

ORIGINAL ARTICLE

Supply and demand for liver transplant surgery: are we training enough surgeons?

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Abstract

The purpose of our study is to determine whether the current level of transplant fellow training is sufficient to meet the future demand for liver transplantation in the United States. Historical data from the Nationwide Inpatient Samples (NIS) for the years 1998 through 2003 were used to construct an estimate of the annual number of liver transplant procedures currently being performed in the United States, and the number projected for each year through 2020. Estimates for the current and future number of surgeons performing liver transplant procedures were also constructed using the same database. The NIS database was used because current national transplant registries do not include information on the number of surgeons performing liver transplant procedures. Using historical data derived from the NIS database, we project that the estimated number of liver transplant procedures per surgeon will remain relatively stable through 2020, with each surgeon performing an average of 12.9 procedures in 2020 compared to 12.9 currently. We conclude that the relationship between demand for liver transplantation in the United States and the supply of liver transplant surgeons will remain stable over the next 15 years.

Introduction

Modern attempts to predict the relationship between the supply and demand for physician services date back to 1980 when the Graduate Medical Education National Advisory Committee released a report warning of an impending surplus of physicians, especially those engaged in specialized care such as surgery [1,2]. As a result of this report, the medical education community implemented policies aimed at limiting the number of medical school graduates within the United States and encouraging medical students to pursue careers in primary care. Over the next two decades, however, this projected physician surplus failed to materialize. Instead, surveys of the physician workforce started to indicate a potential shortage of physicians in general and surgeons in particular [3–5]. As a result, it is difficult to predict whether current levels of general and subspecialty training will be sufficient to meet future demand for these services by the American population.

To our knowledge, very few studies have been published which address the relationship between

the supply of liver transplant surgeons within the United States and the demand for this procedure. Relative to other surgical disciplines, liver transplantation is a relatively young field and as of yet there is no specialty board oversight of training. Another potential reason for the lack of studies in this area is the failure of transplant registries such as that maintained by the Organ Procurement and Transplant Network to report information such as the number of liver transplant surgeons practicing each year and the annual procedural volume of those surgeons. The purpose of our study was therefore to develop projections for the supply–demand relationship for liver transplant surgeons. In order to develop these projections, we used a large national inpatient database that contains information on both the number of liver transplant procedures performed in the country and the number of surgeons performing those procedures.

Material and methods

The Nationwide Inpatient Sample (NIS) database was used for our study [6]. The NIS is a part of the

Healthcare Cost and Utilization Project (HCUP) sponsored by the Agency for Healthcare Research and Quality (AHRQ). The NIS is the largest all-payer inpatient care database that is publicly available in the United States; it contains approximately 5 to 8 million records of inpatient stays per year from about 1,000 hospitals, which is a 20% stratified sample of community hospitals in the United States [7]. To ensure maximal representation of the United States hospitals, the following sampling strata, based on five important hospital characteristics, were used for creation of the NIS: geographic region (Northeast, North Central, West, and South), ownership (public, private not for profit, and private investor-owned), location (urban and rural), teaching status (teaching hospital and non-teaching hospital), and bed size (small, medium, and large).

NIS data sets provide the following information: hospital identifiers (AHRQ-sponsored and American Hospital Association Identifiers), synthetic surgeon identifiers, unique patient visit identifiers, patient demographics, and procedure and diagnostic codes classified according to the *International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM)* [8]. The HCUP has assigned validation and quality assessment of these data sets to an independent contractor [9]. The validation was performed by reviewing univariate statistics for all numeric data elements, determining the frequency distributions for all categorical and some continuous data elements, checking ranges against standard norms, and performing edit checks that identify inconsistencies between related data elements. The NIS has also been extensively validated against the National Hospital Discharge Survey and confirmed to perform very well for many estimates [10].

