

Shortage of Cardiothoracic Surgeons Is Likely by 2020

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Background—Even as the burden of cardiovascular disease in the United States is increasing as the population grows and ages, the number of active cardiothoracic surgeons has fallen for the first time in 20 years. Meanwhile, the treatment of patients with coronary artery disease continues to evolve amid uncertain changes in technology. This study evaluates current and future requirements for cardiothoracic surgeons in light of decreasing rates of coronary artery bypass grafting procedures.

Methods and Results—Projections of supply and demand for cardiothoracic surgeons are based on analysis of population, physician office, hospital, and physician data sets to estimate current patterns of healthcare use and delivery. Using a simulation model, we project the future supply of cardiothoracic surgeons under alternative assumptions about the number of new fellows trained each year. Future demand is modeled, taking into account patient demographics, under current and alternative use rates that include the elimination of open revascularization. By 2025, the demand for cardiothoracic surgeons could increase by 46% on the basis of population growth and aging if current healthcare use and service delivery patterns continue. Even with complete elimination of coronary artery bypass grafting, there is a projected shortfall of cardiothoracic surgeons because the active supply is projected to decrease 21% over the same time period as a result of retirement and declining entrants.

Conclusion—The United States is facing a shortage of cardiothoracic surgeons within the next 10 years, which could diminish quality of care if non-board-certified physicians expand their role in cardiothoracic surgery or if patients must delay appropriate care because of a shortage of well-trained surgeons. (*Circulation*. 2009;120:488-494.)

Key Words: economics ■ surgery ■ technology ■ workforce

Cardiovascular disease, which currently accounts for more than one third of deaths in the United States, is likely to remain the leading cause of mortality and morbidity for the elderly, whose numbers will double between now and 2030.^{1,2} Cardiothoracic surgeons are particularly important in the care of patients with cardiovascular disease and lung disease. Any effort to expand the cardiothoracic surgery workforce for 2020 would need to begin today because cardiothoracic surgeons undergo a longer period of training than any other specialty. The average of 8.3 years of training after medical school includes ≥ 5 years of general surgery training and 2 to 3 years of cardiothoracic training.^{3,4} Subspecialty fellowships in cardiac surgery, congenital surgery, or research extend the length of training. The task of projecting workforce needs for cardiothoracic surgery is further complicated by the fact that individual surgeons over the last 10 to 20 years have increasingly limited their surgical practice to a subspecialty such as general thoracic (mainly lung and esophageal surgery), vascular, or congenital (mainly pedi-

atric cardiac surgery) surgery, although the majority practice adult cardiac and thoracic (mainly coronary artery, valve, and lung) surgery.

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There is now substantial concern about the future supply of cardiothoracic surgeons because half of the active workforce is >55 years of age and nearing retirement.⁵ The number of practicing cardiothoracic surgeons fell in 2003 for the first time in 20 years, and a large exodus of cardiothoracic surgeons from the active workforce is expected over the next decade. At the same time, there has been a precipitous decline in the number of well-qualified applicants to training positions; in 2004, 2005, and 2006, there were more positions than applicants to training programs.⁶ Only 84 of 126 positions offered through the national match were filled for July 2007.⁷

The reasons for this declining interest appear to be multiple. The number of coronary artery bypass grafting (CABG) operations, a mainstay of the specialty, decreased by 28% between 1997 and 2004, whereas the number of claims for

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cardiac stent placement, a procedure performed by cardiologists and not cardiac surgeons, increased by 121%.⁸ Placement of drug-eluting stents for coronary artery disease, first approved in 2003, grew 145% between 2003 and 2004 alone.⁸ The steady drop in CABG rates since 1996⁹ has been accompanied by a 38% decline in Medicare reimbursement for the operation¹⁰ and an increase in the difficulty that recent graduates of cardiothoracic surgical programs have encountered in finding jobs after their training.⁶

Concerned by the falling number of cardiothoracic surgery trainees and the impact on care for a growing patient population with cardiovascular disease, the American Association for Thoracic Surgery, with the support of the Society of Thoracic Surgeons, commissioned the Association of American Medical Colleges' Center for Workforce Studies to undertake a comprehensive study of the supply of cardiothoracic surgeons and demand for their services through 2025. Investigators tested the hypothesis that despite decreasing demand for adult cardiac procedures, the increasing elderly population at risk for cardiovascular and pulmonary disease would lead to a shortage of cardiothoracic surgeons in the next 2 decades. Supply and demand were examined under a variety of scenarios and assumptions.

