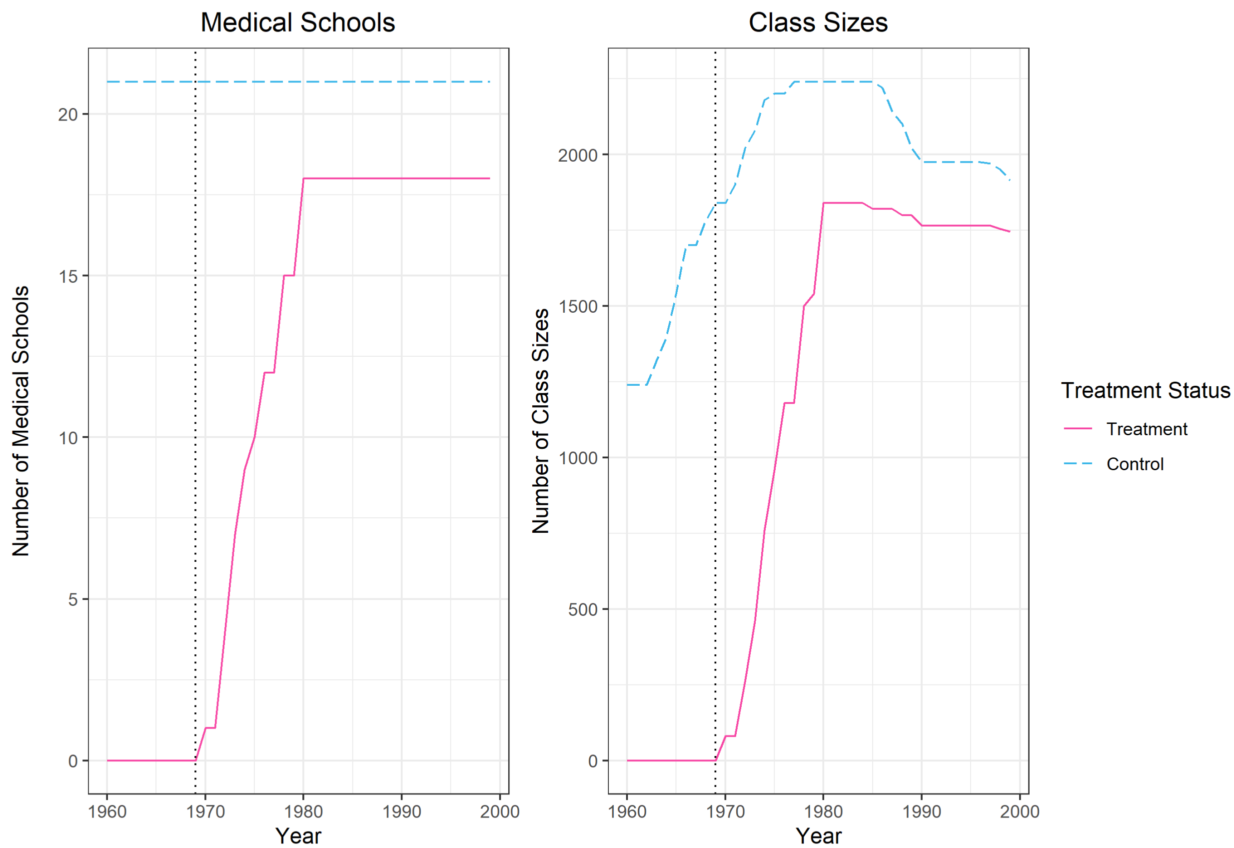


Figure 3: Medical Schools and Class Sizes in Treatment and Control Groups

Note: This figure shows the time series of the number of medical schools and class sizes in the treatment group and the control group. The left panel shows the time series of the number of medical schools in the treatment and the control groups. The right panel shows the time series of class sizes of medical schools in the treatment and the control groups.

