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Commentary

Projecting the General Cardiology Workforce Shortage

Jeffrey L. Williams, MD, MS

A model was developed to project the need for general cardiologists from 2005 through 2050 with Matlab (Mathworks, Inc, Natick, MA). The growth in need for general cardiologists was estimated by incorporating the effect of retirement, prevalence of heart disease, and patient per physician load. At the peak demand in 2038, the projected need is for 62,452 general cardiologists. Current training durations would result in 29,043 and fast-tracking would result in 32,533 general cardiologists, meeting only 46.5% of the projected need in 2038. This situation may result from a complex cascade of declining numbers of US medical graduates and of those matching in internal medicine residencies, combined with patients presenting with increasingly complex cardiovascular disease that require the care of multiple, distinct cardiovascular specialists.

The American Association of Medical Colleges Center for Workforce Studies has reported on the growing evidence that the United States will face a physician shortage over the next 10 to 20 years and recommends a 15% increase in the number of US medical school graduates by 2015.[1] Since 1987, the number of US medical school graduates matching in internal medicine residencies has dramatically declined: 26.5% of US medical school graduates matched in internal medicine in 1987[2] vs 19.0% in 2006.[3] The 35th Bethesda Conference[4] predicted an impending shortage of general cardiologists. However, the conference document did not make projections as to the degree or duration of the shortage. In this article, the author models the projected need for general cardiologists from 2005 through 2050 with current training program durations compared with that of a fast-track program for electrophysiology (EP) and interventional subspecialty fellowships.

Methods

The model, developed with Matlab, based key assumptions on existing workforce estimates and projections. To model the output of general cardiologists over the period from 2005 through 2050, baseline numbers had to be determined of general, EP, and interventional cardiologists trained per year, along with numbers of existing general cardiologists and the estimated growth rate in the need for general cardiologists.

Number of EP and Interventional Spots per Year. In 2004 the 35th Bethesda Conference revealed that only 120 of 173 EP spots and 229 of 269 interventional spots are filled per year.[4] Although a higher proportion of EP and interventional spots are currently being filled, these baseline partial fill rates were used to assess the effect that completely filling these subspecialty fellowship positions would have on the overall number of general cardiologists.

Initial Number of General Cardiovascular Trainees. In 2001, there were 2160 total trainees, 709 of which were first-year fellows.[4] In the baseline conditions of the model, the number of first-year fellows was taken as 709, second-year fellows numbered 726, and third-year fellows numbered 725. Of note, the average number of first-year fellows from 1995 to 2005 was

• From the Division of Electrophysiology, Cardiovascular Institute, University of Pittsburgh, PA
• Address for correspondence: Jeffrey L. Williams, MD, MS, PUH B535, Division of Electrophysiology, University of Pittsburgh Medical Center, 200 Lothrop Street, Pittsburgh, PA 15213; e-mail: williamsJL4@upmc.edu

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Table. Projected Numbers of General Cardiologists (2005–2050) Based on Current Training Program Durations, Projected Number of General Cardiologists Needed, and Number of General Cardiologists Graduated if a Fast Track Were Implemented

Year	No. of General Cardiologists in US Using Current Training Program Durations	Projected No. of General Cardiologists Needed Using the Model	No. of General Cardiologists in US if Fast Track Implemented
2005	16,800	16,800	16,800
2006	17,176	17,590	17,176
2007	17,553	18,416	17,553
2008	17,913	19,282	17,913
2009	18,289	20,188	18,638
2010	18,666	21,137	19,015
2011	19,026	22,130	19,375
2012	19,402	23,171	20,100
2013	19,779	24,260	20,477
2014	20,139	25,400	20,837
2015	20,515	26,594	21,562
2016	20,892	27,843	21,939
2017	21,252	29,152	22,299
2018	21,628	30,522	23,024
2019	22,005	31,957	23,401
2020	22,365	33,459	23,761
2021	22,741	35,031	24,486
2022	23,118	36,678	24,863
2023	23,478	38,402	25,223
2024	23,854	40,206	25,948
2025	24,231	42,096	26,325
2026	24,591	44,075	26,685
2027	24,967	46,146	27,410
2028	25,344	48,315	27,787
2029	25,704	50,586	28,147
2030	26,080	52,963	28,872
2031	26,457	55,146	29,249
2032	26,817	57,098	29,609
2033	27,193	58,788	30,334
2034	27,570	60,187	30,711
2035	27,930	61,270	31,071
2036	28,306	62,018	31,796
2037	28,683	62,415	32,173
2038	29,043	62,452	32,533
2039	29,419	62,127	33,258
2040	29,796	61,444	33,635
2041	30,156	60,529	33,995
2042	30,532	59,391	34,720
2043	30,909	58,042	35,097
2044	31,269	56,498	35,457
2045	31,645	54,775	36,182
2046	32,022	52,891	36,559
2047	32,382	50,865	36,919
2048	32,758	48,719	37,644
2049	33,135	46,473	38,021
2050	33,495	44,149	38,381

