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Conflict of Interest

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A Single Pediatric Surgeon Working in a Single Center: Was There a Change in the Pediatric Surgeon's Role Following 25 Years of Service in Suwon City?

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ABSTRACT

Purpose: Pediatric surgical activity is an important factor for a hospital manager when considering to hire a new pediatric surgeon. The purpose of this study was to investigate the activity of pediatric surgeons by comparing the number of surgeries and local population trends over the history of the institution, and to predict the potential demand for pediatric surgeons in the future.

Method: The annual number of surgeries performed at the Department of Pediatric Surgery of Ajou University Medical Center from May 1994 to December 2018 was investigated. In addition, the total and pediatric populations and demographic trends in Suwon and Gyeonggi-do and nationwide trends were examined, and the change in the number of surgeries performed annually was compared with the total and pediatric populations. Predictive model of future population in the region was created with logarithmic regression.

Results: The average annual number of operations was 539, and neonatal surgeries consisted 6% of all surgeries. The proportion of children in the total population in Gyeonggi-do decreased from 30% (1995) to 17% (2018) and from 31% (1995) to 17% (2018) in Suwon. In 2018, Suwon's population increased by 454,556 compared to that in 1995, but the decrease in the children's population seems to reflect the decrease in the national total fertility rate over the past 25 years. The predictive model suggested an aggravation in the decrease of pediatric population in the region in the next 20 years, predicting a 41.86% decrease in Gyeonggi-do and a 55.15% decrease in Suwon compared to 2020.

Conclusion: According to the results, the number of cases of pediatric surgery has grown relatively, considering the decrease in the pediatric population which may aggravate in the future. These data may be used as indirect evidences for organizations to determine whether to hire new pediatric surgeons.

Keywords: Surgeons; Population decrease; Workforce; Pediatrics; Faculty, Medical

INTRODUCTION

Pediatric surgeons began to work at each medical center in South Korea with the establishment of pediatric surgery in the country in 1984. Fourteen pediatric surgeons founded the Korean Association of Pediatric Surgeons, and the total number of registered

pediatric surgeons and trainees has grown to 155 in the last 25 years [1]. However, the number of first-generation pediatric surgeons who have reached retirement age has grown over recent years. Thus, consideration regarding the proper supply and demand of pediatric surgeons has emerged as an imminent issue in the field.

In the United States, concerns regarding the balance of the supply of pediatric surgeons with the necessity of maintaining surgical skills have been a characteristic of almost every discussion of the future of the subspecialty as it was organized [2]. Studies of the pediatric surgeon workforce and the pediatric population were conducted using different modalities such as questionnaires, physician supply models, and hospital financial data [3-6]. Knowing that the pediatric population will be growing slowly in the coming decades, a recent study pointed to a likely oversupply of general pediatric surgeons unless there are changes in the input [5].

In recent years, the fertility rate in South Korea has decreased gradually, remaining below 1.3 from 2002 to 2017 [7]. Being the only country out of the 11 countries in the Organization for Economic Co-operation and Development demonstrating the “lowest-low fertility” status for the past 17 years, Korea has gained much attention worldwide [7,8]. Meanwhile, adequate supply and demand plans of pediatric surgeons have become a difficult problem. A long-term view on the role of pediatric surgeons in the challenge of population decline is considered to be valuable to institutions as an indirect data applicable when hiring a new pediatric surgeon. In the United States, it is estimated that recruitment depends on the availability of approximately 400 procedures per year to support a new pediatric surgeon [3].

The purpose of this study was to correlate the regional population trends with the annual number of pediatric surgeries performed in the past 25 years and to estimate the expected number of new pediatric surgeons in the local area. One of the authors had been practicing in Suwon, Gyeonggi-do since 1994 as the sole provider of pediatric surgery, whose service may be an objective index of a single surgeon's activity in the region.

METHODS

1. Data collection

Population data collected by Statistics Korea, including total population and fertility rates in South Korea from 1994 to 2018, were retrieved [9]. Data sets of total and pediatric populations in Gyeonggi-do and Suwon from 1995 to 2018 were retrieved from Gyeonggi Statistics and analyzed to estimate the population trends in the region [10]. Regional data from 1994 were not available.

Furthermore, the annual number of pediatric operations performed from May 1994 to December 2018 in Ajou University Medical Center were collected, in terms of total, neonatal, and emergency, to review their proportions and compare their numbers with local population trends.