Methods

Projections of cardiothoracic surgeon supply and demand came from a simulation model used to model the future adequacy of supply under alternative scenarios on the basis of different trends and assumptions in key supply and demand determinants. In this section, we summarize the data and assumptions that underlie the model and the projections; a more complete description of the model was previously documented.¹¹

Modeling the Supply of Cardiothoracic Surgeons

Projecting the future supply of cardiothoracic surgeons starts with the current supply as of 2005; adds estimates of the number of new cardiothoracic surgeons completing fellowships; subtracts estimates of attrition from retirement, mortality, disability, or change in primary activity; and adjusts full-time-equivalent supply to take into consideration changes in average hours worked over time resulting from changes in cardiothoracic surgeon demographics (age and sex). This approach is consistent with the approach described elsewhere.¹² Future supply is projected under alternative scenarios that use different assumptions about fellowship completions and retirement.

Current Supply

We used the American Medical Association Masterfile to identify active cardiothoracic surgeons and their primary specialties. In 2005, the Masterfile identified 4734 physicians categorized as "active" (defined as >20 hours a week in patient care) who reported their primary specialty as cardiothoracic surgery. This is close to the number of active physicians identified within the Masterfile who are board certified in thoracic surgery.

Fellowship Completions

The primary supply determinant modeled was a change in the number of cardiothoracic surgeons completing training annually. We modeled supply assuming that 130 new trainees enter the workforce each year, even though <100 new training positions were filled in the most recent Match, so this assumption could overestimate future supply. Two alternative scenarios modeled were a gradual increase to 150 newly trained cardiothoracic surgeons per year and a continued decline in trainees to 75 per year.

Attrition From the Cardiothoracic Surgeon Workforce

Historically, physicians have retired later than other professionals, and many physicians remain "active" in the Masterfile at >65 years of age.⁹ Use of the Masterfile data to estimate retirement rates can lead to underestimates of attrition because of delays between when a physician retires and when the activity status is updated in the Masterfile. Recent survey data from the Association of American Medical Colleges' Center for Workforce Studies on physicians >50 years of age suggest that almost 60% of physicians will fully retire (including mortality) from clinical practice by 65 years of age. We applied historical retirement rates for all physicians, calculated from the Association of American Medical Colleges survey, to the cardiothoracic surgeon workforce. We incorporated estimates of mortality and disability from the Centers for Disease Control and Prevention, by physician age and sex, to calculate an overall attrition rate. We incorporated findings from the literature that mortality rates for physicians <65 years of age are ≈80% that of demographically adjusted national average mortality rates.¹³ The attrition rates are consistent with previous studies reporting the average age of retirement for cardiothoracic surgeons as 61 years of age, with most retiring earlier, not later, than planned.^{4,14}

Primary Activity and Hours Worked

Information on physician activity was derived from historical Society of Thoracic Surgeons/American Association for Thoracic Surgery workforce survey data and original data collected by the Association of American Medical Colleges Center for Workforce Studies. This includes a random survey of 500 cardiothoracic surgeons <50 years of age to better capture the activities of the current and future cardiothoracic workforce (response rate, 62%). We estimated that surgeons work (and will continue to work) an average of 60 h/wk, slightly more than their noncardiothoracic surgery colleagues. However, this may underestimate work effort because recent survey data suggest that younger surgeons may work as many as 84 hours per week.⁵

Modeling the Demand for Cardiothoracic Surgeons

We projected future demand for cardiothoracic surgeons under alternative scenarios in which current patterns of healthcare use and delivery will continue into the future and will change on the basis of likely trends in technology. Demand projections take into consideration differences in rates of healthcare use by age (<44, 45 to 64, 65 to 74, ≥75 years), sex, race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other, Hispanic), and location where care is provided (physician office, hospital inpatient, hospital outpatient, and emergency care).