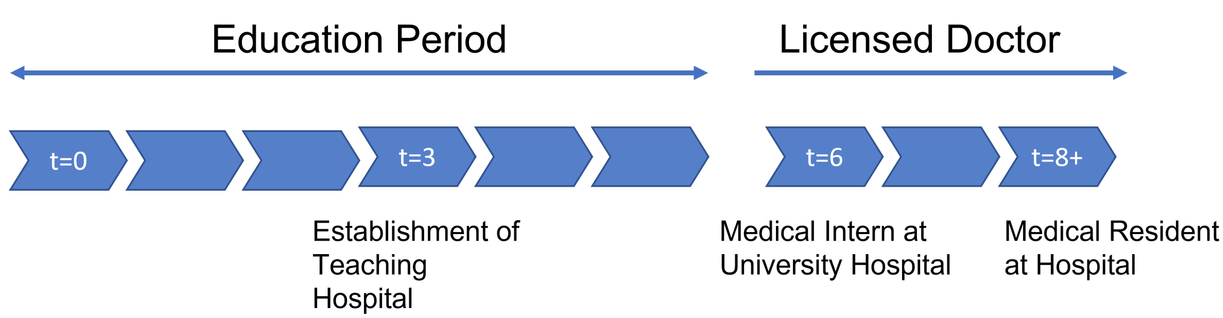
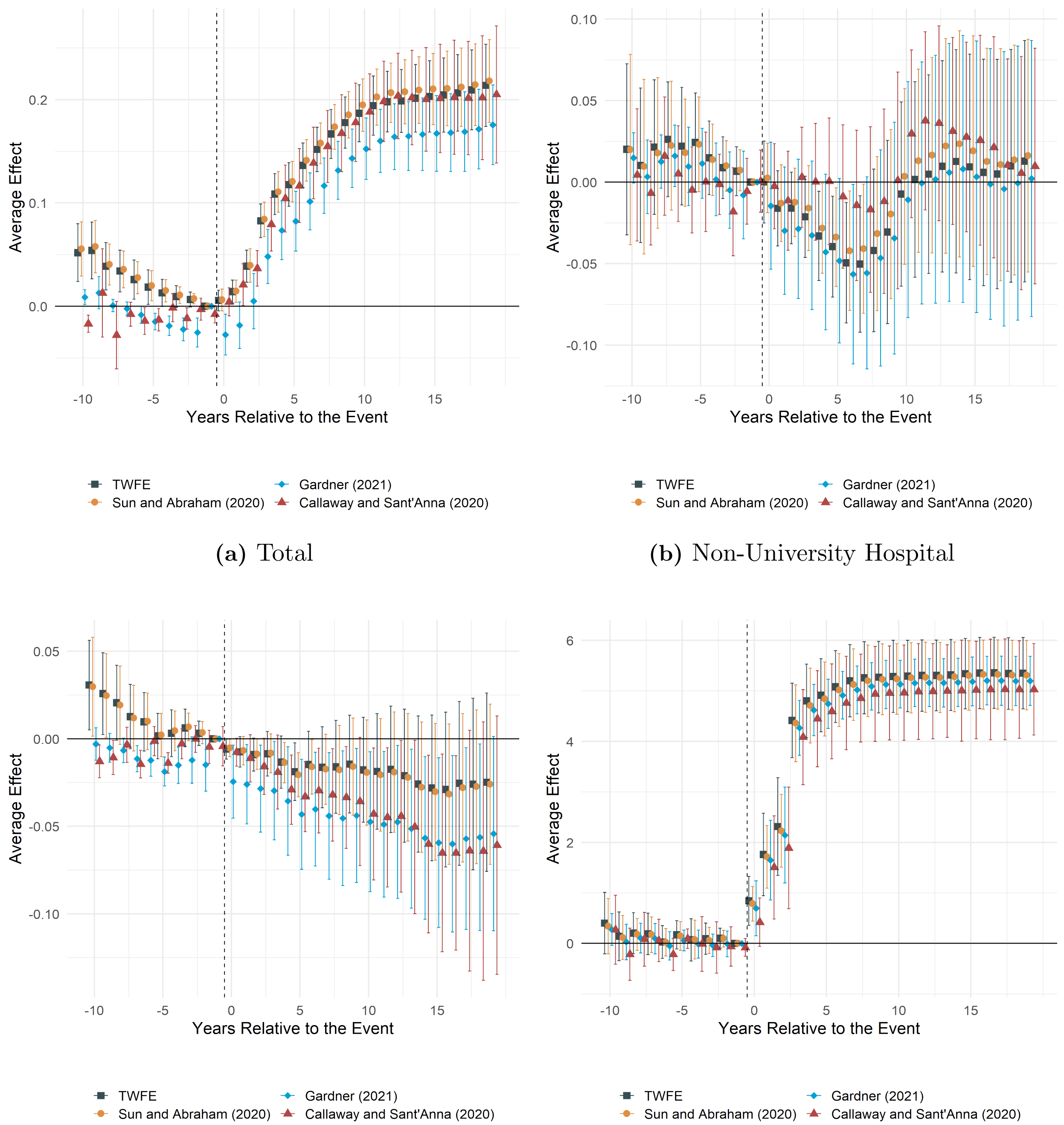