The NIS database for the years 1995 through 2003 was queried for all liver transplant procedures (corresponding with ICD-9-CM code 50.50) being performed in patients 18 years of age or older. This representative historical volume of liver transplantation captured by the NIS database was then used to generate inferences for the total historical volumes for those years using logistic regression modeling. The total number of liver transplant procedures performed each year from 1995 through 2003, as estimated using the NIS database, was then compared with the actual number of these procedures performed during those years as reported by the registry maintained by the Organ Procurement and Transplant Network in order to validate the NIS as a tool for estimating national procedural volume [11].

The trends in the growth of the historical national annual volumes of liver transplant procedures were then used to create projected national annual volumes for the years 2004 through 2020 using a linear regression model, taking into account the changes in the age, race, socio-economic status, and comorbidity index of the United States population over time.

Using the unique surgeon identifiers provided by the NIS database, a similar process was used to generate inferences of the number of surgeons in the United States performing liver transplantation from 1988 through 2003. Trends in the growth in the number of surgeons performing this procedure, as well as patterns in the number of cases operated by each surgeon, were then used to extrapolate to 2020 and thereby develop projected supply of liver transplant surgeons over the next 15 years. The projected demand for adult liver transplant procedures was then compared with the projected supply of liver transplant surgeons in order to develop projections for the mean annual procedure volume for liver transplant surgeons through the year 2020.

Results

The historical estimates of adult liver transplant volume in the United States using data extracted from the NIS database for the years 1995 through 2003 are shown in Figure 1. The actual number of adult liver transplant procedures occurring from 1995 to 2003 using data from the OPTN registry is also shown in Figure 1. The rate of growth in the estimated number of procedures performed nationally using data extracted from the NIS database is 3.15%, compared to an actual growth rate of 4.76% using OPTN registry data. A test of symmetry showed the growth rate trends using these two databases to be significantly similar, validating our use of the NIS database as a tool for predicting the trend in liver transplant volume in the United States.

The historical estimates of liver transplant volume in the United States derived from the NIS database were then used to create projections for future procedure volumes through the year 2020. These projections are displayed in Figure 2a. The projected national liver transplant volume for the year 2020 is 7849 procedures, which represents an overall 35.6% increase in volume from 2006. Similar methods were used to create projections of the number of surgeons performing liver transplantation (Figure 2b). According to these projections, 432 surgeons in the United States currently perform liver transplantation. By the year 2020, 608 surgeons are expected to be performing liver transplant surgery, representing a 40.7% increase in the number of liver transplant surgeons.

Table I gives the projected mean annual volume of liver transplant procedures per surgeon for the next 15 years using data from the NIS database. The current average volume of 13.4 liver transplants per surgeon is projected to decrease by only 3.6% to 12.9 procedures per surgeon by 2020.

Discussion

In this study, we use the Nationwide Inpatient Samples database to construct projections for the

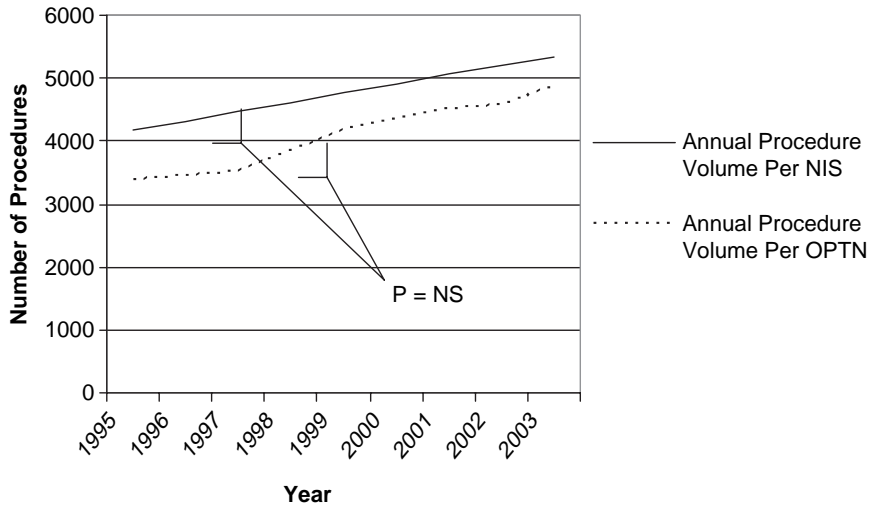


Figure 1. Historical liver transplant volume in United States: Comparison of NIS and OPTN databases. P = NS using test of symmetry; NIS = Nationwide Inpatient Sample; OPTN = Organ Procurement and Transplantation Network.

