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Article

The Current and Future Landscape of Cardiothoracic Surgery in the United States: Bridging the Gap

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Abstract

Background: An aging US population, rate of retiring cardiothoracic (CT) surgeons and graduation rates portend a workforce shortage. How residency matriculation rates and graduates entering the workforce impact this shortage are unknown. **Methods**: Using publicly available data from the Association of American Medical Colleges (AAMC) and Accreditation Council for Graduate Medical Education (ACGME), we gathered data on current cardiothoracic surgical practice. Data from the Census Bureau was used for population projections. Available data from the National Residency Matching Program (NRMP), American Board of Thoracic Surgery (ABTS), immigration population, and retirement information were used to forecast the number of CT surgeons needed. Examination statistics were gathered from the American Board of Surgery (ABS) and ABTS. **Results**: Between 2019–2022, there were an average of N = 137 CT first-year residency positions which were offered (integrated and traditional), demonstrating an increasing fill rate and number of applicants over the past decade. Residency programs have graduated an average of 127 surgeons annually from 2018 to 2022: a 13% increase from 2012. The US population is anticipated to grow 8% by 2050, with a 42% increase in those aged 65 and above. The projected workforce gap predicts a shortage of approximately 12% by 2050 and 18% by 2075. We estimate by 2075, the average surgeon caseload will need to increase to 196 cases per year, a 45% increase in cases per surgeon. **Conclusion**: There is an increasing career interest among candidates towards CT surgery, evidenced by more applicants and higher residency fill rates. In contrast to previous workforce gap and workload estimates, we show that this gap is actually getting smaller, yet it comes with an increasing workload.

Keywords

cardiothoracic surgery; workforce; physician shortage

Introduction

The projected surge in an aging national population and looming scarcity of active cardiothoracic (CT) surgeons in the forthcoming decade heralds a growing workforce imbalance in cardiothoracic surgery (CTS) [1]. As experienced practitioners leave the workforce, there is a need for an active succession plan. Previous analyses of the CTS workforce have predicted a large shortage in our field for decades, with some models forecasting this disparity as early as 2020–2030 [1,2].

Compounding the workforce gap, is an aging population with greater CTS needs. As a field, CTS plays a critical part in the healthcare system as cardiovascular disease (CVD) remains a leading cause of death and thoracic cancers (e.g., lung and bronchial) accounting for 20% of oncologic deaths [3,4]. In 2021, CVD accounted for nearly 700,000 deaths (roughly 1 in 5), and along with cancer, was the top cause of death for those over 55, impacting CTS [3,5]. In 2022, 17% of the population (approximately 58 million) was over 65; this population is expected to comprise 27% of the population by 2075 [6].

Historically, a challenge to building a robust conduit of CT surgeons was a decreasing number of matriculants entering the field [7,8]. A reassessment of contemporary trends given the rising popularity of integrated residency programs, in addition to previously described dynamic factors is overdue [9]. A present-day understanding of these trends is vital to identify strategies that effectively address any impending shortage. Here we posit that the workforce gap, though still critical, is decreasing and requires ongoing curation. Specifically, anticipated demographic and cultural changes (e.g., shifting generational priorities, and rising number of migrants into the US) warrant innovative solutions.

Methods

Data Sources

Data were gathered from the following public databases: U.S. Census Bureau, Association of American Medical Colleges (AAMC), American Board of Surgery (ABS), American Board of Thoracic Surgery (ABTS), National Residency Matching Program (NRMP), and the Accreditation Council for Graduate Medical Education (ACGME).

In addition to the general population, the census bureau collects data from all foreign-born individuals who participate in censuses and surveys, regardless of legal status. Based on the estimates of the unauthorized immigrant population from the Department of Homeland Security, unauthorized immigrants comprise <7% of the total population in leading states with unauthorized immigrants. As such, unauthorized immigrants are accounted for in our analyses.