Figure 4: Timeline after Establishment of a Medical Schools



(a) Total

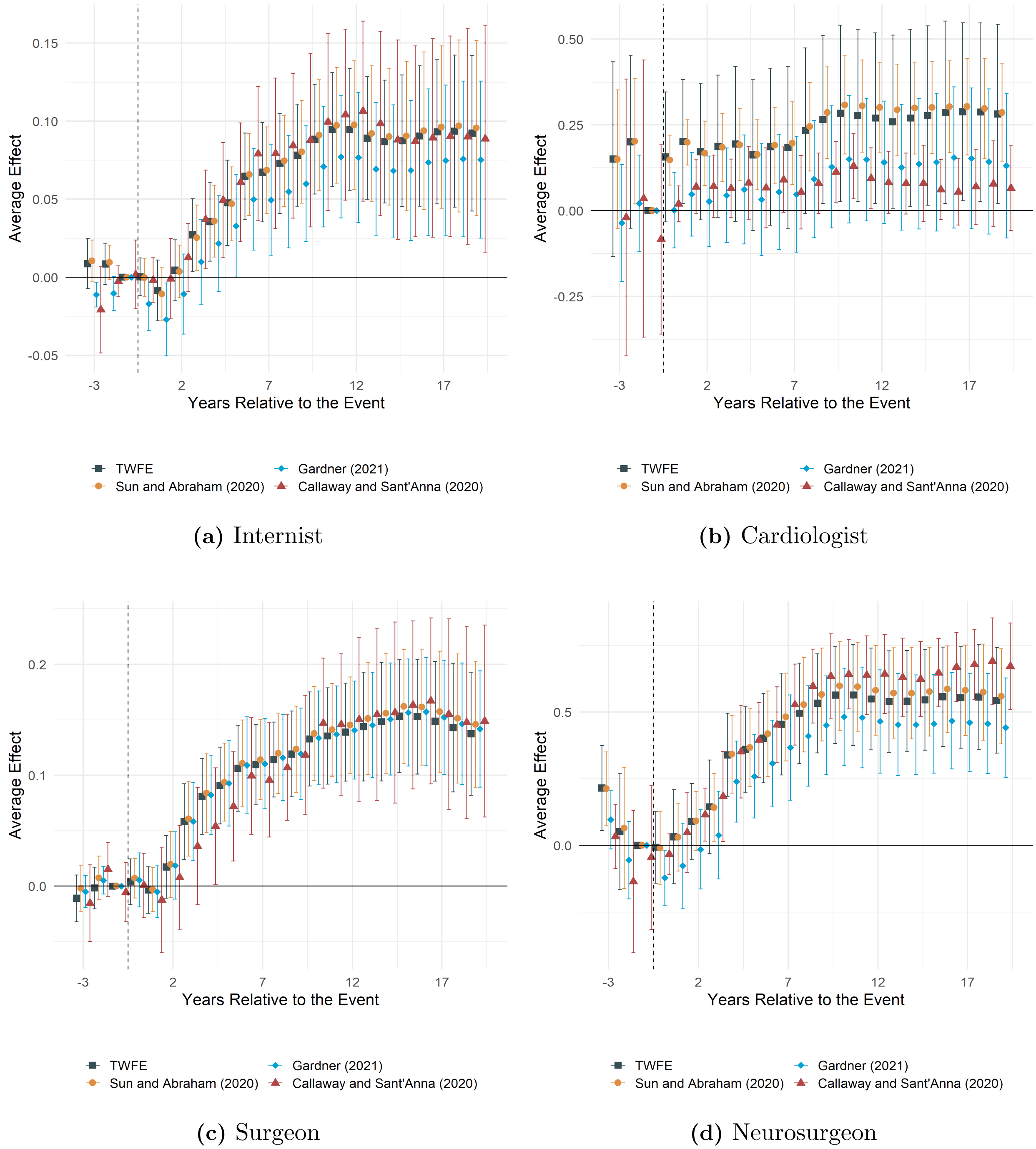
(b) Non-University Hospital

(c) Clinic

(d) University Hospital

Figure 5: Effect on Access to Doctor by Types of Practice (Dynamic)

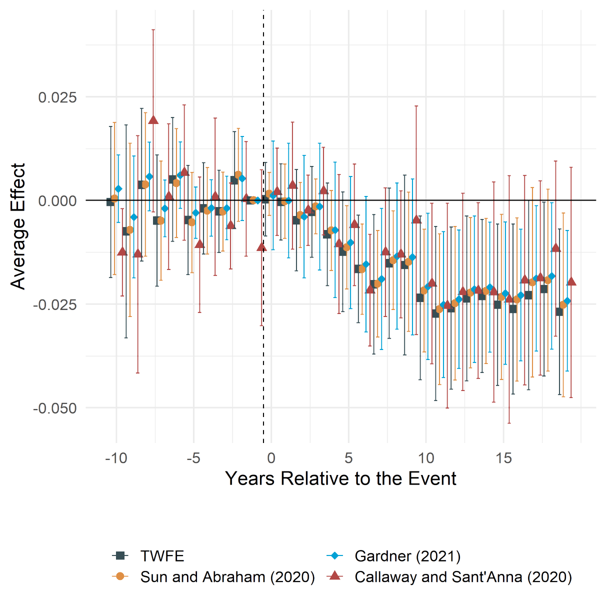
Note: This figure overlays the event-study plots constructed using four different estimators: a dynamic version of TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The effects of the medical school construction on the number of doctors by types of practice estimated by Equation (1). The outcome variables are total number of doctors, the number of doctors at non-university hospitals, the number of doctors at clinics, and the number of doctors at university hospitals. $t = -1$ is a reference year. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.



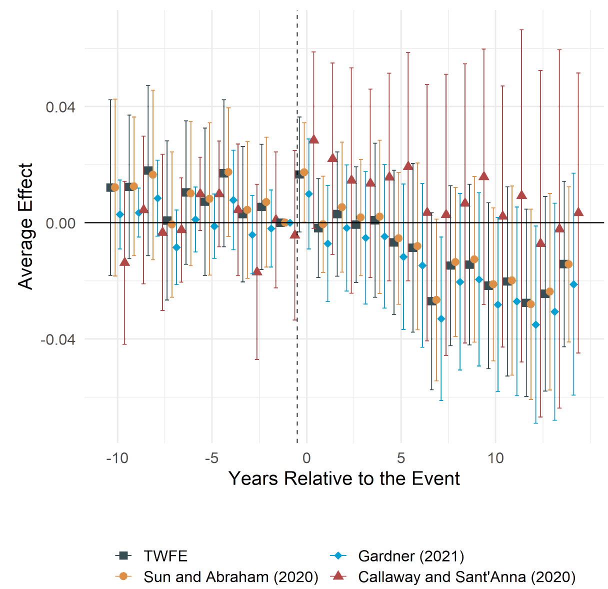
(a) Internist **(b)** Cardiologist **(c)** Surgeon **(d)** Neurosurgeon

Figure 6: Effect on Access to Doctor by specialty (Dynamic)

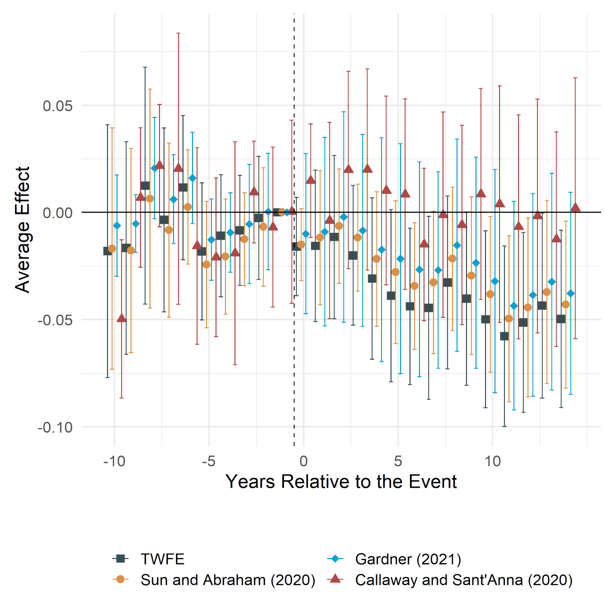
Note: This figure overlays the event-study plots constructed using four different estimators: a dynamic version of TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The effects of the medical school construction on the number of doctors by types of practice estimated by Equation (1). The outcome variables are the number of internalists, the number of cardiologists, the number of surgeons, and the number of neurosurgeons. $t = -1$ is a reference year. Since the number of doctors by specialty is available from 1969, we take the pre-periods up to $t = -3$. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.



