

Simulation experiment for economical impact
by physicians' excessive increase in Japan

Zaiken Nishida

June 1999

Research Paper No. 156

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[Abstract]

We have a difficulty when discussing an oversupply of medical doctors (MDs) if we compare the number of MDs per population (MPP) in the developed countries because of differences in health care systems. We also have a difficulty with demonstrating an oversupply of MDs because of creating a normative discussion when we compare the number of MDs in terms of the ideal health care system. However, we can discuss the oversupply of MDs more realistically and reevaluate MD training programs when we review an MD's future earning power in a health care organization from the view point of the organization's management sustainability under the worse conditions of government's cost containment policy and an oversupply of MDs. In the case of Japan, even if the higher growth rate in health care expenditures is realized and the the MDs' employment is ensured, it is not avoidable for MDs to lose some of their earning power due to a significantly increased number of MDs. And it may cause problems of deteriorating MDs quality because the simulation experiment forecasts that the average MD's wage would become similar to other salaried workers in 30 years in the worst case. Therefore, the Japanese government should control its MD training programs by keeping MPP below the level of USA in 1989 in order to avoid the above problem.

INTRODUCTION

Optimal control of medical expenditure is a common policy agenda among industrialized countries including Japan, where ever inexperienced pace of increase in elderly population makes the situation more urgent in spite of government's tight regulation of service price. Several strategies such as capitation are expected to result in containment of medical service utilization and consequent reduction in medical cost through economic incentives towards physicians. On the other hand, optimization of the number of physician supply tries to control cost by modifying an infrastructure of delivery system. In this paper, we will focus on the latter strategy as a policy agenda.

The Ministry of Health and Welfare (MHW) had set up the Committee of Demand and Supply for Medical Doctor in the Future in 1984. The Committee anticipated approximately 10% oversupply of physicians in 2025 even under optimistic conditions, then, recommended that, at minimum, 10% of physician candidates should be cut off until 1995. In fact, 7.7% cut-off of new enrollment capacity of medical schools in all over Japan had been realized by 1995, though it had not reached the recommended level. The Medical Professions Division at the Health Policy Bureau of MHW in 1992 reported that physician oversupply would become a more serious issue than expected before. Then, they called for the Committee for Review of physicians' Demand and Supply in 1993. Their final report in 1994 also warned forthcoming oversupply of physicians.

However, those reports shared several limitations with previous studies on physician supply. First, since it relied on comparative data of number of physicians per population, it failed to show an optimal level of physician supply corresponding to the characteristics of different financial and delivery systems across countries. In addition, it lacked a theoretical referent framework to which the level of optimization should be discussed. Finally, the impact of physician oversupply on health economics was not discussed due to a lack of framework and suitable methodology to integrate with this issue demands in medical services, and the ability of health sectors to maintain their business. In this paper, we propose an alternative approach and a method to overcome these limitations to analyze the impact of physician oversupply in a dynamic context of health service markets.

ANALYTIC FRAMEWORK

We started from referring to an economic model of interdependent health service markets by Feldstein¹⁾ to obtain a theoretical framework of analysis. In this model, institutional, manpower, and educational markets are interacting with each other and patients' demand for treatment. Thus, the model provides a relevant scheme to describe the relationship of physician oversupply in a manpower market with two other health sector markets and patients' demand for service utilization. However, due to a regulative nature of Japanese health care system, we had to modify the model as shown in Figure 1.

In Japanese system, physicians are either employees in institutions or owners of institutions. Thus, an institution is a basic unit that makes a decision in terms of an economic behavior in health sector market. Since service prices are regulated by the government payer, and minimum requirement of number of physicians per patient set by the government also determines the level of physician demand for most of institutions, quantity of service provision and wages for physicians are historically under institutional control. In this reason, we cannot deny physician induced demand in Japan yet²⁾.

Each institution has to decide market entry/exit by taking consideration of revenue and cost balance, which, in turn, is determined by a decision regarding quantity of service provision and labor cost for physicians and other health providers. Thus, an economic analysis of Japanese health sector market can be reduced to an issue of business sustainability in the institutional level.