2. Definition of terms

The 0- to 17-year age group was defined as the pediatric population. The total fertility rate was defined as the average number of children a woman would bear if she survived until the end of her reproductive age span (age, 10–54 years) and experienced at each age a particular

set of age-specific fertility rates observed in the year of interest [11]. The age-specific fertility rate was defined as the annual number of livebirths to women of a specified age group per 1,000 women in that age group [11]. Population growth was defined as how the size of the population changed over time [12]. The annual population growth rate (APGR) was defined as the average exponential rate of annual growth of the population over a given period [13].

3. Predictive analysis

Prediction of future pediatric population was performed with regression algorithm, using a logistic approximation model with natural logarithmic equation. First, APGRs from 1996 to 2018 were calculated with a function, $[APGR] = \ln \left(\frac{P(t)}{P(t-1)} \right)$, where t is the chosen year and $P(t)$ is the population of the year t in this study. Next, trendlines were drawn for graphs plotted based on the APGRs from 1996 to 2018 with Excel included in Microsoft Office Professional Plus 2016 with their logistic regression algorithm. Then, using the equations derived from the trendlines, further APGRs from 2019 to 2040 were predicted by calculation. Finally, the population function $P(t) = P(t-1) \cdot e^{r(t)}$ was used to predict $P(t)$, with $r(t)$ being the equation of APGR derived from the trendline. The constant value e is the base of the natural logarithms which was approximated to 2.71828 in this study.

Local demand for pediatric surgeon was predicted via 2 channels; 1 by the number of annual operative cases, supporting another surgeon when it exceeds 400, and the other by the number of pediatric surgeons in a million population in Korea, referring to the results by Saing [14].

RESULTS

1. Population change in national, provincial, and municipal aspects

While the national population of South Korea increased from 45.2 million to 51.3 million, the total fertility rate in South Korea decreased from 1.66 in 1994 to 0.98 in 2018 [9]. Annual population growth rates also decreased from 0.94% in 1994/1995 to 0.14% in 2017/2018 (Fig. 1). However, the fractional population growth of Gyeonggi-do and Suwon in 2018 compared to 1995 were 67.9% and 60.9%, respectively. The provincial population increased

Fig. 1. Annual TFRs and national APGRs from 1994/1995 to 2017/2018. TFR, total fertility rate; APGR, annual population growth rate.

Fig. 2. Provincial APGRs from 1995/1996 to 2017/2018, total and pediatric values compared to national values, with trendlines and their logistic equations. APGR, annual population growth rate.

Fig. 3. Municipal APGRs from 1995/1996 to 2017/2018, total and pediatric values compared to national values, with trendlines and their logistic equations. APGR, annual population growth rate.

from 7.79 million in 1995 to 13.08 million in 2018, while the municipal population increased from 0.75 million in 1995 to 1.20 million in 2018. Annual population growth rates of the province and the city from 1995/1996 to 2017/2018 also showed higher values compared to the national values, yet in a decreasing tendency (**Figs. 2 and 3**). Moreover, the annual pediatric population growth rates of the province and the city dropped under zero in the early to mid-2000s. Consequently, the provincial pediatric population decreased by 3.11%, from 2,339,086 in 1995 to 2,266,245 in 2018 (**Table 1**). Also, the municipal pediatric population decreased by 11.32%, from 232,812 in 1995 to 206,467 in 2018. In terms of the ratio of the pediatric population to the total population, the number of 0-to-17-year-olds in Gyeonggi-do occupied 30.03% in 1995 and 17.33% in 2018 while those in Suwon occupied 31.18% in 1995 and 17.19% in 2018, decreasing by 12.70%p and 13.99%p, respectively (**Fig. 4**).

2. Pediatric operations in Ajou University Medical Center: total cases, neonatal surgery, and emergency surgery

The average annual number of pediatric surgeries from 1994 to 2018 was 539, and there appears an oscillating pattern without any significant change, showing the minimum of

Table 1. Pediatric population in Gyeonggi-do and Suwon, 1995–2018

Year	Gyeonggi	Suwon
1995	2,339,086	232,812
1996	2,430,556	238,114
1997	2,490,640	243,888
1998	2,514,211	258,018
1999	2,544,937	271,274
2000	2,580,910	278,075
2001	2,617,622	281,214
2002	2,669,882	290,148
2003	2,685,156	288,528
2004	2,704,977	282,834
2005	2,704,627	277,786
2006	2,697,265	275,790
2007	2,692,590	267,556
2008	2,676,173	260,381
2009	2,635,330	253,131
2010	2,610,656	243,168
2011	2,570,035	237,425
2012	2,531,449	237,518
2013	2,483,663	236,146
2014	2,434,461	234,163
2015	2,393,096	228,258
2016	2,358,077	222,161
2017	2,313,378	215,885
2018	2,266,245	206,467

Fig. 4. Proportion of adult and pediatric population in Gyeonggi-do and Suwon.