Data sources analyzed include Medicare claims files (Medical Provider Analysis and Review File), the 2003 to 2005 Medical Expenditure Panel Survey, the 2003 to 2005 National Ambulatory Medical Survey, the 2003 to 2005 National Hospital Ambulatory Medical Survey, and the 2005 Nationwide Inpatient Sample to determine healthcare use. Medicare data from 1999 and 2004 were used to examine recent trends in cardiothoracic procedures and encounters with cardiothoracic surgeons; data from the Nationwide Inpatient Sample were used to supplement Medicare inpatient data.

Using the above data, we estimated the proportion of cardiothoracic surgeon services provided to each demographic group by age, sex, and race/ethnicity. We applied these proportions to estimates of the active cardiothoracic surgeon workforce in 2005 to calculate physician-to-population ratios by patient demographics. Then, a baseline scenario of future demand was projected by multiplying these physician-to-population ratios by Census Bureau projections of population by age, sex, and race/ethnicity.¹⁵

In addition to modeling changes in demand driven by changing demographics, we modeled scenarios in which the per capita use of cardiothoracic surgery services will change through 2025. Although it remains unlikely that open revascularization procedures will be completely eliminated within the next 10 to 15 years, we modeled the possibility of complete CABG elimination and a drop in per capita CABG rates to Canadian levels (≈50% of US rates).¹⁶ The

Table 1. Per Capita Procedure Rates

Country	CABG per 100 000 Population, n	Stenting per 100 000 Population, n
Australia	77.9	143.1
Canada	97.6	*
Denmark	60	127.7
Finland	77.6	77.7
Germany	87.1	217.8
Iceland	53.9	183.6
Ireland	41.3	80
Italy	46.5	14.8
Luxembourg	75.1	*
The Netherlands	52.8	72.9
New Zealand	95.8	68.3
Norway	84.6	*
Portugal	22.3	48.7
Spain	29.9	81.7
Sweden	75.1	*
Switzerland	35.9	16.4
United Kingdom	55.8	6.1
United States	160.7	184.7

Source: OECD data, 2003.¹⁶
 *Missing data.

latter adjustment was chosen to estimate the impact of aligning US rates with those of other developed nations (Table 1).

Results

Supply of Cardiothoracic Surgeons

The total number of active cardiothoracic surgeons in 2005 approximates the number of active surgeons reported in the American Medical Association Masterfile in the early 1990s, although well below the peak of almost 5100 practicing surgeons in 2002. The model assumes that cardiothoracic surgeons are homogeneous as a group and estimates percent of effort on individual procedural areas rather than physician-

specific activity. Eighteen percent of cardiothoracic surgeons report practicing adult cardiac surgery only, and 19% categorized themselves as “general thoracic” only.³ More than half of those surveyed by the Society of Thoracic Surgeons and American Association for Thoracic Surgery report a “mixed” practice of both adult cardiac and general thoracic surgery. Fewer than 300 surgeons practice congenital cardiac surgery in the United States and Canada.

Nationally, there are <2 active cardiothoracic surgeons for every 100 000 people, and most are concentrated in urban areas. Compared with other physician specialties, cardiothoracic surgeons are older and more likely to be men; >50% of active surgeons are ≥55 years of age (compared with 33% of all physicians), and only 3% are women (compared with 27%). The AMA Masterfile categorizes >15% of active cardiothoracic surgeons as being between 65 and 74 years of age. These data are consistent with surveys of Society of Thoracic Surgeons and American Association for Thoracic Surgery members.^{3,17}

The supply of cardiothoracic surgeons will fall under all tested scenarios, yet by 2030, there will be a nearly 100% growth in the number of Americans >65 years of age (Figure 1). These findings alone suggest that the supply of cardiothoracic surgeons will fail to meet the demands of an expanding and aging US population at current training levels despite major changes in cardiovascular care.