(a) All-cause



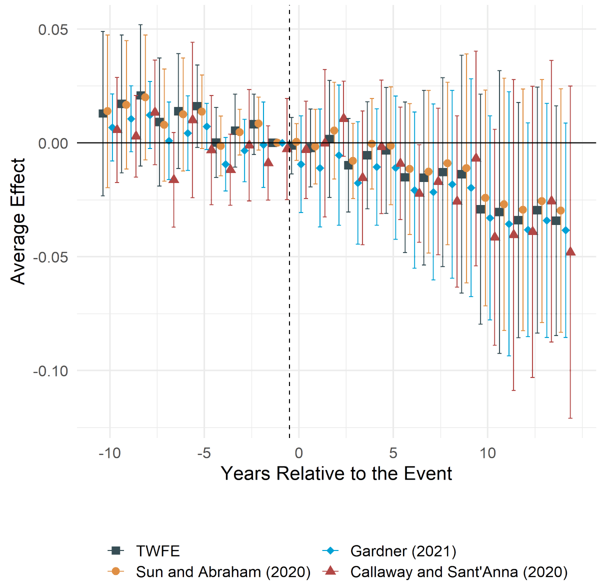
(b) Cancer



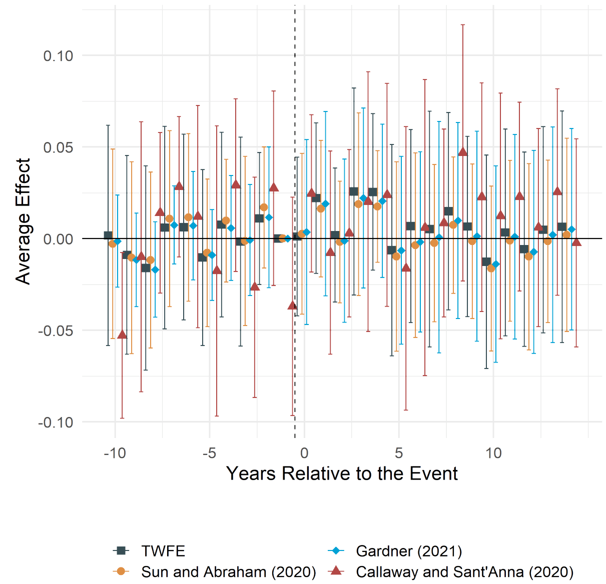
(c) Heart attack

Figure 7: Effect on Mortality by Causes of Death (1) (Dynamic)

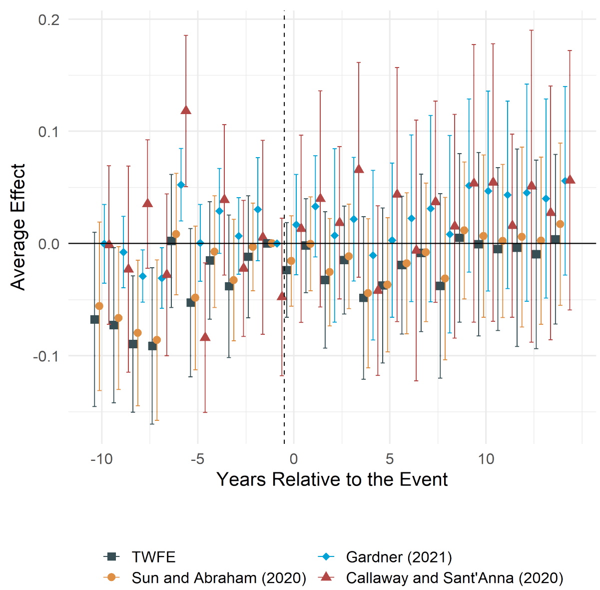
Note: This figure overlays the event-study plots constructed using four different estimators: a dynamic version of TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The effects of the medical school construction on the mortality by main causes of death estimated by Equation (1). The outcome variables are all-cause, cancer, heart attack, stroke, accident, and pneumonia mortalities. $t = -1$ is a reference year. Since the cause-specific mortalities are available until 1994, we take the post-periods up until $t = 14$. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.



