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■ Review Article

Variables in the projection of physician demand and supply in primary care

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Primary care services improve healthcare outcomes and limit unnecessary specialty care. Thus, it is essential to monitor primary care physician demand and supply projections to suggest evidence-based healthcare reforms and promote better healthcare delivery. This study evaluates 28 demand variables, 50 supply variables, and 26 additional variables associated with the demand and supply projections of physicians by reviewing scenarios from other countries, including Taiwan, Singapore, Japan, and the United States of America. The results indicate that Korea uses less diverse demand and supply indicators and suggest the need to implement variables used in the other four countries to improve projection modeling.

Keywords: Forecasting; Supply and Distribution; Health Services Needs and Demand; Statistical Factor Analysis; Primary Care; Physicians

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Introduction

After introducing a series of policies in the essential medical policy package, the Korean government decided to increase the admission quota of medical schools to 5,058 from 3,058 in the previous year [1]. While they enacted these laws to resolve the rising demands of doctors in rural regions and in essential specialties, this decision faced severe backlash from physicians and medical residents, resulting in more than 70% of Korean Medical Association members agreeing to go on collective strikes [2].

Physicians oppose this policy for three major reasons [3]. First, there is a lack of scientific evidence to support an increase in admission quotas. The government perceives that more doctors are needed because Korea has a smaller population-to-doctor ratio than the Organization for Economic Cooperation and Development average: 2.6 doctors per 1,000 people, as opposed to 3.7 doctors per 1,000 people in 2021 [4]. However, those in the medical field claim that this analysis is inappropriate because the Korean medical system provides relatively easier access to health services than other countries via lower health costs [3]. Second, the general health policy was constructed without assessing its practical effects on physicians and patients. Increasing the medical quota is part of the medical reform prohibiting physicians from providing a combination of insured and uninsured treatments. This prohibition of mixed treatment is controversial because low medical fee payments have been a consistent financial issue for physicians [5]. Finally, medical training resources are currently lacking. Schools lack sufficient equipment, rooms, medical personnel, and patients that can properly support students [3], resulting in a lack of training, which may result in reduced care quality for patients and overworked medical trainees and trainers.

The quota policy was implemented based on three research reports indicating that the demand for doctors will increase greatly by 2035 [6-8]. However, the investigators expressed their dissent about the government's direction in organizing the projected numbers independently and failing to consider other suggestions contained in their reports [9]. In other words, the government determined admission quotas without properly assessing the reports. Moreover, the three studies contained scenarios with different factors that could affect physicians' demand and supply projections. Nonetheless, the government did not fully utilize these scenarios and did not account for practical factors that could influence the determination of the medical admission quota. Thus, to estimate the adequate number of additional doctors needed, it is necessary to fully evaluate and review the practical factors that could affect Korea's physician supply and demand estimation.

Accurately forecasting primary care physician projections is essential. Primary care contributes to the health of the population by ensuring accessibility to necessary services and reducing unnecessary specialty care [10]. A greater supply of primary care services is associated with reduced hospitalization [11,12], urgent care visits [11,12], and mortality in hospitals [12]. Therefore, primary care physicians are critical to the healthcare system. Unfortunately, the function of primary medicine has been overlooked in Korea because of factors such as competition between clinics, the absence of insurance coverage for family care, and people's preference for secondary and tertiary clinics [13].

To demonstrate the importance of primary care and evaluate the current outlook, re-evaluation of primary care supply and demand projections is necessary. Given the strike over the medical quota policy and the status of primary care in Korea, this study aims to review the factors that can impact the supply and demand of physicians in primary care and provide better insight into future projections by evaluating the supply and demand factors used in Taiwan, Singapore, Japan, and the United States of America (USA).