Estimate of Active CT Surgeons

Regarding the current US workforce, the number of active certified physicians per specialty were used to calculate future estimates. An active physician is defined as licensed in the US, District of Columbia, or Puerto Rico that works >20 hours per week [10]. However, non-certified or internationally trained surgeons are not included in this calculation, thus our assessment likely underestimates the active CT surgeon workforce to some degree. The number of estimated active CT surgeons in future years was calculated based on two assumptions: (i) that the number of CT surgeons leaving the field remains linear at an average of 133 per year [1,2], and (ii) an average of 127 trainees graduate from an ACGME cardiothoracic surgery program each year entering the workforce [11]. Thus, the number of CT surgeons in forthcoming years were calculated by the multiplying the last recorded number of active surgeons (4449 in 2021) [12] by the difference of those entering and leaving the field to yield the net growth or decline for a given year.

The number of active CT surgeons is reported as one specialty -thoracic surgery - and does not stratify into cardiac (adult versus pediatric), thoracic, or hybrid practices. Practice pattern data were not available for analysis through the ABTS. Therefore, to develop proximate estimates, the number of cardiac or general thoracic surgeons were computed based on reports from Canada (rationale: similar North American population mix and heterogenous disease burden with defined cardiothoracic training tracks) [13,14]. Both Vervoort and colleagues [13] and Abdul *et al.* [14] have shown that there are 0.51 cardiac and 0.36 general thoracic surgeons per 100,000 Canadian population. Hence, applying these ratios to the US population, this translates to approximately 1.4 cardiac surgeons for every one general thoracic surgeon. These values are based on assumptions of linearity and do not account for mixed practices or congenital and/or subspecialists.

Caseload Breakdown by Category and Age

To assess implications of an aging population on our field, calculations were performed based on the following. Computations assumed that 50% of heart surgery cases performed will be on those less than 65 years and 50% on those 65 years and older [1]. Further, the breakdown for lung cases is anticipated to be 30% in those less than 65 years and 70% in those 65 years and older [4,15]. Finally, for esophageal surgery, approximately 37% is anticipated in those aged below 65 years and 63% in those 65 years and older [16].

Expected Caseload per Surgeon

To determine the expected caseload for CT surgeons, several calculations were performed. First, the number of cases for each subcategory were estimated by multiplying the number of cases performed by the projected population growth. These values were summed to yield the total number of CT surgical cases performed annually. The number of CT surgeons needed was calculated by using the current ratio of 1.36 CT surgeons per 100,000 US population and multiplying by the estimated population growth [6,12].

Results

The aging population is expected to rise by 11% by 2075, leading to a 43% increase in cardiac and thoracic cases. The average caseload per surgeon per year is projected to be 160 cases by 2050 and 196 cases by 2075, representing a cumulative 45% increase in cases per surgeon per year (Table 1).

From 2012–2022 there was an evident growth in CTS training positions and interest. Integrated and traditional CTS training pathways have resulted in increasing fill rates, with both exhibiting a 100% fill rate in 2022. In ten years,

Table 1. Forecasted number of cardiothoracic cases.

Year	Age	Lung	Esophagus	Cardiac	Cases per surgeon per year
2010	<65	66,756	6157	145,705	135
	65+	155,764	10,483	145,705	
2050	<65	67,487	6224	147,300	160
	65+	221,352	14,897	207,058	
2075	<65	65,001	5995	141,874	196
	65+	271,586	18,278	254,048	

