THE IMPACT OF PHYSICIAN SUPPLY ON THE HEALTHCARE SYSTEM: EVIDENCE FROM JAPAN’S NEW RESIDENCY PROGRAM

TOSHIKAI IIZUKAa,* and YASUTORA WATANABEb

aFaculty of Economics, University of Tokyo, Tokyo, Japan
bDepartment of Economics, HKUST Business School, Hong Kong University of Science and Technology, Kowloon, Hong Kong

ABSTRACT

Using a 2004 Japanese natural experiment affecting physician supply, we study the physician labor market and its effects on hospital exits and health outcomes. Although physicians play a central role in determining the performance of a healthcare system, identifying their impacts are difficult because physician supply is endogenously determined. We circumvent the problem by exploiting an exogenous shock to physician supply created by the introduction of a new residency program – our natural experiment. Based on panel data covering all physicians in Japan, we find that the introduction of a new residency program substantially decreased the supply of physicians in some rural markets where local hospitals had relied on university hospitals for filling physician positions. We also find that physician market wages increased in the affected markets relative to less affected markets. Finally, we find that this change in physician market wages forced hospitals to exit affected markets and negatively affected patient health outcomes in those markets. These effects may be exacerbated by the fact that the healthcare market was rigidly price-regulated. Copyright © 2015 John Wiley & Sons, Ltd.

Received 5 September 2014; Revised 22 May 2015; Accepted 9 August 2015

KEY WORDS: physician labor market; physician wage; hospital exit; health outcome

1. INTRODUCTION

Physicians play a central role in determining the performance of a healthcare system. How and where they work directly affects the physician wage and labor in each region and specialty. Moreover, a change in physician supply affects not only the physician labor market, but also affects other parts of the healthcare system, including hospital competition and patient health outcomes. Understanding these relationships is important in most, if not all, healthcare systems. For example, rural hospitals in many countries find it difficult to attract and sustain physicians. Of particular interest is whether and to what extent a change in physician supply affects patient access to care and health outcomes in the region.

Regardless of the importance, empirically examining these relationships is difficult because these relationships are endogenously determined. For example, whereas physician supply may affect the physician wage and patient health outcomes, the opposite causality can also be present. In this paper, we circumvent the endogeneity problem by exploiting a sudden, large shift in physician supply in Japan, and examine how physician supply affects the healthcare system including physician wage, access to hospitals, and patient health outcomes. A novel feature of our study is that we can exploit the exogenous shift in physician supply, which

*Correspondence to: Faculty of Economics, University of Tokyo,7-3-1, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan. E-mail: toshi.iizuka@gmail.com

1See, for example, Nicholson and Propper (2012) for a survey on physician labor market. This paper uses an exogenous change in physician supply as a natural experiment to study physician demand.
Our identification strategy is similar to Acemoglu and Finkelstein (2008) where variation of the degree of treatment is used as the main source of identification. In 2004, the Japanese government introduced a policy, the New Postgraduate Medical Education Program (NPGME), which drastically reduced the effective number of hospital physicians in Japan. Importantly, NPGME had particularly large impact in some rural areas where hospitals had relied heavily on informal university organization (called ikyoku) for physician supply before NPGME. For this reason, we focus our analysis on rural areas. Because the pre-NPGME trend in the number of physicians was similar across rural areas, we identify the impact of the policy on physician supply using a within-rural comparison before and after NPGME.

To measure the degree to which a rural area had relied on university hospitals before NPGME for filling physician positions, we calculate the fraction of hospital physicians in a region who were transferred to other hospitals in other regions and use it as a measure of the region’s reliance on university hospitals (located in urban areas). As most other physicians are stationary, this measure captures the degree to which the natural experiment affected rural markets.

Using a panel data set covering the universe of physicians in Japan, we find that the introduction of NPGME – our natural experiment – substantially decreased the supply of physicians in rural markets that had relied on university hospitals for filling physician positions. In fact, the policy reduced the effective number of hospital physicians by up to 20% in more affected rural areas relative to average rural markets. In response to the decrease in physician supply, we also find that physician market wage increased in those rural markets, while they remained unchanged in unaffected rural markets. However, the increase in physician wage in the affected markets was short-lived, indicating that the demand for physician labor is inelastic in the short run but more elastic in the long run.

To understand the difference between short run and long run demand for physician labor, we turn to analyzing hospital behavior in rural markets. Although hospitals may not immediately exit or adjust their capacity, the decrease in physician supply and the increase in physician wages can result in higher costs and lower profitability of hospitals, which can in turn drive hospitals to exit the market or reduce their capacity. Because hospital profits are harder to measure in Japan, we investigate the entry and exit behavior of hospitals as well as number of beds in those markets and find that the number of hospitals and hospital beds significantly decreased in the affected markets. As a result, patient access to hospital services declined in these areas. We suspect that price regulation in the healthcare market accelerated hospital exits, because hospitals were unable to raise fees and absorb higher wages and had to exit the markets in the long run.