Variables

Demand

The demand and supply variables examined in this study are organized according to the model suggested by Lopez et al. [14] in 2015 and used by Seo and Lee [15] in 2017. The indicators are organized into three categories: economic, need, and service target variables. Economic variables predict the "actual observed demand" by considering the effects of population demographics and socio-economic factors [14]. The need variables demonstrate the potential demand by considering the effects of epidemiological trends and the population's health status [14]. Service-target variables extend from need variables and outline general targets for the production of healthcare services [14]. These variables are important factors that can either increase or decrease demand projection. For instance, an increase in service-target indicators, such as the number of inpatients and occupied beds, indicates a more severely ill population. This allows us to predict that physician demand will increase in the near future and consider policy implementations that can support this. In contrast, a decrease in the prevalence or incidence rate of an illness, a need indicator, suggests that there will be less demand for physicians, especially those who work closely with that particular illness. Among the originally categorized 18 indicators and newly categorized 10 indicators (Table 1), 16 were used in scenarios in different countries to provide the best possible projections of physician demand.

Supply

The supply variables are arranged into four categories: training, skill mix, worker-to-population ratio, and labor market productivity. Training variables estimate the availability of physicians by keeping track of the current number of physicians, educational processes, migration flows, and other attritional or additional factors [14]. Skill mix variables indicate that different medical professionals have overlapping skills that can be transferred between disciplines and account for these substitutions [14]. The worker-to-population ratio variables provide desirable worker-to-population ratios, based on comparisons with other countries [14]. Productivity variables include factors that promote higher productivity, such as incentives and services [14]. These factors

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Table 1. Variables used in demand and supply projection

Variable	Indicators
Demand	
Economic	
Population demographics	Total population, age and sex distribution, birth/death, net-migration[a], population projection, worker-to-population ratio (population per workforce)[a], population growth[a]
Socioeconomic variables	Disposable income, gross domestic product growth projections, ethnic factors, education[a]
Need	
Population health status	Age/sex mortality, morbidity, acuity
Epidemiology	Incidence rates, prevalence rates (number of people with condition), hospital discharges, health patterns, uptake rate[a], treatment duration[a]
Service-target	
Utilization patterns	Number of occupied beds, number of inpatients (number of discharges), number of outpatients, number of surgeries/screenings/consultations performed, medical benefit-claims[a], projection of physicians[a], visit per person[a], severity of service (average cost per discharge per visit)[a]
Supply	
Training	
Stock of licensed provider	Baseline stock (licensed, active, registered), age/sex distribution, growth projection
Annual additions to licensed stocks	Graduates (entrance quota, resident positions), in-migration, returned to profession
Education/training programs	Number of enrolled students, attrition rates, years to complete, costs, education and training[a], exam passing rate[a], exam failure rate[a] (number of failed students), exam re-taking rate[a], career option rate[a]
Annual attritions to licensed stocks	Retirement, mortality, career changes, change of specialty[a], emigration, abroad
Skill mix	
Government policy variables	Education funding, alternative delivery model (change in role, change in delivery model, ACO and value-based payment model, expanded retail clinics, APRN, and PA), licensing regulations, professional roles/deployment, recruitment/retention strategies, immigration policy, remuneration rate/types, capacity-building
Worker-to-population ratios	
Health labor workforce	Number of active and employed physicians
Productivity	
Labor market	Occupational participation rates, occupational employment rates, employment projections, vacancy rates, turnover rates, wages rates, productivity growth, productivity (visit per physician)[a], cyclical factors, alternative career options
Employment status	Full-time, part-time, casual, full-time equivalent, average hours (days) worked, direct patient care hours, no longer practicing, probability of continuing[a], trend of reducing work time[a], no licensed in jurisdiction
AI and tele-medicine	
Technological[a]	Technological intensity, observability, trialability, perceived benefits, data reliability and sustainability, data interoperability
Organizational[a]	Organization size and structure, organizational readiness, investment capacity, business networks, organizational support/leadership, internal and external economies of scale, customs and norms, strategic alignment between business viability and AI adaptation, market uncertainty
Governmental[a]	Government support and policies, industry-specific pressure, peer pressure, inclusiveness, environmental concerns
Human factors[a]	Assurance of job security, desirability of implementation, workforce transformation, acceptance rate, human capital, prospects/plans