(a) Stroke



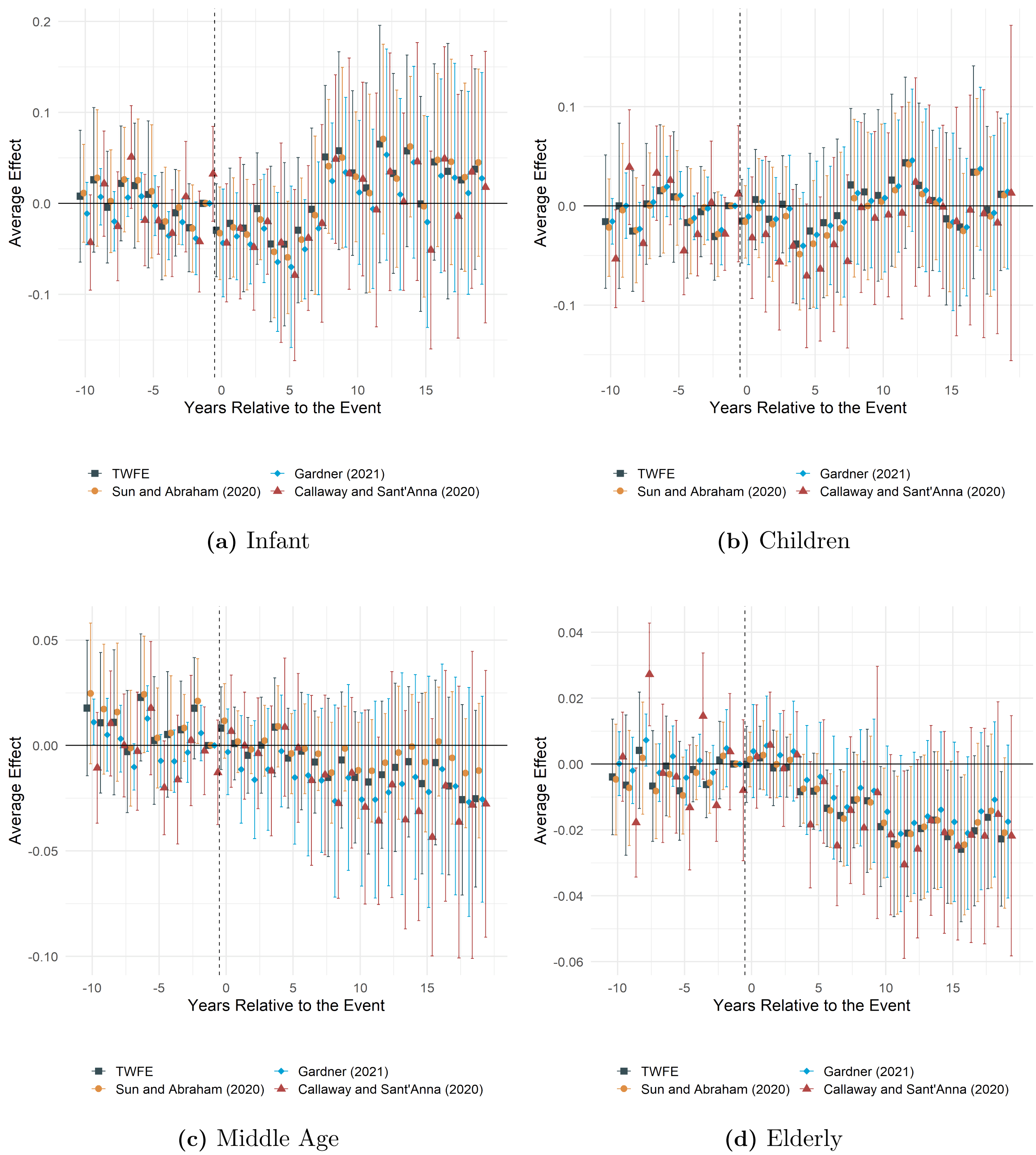
(b) Accident



(c) Pneumonia

Figure 8: Effect on Mortality by Causes of Death (2) (Dynamic)

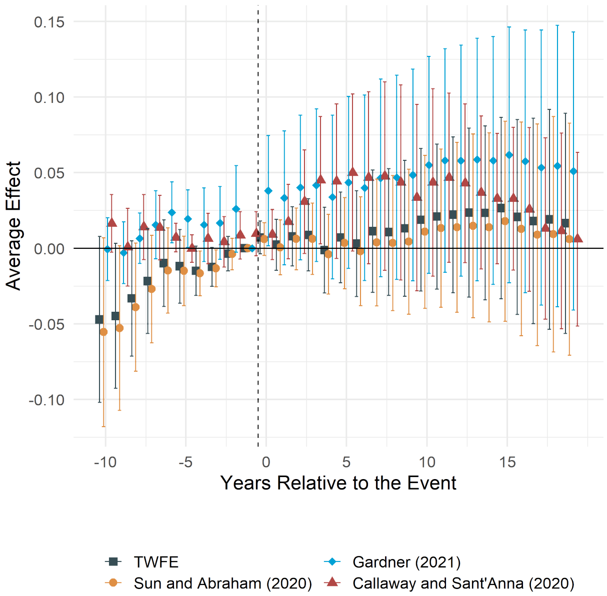
Note: This figure overlays the event-study plots constructed using four different estimators: a dynamic version of TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The effects of the medical school construction on the mortality by main causes of death estimated by Equation (1). The outcome variables are all-cause, cancer, heart attack, stroke, accident, and pneumonia mortalities. $t = -1$ is a reference year. Since the cause-specific mortalities are available until 1994, we take the post-periods up until $t = 14$. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.



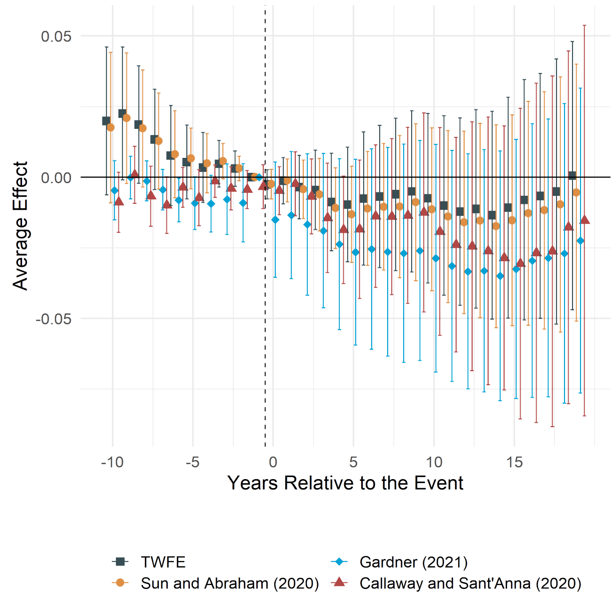
(a) Infant **(b)** Children **(c)** Middle Age **(d)** Elderly

Figure 9: Effect on Mortality by Age Categories (Dynamic)

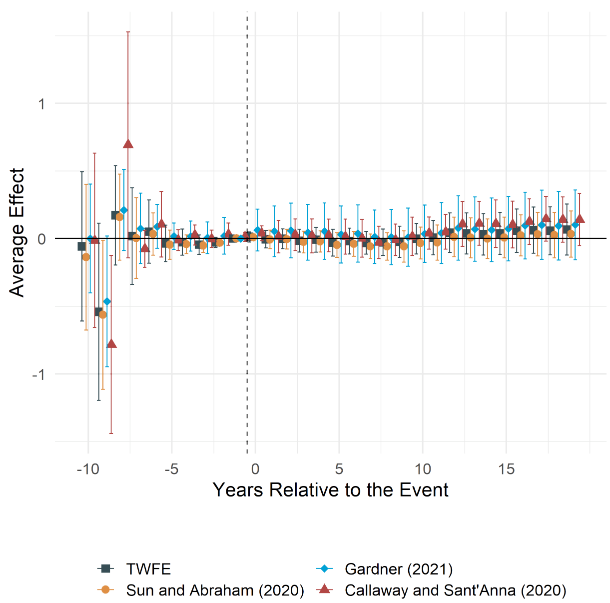
Note: This figure overlays the event-study plots constructed using four different estimators: a dynamic version of TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The effects of the medical school construction on the mortality by age categories estimated by Equation (1). The outcome variables are infant mortality, children mortality, middle age mortality and elderly mortality. $t = -1$ is a reference year. Children are considered to be aged from 0 to 14, middle age are considered to be aged from 50 to 64, and elderly are considered to be aged from 65. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.