Finally, we investigate the effects of physician supply on patient health outcomes. Given the results signifying the existence of fewer physicians and hospitals in those affected markets, patient access to care has declined over the long term, which may produce deteriorating health outcomes. We find that

---

2The new residency program introduced a matching mechanism similar to the one used in the USA to allocate physicians to a 2-year mandatory residency training.
3We conducted the same analysis for urban areas regarding physician supply, physician wage, hospital competition, and health outcomes but did not find the effect of NPGME. It could be because those are the areas to which the rural physicians were recalled after NPGME.
4Relatedly, Newhouse et al. (1982) investigates if rural shortage of physician is created by demand inducement by urban physicians but find that the regular location choice rather than demand inducement explains the pattern. Polsky et al. (2000) finds that new physicians who do not bear any relocation costs affects change in locational distribution. In our study, a significant number of hospital-based specialists moved out of rural markets, but the move was due to the exogenous change in policy, which had a bigger impact than relocation cost.
5Estimating the elasticity of physician demand is generally difficult because exogenous change in supply is usually not available, as well as physician wage is difficult to observe (Nicholson and Propper, 2012). Escarce (1996) and Escarce and Pauly (1998), and Thornton and Eakin (1997) focus on the substitutions among different inputs in health care production. Ours directly examine physician labor demand, and we do so by exploiting the exogenous supply shock.
6Or et al. (2005) and Robst (2001) find that the number of physicians per capita negatively affects mortality. Aakvik and Holmas (2006) did not find this effect, but they find that the composition of physicians (contracted versus directly hired by municipal government) affects mortality. The endogeneity between physician supply and health outcomes is one of the main issues in these studies. We rely on the exogenous shift of physician supply to identify the relationship. In contrast to Starfield et al. (2005), we find that the decrease of specialists has a negative and significant impact on patient health outcomes.
the decrease in the number of physicians and the worsened access to hospitals increased all-cause mortality as well as mortality due to other causes where access to hospitals appears to be important. 

In Section 2, we provide details on the natural experiment and background on the physician labor market in Japan. In Section 3, we examine how the introduction of NPGME affected physician supply in rural markets. Section 4 investigates how the physician wage responded to changes in physician supply. In Sections 5 and 6, we study how the changes in physician labor market affected hospital competition and patient health outcomes, respectively. We conclude our study in Section 7.

2. THE JAPANESE PHYSICIAN MARKET AND THE NATURAL EXPERIMENT

Before the introduction of NPGME, an informal organization called ikyoku played a crucial role in physician supply, particularly to less attractive hospitals such as rural ones. Ikyoku is an informal organization formed under chair professors at each medical school for each specialty. The vast majority of physicians belong to the same ikyoku that they joined after graduating from the medical school, and ikyoku works as a human resource department for the informal network of hospitals under the university hospital’s influence. It possessed the informal authority to assign physicians to these hospitals, and physicians had strong incentive to follow the assignment.7

In 2004, the government introduced NPGME, a 2-year mandatory residency training program focused on primary care, which includes rotation to several specialty departments in large hospitals. Prior to the introduction of NPGME, residency training was not mandatory and residents were trained by a specific specialty department in the university hospital without a rotation to other departments. Hence, residents prior to the introduction of NPGME were trained well enough to provide basic clinical services in their specialty, while residents after NPGME do not provide clinical services. In 2004, the government also permitted non-university hospitals to train residents. Before NPGME, the majority of medical students completed their residencies at the universities where they received their degrees. In our data, 70.2% of the physicians who received a physician license in 2002 began their careers at university hospitals. This number fell to 41.3% in 2004.

The introduction of NPGME not only affected residents but also the entire ikyoku system of human resource allocation among related hospitals. First, university departments lost 2 year’s worth of younger physician labor because, unlike the pre-NPGME period, residents under the mandatory training can no longer contribute labor to a specific department. Second, university hospitals lost their near monopoly on the supply of entry-level physicians because many new residents chose residency training at non-university hospitals, which was not possible before NPGME. As shown in Figure 1, these changes have led to a dramatic reduction in the ‘effective’ number of university hospital physicians with 5 or fewer years of experience after 2004, which excludes physicians under the mandatory residency training. (Hereafter, we report the number of physicians by excluding those under the mandatory training.) In fact, the introduction of NPGME was a major blow to university hospitals because younger physicians with 2 or fewer years of experience accounted for as much as 17% of total hospital physicians in 2002.