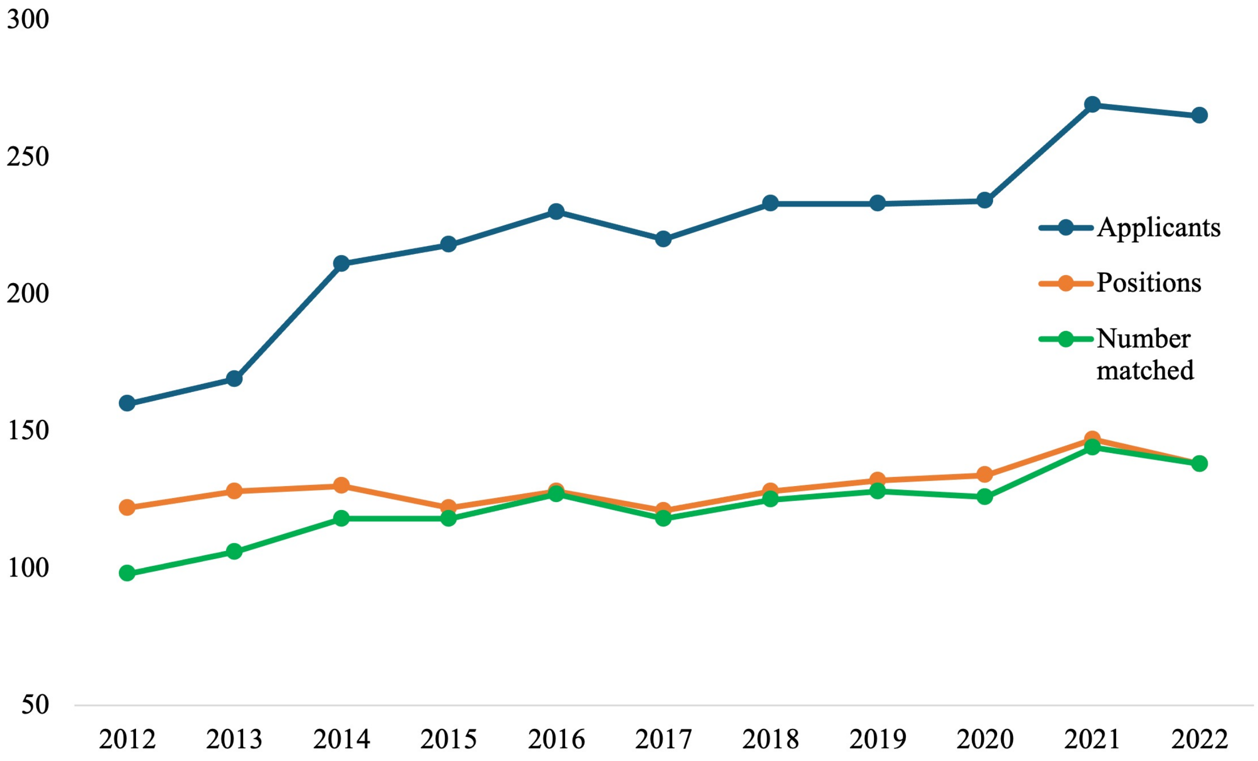

Fig. 1. Ten-year trends in CTS training pathways, integrated and traditional, show an increase in the number of applicants, and the number of positions offered and filled. CTS, Cardiothoracic surgery.

the median overall match rate was 97%, reaching a minimum of 80% in 2012 and steadily climbing in subsequent years. The number of applicants increased by 66%, with a nadir of 160 applicants in 2012 and a peak of 269 applicants in 2021. First-year positions (integrated and traditional) grew 13% (n = 138) in the last five years. Furthermore, ACGME CTS programs have graduated an average of 127 new surgeons annually from 2018 to 2022 (a 13% increase from 2012) [11], reflecting the increase in residency positions during the same period (Fig. 1). On average, nine CT surgeons begin a congenital cardiac fellowship, representing up to 7% of CTS graduates each year [17]. The first-time test taker, versus the repeat tester strata are not available. Between 2018 and 2022, the ABTS average pass rate was 87% (n = 149) for the written examination and 78% (n = 144) for the oral examination [18]. In addition, between 2012 and 2022, the ABS qualifying and certifying exams and ABTS results have had dissimilar patterns (Fig. 2).

US population models predict an 8% increase between 2022–2050, with a 42% increase in individuals over 65. Our data suggests a workforce shortage of approximately 12% by 2050 and 18% by 2075. Overall, these calculations predict a deficit of 900 CT surgeons over the next 50 years if current trends continue (Fig. 3).