450 cases in 1995 and the maximum of 677 cases in 2004 (**Table 2**). The average number of neonatal cases was 31 per year, representing about 6% of all pediatric operations. The ratios of the number of total pediatric operation to the local pediatric population were approximately 1:500 in Suwon and 1:5,000 in Gyeonggi-do.

Emergency surgery cases performed by pediatric surgeons increased by 119.4% in 2018 compared to the number performed in 1995, with a gradual increase every year, reaching 141 per year in average. Emergency surgery represented 26.6% of all pediatric operations, increasing from 23.3% in 1994 up to 42.1% in 2018 (**Table 2**).

Table 2. Number of pediatric surgery, neonatal, and emergency surgery, and their proportions, 1994–2018

Year	No. of pediatric surgery	Neonates (%)	Emergency (%)
1994	219	17 (7.8%)	51 (23.3%)
1995	450	29 (6.4%)	103 (22.9%)
1996	488	35 (7.2%)	105 (21.5%)
1997	522	31 (5.9%)	137 (26.2%)
1998	652	43 (6.6%)	159 (24.4%)
1999	648	38 (5.9%)	132 (20.4%)
2000	504	31 (6.2%)	115 (22.8%)
2001	537	34 (6.3%)	117 (21.8%)
2002	525	33 (6.3%)	87 (16.6%)
2003	570	17 (3.0%)	126 (22.1%)
2004	677	43 (6.4%)	163 (24.1%)
2005	540	40 (7.4%)	106 (19.6%)
2006	576	34 (5.9%)	111 (19.3%)
2007	470	37 (7.9%)	134 (28.5%)
2008	588	27 (4.6%)	135 (23.0%)
2009	576	28 (4.9%)	132 (22.9%)
2010	625	20 (3.2%)	156 (25.0%)
2011	552	9 (1.6%)	129 (23.4%)
2012	535	31 (5.8%)	132 (24.7%)
2013	467	28 (6.0%)	145 (31.0%)
2014	507	39 (7.7%)	184 (36.3%)
2015	486	32 (6.6%)	176 (36.2%)
2016	526	17 (3.2%)	196 (37.3%)
2017	527	43 (8.2%)	217 (41.2%)
2018	537	20 (3.7%)	226 (42.1%)

3. Predictive analysis of pediatric population in local area and estimation of local demand for pediatric surgeons

APGRs from 2019 to 2040 were calculated using the logistic equation derived from the trendlines of local annual population growth rates from 1995 to 2018. The obtained APGR values were applied to $[P(t)=P(t-1) \cdot e^{r(t)}]$ in replacement for $r(t)$ to predict the population from 2019 to 2040. According to the prediction model, the total population of Gyeonggi province would reach 15.91 million in 2040 while the pediatric population would decrease to 1.29 million (**Fig. 5**). The provincial pediatric population would show a 41.7% decrease compared to 2.18 million 2020. Also, the total population of Suwon would reach its ceiling at 1.25 million in 2028 to 2032 and drop to 1.22 million by 2040 (**Fig. 6**). Moreover, the municipal

Fig. 5. Population projection from 1995 to 2040, Gyeonggi-do.

Fig. 6. Population projection from 1995 to 2040, Suwon.

pediatric population would keep decreasing more dramatically, to as low as 87,000 in 2040. This would be a 55.15% decrease compared to 194,000 in 2020.

In 2040, pediatric surgeries may be reduced to 174–258 cases per year, considering the current proportion of the number of annual pediatric operation to the local pediatric population, which is 1:500 in Suwon and 1:5,000 in Gyeonggi-do. This would be a number enough for 1 pediatric surgeon to handle by oneself. Considering that 0.9 pediatric surgeon currently serves per million population in South Korea, Suwon would need only 1 pediatric surgeon in 2040 while Gyeonggi province would need 14, theoretically. However, considering that the provincial pediatric population would take up to 8.12% of the total, it is not likely for so many positions to be available in the province.

DISCUSSION

Since the establishment of the Korean Association of Pediatric Surgeons in 1984, the number of pediatric surgeons who have reached the retirement age has gradually increased, raising the issue of hiring new pediatric surgeons to take over. While there exists no comprehensive governmental policy that regulates the supply and demand of pediatric surgeons, there is an organizational policy in the pediatric surgeon's association to acknowledge regular membership and subspecialist qualification through tests. However, this policy is insufficient because there is no legal restriction on non-members or non-subspecialists performing pediatric surgery. Therefore, regular membership of the association and the subspecialty qualification are regarded to have only a symbolic effect on the supply and demand of pediatric surgeons.