Facing this dramatic reduction in younger physicians, university hospitals (located in urban areas) appeared to have pulled the physicians in their informal network out of rural hospitals. Anecdotal evidence on such a pull-out is abundant.8 Figure 2 also indicates that university hospitals increased the number of physicians after 2008 primarily by attracting more experienced physicians. As a result, by 2010, the number of university

---

7Even for physicians who do not pursue a career at hospitals and open their own clinics, they need good relationships with ikyoku for referrals to hospitals.

hospital physicians climbed back to the pre-NPGME level. The Supporting Information Figure A1 also reports that the number of physicians in rural areas substantially declined after 2004.

Importantly, as we show in the following, the impact of NPGME on rural hospitals appeared to differ across rural markets. It was particularly large in some rural areas where local hospitals had relied heavily on ickyoku networks for physician supply before NPGME. In the next section, we use this difference in physician supply across rural areas stemming from the introduction of NPGME to identify the impact of NPGME on our measures of interests.

3. EFFECTS ON PHYSICIAN SUPPLY

This section examines the effects of the introduction of NPGME on physician supply, using econometric analysis. Our physician data come from a government survey (Sanshi Chosa) conducted every other year. The data cover the universe of physicians and include gender, registration date, birth date, type of practice, place of work.
THE IMPACT OF PHYSICIAN SUPPLY

(i.e., municipality), and clinical specialty of the physician. Each physician has an identification number, and we can track the information for each physician over time as panel.

In most of our analysis, we aggregate data at the medical care area level and use it as a unit of analysis. The medical care area we use is the one defined by the Ministry of Health, Labour and Welfare (Niji iryou ken) in which the government targets to meet the needs for inpatient medical services (excluding those requiring advanced technologies) and comprehensive healthcare services. Mean population size per medical care area is about 183,000. We have a balanced panel data set covering 344 medical care areas between 1996 and 2010. Additional details on the physician data are reported in the Supporting Information.

To better understand how NPGME differentially affected physician supply in rural areas after 2004, we constructed an index, Rotation, which captures the degree to which a region had relied on university hospitals before NPGME for filling physician positions; Rotation is the proportion of hospital physicians who were in medical care area \( j \) in 2000 but moved to a different hospital in non-\( j \) area in 2002.\(^9\) As shown in Figure 3, Rotation in rural areas is much higher, on average, in rural areas (where population size is small) as expected. Furthermore, physicians in their 30s are more likely to be transferred to other medical care areas than other physicians (see Figure A4 in the Supporting Information). Both of these results are consistent with the patterns documented in the detailed study by Ikai (2000) that uncovers rotation and career paths within ikyoku networks. This suggests that Rotation may be a reasonable measure for capturing the extent to which a region relied on ikyoku networks for physician supply before NPGME.

As a preliminary analysis, we divide the rural areas roughly in half by Rotation and see if the impact of NPGME on physician supply differs between the two rural areas. Specifically, we estimate a simple medical–care–area fixed effects model with only year dummy variables on the right-hand side. The dependent variable is a natural logarithm of the number of hospital physicians in rural areas. We designate an area as urban if it includes a prefectural capital, an ordinance-designated city, or it has more than 500,000 population in 2010, which classified 248 out of 348 areas as rural.\(^10\) Figure 4 presents the coefficients of the year dummy variables.

Figure 4 indicates that, prior to 2004, the number of hospital physicians in rural areas increased at a similar pace regardless of Rotation, reflecting the overall increase of physicians in Japan.\(^11\) After 2006, however, the two groups followed different paths: while the number of physicians dramatically decreased in high Rotation (i.e., \( R \geq 0.3 \)) rural areas, the number of physicians with low Rotation (i.e., \( R < 0.3 \)) barely changed. Thus, our initial evidence indicates that the impact of NPGME on physician supply substantially differed between high Rotation and low Rotation rural areas after 2004.

An alternative way of examining the impact of NPGME is to recognize that Rotation is a continuous variable rather than a dichotomous one. Thus, by interacting Rotation with a dummy variable indicating the introduction of NPGME, we can more efficiently use the variation in Rotation for identification. Specifically, we estimate the following fixed effects model:

\[
\ln N_{jt} = A_t + B_j + \alpha R_j \times POST_t + X_{jt} \beta + \epsilon_{jt},
\]

where \( \ln N_{jt} \) is a natural logarithm of the number of hospital physicians in medical care area \( j \) in year \( t \).\(^12\) \( A_t \) and \( B_j \) are year and medical care area fixed effects, respectively. \( R_j \) denotes Rotation discussed previously. \( POST_t \) is a dummy variable, which equals 1 for the years after 2004 and 0 otherwise. \( X_{jt} \) is a vector of control variables,

\(^9\)It would be ideal if we know which physician belongs to which informal network. Unfortunately, our data do not include such detailed information.