(a) Non-University Hospital



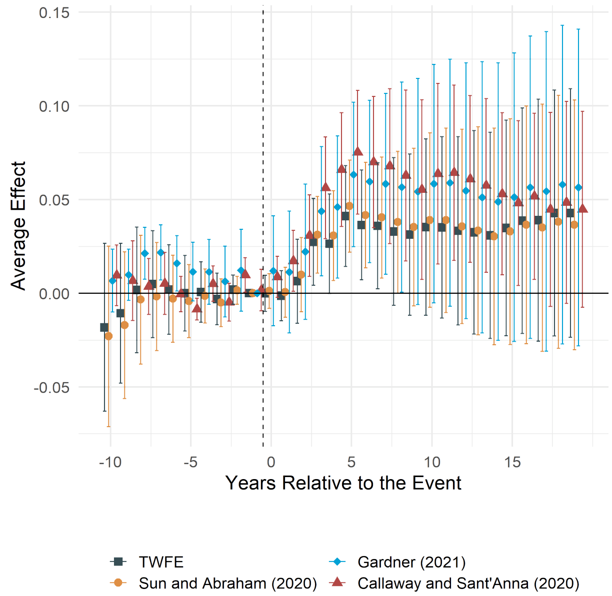
(b) Clinic



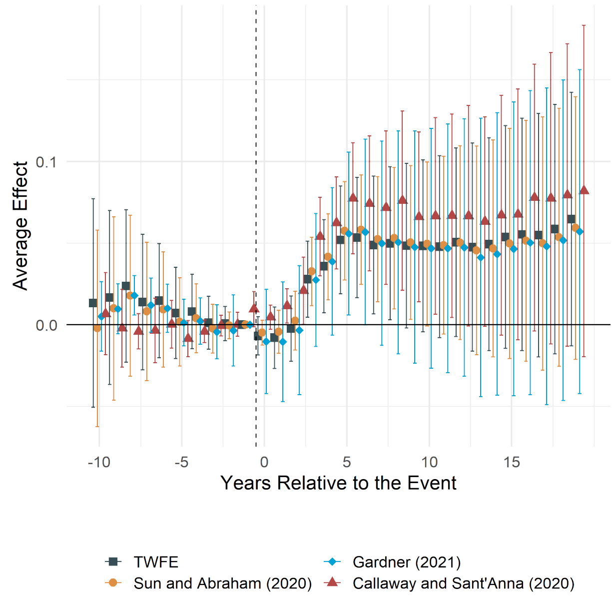
(c) Emergency Hospital

Figure 10: Effect on Access to Facilities (Dynamic)

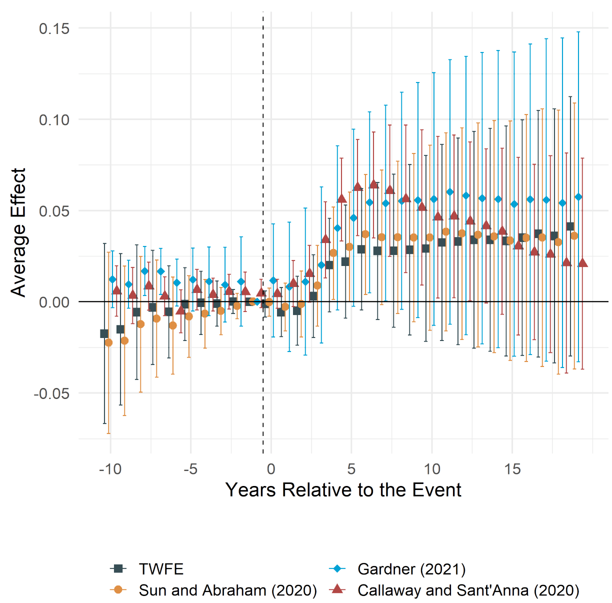
Note: This figure overlays the event-study plots constructed using four different estimators: a dynamic version of TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The effects of the medical school construction on the access to facilities estimated by Equation (1). The outcome variables are the number of hospitals, the number of clinics and the number of emergency hospitals. $t = -1$ is a reference year. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.