next 15 years of both the demand for adult liver transplant procedures in the United States and the supply of surgeons who perform these procedures. To our knowledge, this is the first study reported in the

medical literature which attempts to define the demand–supply relationship for liver transplant surgery. Our findings indicate that between 2006 and 2020, the number of liver transplant procedures being

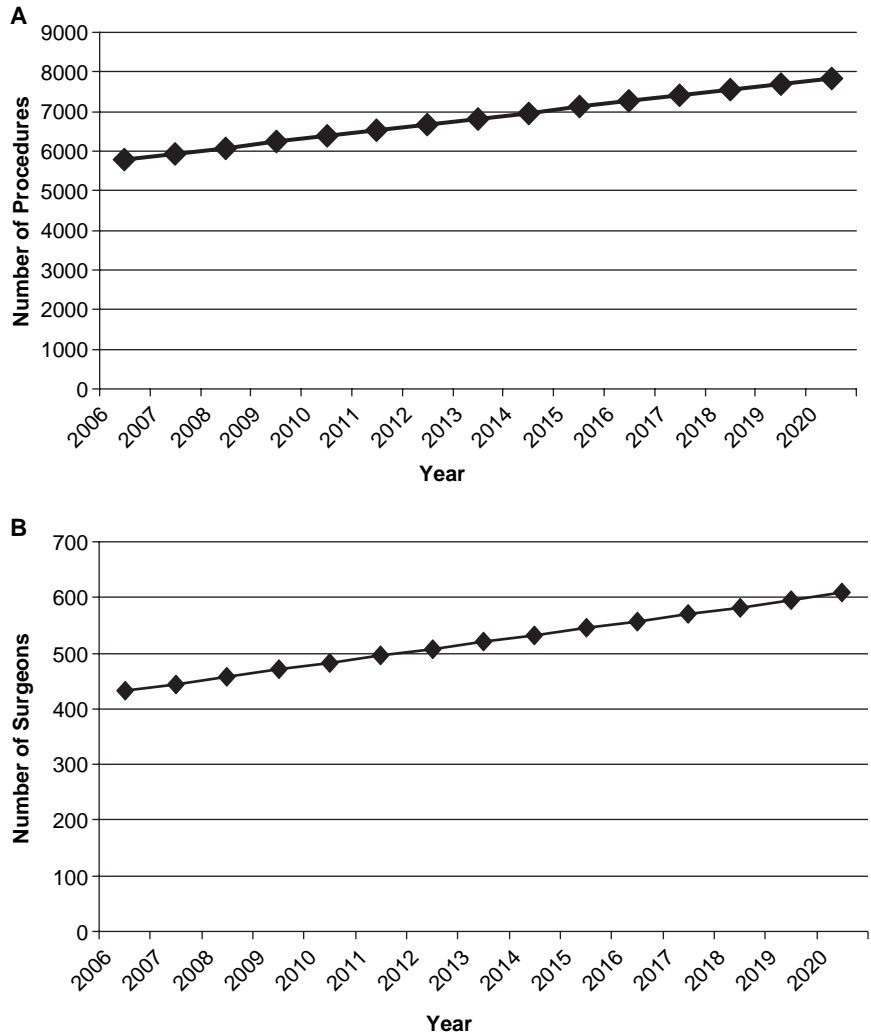


Figure 2. Projected number of liver transplant procedures in the United States through 2020.