ACO, accountable care organizations; APRN, advanced practice registered nurses; PA, physician assistant; AI, artificial intelligence.
[a]Specifies an indicator and a variable newly categorized in this paper.

assist in evaluating physician supply projections. For example, the number of graduates, which is a training indicator, is a definitive addition to the physician workforce, and a larger number of graduates results in a higher supply projection. In contrast, the retirement rate, also a training indicator, results in a definitive reduction in the workforce. An increase in retiring physicians will decrease the projection of physician supply. From the 41 originally identified and nine newly identified indicators (Table 1), 16 indicators were used in the scenarios introduced in this study. However, it is important to note that some demand projection models reviewed in this study utilized supply variables, namely the alternative delivery model factor from the skill mix category and the productivity factor from the productivity category.

Additional variables

Many recent studies have investigated the use of artificial intelligence (AI) computational programs that can perform tasks involving human intellectual processes in the analysis of diseases and interpretation of patient data [16]. In response to this trend, the American Medical Association has been developing principles and recommendations to promote the use of AI, attempting to reduce physicians' workload and burnout [17]. If the implementation of AI is successful, it is expected to resolve the issue of physician shortage and affect the supply of physicians. This finding suggests the importance of factoring in AI development in physician supply and demand projections. Usmani et al. [18] in 2023, Deveci [19] in 2023, and Kumar et al. [20] in 2023 analyzed the factors that affect the diffusion and implementation of AI; these factors were organized as additional variables and divided into four catego-

ries: technological, organizational, governmental, and human factors (Table 1).

Scenarios

Wu et al. [21] in 2009 examined the demand and supply projections of physicians on remote islands of Taiwan from 2008 to 2012. For the projection of supply, they only used the number of physicians from 2003 to 2007 as a variable, which is a factor from the training category, and adjusted this number using a gray forecast mathematical model to project the number of physicians from 2008 to 2012. For demand projections, they used the number of medical services and physician productivity. The number of outpatient visits and inpatient or emergency visits were categorized into service target variables, which were combined to generate a medical services variable [21]. Physicians' productivity values were determined using the number of projected physicians (from supply projections) and medical services [21]. Physicians' productivity was labeled as a productivity supply variable, and its component, the number of projected physicians, was labeled as a service target variable. Lin et al. [22] in 2023 assessed the demand and supply of psychiatric services in Taiwan and noted that they did not use an epidemiological approach (need) but rather a utilization approach (service-target). Among the indicators examined, this study identified outpatient visits and medical benefit claims as strong indicators, both labeled as service-target variables. For the projection of psychiatrist supply, the study incorporated the number of board-certified psychiatrists from 2007 to 2018 [22]. This number was adjusted according to the probability of a psychiatrist continuing to practice (productivity variable) and the annual supply of 56 psychiatric residents (training variable). The probability of continuing practice was a function of gender and age; therefore, the age or sex distribution was labeled as another training indicator and used in the study (Table 2).

Ansah et al. [23] in 2017 forecasted the demand for ophthalmologists in Singapore using four scenarios: workforce-to-population, needs-based, utilization-based, and integrated approaches. The workforce-to-population model used two factors: total population and average population per workforce. While it used the total population for the base and launch years, it also used a population projection that accounted for birth, death, and net migration in the projecting years [23]. The needs-based model implemented three factors: number of people with eye disease (combination of population projection and eye disease prevalence), average visits per person, and average patient visits per ophthalmologist (productivity) [23]. The disease prevalence was disaggregated according to age, sex, ethnicity, and education. The utilization-based approach used two factors: the number of expected patient visits and the average number of patient visits per ophthalmologist (productivity) [23]. The number of expected patient visits was a combined estimate of people with eye disease, average visits per person, and uptake rate (proportion of the population with eye illness likely to seek eye care) [19]. The integrated approach applied all the indicators from the utilization-based approach but adjusted the number of people with eye disease according to treatment completion or mortality rate and changed the uptake rate by accounting for education level [19]. Overall, the first model included indicators from economic variables and one indicator from productivity supply variables, whereas the other three models used indicators from all three variables and one from the productivity variable. In contrast, the healthcare projection for demand by the National Manpower Council of the Singapore Ministry of Manpower included population growth, age, education, productivity, immigration of foreign healthcare workers, changes in the healthcare worker's role, and changes in the service delivery model using economic demand variables as well as training, skill mix, and productivity supply variables [24,25]. They provided supply indicator-based demand projections. For supply, the institution included the