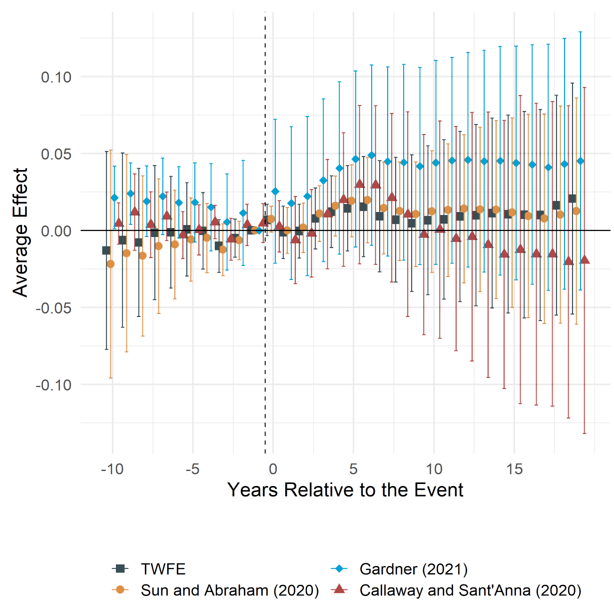
(a) Bed



(b) Nurse



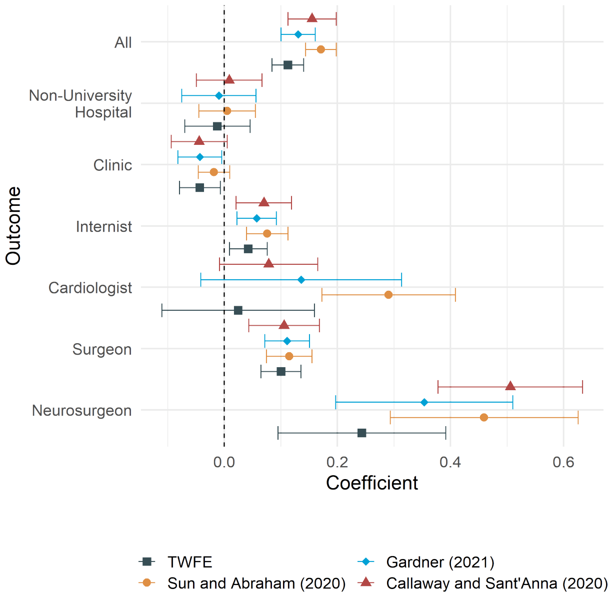
(c) Inpatient



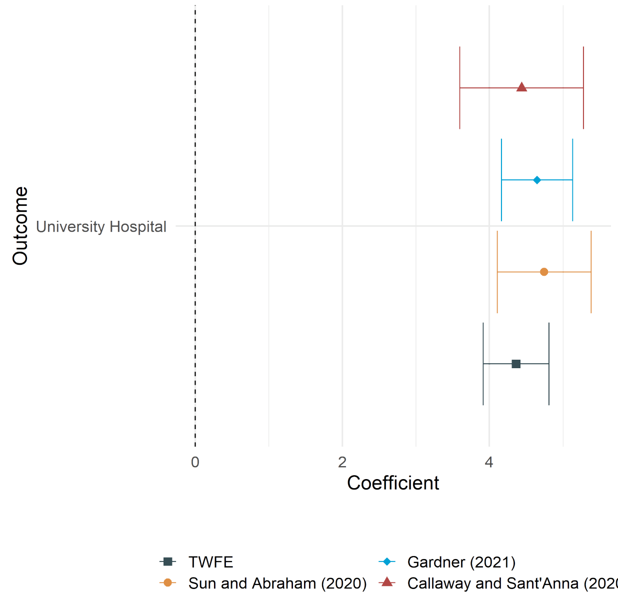
(d) Outpatient

Figure 11: Effect on Capacity and Utilization (Dynamic)

Note: This figure overlays the event-study plots constructed using four different estimators: a dynamic version of TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The effects of the medical school construction on medical capacity and utilization estimated by Equation (1). The outcome variables are the number of beds, the number of nurses, the number of inpatients and the number of outpatients. $t = -1$ is a reference year. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.



(a) Doctor (1)



(b) Doctor (2)

Figure 12: Effect on Access to Doctor

Note: This figure presents estimates of coefficient β from equation (2) constructed using four different estimators: TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The outcome variables are total number of doctors, the number of doctors at non-university hospitals, the number of doctors at clinic, the number of doctors at university hospitals, the number of internalists, the number of cardiologists, the number of surgeons, and the number of neurosurgeons. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.