Recently published estimates from the US Department of Health and Human Services suggest that the effective supply of cardiothoracic surgeons in clinical practice will decline 15% by 2020.¹² However, our findings indicate that the effective supply of cardiothoracic surgeons will decrease by 18% (excluding fellows in training) by 2020 because our model uses more recent supply trends (which estimate slightly earlier retirement ages and fewer trainees than the Health and Human Services model). These findings are consistent with Society of Thoracic Surgeons/American Association for Thoracic Surgery surveys, which suggest that 54% of active cardiothoracic surgeons expect to retire within

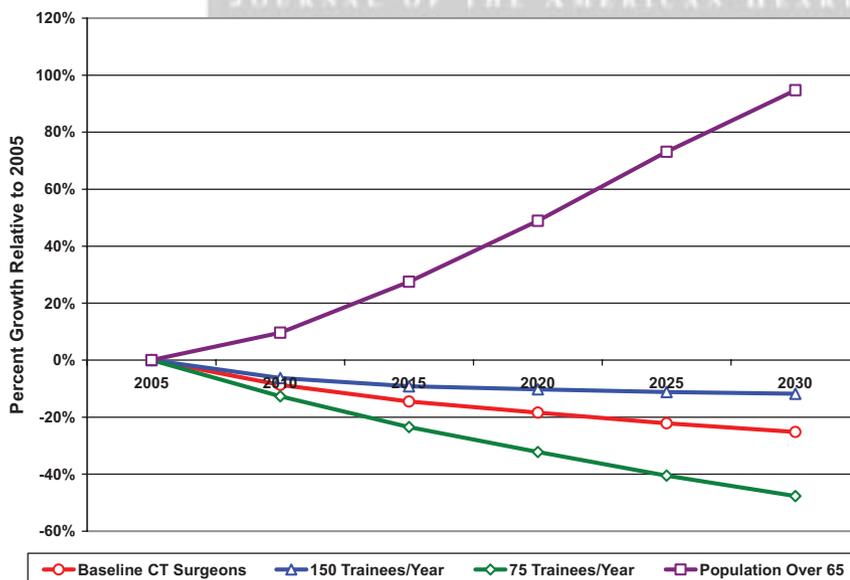


Figure 1. Growth in population >65 years of age relative to cardiothoracic (CT) surgeon growth.

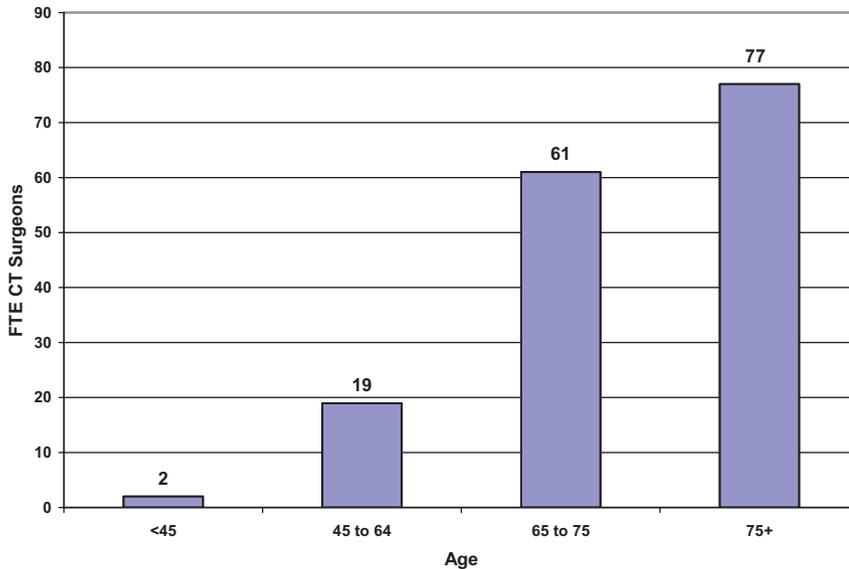


Figure 2. Full-time–equivalent cardiothoracic (FTE CT) surgeons per 1 million population by age group.