A factor that may have a direct effect is the revenue from pediatric surgery. Hospital income earned by pediatric surgeons is relatively low compared to contributions of general surgeons in the public health insurance system in Korea. In addition, the decreasing birthrate has led to a subsequent gradual decrease in the pediatric population, making it difficult to expect an increase in the revenue generated by pediatric surgery. It is because of this realistic financial concern that hospital managers may make the decisions to not hire new pediatric surgeons for their institutions.

In effect, the research scope of this study spanned over the career of one single pediatric surgeon in Suwon. As he has been working at Ajou University Medical Center for 25 years since 1994, the role of the pediatric surgeon could be better understood by comparing the variation in the population and the number of pediatric surgeries during that period. The local coverage of the institution was thought to be an ideal situation to analyze the activity of the pediatric surgeons and its relationship with the change of population. Suwon is located about 40 km south of Seoul and is the capital and the largest metropolis of Gyeonggi-do. It is located in the heart of the province, surrounded by 4 other cities: Yongin in the east, Ansan in the west, Hwaseong in the south, and Uiwang in the north. While the large tertiary hospitals located in Seoul, commonly called the “Big Five,” take patients from not only Seoul but all over the nation, Ajou University Medical Center covers the city, its neighboring areas, and the southern Gyeonggi region only. Thus, it was hypothesized that pediatric surgical data from this institution would be directly correlated to the demographic change in the region.

The most obvious change observed in this study is the large decrease in the total fertility rate in Korea; the size and proportion of the pediatric population decreased despite the increase in the total population in Suwon and Gyeonggi-do. The average number of pediatric surgeries in the authors' institution was 539 per year, which has remained nearly constant over the last 25 years. In other words, notwithstanding the decrease in the size of pediatric population, the number of pediatric surgeries did not follow a significant decreasing trend. The following can be inferred as the causes: first, the increased number of visits by patients living outside of Suwon; second, the increased number of pediatric surgical diseases; third, the avoidance of practicing pediatric surgery at hospitals other than tertiary hospitals; and fourth, changes in the hospital environment that make pediatric surgeons to work in tertiary hospitals only, to secure cooperation from other departments related to pediatric surgery such as radiology, anesthesiology, and pediatrics.

When discussing the appropriate ratio of pediatric surgeons to the population in Korea, the cases of Japan or the United States may be referred for comparison. However, it is difficult to apply cases from other countries due to differences in population, economy, and medical infrastructure. In addition, as the employment of new pediatric surgeon is a decision made by not the government but individual medical institutions according to their circumstances, it is difficult to establish an employment policy for pediatric surgeons in Korea. Thus far, one definite condition for hiring is the retirement of a preceptor or the absence in the position. One of the authors has been performing pediatric surgery since 1994 and it was only 3 years ago that a new general surgeon trained in pediatric surgery joined the department. In other words, the institution recruited a new pediatric surgeon only when the preceptor approached his retirement age.

However, at least 2 doctors are needed for the department of pediatric surgery to function as a fully independent unit. Pediatric surgeons with the same qualifications and abilities are required for non-clinical tasks such as academic activities and teaching at medical school. Furthermore, considering the on-call duties of a pediatric surgeon, long-term dependence on a single person could render the service vulnerable [15]. Saing [14] reported the numbers of pediatric surgeons per million population in 14 countries in Asia in 2000; South Korea had 0.9 pediatric surgeons per million, which was the same number as that of Malaysia. There was a mean of 7.5 pediatric surgeons per million in Japan, 2.7 in Taiwan, 2.5 in Hong Kong and Cambodia, and 2.4 in Singapore [14].

Although many medical institutions recognize these requirements to be necessary, the main reason for not hiring a pediatric surgeon is the increasing economic burden. According to our predictive analysis, the decline in the pediatric population is expected to aggravate in the future. Even if an additional pediatric surgeon is hired, it is unlikely that the department would gain twice the income. Therefore, if other institutions planning to hire new pediatric surgeons were to consult the authors' data and the population trends, the grounds for hiring a new surgeon would seem very weak.

The authors analyzed the activities of pediatric surgeons per capita by comparing the number of pediatric surgeries and trends of the population in their region. Over the past 25 years, while the total populations of Suwon and Gyeonggi-do have increased massively, the pediatric population has decreased, and the total number of surgeries has not increased significantly. The estimated outlook on the local demand for pediatric surgeons would be therefore not very optimistic if the pediatric population were to keep decreasing.

In conclusion, given the decline in national total fertility rates and statistics suggesting that the population will exhibit a precipitous decline in the future, it is likely that the supply of pediatric surgeons in South Korea will continue by merely replenishing the positions after the retirement of preceptors, especially in tertiary hospitals located in areas other than the national capital.

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