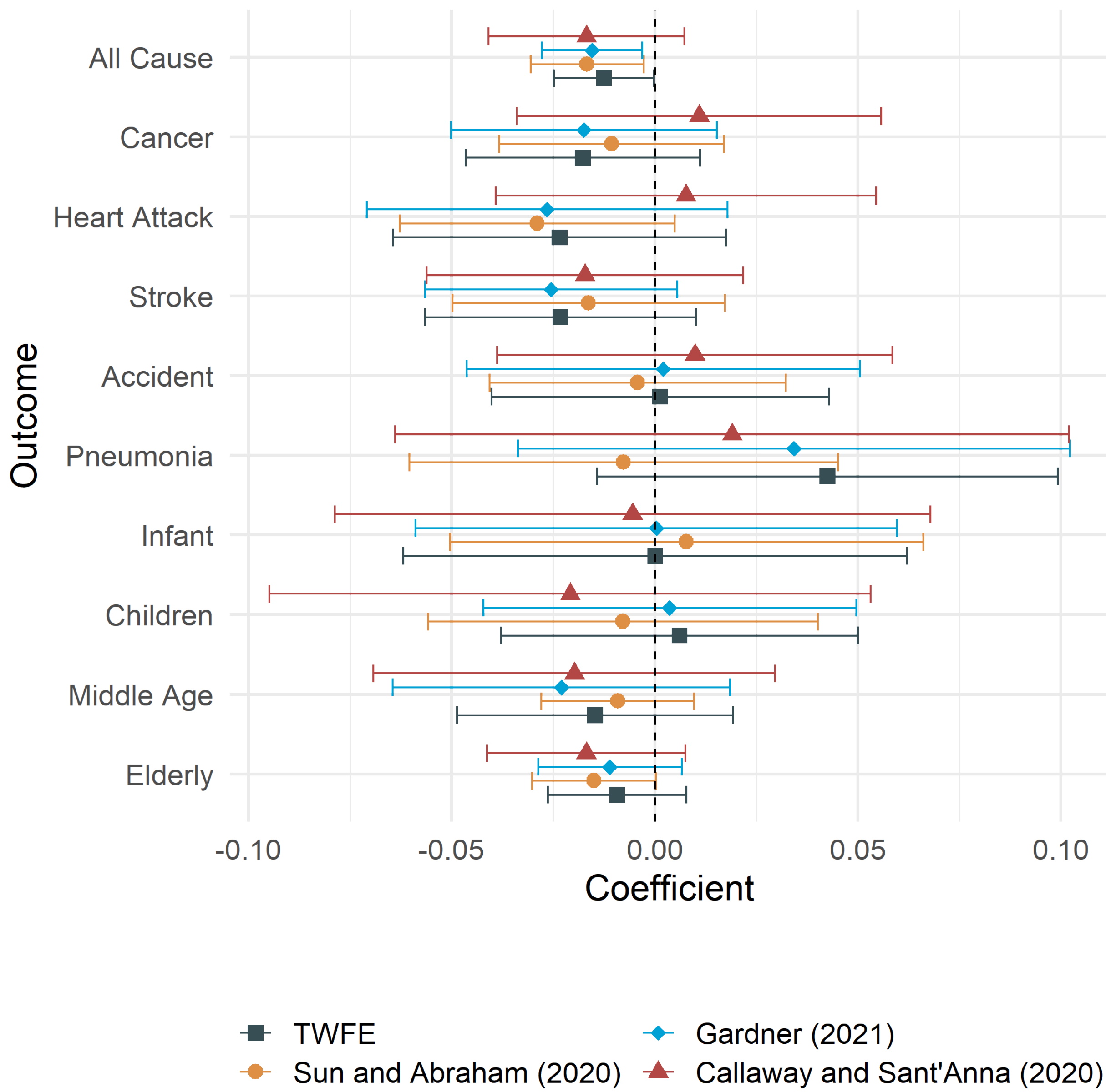


Figure 13: Effect on Mortality

Note: This figure presents estimates of coefficient β from Equation (2) constructed using four different estimators: TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The outcome variables are all-cause, cancer, heart attack, stroke, accident, pneumonia, infant, children, middle age and elderly mortalities. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.

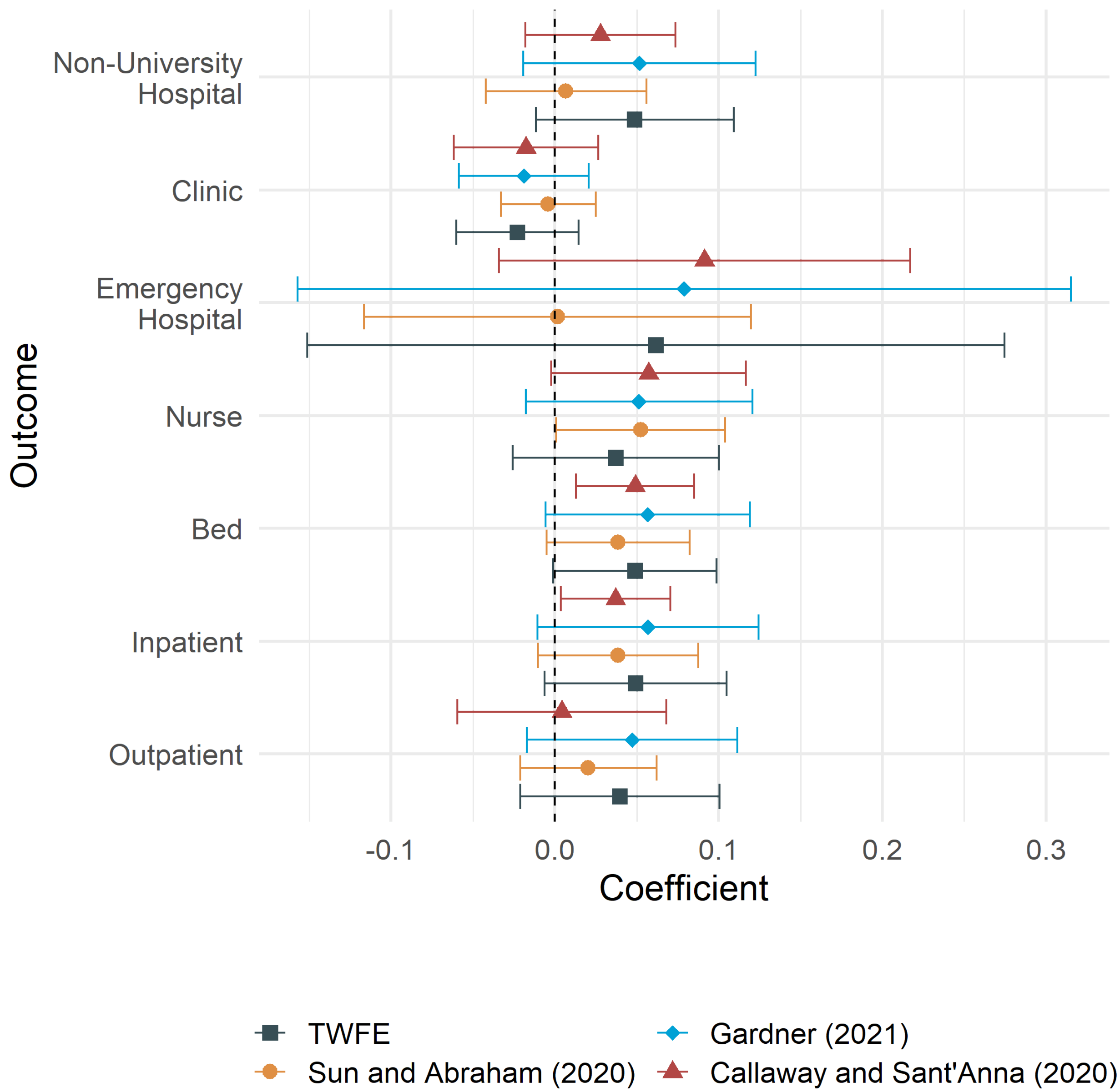


Figure 14: Effect on Access to Facilities, Capacity and Utilization

Note: This figure presents estimates of coefficient β from Equation (2) constructed using four different estimators: TWFE, Gardner (2022), Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The outcome variables are the number of non-university hospitals, the number of clinics, the number of emergency hospitals, the number of beds, the number of nurses, the number of inpatients and the number of outpatients. The bars represent 95% confidence intervals. Standard errors are clustered at the prefecture level.

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