Table 2. Comparison of variables used between different countries

	Demand	Supply
Taiwan	4 Service-target: out-patient visits, in-patient visits, medical benefit claims, projection of physicians	3 Training: total number of physicians, graduates (resident position), age/sex distribution 2 Productivity: productivity, probability of continuing practice
Singapore	9 Economic: total population, population projection, birth/death, net-migration, worker-to-population ratio, age and sex distribution, population growth, education, ethnicity 4 Need: prevalence, uptake rate, treatment duration, age mortality 1 Service-target: average visit per person	3 Training: immigration, graduates (non-local), education and training 1 Skill mix: alternative delivery mode (change in healthcare worker's role, change in service delivery model) 1 Productivity: productivity
Japan	3 Economic: total population, population projection, age, and sex distribution 3 Service-target: number of discharges, number of consultations, severity of service (average cost per discharge)	6 Training: number of physicians (registered), age/sex distribution, graduates (entrance quota), exam passing rate, death, change of specialty 1 Productivity: average working hours
USA (AAMC)	5 Economic: total population, population projection, age sex, ethnicity 1 Need: health patterns	3 Training: growth projection, graduates, retirement rate 1 Skill mix: alternative delivery mode (ACO and value-based payment model, expanded retail clinics, APRN and PA increase) 1 Productivity: hours worked
Korea	2 Economic: age, worker-to-population ratio 2 Service-target: number of inpatient visits and number of outpatient visits	10 Training: age, number of physicians (registered), graduates, mortality, emigration, retirement, exam passing rate, exam failure rate (number of failed students), exam re-taking rate, medical admission quota 3 Productivity: productivity, trend of reducing work time, working hours/days

AAMC, American Association of Medical Colleges; ACO, accountable care organizations; APRN, advanced practice registered nurses; PA, physician assistant.

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education and training of local healthcare workers and the recruitment of non-local graduates [24,25], implementing only training variables.

In 2006, the Japanese government's Ministry of Health, Labour and Welfare assessed the projections for supply and demand of physicians from 2005 to 2040 [26]. For this report, in their demand model, they used population projections by total population, age, and sex, number of discharges, number of outpatient consultations, and severity of service (average cost per discharge or visit for each age group) [26,27], implementing a mix of economic and service-target variables. Their supply projection included factors such as entry into medical schools (medical school quota), number of registered physicians, and average working hours of physicians by age, sex, and location of practice [26,27], using training and productivity variables. Another supply projection model, by Ishikawa et al. [28] in 2008, applied the current physician supply, medical school quota, national exam passing rate, career option rate, and retirement rate (including death and change of specialty). Their model assumed that all medical students graduated and that the retirement rate would be constant throughout the projection years from 2008 to 2030 [28]. They used only training variables in their study.

A report by the Association of American Medical Colleges (AAMC) in the USA portrayed six physician demand scenarios and five scenarios building off the status quo scenario [29]. The status quo scenario accounted for projected demographic shifts (age, race, ethnicity, and economic variables) with a constant epidemiological status for each demographic group [29]. The other four scenarios—managed care, retail clinics, moderate and high use of advanced practice registered nurses (APRNs) and physician assistants (PAs), and population health scenarios—accounted for factors such as management through accountable care organizations, expanded use of retail clinics, increased use of other medical staff (APRNs and PAs), and improvement in health conditions, such as obesity, high blood pressure, and smoking [29]. The status quo and population health scenarios utilized demand, economic, and need variables. However, the other three scenarios were primarily supply based demand scenarios that estimated demand under the assumption that there was an increased measure of supply indicators (skill mix variable). The AAMC report demonstrated four supply scenarios. The status quo scenario assumed the patterns of hours worked and retirement to remain constant in the projected years (2021–2036) and applied the additional graduate medical education (GME, equivalent to medical quota) positions updated by a recent law in 2021 [29]. There were two versions of this scenario, with or without an assumed 1% annual growth of newly entering physicians, and other scenarios were built based on the status quo scenario [29]. The early and delayed retirement scenario factored in earlier or later retirement (with or without 1%) [29]. The changing hours worked scenario accounted for the average annual trend of physicians' work hours in the past 15 years (with or without 1%) [29]. The GME expansion scenarios accounted for an additional 3,750 new physicians entering the workforce beginning in 2027, based on two laws enacted in 2021 (only 1%) [29]. The AAMC report used complex models and all scenarios accounted for indicators in the training and productivity variables.

