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Study of health resource and health outcomes: Organization of economic corporation and development panel data analysis

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Abstract:

CONTEXT: There are numerous factors which affect the health status in different ways, including financing mechanisms, health-care expenditures, socioeconomic characteristics, and health-care resources. One of the most important factors which contribute to the health status of a population is health-care resource which includes number of beds or health-care professionals for instance.

AIMS: The objectives of this study were as follows: to examine the regression of the life expectancy and health-care inputs and also to investigate the regression of death rate and health-care inputs.

SETTINGS AND DESIGN: This study was a panel dataset analysis of OECD countries.

MATERIALS AND METHODS: A generalized method of moment (GMM) regression models with country-level health outcomes (death rate and life expectancy) as dependent variables were estimated. A panel dataset with $n = 26$ (the number of countries) and $T = 12$ (the number of time periods) was used. The GMM regression model was used to estimate the effect of health-care resources on health outcomes.

RESULTS: Findings showed that there are strong reverse correlations between immunization rate and number of physicians with crude rate of death (−2.64 [$P < 001$] and −76.50 [$P < 001$], respectively). There were also positive correlations between immunization rate and number of physicians with life expectancy at birth (0.01 [$P < 001$] and 1.03 [$P < 001$], respectively). Moreover, there were negative correlations between inpatient rate and beds with life expectancy (−0.00003 [$P < 001$] and −0.12 [$P < 001$], respectively).

CONCLUSIONS: It is essential for policymakers to consider the optimal level of health resource to achieve better health outcomes. Oversupply of hospital beds and specialist doctors could lead to induced demand and put the patients at risk of unnecessary procedures.

Keywords:

Health, health resource, life expectancy, mortality

Introduction

Health alongside with factors such as education and income is a key element to have a productive and developed society; there are numerous factors which affect the health status in different ways, including financing mechanisms, health-care expenditures, socioeconomic characteristics, and health-care resources. One of the most important factors which contribute to the health status of a population is health-care resource which includes number of beds or health-care professionals for instance.[1]

Health-care resources, including both human resource (e.g., physicians) and physical resource (e.g., hospital beds), are inputs of health-care services, which in turn are important inputs in the health

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production function, as well as good health behavior and a good environment.[1] Health interventions cannot be carried out without health workers. Personal health interventions involving patient contacts require the services of doctors, nurses, or other types of health-care providers.[2]

An international comparison of health-care resources reveals two facts. First, at a single point in time, there is substantial difference in health-care resources among countries. That is, around the world, health-care resources are distributed unequally. High-income countries are more likely to have more health-care resources (in terms of higher numbers of health workers and hospital beds) than low-income countries. Second, there is also substantial variation in the density of health-care resources within regions and countries.[1]

Life expectancy or mortality rates in a country are broad measures of the nation's health status, which are outcomes of several socioeconomic and environmental factors. Life expectancy at birth (LEB) varies greatly between and within countries. According to the life expectancy literature, the determinants of life expectancy can be classified into social, economic, and environmental factors.[3]

Regarding the growth of health-care-related industries and rising costs in medical and insurance industries, the determinants of life expectancy for a given country become a very important issue. Indeed, the main aim of a public health-care policy is to maintain and improve the nation's health status. Hence, it is crucial to identify to what extent each factor is contributed to the health of the population. The information on the nation's health status helps policymakers and practitioners in their search for cost-effective interventions to provide health services and reallocation of health resources to optimize the gains.[4]

Building and strengthening capacity in human resources for health has been recognized as critical to reduce health crises in less developed countries, in addition to contributing to the sustainable development of health systems in all countries. Multiple studies demonstrate that countries with higher levels of human resources for health typically have better population health. The density of human resources for health, including the supply of physicians, nurses, and other health professionals, has been shown to be positively correlated with percentage of deliveries assisted by skilled birth attendants and the proportion of children fully immunized against measles and negatively correlated with maternal, infant, and under-five mortalities.[5]