\(^10\)We use this definition because most of medical universities are located in major cities such as prefectural capital, ordinance-designated city, and other large cities. We also used thresholds other than 500,000, but the results were very similar.

\(^11\)According to the Ministry of Health, Labour and Welfare, the number of physicians increased 22% between 1996 and 2010 (source: http://www.mhlw.go.jp/toukei/saikin/hw/shishi/10/dl/01.pdf).

\(^12\)As noted previously, we exclude the first-year residents in 2004 and the first-year and second-year residents in the following years from the number of hospital physicians, \( \ln N \).

which includes per household income, land price, and population by 10-year age group. These variables are in natural logarithm. $\varepsilon_{jt}$ is an error term. In all regressions, standard errors are corrected for clustering at the medical care area level. We also weight observations by the square root of the average population of each area.

Our identifying assumption is that, prior to 2004, rural medical care areas with high or low Rotation follow a similar trend in the number of physicians, conditioning on covariates. However, the impact of NPGME differs across rural areas after 2004 depending on pre-NPGME Rotation, which identifies the impact of NPGME on the number of physicians. Note that this identification strategy is similar to Acemoglu and Finkelstein (2008) where variation of the degree of treatment is used as the main source of identification. Our main interest in Equation (1) is $\alpha_1$, which identifies the effect of Rotation on the number of hospital physicians in rural areas after the introduction of NPGME in 2004.

A useful variant of this equation is

$$
\ln N_{jt} = A_t + B_j + \phi R_j \cdot d_{2002} + \alpha_1 R_j \cdot \text{POST}_t + X_{jt} \beta_1 + \varepsilon_{jt},
$$

which adds a dummy variable for the year 2002, $d_{2002}$, to Equation (1). This model allows us to check whether the trend captured by $\alpha_1$ in Equation (1) already existed before 2004. A statistically significant $\phi$ with the same sign as $\alpha_1$ casts doubt on the causal relationship between the introduction of NPGME and the number of affected physicians.

Equation (3) replaces the POST$_t$ dummy in Equation (2) by the post-2004 linear trend, POSTTREND$_t$. This specification was motivated by Figure 4, which suggested that the difference in the number of physicians continued to widen year by year between high Rotation and low Rotation rural areas after 2004.

$$
\ln N_{jt} = A_t + B_j + \phi R_j \cdot d_{2002} + \alpha_2 R_j \cdot \text{POSTTREND}_t + X_{jt} \beta_1 + \varepsilon_{jt}.
$$

As noted previously, we rely on the identification assumption that, prior to 2004, medical care areas with high Rotation and low Rotation follow the same trend in the number of hospital physicians. Although Figure 4

---

13 Because of data limitation, those who are 80 years old or older are grouped together as one category. We further divide the youngest (0–9 years) and oldest (70–79 years) age groups into two groups and separately include them in the regression.

14 To be precise, POSTTREND$_t$ = year-2003 if year ≥2004 and 0 otherwise.
supports this assumption, in Equation (4), we further control for potentially different region-specific pre-NPGME time trends by including an interaction term between Rotation and a linear time trend, $R_j \times t$.

$$\ln N_{jt} = A_t + B_j + \theta R_j \times t + \phi R_j \times d_{2002} + \alpha_2 R_j \times POSTTREND_t + X_j \beta_1 + \epsilon_{jt}. \quad (4)$$

Table I reports the results. Our main results are robust to different specifications. Table I, column (1) shows that $\alpha_1$ in Equation (1) is negative and statistically significant, indicating that the reduction in the number of physicians in rural areas was larger in high Rotation areas after 2004. Column (2) reports the results from Equation (2), which indicates that parameter values change little with the addition of $R_j \times d_{2002}$. Moreover, $\phi$ is not statistically significant, indicating that Rotation did not have an effect on the number of physicians before 2004 in rural areas.