Based on this framework, we recognized that our model should be composed of three functions; service demand, physician and institutional supply, and balance for institutional sustainability as shown in Figure 2.

Service demand is mainly a function of the demographic structure of Japanese population. Physician supply, on the other hand, is determined by government policies regarding medical graduates and physicians to be employed. Then, these two components determine institutional revenue and cost balance. To describe these interactions, all variables are described in a monetary term (YEN) as a common unit of analysis.

Finally, it was a challenge to include all these functions into a single analytic platform. To overcome this, we decided to use System Dynamics (SD) method for several reasons. First, SD is a well developed analytic tool that has been applied since 1950's to an analysis of complex social systems. Second, through a process of SD analysis, we can obtain a clear view of causal relationship among variables, which helps us identify key influential elements. Third, SD can provide a trend forecast of targeted variables by simulating an obtained model. Finally, we can assess political feasibility and relevance of alternative policies by sensitivity analysis in SD. Recent availability of a relevant PC-based software³⁾ makes it easier for us to use the method in our study.

DEVELOPMENT OF CAUSAL MODEL

1. Service Demand

The amount of medical service demand was extrapolated based on currently available age-specific data on service utilization⁴⁾ and forecast data of population structure⁵⁾. Utilization was estimated respectively according to types of institutions (hospital vs. clinic) and types of service (inpatient vs. outpatient service), because reimbursement rate differs across those categories. In addition, since utilization pattern varies across age, mainly due to distinctive senior health plan for over 65 years old, population structure was also

categorized into three levels; under 15 years old, from 15 to 64 years old, and over 65 years old. Then, obtained number of service utilization was transformed into monetary values by multiplying average charge for each type of service and institution.

2. Service supply and related cost

2-a) Physician supply

The number of enrollment into medical education has been regulated by the Government. The enrollment capacity of medical schools almost equals to the number of graduates. Although licenser is limited to those medical graduates, boarding exam does not seem a major barrier to restrict the number of physician since more than 98% of examinees on average passed the exam. Thus, number of physician entry is defined by the following form.

$$\text{Eq. (1) } R(t) = f (e(t), p(t))$$

where, $R(t)$: # of physician entry

$e(t)$: enrollment capacity for medical schools

$p(t)$: passing rate of the National Examination for Medical Doctor License

Then, we needed to separate physicians working at hospital settings and those working at clinic settings because different institutional types imply different cost structures, which must be integrated into our model of economic impact of physician oversupply. Physicians were categorized into three types; physicians working in clinics (MDC), those in hospitals (MDH), and those working in non-clinical services (NMD). A physician can transit across these types over time. However, we omit transit flows from MDC to MDH or NMD to simplify our model because they were rare cases. We also neglect the flows from NMD to MDH or MDC with similar reasons. Transit rate across categories was estimated from the statistics⁶⁾ by MHW in 1990 and 1992.

Physician cohort was also divided into 6 sub-cohorts according to age. Then, number of physicians in each sub-cohort was estimated by taking consideration of transit across institutions and age, and mortality rates. Mortality rate of each age subcohort was derived from the census statistics in 1990. Then, we can represent physicians number at year (t) by age and by institutional types as a following form of differential equation.

$$\text{Eq. (2) } D_{hj}(t+dt) = D_{hj}(t) + dt (m_{hh,j}-1 - m_{hh,j} - m_{hc,j} - m_{hn,j} - d_j)$$

where $D_{hj}(t)$: number of MDH in cohort(j)

$m_{hh,j}$: portion of MDH in cohort(j), transferring to MDH in the next cohort(j+1)

$m_{hc,j}$: portion of MDH in cohort(j), transferring to MDC in the next cohort(j+1)

$m_{hn,j}$: portion of MDH in cohort(j), transferring to in the next cohort(j+1)

d_j : mortality of MDH in cohort(j)

Then, each physician cohorts and transit flows in physician supply is depicted in Figure 3.