Abbreviation: US, United States.

709; thus, these assumptions appear to be consistent with current training program class size.[5]

Total General Cardiologists. The estimate of 6 cardiologists per 100,000 US residents[4] was used as the basis for calculating the number of cardiologists in the United States at 16,800 in 2005. A 1974 study of the general cardiology workforce estimated 5.6 cardiologists per 100,000 population.[6] According to the American Board of Internal Medicine, as of February 16, 2006, there were 22,182, 1396, and 5020 valid certificates in cardiovascular disease, EP, and interventional cardiology, respectively. If the cardiovascular subspecialists are removed from the total number of cardiovascular disease–certified individuals, the total general cardiologists would be 15,766. Nevertheless, the model in the present study used the higher estimate of current general cardiologists as noted (n=16,800). In addition, the model assumes the current supply of general cardiologists is adequate. In fact, it is likely that the current supply is inadequate, as "about 40% of the nation's hospitals with 100 or more beds are seeking cardiologists, and about one-half of these institutions believe it is 'very hard' to recruit them."[4]

Growth in Need for General Cardiologists. ***Effect of Retirement.*** It is estimated that 10% of cardiologists will retire within the next decade.[7] Thus, the model uses a 1% per year increase in need due to retirement. This assumption, although likely to underestimate retirement rates, was carried out until 2050. Sensitivity analyses were performed to assess the effect varying rates of retirement (from 0.5% to 4.0% per year) would have on cardiology workforce requirements.

Effect of Prevalence of Heart Disease. Deaths from heart disease (HD) indicate a need for cardiologists, but prevalence of HD is more important than death in determining workforce requirements.[7] In this model, it was assumed that the prevalence of HD will grow an average of 1.7% per year until 2030.[7] As the baby boomer population dies, the prevalence of HD will decrease by 0.58% per year from 2030 to 2040 and 0.39% per year from 2040 to 2050.[7] Sensitivity analyses were performed to assess the effect varying HD prevalence would have on cardiology workforce requirements. The prevalence rates examined in the initial model represent an average HD prevalence; however, the sensitivity analysis includes both low and high estimates of HD prevalence.[7]

Effect of Decreasing Patient Per Physician Load. The average physician's patient load in cardiovascular medicine declined by over one-third from 1980 to 1995.[7] This may be explained by the increasing complexity of care needed by patients with cardiovascular disease. A higher proportion of patients require the care of more than 1 cardiovascular specialist (eg, a general cardiologist, electrophysiologist, interventionalist, and/or heart failure specialist). For every 10% decrease in average patient load, 20% more physicians were required. The model uses 2% per year increase in demand from decreasing patient per physician load.

Effect of Cardiovascular Subspecialty Fast-Tracking. The 8th Working Group of the 35th Bethesda Conference suggested a means to allow a 5-year short track to train general cardiologists and thereby increase the potential number of practicing cardiologists.[8] The trainee would complete 2 years of general internal medicine, then 3 years of cardiology; however, the conference did not discuss the possibility of fast-tracking for interventional or EP fellowships for those who have already completed a 3-year internal medicine residency.