Discussion

US population models suggest a rapidly increasing number of individuals living over 65, while a concomitant imbalance of physicians entering and leaving the workforce raises concern for a physician shortage unable to address growing patient needs. Promisingly, the number of first-year CTS training positions has increased by 37% since 2014, underscoring a concerted effort within the CTS community to address the shortage. Expanded training opportunities coupled with increasing residency fill rates bodes well in filling the ranks with future CT surgeons [19]. Furthermore, the steady output of CTS graduates, averaging 127 annually between 2018–2022, is optimistic amidst concerns of workforce scarcity [11]. Previous work has predicted a severe shortage of CT surgeons by 2030, and a 121% increase in average caseload per surgeon by 2035 [1,2]. In contrast, our work shows that in the current era, the workforce gap is less dire (45% increase in annual surgeon caseload) and highlights how dynamic these projections are in light of fluctuating trends. We also show that with an aging population, and despite improved workforce gap estimates, surgeon caseload is likely on the rise. Along these lines, it is important to accept that these workforce projections are based on current clinical practice patterns, which are continually evolving and likely to influence fu-

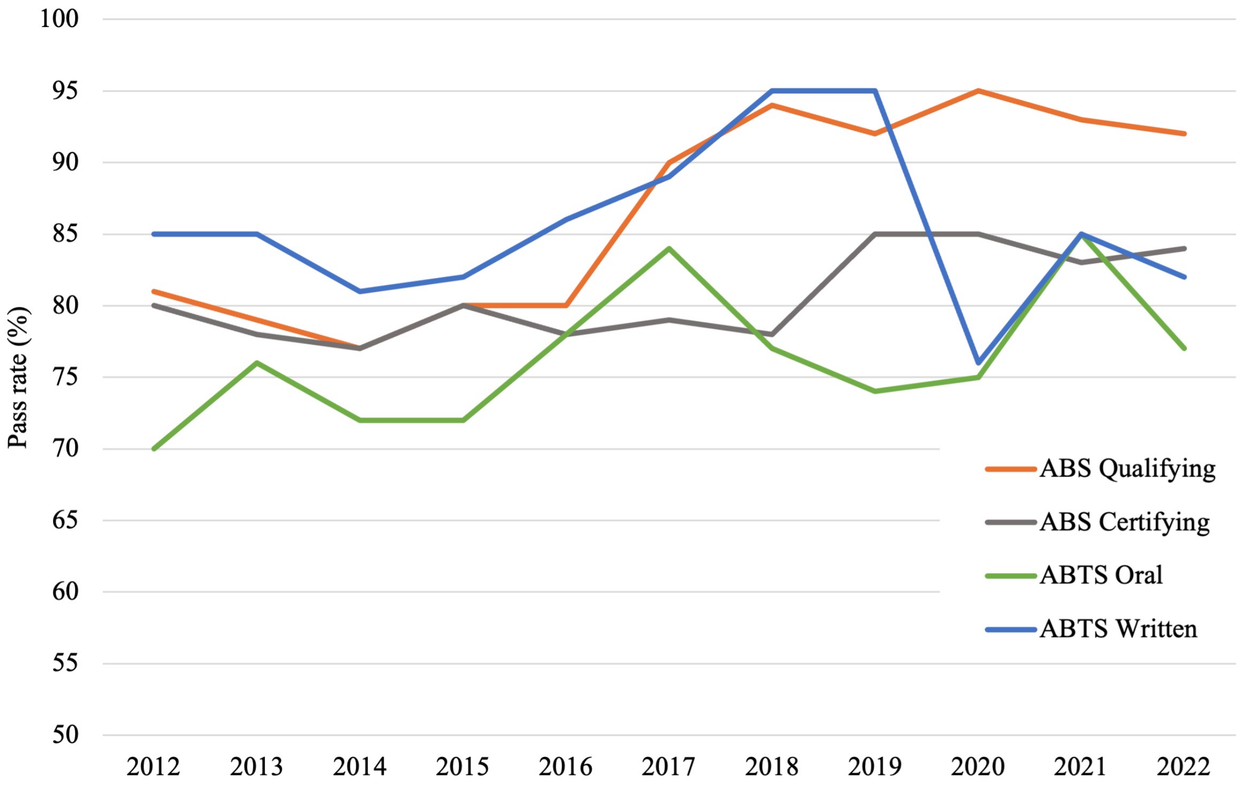

Fig. 2. ABS and ABTS boards examination pass rates for 2012–2022. ABS, American Board of Surgery; ABTS, American Board of Thoracic Surgery.

ture forecasts. This workforce gap needs constant attention, and international medical graduates (IMGs), the burden of disease in immigrant populations, and shifts in generational priorities, add to the complexity. There is no single solution to the imbalance of supply and demand in the CTS workforce, but identifying various areas to adapt to the changing landscape will evolve a more balanced supply and demand paradigm.