Though estimated number of physicians were assumed to fully be employed by medical institutions, this assumption seems reasonable during simulation, which we will discuss later in this paper. Increased number of physicians was supposed to reflect on cost of institutions. In addition, we assume that increased number of physician also contribute to institutional revenue indirectly through induced demand as we will discuss shortly.

2-b) Institutional cost.

We used different units of measuring cost between hospital and clinic settings; in clinics, cost per facility was estimated, whereas cost per bed was estimated as proxy in hospital settings.

Labor costs often occupy a dominant share in hospital costs. Therefore, we analyzed costs by dividing them into three parts, physician cost, non-physician cost and non-labor costs. Then, costs were estimated by following formats;

- Physician cost : $W_{MD} = f(\text{physician\# increase, physician wage growth rate})$
- Other employee cost : $W_{OE} = f(\text{other employees' wage growth rate})$
- Other expenses : $E = f(\text{price index growth rate})$

3) Cost/revenue balance

3-a) Effects of Induced Demand on revenue

Finally, information regarding service demand and service supply was integrated into cost/revenue balance at institutional levels. Service demand was transformed into total amount of service charge, which made institutional revenue, whereas physician supply and other non-labor attributes were used for calculating institutional costs. In addition, the impact of physician increase was incorporated not only into their direct cost increase, but also into institutions' revenue increase via induced demand.

We cannot distinguish whether the induced demand (IND) is caused by physician autonomy, or by improved patient's accessibility to medical services. However, we can empirically find a strong correlation between physician density (PHD), and health care expense and utilization rates across regions in Japan. The both correlation were built in our simulation experiments respectively; model 1 for correlation with health expense, and model 2 for correlation with utilization rate.

< model 1 > Adopting the correlation between PHD and HEI

The Health Expense Index (HEI) by prefecture is derived from age-adjusted medical expense based on the National Health Insurance which covers all people uncovered by the Employees' insurance because of self-employed or retired⁷⁾. The PHD is a number of physicians per 100,000 people by prefecture⁶⁾. The correlation between them in 1990 is depicted in Figure 4 and analyzed with ordinary least-square regression techniques to determine their relation as follow.

$$Y = 0.0028X + 0.534 \quad (R^2=0.67)$$

where Y : health expense index (HEI), X : physician density (PHD)

Then, we employ HEI as IND index making the data in 1990 for the bench mark since the year is the starting of the simulation experiment. Namely, the PHD in 1990 is 165, then the HEI index is 0.996 by the regression equation above. With ratio of the following year HEI to the base year HEI would be swelled the health expenses. Then, revenues of medical institutes would be increased with the swelled rate parallely. In proportion to increasing physician supply, PHD changes and reflects its effect to HEI as IDD index. Then, we can observe the financial balances between revenues and costs at hospitals and clinics influenced by physicians' increase. Here, the rates of seeing a doctor are fixed with figures of 1990.

< model 2 > Adopting the correlation between PHD and RSD

Based on the statistics of the National Health Insurance, Rate of Seeing Doctor (RSD) by prefecture are more specifically available by age, by inpatient or outpatient⁷). The correlation between PHD and RSD in 1990 is depicted in Figure 5 and analyzed with ordinary least-squares regression techniques to determine their relation by age and by inpatient or outpatient respectively as follows.

- Correlation between IND and RSD for outpatient by age

(1) People 65-year old or more

$$Y = 46.7 X + 5031 \quad (R^2=0.34)$$

(2) People younger than 65-year old

$$Y = 12.0 X + 2472 \quad (R^2=0.40)$$

- Correlation between IND and RSD for inpatient by age

(1) People 65-year old or more

$$Z = 29.3 X - 305.7 \quad (R^2=0.35)$$

(2) People younger than 65-year old

$$Z = 3.82 X + 184.7 \quad (R^2=0.31)$$

where X : physician density (PHD),

Y : RSD for outpatient,

Z : RSD for inpatient

However, as the R^2 -values of the regression lines employed in model 2 are much smaller than the regression line in model 1, it would be preferable to explaining the influence of IND for financial balance of medical institutes by model 1.