In this model, fast-tracking would comprise 2 years of a general cardiology fellowship, then 2 years of either interventional or EP training. This concept of fast-tracking was incorporated into the model to assess its effect on the general cardiology workforce numbers.

Developing the Model in Matlab. Matlab is a computing environment that combines numeric computation, advanced graphics, and a sophisticated programming language similar to C++. It permits the researcher to "program" complex models with a minimum amount of code. A sample Matlab script, as an example of that used to model the projected need for general cardiologists from 2005 through 2050, is available by contacting the author via e-mail.

Results

General Cardiology Workforce From 2005 Through 2020. The Table lists the numbers of general cardiologists from 2005 through 2050 using current training program durations, the projected number of general cardiologists needed, and the number of general cardiologists trained if a fast track were implemented. The growth in need for general cardiologists was estimated by incorporating the effect of retirement, prevalence of HD, and patient per physician load, then modeled using Matlab. Current training program durations and fellowship spots would result in 66.8% of the projected need for general cardiologists

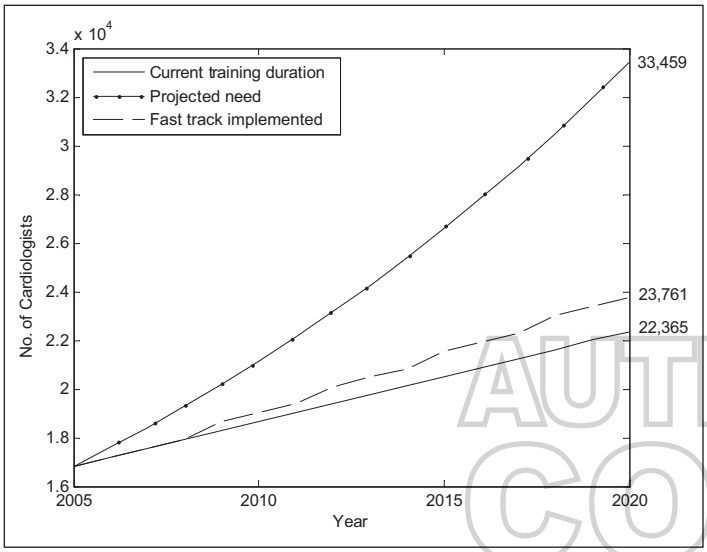

Figure 1. Projection of number of general cardiologists (2005–2020). Current training durations would result in only 66.8% of the projected need in 2020. Fast-tracking would add 1396 general cardiologists by 2020. (Projection includes 1% annual growth for retirement, 1.7% annual growth for increasing prevalence of coronary artery disease, and 2% annual growth to account for decreasing physician/patient load).

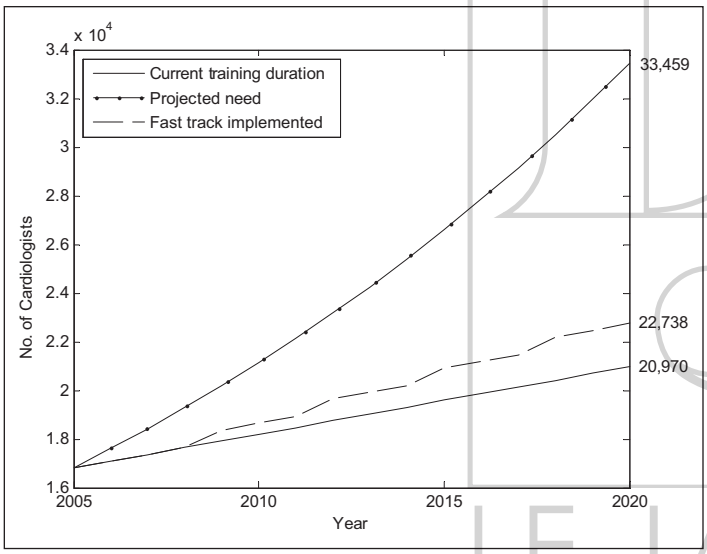

Figure 2. Effect of filling 100% of electrophysiology and interventional fellowship spots starting in 2006.

in 2020 (22,365 available vs 33,459 needed). Fast-tracking would increase the number of general cardiologists by 1396 (to a total of 23,761) over the next 15 years. Figure 1 summarizes the production of general cardiologists using the current system and if fast-tracking were implemented.