The next two columns report the results from Equations (3) and (4), both of which replace the post-2004 dummy variable by the post-2004 linear trend. In column (3), $\alpha_2$ is estimated to be negative and statistically significant, indicating that the impact of Rotation on the number of physicians became increasingly large in rural areas after 2004. This is consistent with the results shown in Figure 4. $\phi$ continues to be statistically insignificant in this regression, indicating that the impact of Rotation was not present before 2004. Column (4) reports the results from Equation (4), which adds the area-specific linear time trend. Qualitative results stay the same even with this addition. Specifically, the estimated $\alpha_2$ continues to be negative and statistically significant. The estimated $\theta$ is positive but not statistically significant, suggesting that medical care areas with different Rotation did not follow different trends prior to the introduction of NPGME. The estimated $\alpha_2$ implies that in rural areas one standard deviation increase in Rotation will result in a decrease in the number of physicians by 0.78% per year after 2004 (which is equivalent to a decrease of 5.5% between 2004 and 2010).\textsuperscript{15,16}

So far, we have examined the impact of NPGME on the total number of hospital physicians. In Table A3 in the Supporting Information, we report the results that re-estimate Equation (4) for eight medical specialties.\textsuperscript{17} We find that the coefficient for $R_j \times POSTTREND$ in rural areas is negative in all specialties.

\textsuperscript{15}This is obtained by $100 \times (\exp (0.0941) − 1) \times 0.079$.

\textsuperscript{16}We also note that, relative to average rural areas, the impact on more affected rural areas is given by $100 \times (\exp (0.0941) − 1) \times (0.6 − 0.31) \times 7 = 20\%$ after 2004.

\textsuperscript{17}We used the ‘principal’ clinical specialty of the physician to identify a specialty.
except one, which further supports the previous finding that the introduction of NPGME negatively affected the number of physicians in rural areas with high Rotation after 2004. We also find that the reduction in the number of physicians is statistically significant in some specialty areas, including pediatrics, cerebrovascular surgery, and psychiatry, indicating that the impact of NPGME was particularly large in these specialties.

4. EFFECTS ON PHYSICIAN WAGES

In this section, we examine the impact of the introduction of NPGME on physician wages. In particular, we estimate a variant of a Mincer-style wage equation for hospital physicians, by augmenting the equation with the Rotation variables that we used in the previous section. Various physician characteristics that usually appear in a Mincer equation, such as tenure, experience, gender, and the type of hospital, are also included in the regression. The identification is the same as in the previous section based on Acemoglu and Finkelstein (2008).

For this analysis, we use physician wage data obtained from the Basic Survey on Wage Structure. Unfortunately, we cannot match these data to the physician data at the individual physician level. We instead match the two data sets using the place of work that is recorded in both data sets. We have a total of 9429 observations between 1996 and 2010. Please see the Supporting Information for more about the data.

We first estimate the following Mincer equation, which includes an interaction term between Rotation and post-NPGME linear trend in the same manner as Equation (4).

\[
\ln wage_{ijt} = A_t + B_j + \theta R_j \cdot t + \phi R_j \cdot d_{2002} + \alpha_1 R_j \cdot POSTTREND_t + X_{ijt} \beta_1 + Y_{ijt} \gamma + \epsilon_{ijt},
\]

(5)

where \(\ln \text{wage}_{ijt}\) is a natural logarithm of hourly wage of physician \(i\) in medical care area \(j\) in year \(t\). \(Y_{ijt}\) is a vector of physician characteristics, including gender, tenure and its squared, experience and its squared, and the characteristics of the hospital (such as bed categories). All of the remaining variables and the estimation approach are the same as Equation (4).

The results reported in Table II show that none of the coefficients on the interaction terms between Rotation and time trends are significant at the conventional level. This indicates that, unlike physician supply that continuously declined after the introduction of NPGME, no comparable linear trend exists in physician wages.
result can be interpreted that, in the long run, physician wages were unaffected by the physician supply shock caused by NPGME.

To further examine the short run impact of NPGME on physician wages, we estimate the following more flexible model, which replaces the post-NPGME linear trend by interaction terms between Rotation and year dummies.

\[
\ln w_{ijt} = \alpha_t + \beta_j + \sum_{t=1998}^{2010} \alpha_t R_{j,t} + \gamma Y_{ijt} + \epsilon_{ijt}, \tag{6}
\]

Table III reports the results. We focus our discussion on the interaction terms between Rotation and the year dummies, our main interests. The column (1) results indicate that in rural areas, there was no difference in hourly wages with regard to Rotation up to 2004, but hourly wages significantly increased in high Rotation rural areas in 2006. After 2008, however, physician wages are again not distinguishable from that of the original level. This result is consistent with our finding in Table II that no clear linear trend exists in physician hourly wage after 2004. The estimated coefficient on Rotation*2006 indicate that one standard deviation increase in Rotation in rural areas increased physician hourly wage by 13.0% in 2 years between 2004 and 2006. \(^{18}\) Recall that in Section 3, we reported that in rural areas one standard deviation increase in Rotation resulted in a decrease in the number of physicians by 0.78% per year after 2004. Combining these two estimates together, we can conclude that the short run price elasticity of demand for physician labor in rural areas is inelastic with an elasticity of \(-0.12 = 0.78 / (13.0/2)\). \(^{19}\)