Human resources for health are clearly a prerequisite for health care, with most medical interventions needing the services of doctors, nurses, or other types of health workers. In turn, health care is one of the determinants of population health, alongside with other determinants including socioeconomic, environmental, and behavioral factors. These two relations generate a link between human resources and population health, even if the link might be weakened by the presence of non-healthcare factors.[6]

In a study examining the effect of changes in health sector resources on infant mortality, using a longitudinal econometric analysis with dataset of 99 countries, findings show that increasing the number of physicians by one per 1000 population, decreases the infant mortality rate by 15% within 5 years.[5]

In the study of international differences in the impact of doctors on health, a multilevel analysis of OECD countries, the research findings show that number of physicians is an important determinant of mortality across OECD countries, and cross-country heterogeneity in the effect of physician's availability on health is significant.[7]

The present study was aimed to to estimate the regression of the life expectancy and healthcare inputs and also regression of death rate and healthcare inputs using generalized method of moment (GMM) model.

Here, we tested to what extent health-care resources, including number of beds, doctors, inpatient rate, and immunization rate, affect population health outcomes of OECD countries in terms of mortality rate and life expectancy.

Materials and Methods

Data

A longitudinal panel dataset from the OECD was used,[8] and life expectancy and death rate were selected as dependent variables, number of doctors, beds, inpatient rate, and immunization rate were considered as independent ones. Then, missing data were sorted and the panel set was modified to a 12-time series from 2000 to 2012 for 26 countries including Australia, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Korea, Luxemburg, Mexico, New Zealand, Norway, Poland, Slovakia, Slovenia, Spain, Sweden, Switzerland, the UK, and the USA. The dependent variables, including number of beds, physicians, and inpatient rate, are measured as per 1000 population. Immune rate is measured as percentage of whole population, and death rate is measured as per 100,000 populations as crud rate.

Econometrical model

GMM regression models with country-level health outcomes (death rate and life expectancy) as dependent variables were examined. A panel dataset with $n = 26$ (the number of countries) and $T = 12$ (the number of time periods) was used. When the time horizon is short, panel econometric models can be estimated using the GMM technique developed by Arellano and Bond.[9]

A major issue in this kind of study is identifying a causal effect as opposed to merely an association between physician density and health. There are two issues of concern. First, there is the threat that both good health and high density of physicians are associated with some other country-level factor, such as "good government," that is, not included in the model. With variables removed from the model, a statistical relationship between health and physician density may be merely an incidental association. Using panel data and allowing for country fixed effects can reduce this concern to some extent. The second possibility is that countries with good health could have higher demand for health-care professionals, which subsequently results in a higher number of physicians per capita. In this case, a statistical relationship between health and physician density does not establish causality between physician density and better health (a case of reverse causation).[4]

To address these problems, a model using the GMM estimator was used which corrects for the potential endogeneity of simultaneous changes in the independent variables and the endogeneity of the lagged level of death rate in the dynamic specification.[6] The foundation of the GMM estimator is that sufficiently long lags of the variables, either in levels or differences, are exogenous and uncorrelated with the current error term or its difference. This GMM approach to estimation deals consistently and efficiently with the estimation problems such as endogeneity and unobservable country-specific heterogeneity. This consistency, however, critically hinges on the identifying assumption that the lagged values of the X variables we use are uncorrelated with the current error term. This assumption will fail if the X variables are endogenous and depend on contemporaneous errors or if the errors are correlated over long lags. To address this concern, a battery of specification tests complements the estimation results. In particular, a Sargan test of overidentifying restrictions was performed.[7]

Results

Table 1 shows the descriptive statistics of the dataset. As shown, immunization ranges from 81% to 99% among these OECD countries. LEB (for both sexes) ranges from 75.7 to 86.4 years. The mean of inpatient rate is 16637.71 patient day per 1000 population. Number of physician and beds ranges from 1.3 to 4.84 and 1.59 to 14.69/1000 population, respectively. The mean of crude death rate is about 877/100,000 populations.