12 years.¹⁷ Baseline projections assume that 130 trainees complete training each year, although the current number is far less; alternatively, if only 75 complete training annually, a 34% decrease in the number of cardiothoracic surgeons is likely by 2020. Even if 150 physicians were to complete training annually (effective immediately), this would result in a 9% decline in the total number of active cardiothoracic surgeons in 2020 relative to 2005 as the population continues to age and grow.

Demand for Cardiothoracic Surgeons

Cardiothoracic surgeons care predominantly for the elderly, with more than two thirds of Americans >65 years of age currently having diagnosed cardiovascular disease.¹⁸ The size of the elderly population is projected to grow by 50% by 2020 and by nearly 100% by 2030 to an estimated 71.4 million Americans.¹ Other factors contributing to an increase in cardiovascular disease include the rising prevalence of obesity and other chronic conditions (eg, hypertension and diabetes mellitus).^{19–23}

Our analysis of current patterns of healthcare use estimates the proportion of cardiothoracic surgeon services provided to each demographic group. Applying these proportions to the active cardiothoracic surgeon workforce in 2005 provides detailed physician-to-population ratios for each demographic group. Aggregating across sex and race/ethnicity, Figure 2 reports estimates of the ratio of full-time–equivalent cardiothoracic surgeons per 1 million population for each age group. This ratio increases rapidly with age, from ≈2 per 1 million population ≤44 years of age to 77 per 1 million

population ≥75 years of age. The high use of cardiothoracic surgeon services by the elderly (especially the population 65 to 84 years of age) is demonstrated by examining the number of CABG and pulmonary resections performed by age group (Table 2).

According to Medicare data, although CABG claims for those <80 years of age dropped between 1999 and 2004, total procedures increased for patients ≥80 years of age.²⁴ Elderly patients are undergoing CABG well beyond the ages considered acceptable in past decades with decreasing operative mortality despite higher incidences of left main disease, left ventricular dysfunction, and reoperation as the indication for surgery.²⁵ Comorbid conditions such as diabetes mellitus, hypertension, chronic obstructive pulmonary disease, peripheral vascular disease, and renal disease also are more prevalent in this population, which may contribute to the choice of CABG.²⁶

The elimination of open revascularization would significantly decrease the demand for cardiothoracic surgeons. Although CABG is only one of many cardiothoracic procedures performed in the United States annually, it represents a large proportion of operative time for cardiac surgeons. Using average relative value units, we estimate that almost 39% of cardiothoracic surgeons' total time is spent caring for CABG patients intraoperatively or perioperatively. As a result, complete elimination of open bypass procedures would be expected to decrease the demand for cardiothoracic surgery services by nearly 40%. However, all of the scenarios tested demonstrate an increase in demand for cardiothoracic surgery driven by the aging of the population, even with complete elimination of CABG.

Table 2. Operations Per Capita by Age Group, 2004

Age, y	2004 Population	CABG Operations	Lobectomy or Pneumonectomy Operations	CABG per 100 000 Population	Lobectomy Pneumonectomy per 100 000 Population
45–64	70 692 944	109 021	26 407	154	37
65–84	36 333 025	134 049	33 937	368	93
≥85	4 867 438	4663	998	95	21

Source: Nationwide Inpatient Sample, 2004⁸; Agency for Healthcare Research and Quality⁹; and US Census.^{1,15}