The US population fluctuates with changes in immigration trends and birth rates, as showed in our trend analysis. The US Census Bureau projects that without immigration, the national population would decrease by over 32% by 2100 [20]. However, it is expected that net immigration will account for nearly all national population growth by 2040, partly due to low birth rates [21,22]. For CTS, this will impact both the supply and demand of surgeons. Firstly regarding supply, approximately 1 in 4 licensed physicians in the US are IMGs, representing up to 20% of active general and thoracic surgeons [23]. IMGs are a robust part of the physician workforce, yet often face added barriers such as visa challenges, administrative delays, and implicit bias [24]. The immigrant population contributes significantly to both the CTS workforce and patient population, which necessitates greater advocacy and agency. Next, regarding demand, migrants often experience a different set of health challenges influenced by unique modifiable and non-modifiable factors, namely -untreated communicable disease, poor maternal health, and environmental stressors [25,26]. Evidence on the contribution by migrant populations to the burden of cardiovascular disease, thoracic cancers, congenital heart defects, or other demands on the cardiothoracic workforce is limited. Though it is anticipated that over time, through assimilation, habituation, and exposure, the risk factors for many migrant groups align with the host population. This, by extension, suggests that eventually they would follow our forecast of increasing demand for CT surgeons [25]. Limited data exists to quantify the effect of this demographic shift on CVD and malignancy risk, but examining these trends is crucial when developing strategies to address an evolving admixture of the population.

Since 2016, there has been an 7% increase overall in the number of physicians, with the greatest growth being in sports medicine (42%). Notably, only 8 of 48 specialities showed a decrease in the number of physicians between 2016–2021, including thoracic surgery and general surgery (–0.2% and –2.2%, respectively). Recent studies show that commonly quoted barriers to pursuing a career in surgery are work hours (90%), length of training (67%), and competitiveness (26%) [27–29]. Interestingly, factors largely considered “neutral” are medico-legal implications, educational debt, and expected income [28]. These find-