3-b) Hypotheses of business sustainability for private medical institutions

The model traces balance between those revenues and expenses with time series and shows sustainability of finance of hospitals and clinics under the hypothesis of their management behavior mentioning here.

As hiring physicians at medical institutes becomes both cost pressure and revenue promotion, our quantitative analysis incorporates with hypotheses for those balances impacting medical institutes'

management. In short, we exemplify patterns of the resulting financial balances to transform into the management sustainability of hospitals and clinics.

One of the structural characters of Japanese healthcare delivery system is coexistence of public medical institutions (PUMs) and private medical institutions (PRMs) which are rivalry in terms of quantity (PUMs : PRMs = 33 : 67 in hospital beds, and PUMs : PRMs = 6 : 94 in clinics). However, their management behaviors are apparently different. PRMs are clearly responsive to financial conditions in the market, whereas PUMs do not respond to competitions in the market because they have no commercial risk with enough financial compensation from the government. Thus, PUMs will not behave according to their financial balance status.

Based on our previous financial analysis of Japanese PRMs, we reached hypotheses on institutional behaviors of market entry/exit according to profit status (Figure 6). In the case of private hospitals, it is represented by the change of sustainable bed capacity depending on their average balance of profit and loss. The increase and/or decrease ratio of beds are given in the model within a reasonable range based on empirical financial data. Similarly, in the case of private clinics, we set up 15 % of profit ratio as the critical point of opening and/or closing. Since 15% of average revenue of clinic in 1990 was approximately identical with average salaries of senior clinical attendant physicians in hospitals, and if the profitability would become less, clinic owner physicians would reconsider to keep their business, the hypothesized number would seem within an acceptable range. On the other hand, there must be financial incentives for salaried physicians to open their own clinics, if the profitability would become more than the critical value.

Finally, the full perspective of the model is depicted in Figure 7.

MODEL BUILDING FOR TIME-SERIES QUANTITATIVE ANALYSIS

1. System Dynamics method

We apply SD method to build up an analytical model by incorporating with all elements discussed until here. SD can deal with complex relations among them not only by qualitative analysis but also by quantitative analysis dynamically reflecting physicians' increase.

SD method has been developed since 1950's by J. W. Forrester, the former professor of Massachusetts Institute of Technology and applied to social system analyses very well for more than forty years. The Analysis by SD typically carries out through the five processes as follows.

- (1) building a Causal Diagram by mapping elements in the object world and linking them in consideration their mutual effects. The Causal Diagram is very helpful to sort out key players and/or key elements in a messy actual policymaking.
- (2) translating the Causal Diagram into a SD Flow Diagram by using special SD symbols which assists computer simulation programming
- (3) programming the SD Flow Diagram by SD simulation language that is called DYNAMO originally.
- (4) running Prototype Computer Model to verify whether it represents the object world or not, that is to say, there are no strange figures in the result of computer simulation.
- (5) carrying on Sensitivity Analyses to assess the feasibility of alternatives and to support processes of decision making.

The PC-based software, "ithink" has been developed recently for the SD method which allows us having computerized supports for the steps of (2) to (5) above, while such computerized support is not available for the step (1), building a Causal Diagram²⁾.

Hypothesizing those above all, the model is programmed by SD simulation language. We use "ithink" as the language which works on the both of Macintosh and Windows. The software also supports to design SD flow diagram depicted in Figure 8 in the case of model 1. The physician supply flows are so complex that they are treated by a subsector as depicted in figure 9.

2. RESULTS OF SIMULATION EXPERIMENT

2-a) Trends of physician supply

Physician supply would be saturated with around 310,000 as depicted in Figure 10 if the government stops their effort to decrease enrollment capacity of medical schools by the level in 1994. The simulation result shows that it would take more than 50 years until hitting the peak. Keeping the condition of physicians' mobility as observed in MHW statistics between 1990 and 1992, clinic physicians would become double.