Table III, column (2) further estimates the same model by restricting the sample to the physicians who worked full time. That is, we exclude part-time physicians (who work regularly but with shorter hours than ordinary physicians) and temporary physicians from the sample. Note that the wage of full

\(^{18}\)This is obtained by 100 * (exp (0.023438) – 1) * 100 * 0.055. Anecdotal evidence for such a salary increase exists. For example, in response to the difficulty of recruiting a physician, Yubari Municipal Hospital raised the salary for a full-time physician by approximately 30% (Hokkaido Newspaper 25/9/2006).

\(^{19}\)We obtain a similar elasticity of \(-0.08\) if we replace \(R_{j,t}\), \(R_{j,2002}\), and \(R_{j,posttrend}\) in Equation (4) by \(\sum_{t=1998}^{2010} R_{j,t} d_{ijt}\) and calculate the impact of NPBME on physician supply by the difference in the coefficients on \(R_{j,2004}\) and \(R_{j,2006}\).
time physicians is determined by a fixed salary plus a bonus and is not linked to the number of patient visits. Part-time physicians are paid per hour. Hence, one may expect that, to meet the sudden reduction in physician labor, hospitals may try to attract temporary or part-time physicians by paying higher wages. The results are consistent with this reasoning: after excluding temporary or part-time workers, the wage increase in 2006 becomes only weakly significant, suggesting that the wage increase was higher for such physicians.20

The reader may wonder why the wage increase in high Rotation areas was a one-time phenomenon and did not last after 2006. It is indeed puzzling in light of the results presented in Section 3 showing that the number of hospital physicians in rural areas with high Rotation continued to decline even after 2006.

We think that the keys to this puzzle lie in the short run versus long run decisions of hospitals and price regulation in the healthcare market. We illustrate the idea using a simple partial equilibrium analysis presented in Figure 5. In the short run, a sudden decrease in physician supply may increase physician wages, but hospitals may still choose to stay in the market because many of the fixed costs of operating a hospital are sunk in the short run.21 In the long run, however, these costs may be variable and hospitals may choose to exit the market. A hospital’s exit from the market reduces the demand for physician labor in the medical care area, which in turn reduces physician wages. This may not be the

20 Obviously, one would like to estimate the same model by looking only at temporary or part-time physicians. Unfortunately, a small sample size did not allow us to do that.

21 In addition, it may be difficult to find an alternative hospital for all hospital inpatients in the short run.
case if the healthcare market is not heavily price-regulated because the price increase in the healthcare market can increase the marginal revenue product of physician labor. We argue that hospital exits are more likely to occur in the Japanese market, where the fees that hospitals can charge patients are heavily regulated by the central government and where hospitals are required to employ at least three physicians.\textsuperscript{22,23} A natural question to ask is whether the introduction of NPGME triggered hospitals’ exits. We address this question in the following section.

5. EFFECTS ON HOSPITAL ACCESS

This section examines whether the introduction of NPGME resulted in hospital exits in affected rural areas. We draw our data from the Survey of Medical Institutions, a panel data set covering the universe of medical institutions in Japan. Using this data set, we count the number of hospitals and hospital beds in each medical care area. As part of preliminary analysis, we checked the overall trend in the number of hospitals by estimating a medical care area fixed effects model with only year dummy variables on the right-hand side. As shown in the Supporting Information Figure A2, between 1996 and 2010 the number of hospitals has decreased in rural areas by 7.4\%. Moreover, the reduction in rural areas appears to have accelerated after 2006. Figure A3 shows the results that further divide the rural sample by high Rotation (i.e., $R\geq 0.3$) and low Rotation areas. This figure indicates that the reduction in the number of hospitals is somewhat higher in high Rotation rural areas, but, obviously, we require more careful examinations before reaching any conclusion.

\textsuperscript{22}Hospital exits may be less likely in non-price-regulated markets where hospitals can charge higher prices to cover the increased cost of labor.

\textsuperscript{23}Alternatively, hospitals may substitute physical capital and nurses for physician labor. However, hospitals are required to employ at least three physicians, which limits the possibility of factor substitution for small hospitals.
Our main regression model is the same as Equation (4).

\[ \ln N_{jt} = A_t + B_j + \theta R_j \cdot t + \phi R_j \cdot R_{2002} + \alpha_2 R_j \cdot POSTTREND_t + X_{jt} \beta + \epsilon_{jt}, \]  

where \( N \) takes either (1) total number of hospitals or (2) total number of hospital beds in medical care area \( j \) in year \( t \). All of these variables are in natural logarithm. All of the remaining variables and the estimation approach is the same as Equation (4). The Supporting Information provides additional details about the data.