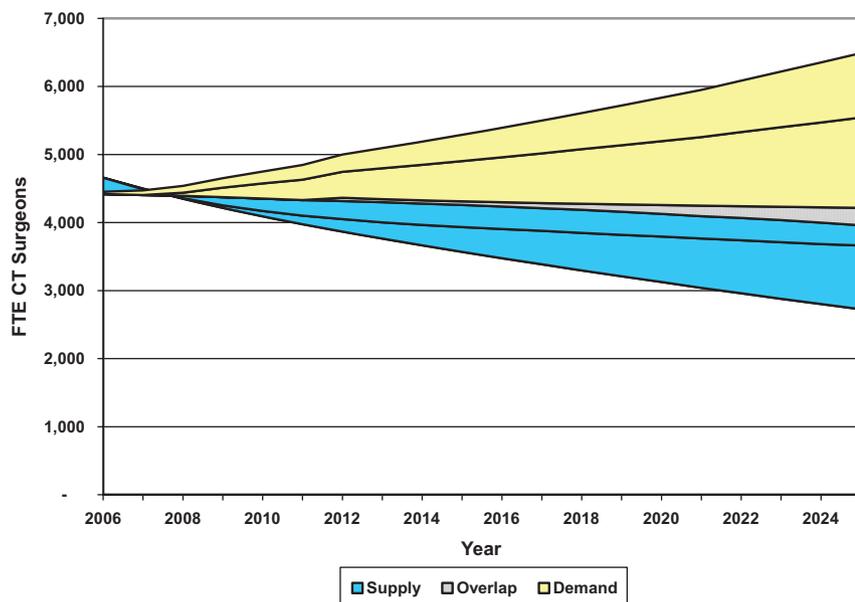


Figure 3. Supply and demand for cardiothoracic surgeons, 2006 to 2025.

According to Nationwide Inpatient Sample data, non-CABG, cardiothoracic discharges increased for valve procedures (28%), other open heart procedures (24%), and lobectomies or pneumonectomies (11%) over the last decade. Moreover, the overall incidence of lung and bronchus cancer in the United States remained virtually unchanged between 1983 and 2003 and is likely to be unchanged in the coming decades as early detection and resection increase.^{27,28} We therefore modeled a 20% increase in the per capita rates of non-CABG cardiac and general thoracic operations as well.

Baseline demand for cardiothoracic surgeons is projected to rise throughout the next 2 decades given the current epidemiology of disease; however, the demand estimates we present are conservative and do not assume the increased per capita consumption of services that others have suggested.²⁹ The estimates presented are aggressively reduced by the modeling of a complete elimination of open revascularization, which few suggest will occur in the next decade.

Discussion

The future supply of cardiothoracic surgeons is likely to be sufficient only if all 3 following conditions are met: A current “surplus” in available supply of cardiothoracic surgeons exists; CABG is completely eliminated; and the number of thoracic surgery trainees entering practice each year rises to levels in the 1990s (Figure 3). Each scenario is extremely unlikely; thus, the analysis suggests that the number of surgeons entering training in cardiothoracic surgery is inadequate to care for the US population in the coming decades. By 2025, it is probable that there will be a shortage of at least 1500 surgeons or 25% of the likely projected need.

Projections of a shortfall of cardiothoracic surgeons come at the same time as projections of a growing shortfall of cardiologists, making it unclear whether nonsurgical modalities of treatment can continue to grow to meet the needs of the population.^{12,30–33} Limitations of projecting future supply and demand for cardiothoracic surgeons include both data limitations and the uncertainty of how new technology and

reimbursement practices will affect healthcare use and delivery patterns or how surgical productivity may change in the future.

Physician supply data sources have significant limitations, and no single, audited, mandatory, national source of active physicians exists. Within the Masterfile, a physician can designate primary and secondary specialties of record despite training history or board certification status. More than 400 physicians, predominantly foreign medical graduates, reported that cardiothoracic surgery was their primary or secondary specialty without any known history of board certification in the United States by the American Board of Thoracic Surgery. Conversely, some physicians who are board certified in thoracic surgery report an alternative primary specialty. These reports may reflect actual surgical practice; general thoracic surgery is often performed by those without accredited training in thoracic surgery, although outcomes for procedures such as pneumonectomy appear to be better for surgeons who are board certified.^{14,34} We have attempted to control for these factors and assume that the activity of future surgeons, including those performing thoracic surgery without board certification, will remain unchanged. However, this likely overestimates the future supply of general thoracic surgeons given the increasing tendency of payers and patients to scrutinize physician qualifications and outcomes.