Because the population in Japan would soon hit the peak, PHD, i.e. physicians per 100,000 people would increase linearly as shown in Figure 11. The figure shows that Japan would take a long time to reach the level of the US, France and Germany in 1989, though Japanese government currently feels their excessive physician supply.

It implies nonsense to discuss such an oversupply by comparing with physician density among industrialized countries because difference of those figures are coming from not only their health care system but also economical sustainability.

2-b) Trends of physician filling in medical institutions

Japanese Medical Care Law provides standards of physician numbers per bed. Roughly calculating those figures as a capacity of job markets for physicians in the future, and comparing them with anticipated physician numbers in both of model 1 and 2, job filling ratio would keep around 100% even if it would be under pessimistic conditions as shown in Figure 12.

It implies that physicians in Japan would have enough job opportunities insofar as Medical Care Law works.

2-c) Business sustainability for private institutions

According to the report of MHW, total health expenditure would grow with high rate. It means that the revenues of hospitals and clinics would be expected to rapidly grow.

Our computer simulation experiments carry on along with the growing of MHW's forecasting. Since physician costs in the medical institutions go on with no restraint of physicians' employment as reviewing above, they would increase as well as physician numbers growing. Then, we can observe the induced demand affects financial balances very much as shown in Figure 13.

3. SENSITIVITY ANALYSIS FOR POLITICAL FEASIBILITY ASSESSMENT

We reconsider the reality of the forecasting because that the growth rate of THE given by MHW might be much higher than recent Japanese economic growth. Reviewing the co-medical staff expense from 1989 to 1994, we recognize their annual growth rate is 3.9 % as similar as the hypothesis of THE growth. However, physician wage grows with approximately 1.2 % which is too lower to follow with THE growth. Accordingly, we need sensitivity analysis on the labor cost growth rate to certify the reality.

In the both of model (1) and (2), the financial balances of hospitals and clinics would get down explicitly as shown in Figure 14 when the labor cost growth rate is one point more than the growth of THE.

It suggests that management of medical institutions necessarily keep to pay their attentions to controlling labor cost in the future. Especially have to they focus on physicians cost management because they had once curtailed costs of nurses and ancillaries except physicians. As a consequence, physician wage growth would be curtailed next.

By the way, if medical institutions keep hiring physicians to fill their facilities along with the provision of the Medical Care Law; the standard physician number for patients, their management must be ceiling a portion of physician cost relative to their total expense. Then, if such a budget ceiling would be kept, physicians' average wage keep decreasing adversely in proportion to physicians' growing supply. As shown in Figure 15, 20% down for hospital physician wage and 40% down for clinic physician wage are respectively expected when comparing with the present wage level based on real value. Temporarily, physician wage level is 70% more than that of average salaried people. This calculation means that it would be no difference in income level between physicians and ordinary salaried men in around 2020.

DISCUSSION

We have a difficulty when discussing physician oversupply if we compare the number of physicians per population in the developed countries because of differences in several conditions. We also have a difficulty with demonstrating the oversupply because of a controversy pertaining to adequate number of physicians in terms of an ideal health care delivery. However, the oversupply of physicians can be discussed in its economic impact, when we focus on physician's earning power in future organization's management sustainability under the worse conditions of government's cost containment policy and an oversupply of physicians.

One simulation suggested that, even if the higher growth rate in health care expenditures is realized and the physicians' employment is ensured, it is unavoidable that physician will lose their bargaining power against hospitals/clinics, otherwise, medical institutions lose their business.

In this context it may cause problems of deteriorating physicians quality because the simulation experiment forecasts that the average physician's wage would become similar to other salaried workers in 30 years in the worst case. In any case, we suggest that Japanese government should control its physician training programs by keeping its physician density below the level of USA in 1989 in order to avoid the problem of physicians quality.

ACKNOWLEDGEMENT

I thank Dr. Hideki Hashimoto for his help in reviewing the manuscript and providing in insightful comments. And, I thank Dr. Michael Reich, Harvard School of Public Health and Dr. Sakai Iwasaki, Nippon Medical School who accepted my challenging study tolerantly. I have great respects for their warm-hearted supporting junior researchers.

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