Table I. Projected mean number of liver transplant procedures per surgeon in United States through 2020

Year	Mean annual procedure volume
2006	13.4
2010	13.2
2015	13.1
2020	12.9

performed will increase by 35.6%, while the number of liver transplant surgeons will increase by 40.7%. At these growth rates, we anticipate that the mean annual procedure volume for liver transplant surgeons will remain relatively stable, decreasing from a current value of 13.4 procedures per surgeon to 12.9 procedures per surgeon in 2020. We therefore believe that the current level of fellowship training for liver transplant surgery is adequate to meet national demand for the procedure over the next 15 years.

There are two primary limitations to our study. The first arises from our use of an administrative database. While the NIS database is the largest publicly available database of its kind in the United States, it is an administrative database that was not designed to for the purpose of estimating future workforce requirements. For example, we can derive only estimates of historical procedure volume using the NIS database, in contradistinction to the registry provided by OPTN, which reports the actual volume of liver transplant procedures. Unfortunately, the OPTN registry does not report the number of surgeons performing liver transplantation each year. Therefore, we chose the NIS as an alternative data source because it contains information on both the number of liver transplant procedures and the number of liver transplant surgeons. Our use of the NIS for this purpose is at least partially validated through a test of symmetry which shows that our estimated historical growth rate in the number of liver transplant procedures as obtained from the NIS is statistically similar to the actual historical growth rate as reported by the OPTN. We therefore believe that the NIS can serve as a reasonable proxy for estimating workforce projections, although we admit that it is not an ideal data source.

A second limitation of our study is our inability to determine the minimum number of liver transplant surgeons that will be needed to meet demand over the next 15 years. A report by Kaufman and colleagues on behalf of the Education Committee of the American Society of Transplant Surgeons indicated that an increasing percentage of graduates from liver transplant fellowships in the United States were not securing positions in liver transplant programs [12]. Whether this is due to an inability to find such positions or an increasing lack of interest in such positions is not addressed. Nevertheless, the findings of the Education Committee indicate that there may

be too many fellowship programs relative to the national demand for this procedure. There is an increasing volume of data indicating that the individual surgeon volume of certain procedures is directly related to both patient outcomes and efficiency of health-care resource utilization. More than likely, liver transplantation should also be included in this list of procedures, even for those surgeons who also perform kidney and/or pancreas transplantation [13,14]. If we are training too many liver transplant surgeons, we may create an environment whereby those surgeons have difficulty in meeting a currently undefined minimum annual volume of procedures needed to maintain proficiency. Our study suggests that, on average, liver transplant surgeons will perform 12.9 procedures per year in 2020. Whether this value is above or below the minimum number required for proficiency is unknown.

While an oversupply of liver transplant surgeons may or may not currently exist, an even more concerning situation would be if there were not enough surgeons. This would exacerbate waiting times for liver transplantation beyond that caused by a shortage of available organs. Our findings indicate that such a scenario is unlikely to develop over the next 15 years barring a major breakthrough in organ supply. Our use of the historical trends in liver transplant volume to predict future volumes inherently incorporates recent advances in organ preservation, recent changes in the number of organ donors due to increasing use of extended criteria organs, and other developments that affect the number of liver transplant procedures performed in the United States.

Thus, we can conclude that, at the current level of fellowship training and given the current organ donation and procurement environment, we are unlikely to face a shortage of liver transplant surgeons through 2020. In order to better define the current and projected supply of liver transplant surgeons, we advocate the collection and reporting of individual surgeon procedure volumes by transplant registries such as that provided by OPTN. This would improve the ability of the transplant community in the United States to gauge adequately whether it is training the ideal number of surgeons relative to anticipated future demand for the procedure. Furthermore, we believe that there needs to be greater oversight and more formalized credentialing of those surgeons that perform liver transplantation. Only by such oversight will the transplant community be able to balance the future supply of liver transplant surgeons with demand for liver transplantation in such a way that there are always sufficient number of surgeons performing an acceptable annual volume of procedures [15].

Acknowledgements and disclosures

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