



# Global comparison of pediatric surgery workforce and training



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## ABSTRACT

**Introduction:** The number of pediatric surgeons and their distribution vary greatly throughout the world. The purpose of this study is to examine potential influential factors including the length of education and training, pediatric population, birth rate, and gross domestic product (GDP) per capita.

**Methods:** An internet search was conducted to determine the duration of education from grade school to pediatric surgery fellowship, number of pediatric surgeons, birth rate, GDP, and population under 15 years of age in 15 countries. The number of pediatric surgeons per million children was correlated with these factors.

**Results:** The number of pediatric surgeons per million children varied from 0.51 to 29.3. The total length of education from grade school to completion of pediatric surgery training ranged from 23 to 29 years. There was no correlation between pediatric surgeons per million children with the duration of training. The number of pediatric surgeon per million children was inversely correlated with the birth rate. There was a positive correlation between the GDP per capita and pediatric surgeons per million children.

**Conclusion:** There is a tremendous variability in pediatric surgeons around the world. There appears to be a significant shortage of pediatric surgeons in countries with a high birth rate and low GDP per capita.

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The pediatric surgery workforce around the world consists of thousands of pediatric surgeons practicing in all corners of the world, but their distribution varies greatly. Despite the difficulties in quantifying the pediatric surgery workforce, previous studies have reported that pediatric surgeons are in a shortage around the world [1–3]. It is, however, unclear what factors contribute to the overall scarcity of pediatric surgeons worldwide. Several studies have analyzed the geographic distribution, cost of surgical care, social statistics, length of education and curriculum of pediatric surgeons in select countries [1–5]. These studies highlighted areas which may contribute to the differences in the delivery of pediatric surgical care, yet limited data exist on pediatric surgery workforce globally. Identifying and addressing the most influential causes of variation can ultimately lead to an increase in the supply of pediatric surgeons to meet the worldwide need. The purpose of this study is to further examine and analyze various educational, economic and social factors that impact the pediatric surgery workforce throughout the world. The number of pediatric surgeons, pediatric population, birth rate, gross domestic product (GDP), and length and structure of training in 15 countries were compared and analyzed.

## 1. Materials and methods

An internet search was conducted of 15 countries: Brazil, Canada, China, England, Ghana, Germany, India, Ireland, Nigeria, Philippines,

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South Africa, Taiwan, Netherlands, Norway and the United States of America [1–48]. Data on the duration of education from grade school to pediatric surgery fellowship, number of pediatric surgeons, birth rate, GDP, and population under 15 years of age were gathered from each country. Education was sub-divided into pre-medical training and medical training. Pre-medical training was the cumulative years of education from grade school until the matriculation into medical school. Medical training was defined as years spent in medical school, clinical post-graduate surgery training and pediatric surgery sub-specialty training. The number of pediatric surgeons per million children was correlated with these factors. Graphs with polynomial regression lines and coefficient of determination were calculated to assess correlation.

## 2. Results

The length and duration of total education and training in 15 countries are summarized in Table 1. Overall, the length of pediatric surgery training varied significantly between countries, ranging from 23 to 29 years of total education from grade school until the conclusion of sub-specialty pediatric surgery training. There was a greater difference in the years to complete pre-medical training, ranging from 12 to 17 years with a mean of 13.9 years. Medical training ranged from 11 to 15.5 years, with a mean of 12.5 years. There was no correlation between pediatric surgeons per million children with the duration of education and medical training.

The number of pediatric surgeons per country, the pediatric population under 15 years of age, the population growth rate, the birth rate, and the GDP per capita in each of the 15 countries are summarized in

**Table 1**

Length of education and training of pediatric surgeons.

| Country      | Pre-medical training (years) | Medical school (years) | Post-graduate clinical training (years) | Pediatric sub-specialty training (years) | Medical training (years) | Total education (years) |
|--------------|------------------------------|------------------------|-----------------------------------------|------------------------------------------|--------------------------|-------------------------|
| Brazil       | 12                           | 6                      | 2                                       | 3                                        | 11                       | 23                      |
| Canada       | 17                           | 4                      | 5                                       | 2                                        | 11                       | 28                      |
| China        | 12                           | 5                      | 3                                       | 3                                        | 11                       | 23                      |
| England      | 14                           | 5                      | 4                                       | 6                                        | 15                       | 29                      |
| Germany      | 15                           | 6                      | 2                                       | 4                                        | 12                       | 27                      |
| Ghana        | 15                           | 6                      | 5                                       | 3                                        | 14                       | 29                      |
| India        | 12                           | 5                      | 3                                       | 3                                        | 11                       | 23                      |
| Ireland      | 14                           | 5                      | 2                                       | 6                                        | 13                       | 27                      |
| Netherlands  | 14                           | 6                      | 6                                       | 2                                        | 14                       | 28                      |
| Nigeria      | 12                           | 5                      | 4                                       | 4.5                                      | 13.5                     | 25.5                    |
| Norway       | 13                           | 7.5                    | 5                                       | 3                                        | 15.5                     | 28.5                    |
| Philippines  | 17                           | 4                      | 5                                       | 2                                        | 11                       | 28                      |
| South Africa | 13                           | 5                      | 2                                       | 4                                        | 11                       | 24                      |
| Taiwan       | 12                           | 7                      | 4                                       | 2                                        | 13                       | 25                      |
| USA          | 17                           | 4                      | 5                                       | 2                                        | 11                       | 28                      |

**Table 2.** The number of pediatric surgeons per million children varied from 0.51 to 29.30. The number of pediatric surgeons per million children was inversely correlated with the country's birth rate (Fig. 1). As the birth rate increased, the number of pediatric surgeons per million children decreased ( $R^2 = 0.77$ ).