Another potential limitation is that our analyses are based on an assumption that supply and demand are equal at baseline (ie, that current service levels are appropriate and that surgeons are not overused or underused). This assumption is particularly important in cardiothoracic surgery in which the current supply has been suggested to exceed requirements by those actively seeking employment in the field. We attempted to test this assumption by comparing historical discharge data with present use. In 1993, there were ≈165 discharges per cardiothoracic surgeon in the United States. Although the number of inpatient procedures per surgeon peaked at 178 in 1997, current (2004) levels remain

similar to 1993 levels. However, the nature of these discharges has changed over time; Medicare claims made by self-designated cardiothoracic surgeons increased by 16% between 1999 and 2004 despite a 10% decrease in CABG. Although the comparison between surgeons (and surgical procedures) over the last decade is imperfect, we tested the assumption that the current supply of cardiothoracic surgery services exceeds demand by 8% and that supply and demand were last in balance in 1997. Despite this adjustment, estimated supply and demand under likely scenarios through 2025 continue to suggest a future shortage of cardiothoracic surgeons.

Coronary disease is likely to remain the single largest cause of death in the United States³⁵ and will continue to increase demand for related surgical services. According to the Centers for Disease Control and Prevention, heart disease accounted for 13% of hospitalizations in 2004,³⁶ and costs for all cardiovascular disease are estimated to exceed \$400 billion a year.² Rapid changes in the treatment of coronary artery disease such as stents placed by cardiologists may reduce the role of cardiac surgeons in the care of cardiovascular disease. However, the natural progression of disease in stented patients is unclear and could potentially lead to CABG in the future, which we have not modeled. Moreover, increased attention to outcomes and evidence-based application of new technologies may further decrease the use of drug-eluting stents because it is estimated that >60% of the use of these devices is off-label.³⁷

Cardiothoracic surgeons will continue to perform non-CABG procedures for the foreseeable future. Arrhythmia operations, cardiac remodeling, and other open or minimally invasive procedures also could increase procedural volume in the future as treatment for cardiac disease continues to evolve^{27,38}; for example, discharges of patients undergoing Cox Maze procedures for atrial fibrillation exceeded 14 000 in 2004,⁸ a 368% increase from 1994. We did not model these potential increases in cardiac surgery volume, nor did we include the likely increase in future demand for revisions and the continued care of patients with congenital disease, although most survive to adulthood and often need further surgical care.³⁹

General thoracic procedures for pulmonary disease also are likely to continue to increase in the future. Recommendations against routine, periodic screening for those at risk for lung cancer have come under increasing debate,²⁸ and surgical resection continues to offer the greatest chance for cure to those with early-stage disease.²⁷ As is the case with CABG rates, pulmonary procedures are greater in the United States than in other developed nations. However, British authors have suggested that the low rate of lung cancer resection in the United Kingdom compared with US rates may indicate underuse in a stressed healthcare system rather than an indication of overuse in the United States.³⁸ As a result, we have not modeled a decrease in per capita rates of general thoracic procedures for this study because this is not likely to occur in the future.

According to these statistical models, the United States is facing a severe shortage of cardiothoracic surgeons within the next 10 years. Evidence suggests that outcomes are likely to

be worse for patients if non-board-certified physicians expand their role in cardiothoracic surgery or patients must delay appropriate care because of a shortage of well-trained surgeons. Multiple strategies for ensuring adequate access to care must be explored if this crisis is to be averted.

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Disclosures

None.

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CLINICAL PERSPECTIVE

Even as the burden of cardiovascular disease in the United States is increasing as the population grows and ages, the number of active cardiothoracic surgeons has fallen for the first time in 20 years. This study evaluates current and future requirements for cardiothoracic surgeons in light of decreasing rates of coronary artery bypass grafting procedures. By 2025, the demand for cardiothoracic surgeons could increase by 46% on the basis of population growth and aging if current healthcare use and service delivery patterns continue. Even with complete elimination of coronary artery bypass grafting, there is a projected shortfall of cardiothoracic surgeons because the active supply is projected to decrease 21% over the same time period as a result of retirement and declining entrants. This shortage of cardiothoracic surgeons within the next 10 years could diminish quality of care if non-board-certified physicians expand their role in cardiothoracic surgery or if patients must delay appropriate care because of a shortage of well-trained surgeons.

Shortage of Cardiothoracic Surgeons Is Likely by 2020

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