Table IV reports estimation results. Column (1) indicates that the number of hospitals in rural areas decreased in high Rotation areas relative to low Rotation areas after 2004. In column (2), we report the results for the number of hospital beds. Not surprisingly, the results are similar to the results for the number of hospitals reported in column (1). These results support our conjecture discussed at the end of Section 4 that the introduction of NPGME had a larger impact on hospital exits in high Rotation rural areas, which made the high demand for hospital physicians and the resulting wage increases a temporary phenomenon.\(^{24}\)

Estimation results indicate that one standard deviation increase in Rotation in rural areas resulted in a decrease in the number of hospitals by 0.35% per year after 2004 (which is equivalent to a decrease of 2.5% between 2004 and 2010). The impact on hospital beds was similar, as indicated by the \( \alpha_2 \) coefficient.

### 6. EFFECTS ON HEALTH OUTCOMES

We have found so far that the introduction of NPGME reduced not only the number of hospital physicians in some areas but also access to hospitals in those areas. We may expect that such a system-wide supply shock would negatively affect not just a few, but many different health outcomes in those areas. We address this issue, using the same identification approach as before. As the measure for health outcomes, we use all-cause

\(^{24}\)One potential concern in interpreting the result is the possibility of mean reversion: because hospital capacity was increasing in markets with a relatively high ‘Rotation’ value in the pre-NPGME period (as manifested by the significantly positive coefficient on \( R \cdot t \)), \( R \cdot POSTTREND \) coefficient may be capturing reversion to the mean rather than the effect of reduced physician supply. To address this concern, we also run a specification to control for the increase of capacity during the pre-NPGME period and find that the results are very similar with the control. We also run the same for the models in Table V and find that the results change little.
mortality as well as five leading causes of death in Japan, which are malignant neoplasm, cardiac disease, pneumonia, cerebrovascular disease, and accidental death.

Our regression model is identical to Equation (4):

$$\ln D_{jt} = A_t + B_j + \theta R_j t + \phi R_j \cdot d_{2002} + \alpha_2 R_j \cdot POSTTREND_j + X_j \beta + \varepsilon_{jt}$$

(8)

where $\ln D_{jt}$ is the number of deaths by all cause or by each of the five leading causes in medical care area $j$ in year $t$. We estimate these six regressions separately. All of the remaining variables and the estimation approach are the same as before. We draw the deaths data from Vital Statistics, which is publicly available at the municipality level. Please see the Supporting Information for more about the data.

Table V, column (1) reports the results for all-cause mortality. Our main interest is $\alpha_2$, the coefficient on $R_j \cdot POSTTREND$, which indicates that the number of all-cause deaths weakly significantly increased in high Rotation rural areas after 2004. This provides weak evidence that the reduction of physicians and the worsened access to hospitals in high Rotation rural areas negatively affected the overall health outcomes of those areas. Estimation results indicate that in rural areas one standard deviation increase in Rotation increases death by cardiac disease by 0.57% per year after 2004 (which is equivalent to 4.0% between 2004 and 2010) and increase death by all-cause by 0.17% per year after 2004 (which is equivalent to an increase of 1.2% between 2004 and 2010).

Columns (2)–(6) in the same table report the results for the five leading causes of death. These indicate that mortality due to cardiac disease and accidental death significantly increased in high Rotation rural areas after 2004, whereas mortality was unaffected for other causes such as malignant neoplasm. One interpretation for these differential responses may be that access to hospitals is more important for acute conditions such as cardiac disease and accidental injuries, and thus, the worsened access had a larger impact on these causes. On the other hand, patients with malignant neoplasm may have more time to travel to distant hospitals, and this may explain why the impact of reduced access to hospitals was insignificant for this cause. Overall, these results provide additional evidence that the supply of physicians and the resulting access to hospitals have important impacts on the health outcomes of the region.