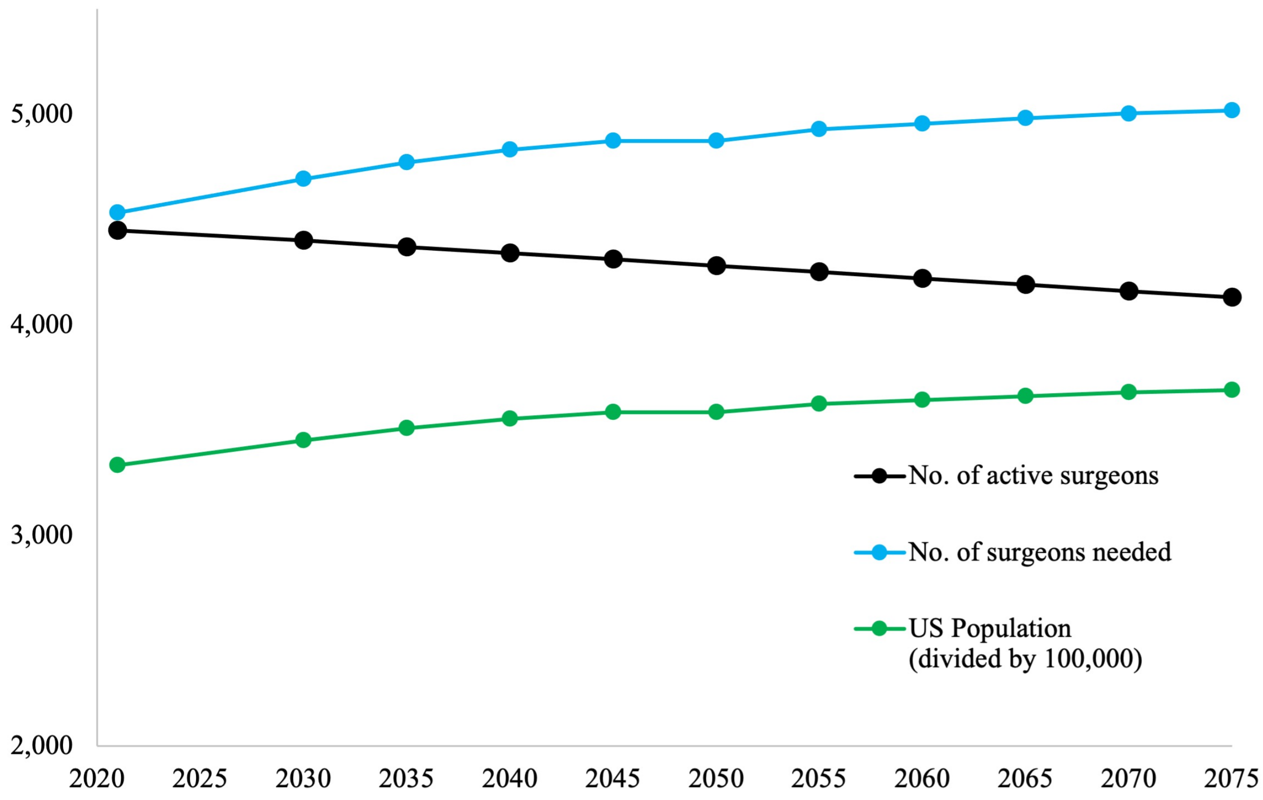

Fig. 3. Supply and demand for CTS, which demonstrates a decrease in supply of surgeons, met by an increase in need to serve the aging US population.

ings reflect a cultural shift that can beseen as Generation Z (generally accepted to be people with their birth years between 1997 and 2012) enters the workforce. The younger generations desire to make work fit around their lifestyle, not vice versa as has been modeled for decades (in CTS) [30]. However, Generation Z also values growth potential and seeks careers that provide ample opportunities for advancement [30]. CT surgeons providing early exposure and strong mentorship (e.g., student interest groups, summer internships), which have historically proven effective, are critical to fostering interest and opportunities during the early training (i.e., impressionable) years [31,32]. We as a field must consider the shift in both career and lifestyle goals as we strive to reach and engage the next generation of CT surgeons.

The primary CT surgeon is ultimately responsible for patient outcomes from a reporting perspective (e.g., Society of Thoracic Surgeons, Vizient, other quality registry, etc.), and the surgeon who evaluated and/or performed the index procedure with vested interest can heavily influence perioperative care. But, the operational and daily engagement of CT surgeons is dynamic and germane to the cultural and systemic processes at a particular institution. This engagement is most intense through the first 30 days. The rationale of this level of engagement is a derivative of the mandated surgeon-specific outcomes that are publicly reported [33,34]. Instead of a system-owning the outcome metric and process measure, CT surgeons, often in a matrixed system, are held accountable, even though they have marginal individual leverage. A pilot model project may be timely [34,35]. Appealing to the next generations requires prioritizing surgeon wellness and work-life balance; therefore, the CTS community must embrace a cultural shift in patient ownership. The historical model of unrestricted hours in surgical training is increasingly replaced by finite work equivalents (i.e., sessions, shifts, reads, etc.), spurred by the 2003 ACGME duty-hour restrictions [36,37]. These changes aim to reduce physician fatigue and burnout. However, concerns about continuity of care and educational commitment are apropos. Innovative solutions to adopt the evolving landscape (e.g., doc-of-the-week for the service) are crucial for sustaining both physician well-being and high-quality patient outcomes.