Table 2 shows the result of GMM model treating death rate as dependent variable. As shown above, there are strong reverse correlations between immunization rate and number of physicians with crude rate of death (−2.64 and − 76.50, respectively). The positive correlations of inpatient rate and beds with death rate are not statistically significant.

Sargan test for overidentifying restrictions

- Chi-square (54) =19.75
- Probe > χ^2 = 1.00.

As shown in Table 3, in this model, Arellano–Bond test shows a first-order autocorrelation. Since Sargan test shows Probe > χ^2 = 1.000, the overidentifying restrictions are valid.

Table 4 shows the result of GMM model treating life expectancy as dependent variable. As shown above, there are positive correlations between immunization rate and number of physicians with LEB (0.01 and 1.03, respectively). Moreover, there are a negative correlation of inpatient rate and beds with life expectancy (−0.00003 and −0.12, respectively). All the correlations are statistically significant.

Sargan test for overidentifying restrictions

- Chi-square (54) =19.87
- Probe > χ^2 = 1.00.

As shown in Table 5, in this model, Arellano–Bond test shows a first-order autocorrelation. Since Sargan test

Table 1: Descriptive statistics

Variable	Observations	Mean	SD	Minimum	Maximum
Immunization	336	94.94	3.84	81	99
Life expectancy	334	81.67	2.30	75.70	86.40
Inpatient rate	308	16,637.71	4379.02	4016.6	28,114.50
Physicians	282	2.93	0.69	1.30	4.84
Beds	312	5.61	2.51	1.59	14.69
Death rate	328	877.38	211.47	431.50	1502.30

SD=Standard deviation

Table 2: Arellano-Bond dynamic panel data estimation

Death	Coefficient	SE	Z	P>Z	95% CI
Death L1	0.26	0.04	5.38	<0.001	0.16-0.36
Immunization	−2.64	0.57	−4.62	<0.001	−3.76-−1.52
Inpatient rate	0.002	0.001	1.45	0.147	−0.0009-0.006
Physicians	−0.76	11.27	−6.79	<0.001	−98.59-−54.41
Beds	10.84	9.85	1.10	0.271	−8.46-30.16
Cons	1037.08	86.38	12.00	<0.001	867.76-1206.40

Wald χ^2 (5)=3799.46. SE=Standard error, CI=Confidence interval

Table 3: Arellano-Bond test for zero autocorrelation

Order	Z	P>Z
1	−2.40	0.01
2	0.74	0.45

Table 4: Arellano-Bond dynamic panel data estimation

Life expectancy	Coefficient	SE	Z	P>Z	95% CI
Life expectancy L1	0.74	0.003	217.19	<0.001	0.74-0.75
Immunization	0.01	0.001	9.24	<0.001	0.01-0.01
Inpatient	−0.00	2.28e-06	−17.49	<0.001	−0.00-−0.00
Physician	1.03	0.02	41.13	<0.001	0.98-1.08
Beds	−0.12	0.00	0.25.63	<0.001	−0.13-−0.11
Cons	17.70	0.49	35.78	<0.001	16.73-18.67

Wald χ^2 (5)=2.15e + 06, $P>\chi^2=P<0.001$. SE=Standard error, CI=Confidence interval

Table 5: Arellano-Bond test for zero autocorrelation

Order	Z	P>Z
1	−3.03	0.002
2	1.21	0.224

shows Probe > χ^2 = 1.000, the overidentifying restrictions are valid.