There is a positive correlation between GDP per capita and the number of pediatric surgeons per million children in countries with GDP per capita less than US \$20,000 ( $R^2 = 0.81$ ) (Fig. 2). No correlation was found when the GDP per capita exceeded US \$20,000.

### 3. Discussion

There is a tremendous variability in the pediatric surgery workforce around the world. This leads to an imbalance between the supply and demand of pediatric surgeons, therefore limiting the delivery of specialty pediatric surgery services. For that reason, it is essential to examine and analyze the social, economic and educational factors that impact the global pediatric surgery workforce.

The data show that it requires a tremendous amount of time and dedication to become a pediatric surgeon. While the data do not show a relationship between the length of training and pediatric surgeons per million children, it is possible that our sample size may be too small. Interestingly, pre-medical education, not medical education, accounts for a large percentage of the time required to become a pediatric surgeon. The structure and length of medical education and clinical training also vary among these countries because no global

standardization currently exists. In this sample selection, all countries had post-graduate clinical surgery training prior to further focused training in pediatric surgery. Some countries require more years to be spent training in general surgery, while others train longer in the pediatric surgery sub-specialty. There are countries, however, that do not have a general post-graduate clinical surgery program. In these countries, focused pediatric surgery sub-specialty training begins immediately following the conclusion of medical school. It is possible that the length of medical education and post-graduate surgery training has a bearing on disciples who choose to pursue this career. Other studies have discussed that medical students are deterred from pursuing a career in pediatric surgery due to the lengthy medical training, emphasis on academia, and limited training sites when compared to other surgical specialties [2,3,44,45]. It is unclear how much pre-medical education and post-graduate clinical general surgery training contribute to the knowledge and skills necessary to be a competent pediatric surgeon. If education and training were shortened, it may incentivize young medical professionals to follow this path and therefore increase the supply of pediatric surgeons worldwide.

Furthermore, the definition of a pediatric surgeon is also not universal. Some may be certified by a regulating body or organization while others are considered pediatric surgeons by other parameters, such as clinical experience and apprenticeship. Therefore, it is difficult to determine the true number of pediatric surgeons practicing in each country as some might go unrecognized because they are without board certification or practice another surgical specialty as well. Additionally, certification and

**Table 2**

Pediatric surgeons, mid-year population, population growth rate, birth rate, growth domestic product (GDP), and the number of pediatric surgeons to million children.

| Country      | Number of pediatric surgeons | Population ages (0–14 years) (in millions) | Population growth rate (%) | Birth rate (per 1000 population) | Pediatric surgeons per 1,000,000 people | GDP per capita (US \$1000) |
|--------------|------------------------------|--------------------------------------------|----------------------------|----------------------------------|-----------------------------------------|----------------------------|
| Brazil       | 851                          | 48.1                                       | 0.8                        | 15                               | 17.70                                   | 11.70                      |
| Canada       | 45                           | 5.6                                        | 0.8                        | 10                               | 8.00                                    | 42.30                      |
| China        | 1850                         | 244.3                                      | 0.5                        | 12                               | 7.57                                    | 9.10                       |
| England      | 338                          | 11.5                                       | 0.5                        | 12                               | 29.30                                   | 36.60                      |
| Germany      | 250                          | 10.5                                       | −0.2                       | 8                                | 23.85                                   | 38.70                      |
| Ghana        | 5                            | 9.8                                        | 2.2                        | 32                               | 0.51                                    | 3.30                       |
| India        | 470                          | 363.1                                      | 1.3                        | 20                               | 1.29                                    | 3.80                       |
| Ireland      | 4                            | 1.0                                        | 1.2                        | 16                               | 3.96                                    | 40.70                      |
| Netherlands  | 24                           | 2.98                                       | 0.4                        | 11                               | 8.40                                    | 41.50                      |
| Nigeria      | 42                           | 76.4                                       | 2.5                        | 38                               | 0.55                                    | 2.70                       |
| Norway       | 10                           | 1.0                                        | 0.3                        | 11                               | 10.35                                   | 54.40                      |
| Philippines  | 30                           | 33.5                                       | 1.8                        | 25                               | 0.90                                    | 4.40                       |
| South Africa | 107                          | 15.4                                       | −0.4                       | 19                               | 6.96                                    | 11.30                      |
| Taiwan       | 61                           | 3.4                                        | 0.3                        | 9                                | 2.62                                    | 38.40                      |
| USA          | 1150                         | 63.2                                       | 0.9                        | 14                               | 18.19                                   | 51.70                      |

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