Table V. Estimation results for health outcomes

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1) All-cause mortality</th>
<th>(2) Malignant neoplasm</th>
<th>(3) Cardiac disease</th>
<th>(4) Pneumonia</th>
<th>(5) Cerebrovascular disease</th>
<th>(6) Accidental death</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_j \cdot 2002$</td>
<td>-0.0180</td>
<td>-0.0757</td>
<td>-0.0013</td>
<td>0.1129</td>
<td>0.0092</td>
<td>0.1907</td>
</tr>
<tr>
<td>($0.0367$)</td>
<td>($0.0605$)</td>
<td>($0.0882$)</td>
<td>($0.1130$)</td>
<td>($0.0908$)</td>
<td>($0.1416$)</td>
<td></td>
</tr>
<tr>
<td>$R_j \cdot POSTTREND$</td>
<td>0.0209*</td>
<td>-0.0043</td>
<td>0.0701***</td>
<td>0.0673*</td>
<td>-0.0179</td>
<td>0.1174**</td>
</tr>
<tr>
<td>($0.0114$)</td>
<td>($0.0189$)</td>
<td>($0.0254$)</td>
<td>($0.0402$)</td>
<td>($0.0349$)</td>
<td>($0.0477$)</td>
<td></td>
</tr>
<tr>
<td>$R_j \cdot t$</td>
<td>-0.0112</td>
<td>-0.0013</td>
<td>-0.0392***</td>
<td>-0.0327</td>
<td>0.0242</td>
<td>-0.0756***</td>
</tr>
<tr>
<td>($0.0064$)</td>
<td>($0.0107$)</td>
<td>($0.0145$)</td>
<td>($0.0238$)</td>
<td>($0.0205$)</td>
<td>($0.0261$)</td>
<td></td>
</tr>
<tr>
<td>Area FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Area characteristics</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>$R$-squared</td>
<td>0.8901</td>
<td>0.7117</td>
<td>0.6646</td>
<td>0.6835</td>
<td>0.3539</td>
<td>0.0524</td>
</tr>
<tr>
<td>$N$ of medical care area</td>
<td>244</td>
<td>244</td>
<td>244</td>
<td>244</td>
<td>244</td>
<td>244</td>
</tr>
</tbody>
</table>

FE, fixed effects.

This table reports the estimation results from Equation (8). Dependent variables are a natural logarithm of the number of mortality because of the specified causes in each medical care area. Robust standard errors corrected for clustering at the medical care level are in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

---

25The results for ‘cardiac disease’ stay the same even when we exclude the number of deaths due to ‘cardiac arrests’ out of ‘cardiac disease’.

---

7. CONCLUSION

In this paper, we studied the physician labor market in Japan and examined the effects of an exogenous supply shock on the geographic distribution of physicians, physician wage, access to hospitals, and health outcomes. Although attempts have been made to uncover these relationships in the past, endogeneity of the relationships made identification particularly difficult. We addressed this issue by exploiting the introduction of a new residency program in Japan whose effects differed across rural areas in an exogenous way.

Based on panel data covering all physicians in Japan, we find a short run increase in physician wage and a decrease in the number of physicians in response to the negative supply shock. However, the wage increase diminished in the long run, while the number of physicians continued to decline in affected areas. This indicates that the demand for physician labor is inelastic in the short run but more elastic in the long run. We attribute this long run change of the physician labor demand to the change in hospital competition: we find that hospitals in the markets with negative physician supply shock are more likely to exit. Also, this change resulted in the deterioration of patient health outcomes in those markets.

Our findings suggest that when hospital services are price-regulated, a reduction in physician supply may potentially cause a large impact on patient access to care and patient health outcomes. This is because hospitals are unable to raise fees for patients and absorb higher wages and have to exit the markets in the long run. The discrepancy between the short run and long run wages and the hospital exits we observed are consistent with this view. Unfortunately, without a relevant counterfactual, we are unable to isolate the effect of price regulation on our outcomes. Nonetheless, policy makers should be aware of such possibilities when implementing policies that may have a large impact on the distribution of physician supply.

CONFLICT OF INTEREST

Authors have no financial conflicts of interests.

ACKNOWLEDGEMENTS

This work is supported by JSPS KAKENHI grant number 23330078 and 262850648. The use of data in this paper was approved by the Ministry of Health, Labour, and Welfare under this grant. We are grateful to Jeffrey Clemens, David Dranove, Hideki Hashimoto, Naoki Ikegami, Frank Limbrock, Haruko Noguchi, Wei-Der Tsai, and seminar participants at 2013 iHEA Congress in Sydney, the University of Tokyo, the Conference on Empirical Social Sciences Studies in 2013, Japanese Economic Association Spring Meetings in 2014, Tokyo Labor Economics Workshop in 2014, the 7th Tri-Country Health Economics conference in 2015, and the 2nd Economics of the Health Workforce Conference in 2015 for helpful comments and suggestions. All remaining errors are our own.

REFERENCES


---

26The reader may also wonder how the number of services provided by hospital physicians responded to the decrease in physician supply. We looked at data of hours worked (although we cannot know the specialty of physicians), finding that the number of hours worked by full-time physicians was unaffected by NPGME.
THE IMPACT OF PHYSICIAN SUPPLY


SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at publisher's website.