Implications

Physicians oppose the change in South Korea's medical admission quota because it was implemented without considerable analysis of relevant reports. For instance, one study estimated the lack of 9,654 physicians in 2035 [8]. This was calculated using the statistical autoregressive integrated moving average model, which sets the physicians' workdays to 265 days. However, the government did not consider the fact that this number "is not realistic if considering the 104 days of weekends and other holidays" as the author, Youngseok Shin, stated [6]. Moreover, the author generated different predictions using different workday values, such as 240 and 255 days, which yielded different predictive measures. This was not accounted for in the government's decision to increase the medical quota to 2,000 seats. Thus, to address this issue, this study aimed to organize and review the practical factors of physician supply and demand projections that other countries utilize and analyze factors that can be implemented in Korea's physician projections.

All the studies analyzed used at least two categories of demand indicators, except for studies conducted in Taiwan, which used only four indicators from the service target variables. Overall, studies in Korea used less diverse demand variables compared to other countries, but it is important to note that researchers incorporated a supply variable (productivity) in their demand projection similar to research conducted in Singapore and the USA, providing a more integrated forecast. Studies in Singapore had the most complex projections and implemented all three demand variables, although this complex projection was not used in studies conducted by the Singapore Ministry of Manpower but was observed in the study by Ansah et al. [23] in 2017. In this study, 15 demand indicators—nine economic, four need, and one service target variable—and three supply indicators were used in demand projection. In contrast, the AAMC used six demand indicators, five economic and one need, and one supply indicator in its projection. Unlike projections from studies in Taiwan and Singapore that applied new indicators, the AAMC used indicators that matched the original indicators in Seo and Lee [15] in 2017. However, it lacked diverse use of demand indicators, primarily economic indicators. Studies in Japan used six indicators—three economic and three service-target variables—but did not include any supply variables in their projections. Similar to the AAMC report, demand indicators that were well aligned with the original indicators were used.

Studies in Taiwan and Japan used two supply variables: training and productivity. Wu et al. [21] in 2003 and Lin al. [22] in 2023 used five supply indicators, three training indicators, and two productivity indicators. The Ministry of Health, Labour and Welfare of Japan [26] and Ishikawa et al. [28] in 2013 used seven indicators: six for training and one for productivity. In contrast, studies in Singapore and the USA incorporated three supply variables using three indicators in the training

category, one indicator in the skill mix, and one indicator in productivity. While studies in Japan used many supply indicators, they demonstrated a comparatively less diverse use of supply indicators, with six out of seven supply indicators in the training category. In the remaining studies in Taiwan and Singapore and the AAMC report, only five supply indicators but more diverse supply factors were used. Most notably, in the AAMC report, changes in medical admission quotas due to the 2021 laws in supply projection were applied, providing a forecast more relevant to the current supply. They also used supply indicators that matched those of Seo and Lee [15] in 2017.