Burnout of the surgical workforce has been estimated as much as 50% [38]. A 2019 survey on the correlation of burnout and retirement found that the mean age of retirement for respondents was 63.9 years [39]. In 2022, the mean age of retirement in the US was 65 for men and 62 for women, suggesting that surgeons generally follow the same trends of retirement as the national population [40]. Each surgeon has unique financial commitments that influence retirement timing informed by many (societal) macro and micro economic factors. For example, inferring from the Congressional Research Service report on retirement trends between 2020–2022, an estimated 462 cardiothoracic surgeons would retire in that year -possible, but unlikely. Thus, we posit that changes to the CT surgeon workforce based on retirements influenced by economics would largely mirror the general population and remain largely unaffected by these workforce changes. However, if we as a field fail to address the generational shifts in lifestyle and career priorities as discussed above, we postulate that earlier retirement and continued high rates of burnout may be observed in the coming decades. Altered training paradigms (e.g., separation of cardiac and thoracic certifications, incorporation of other exposures like extracorporeal membrane oxygenation (ECMO) transport, advanced transcatheter skills to support ST-elevated myocardial infarction (STEMI) call) also present an opportunity for improving the workforce. Ultimately, this is an ongoing conversation within the field that requires large scale agreement on the need for change before formal recommendations are to be enacted.

Limitations

Data from non-accredited CT surgery programs were not included in this study as they are unreliable, annually variable, and do not have a systematic tracking process. Multiple other fellowships in advanced heart failure surgery, aortic surgery, structural heart disease management, and advanced cardiac surgery are being offered by many institutions. Minimally invasive, robotics, lung transplant and esophageal surgery are some of the other advanced training opportunities that are provided to trainees interested in subspecializing. As such, these training programs are not catalogued or centralized for access and are a burden and a boon to our training model(s). Furthermore, because data for these groups is not readily available, practice patterns and workload are not well characterized for individual subspecialties within CT surgery.

Next, limitations of our workforce projections include non-adjusted (unamortized) patterns, our assumptions may have variance, and publicly reported data may be inaccurate or have inherent reporting bias. Additionally, the databases utilized do not capture regional demands that may affect the distribution of the workforce and thus have not been accounted for.

Additionally, this study does not address the unpredictable impact of future technological advances (e.g., capacity constraints) and potential shifts in surgical productivity (e.g., how work relative value unit (RVU) is computed). Unfortunately, these workforce changes and ever evolving technological advancements are impossible to predict and we must remain engaged and vigilant to contemporary data.

Lastly, the calculations for forecasts were made on a simplified linear model, hence alterations from current trends, payor status, and referral changes will impact these projections. Sudden changes to either supply (e.g., more training programs, earlier retirement) or demand (e.g., surgical caseload) may lead to deviations from our workforce projection. In this age of rapid technological advancements, future research leveraging machine learning to integrate these dynamic factors would be invaluable for generating real-time workforce projections with greater accuracy.

Conclusions

In summary, our analysis suggests encouraging trends, and this work provides evidence that concerted efforts to expand training opportunities, support workforce retention, and adoption of evolving healthcare needs are indeed contributing to narrowing the CTS workforce gap. Stakeholders across our profession should remain committed to these ongoing efforts and pursue innovative strategies to further reduce the workforce and productivity gap in future decades.

Abbreviations

AAMC, Association of American Medical Colleges; ABS, American Board of Surgery; ABTS, American Board of Thoracic Surgery; ACGME, Accreditation Council for Graduate Medical Education; CT, Cardiothoracic; CTS, Cardiothoracic surgery; CVD, Cardiovascular disease; ECMO, Extracorporeal membrane oxygenation; IMG, International medical graduate; NRMP, National Residency Matching Program; RVU, Relative value unit; STEMI, ST-elevated myocardial infarction.

Availability of Data and Materials

The data underlying this article are available in the article.

Author Contributions

KB, EK, and CMB, Substantial contributions to the conception or design of the work; or the acquisition, analysis. KB, EK, RT, HKS, FAT, PS, GL, JWD, and CMB, Substantial contributions to the interpretation of data for the work. KB, EK, RT, HKS, FAT, PS, GL, JWD and CMB, Drafting the work or reviewing it critically for important intellectual content and final approval of the version to be published. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

The study was carried out in accordance with the guidelines of the Declaration of Helsinki. This study was retrospective and therefore did not require OHSU IRB approval as it did not involve human subjects, human data, or human tissue.

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Conflict of Interest

The authors declare no conflict of interest. Castigliano M. Bhamidipati is serving as one of the Editorial Board members of this journal. We declare that Castigliano M Bhamidipati had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to Curtis G Tribble.

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