Discussion

Health-care resources have short-run and long-run effects on health; these effects have been studied in terms of health output (e.g., number of surgeries) or health outcomes (e.g., life expectancy and mortality rate). Multiple studies demonstrate that countries with higher levels of human resources for health typically have better population health.[5]

As shown above in findings, crude death rate has a negative correlation with immunization rate and number of physicians, which seems reasonable. Because, immunization could prevent from developing certain conditions and early-childhood death. Moreover, number of physicians who help to the early diagnosis of diseases could alleviate certain causes of death.[10-12]

The density of human resources for health, including the supply of physicians, nurses, and other health professionals, has been shown to be positively correlated with percentage of deliveries assisted by skilled birth attendants and the proportion of children fully immunized against measles and negatively correlated with maternal, infant, and under-five mortalities.[5]

In a nationwide study using bivariate regression on 147 countries in 2016, a significantly strong negative relationship between number of physicians and infant mortality was found across nations, and that the number of physicians in a population could explain 46% of the variability in infant mortality across nations. Data were derived from the World Bank for two specific years, 2010 and 2013. Further studies need to be conducted to determine what other variables have an effect on infant mortality since this study was limited to the amount of physicians in a population. In addition, other dependent variables, such as life expectancy rate and maternal mortality rate, should be included in these studies to determine the effect that the number of physicians has on those health outcomes.[13]

In a cross-sectional study using data from health-care-related public surveys conducted in 2008, social, economic, and environmental variables were also analyzed. The geographical units of analysis were 348 secondary healthcare service areas, which provide and manage most health-care services in Japan. Multiple regression analysis showed that hospital physician density, the elderly ratio, and hospital bed density were all correlated with the inpatient flow ratio.[14]

In a cross-country multiple regression study, coverage of three vaccinations was examined against aggregate health worker density including doctors and nurses. Health worker density was significantly associated with coverage of all three vaccinations. However, when the effects of doctors and nurses were assessed separately, nurse density was significantly associated with coverage of all three vaccinations. However, doctor density was not. A higher density of health workers (nurses) increases the availability of vaccination services over time and space, making it more likely that children will be vaccinated. After controlling for other determinants, the level of income does not contribute to improved immunization coverage. Health workers can be a major constraining factor on vaccination coverage in developing countries.[15]

In our study, findings show that life expectancy has a positive correlation with immunization rate and number of physicians, which is probably due to the prevention of early life death which contributes to the prolonged life and raises LEB.

Life expectancy also has a negative correlation with inpatient rates and number of beds. It is obvious that severe patients are more likely to be hospitalized and undertake surgeries and risky procedures, but this finding may also shows the negative impact of hospitalization on health which may raise the risk of death and shorten the life expectancy.

In the study of the impact of doctors per capita on mortality rate in Asia 2014, data were obtained from The World Health Organization and The World Factbook and were analyzed under four subcontinental groups to determine the bearing of the number of doctors on mortality in Asian countries. Afghanistan had the highest and Qatar had the lowest mortality rate. Doctors per capita were highest in Kazakhstan and least in Bhutan, and the doctors per capita had an inverse association with mortality rate.[16]

In the study of the effect of changes in health sector resources on infant mortality in the short run and the long run, a longitudinal econometric analysis using a dataset of 99 countries at 5-year intervals, findings show that increasing the number of physicians by one per 1000 population, decreases the infant mortality rate by 15% within 5 years and by 45% in the long run with half the long-run gain being achieved in 15 years.[5]

In the study of international differences in the impact of doctors on health, a multilevel analysis of OECD countries, the research findings show that physician numbers are an important determinant of mortality across OECD countries, and cross-country heterogeneity in the effect of physician availability on health is significant.[7]

Conclusions

Overall, the level of health resources, including human and physical resource is positively correlated with better health outcomes including decreased death rate and prolonged life. However, it is essential for policymakers to consider the optimal level of health resource in terms of number of physicians, nurses, and beds to achieve better health outcomes. They should consider the potential negative effects of oversupply on population health. Oversupply of hospital beds and specialist doctors could lead to induced demand and put the patients at risk of unnecessary procedures.

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Conflicts of interest

There are no conflicts of interest to publish this study.

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