Many studies in South Korea have investigated the demand and supply projections of physicians, even before the recent strikes. Yu et al. [30] in 1988 estimated the supply of physicians using the number of registered or domestic physicians, newly entering physicians (graduates), mortality, emigration, and retirement, which are five indicators from the training variable. Song et al. [31] in 1994 estimated supply projections using the number of alive (active) physicians, graduates, students who failed national exams, exam re-taking rates, exam passing rates, mortality, and emigration. This supply model used seven indicators, all from the training variable. In contrast, their demand projection used the worker-to-population ratio, average days worked, and trend of workday reducing [31], utilizing three indicators (two indicators being supply variables) from economic and productivity variables. The literature indicates a large focus on utilizing supply, training, and productivity variables, even for demand projections. However, a recent report released in 2020 [6], which the government used in support of its policy, used age (economic), outpatient visits (service targets), and inpatient visits (service targets) for demand projection. Age, medical admission quota, mortality, retirement, and exam-passing rate (all training variables) were used for supply projections [6]. The report is particularly notable as it used scenarios similar to those in the AAMC report, but evaluated the number of necessary physicians by combining supply and demand projections. There were eight scenarios in total, and they estimated the projection under the assumption that the factors of days worked (productivity), productivity (productivity), medical admission quota, age, and retirement were maintained or reduced at a certain value. Considering that the other two reports also included various scenarios with diverse factors for physician projections [7,8], it can be concluded that Korea's demand and supply projection of physicians has developed robustly and complex models have been built that consider more factors.

The physician projections reviewed demonstrate that Korea considers a moderate number of demand and supply indicators, utilizing the most training indicators compared to other countries. However, it would be optimal to implement diverse indicators from the need and skill mix variables, particularly to predict how the enactment of essential medical policy packages will affect the next demand-supply projections. As almost all Koreans are enrolled in the national health insurance program, medical benefit claims (Taiwan) and the severity of service (Japan) are good variables to consider in the projection. Among the countries investigated, Taiwan and Japan experience issues similar to those in South Korea concerning primary care having a weak gatekeeping role and providing easier access to secondary and tertiary medical institutions [32,33]. In contrast, primary care in the USA is mostly provided by primary care physicians, nurse practitioners (NPs), and PAs who work closely with professionals such as community health workers, health coaches, and certified nurse-midwives [2]. The rapid growth of non-physician healthcare professionals and team-based primary care has contributed significantly to primary care in the USA [34]. Singapore has clear boundaries for primary care provided by a network of outpatient polyclinics and clinics run by general practitioners (GPs) [35]. Approximately 80% of primary care demands are met by GPs [3]. Hence, considering these differences in primary care settings, it is recommended that Korea observe and refer to physician projections from Taiwan and Japan, especially since they have a fast-aging population similar to Korea, who will need more primary care; over 20% of the population in Taiwan and Korea [36,37] one in three citizens in Japan [38] would be over 65 years of age by 2025. It is also suggested that Korea refer to primary care models from Singapore and the USA and consider the inclusion of more indicators from these two countries in the future. For example, the U.S. Bureau of Health Workforce accounts for the number of PAs and NPs in their demand and supply projections for primary care physicians [39]. Identifying medical positions similar to PAs and NPs in South Korea and predicting their supply will be important indicators in primary care physician projections.

Conclusion

The Korean government announced a package of essential healthcare policies but did not propose a detailed plan to strengthen primary care and increase the supply of primary care physicians. The concept of essential healthcare in the Korean government's policies refers to emergency medical care and critical care needed in life-threatening situations, rather than primary care, which has been proven to improve long-term health outcomes. The number of primary care physicians available is insufficient, particularly in rural areas. It is crucial to note that the supply of primary care physicians is a key strategy to improve the healthcare system. The estimation of the demand and supply of primary care physicians is the cornerstone of healthcare system reform. Thus, this study reviewed indicators that may affect the demand and supply projection of physicians by evaluating projections from Taiwan, Singapore, Japan, and the USA. This study identified 10 demand indicators and nine supply indicators apart from the original 18 demand indicators and 41 supply indicators, resulting in 28 demand indicators and 50 supply indicators. Moreover, 26 additional variables concerning AI were identified by reviewing three studies that investigated factors associated with AI implementation. The assessment of these variables demonstrated less diversity in the variables used in Korea's physician projections.

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