Currently, only 120 of 173 (69%) of EP fellowship positions and 229 of 269 (85%) of interventional fellowship positions are filled. A 100% fill rate, using current training duration, would lead to a 6.2% decrease in general cardiologists (n=1395). Figure 2 summarizes the effect of filling 100% of EP and interventional fellowship positions starting in 2006. Fast-tracking would help to offset this decrease.

General Cardiology Workforce From 2005 Through 2050. Extending the model out to 2050 allows us to encompass both the rise and fall in HD prevalence due to the baby boomer population. This model incorporates a rise in the prevalence of HD by 1.7% per year until 2030 and a decline by 0.58% per year from 2030 to 2040 and 0.39% per year from 2040 through 2050. Figure 3 depicts the model's projections of the cardiology workforce from 2005 through 2050. Current training duration (solid line) and fast track (dashed line) would still result in a deficit when compared with the model projection of need for general cardiologists (dotted line). At the peak demand in 2038, the projected need is 62,452 general cardiologists. Current training durations would result in 46.5% (n=29,043 total cardiologists) of the projected need and fast-tracking would result in 52.1% of the projected need (n=32,533).

Figure 4 summarizes the effect of doubling the number of general cardiology fellows trained per year starting in 2006. The current number of total fellows is 2160. The solid line indicates the total number of general cardiologists trained if the number of total fellows increased from 2160 to 4320. The dashed line indicates the number of general cardiologists trained if fast-tracking were implemented. Although unlikely to ever occur given limitations in Graduate Medical Education funding, doubling the number of general fellows trained and incorporating fast track for EP and interventional fellows would help offset the predicted shortage in general cardiologists (dotted line) by year 2020; however, this would result in an oversupply in general cardiologists by the year 2050.

Sensitivity Analyses of HD Prevalence and Retirement Rates. To identify which variables drive the results of the model, the effects of HD prevalence and retirement rates were assessed. Figure 5 depicts the sensitivity analysis of the model varying HD prevalence. The original projected need is compared with low, medium, and high prevalence of HD. Low prevalence was defined as a change in HD prevalence of +1.05% per year from 2005 to 2030, –0.78% per year from 2030 to 2040, and –0.52% per year from 2040 through 2050. Medium prevalence was defined as a change in prevalence of +1.59% per year from 2005 to 2030, –0.68% per year from 2030 to 2040, and –0.455% per year from 2040 through 2050. High HD prevalence was defined as a change

in prevalence of +2.13% per year from 2005 to 2030, –0.78% per year from 2030 to 2040, and –0.52% per year from 2040 to 2050. Even with low HD prevalence, in 2035 the projected shortfall is 56.7% of the projected need for general cardiologists.

Figure 6 depicts the sensitivity analysis of the model varying cardiologist retirement rates. Original projected need is compared with low (0.5% per year), medium (2.0% per year), and high (4.0% per year) rates of retirement. Even with an unreasonably low rate of retirement of 0.5% per year, a projected shortfall of general cardiologists remains during the peak of need.

Discussion

General Cardiology Workforce Projections. At the peak demand in 2038, the projected need is 62,452 general cardiologists. Current training durations would result in 46.5% (n=29,043 total cardiologists) of the projected need and fast-tracking would result in 52.1% (n=32,533). Completely filling all currently available EP and interventional fellowship spots would negatively impact the number of general cardiologists available over the next 45 years.

The Patient per Physician Load. The effect of decreasing the patient per physician load is an interesting model component. As described in the Methods section, the increasing complexity of the care needed by patients with cardiovascular disease results in a higher proportion of patients who require the care of more than 1 cardiovascular specialist (eg, a general cardiologist, electrophysiologist, interventionalist, and/or heart failure specialist). The model incorporated a 2% per year increase in demand due to decreasing patient per physician load. One solution to the predicted general cardiology workforce shortage would be to minimize the "intra-cardiology" and general cardiology referrals.

Another means to reduce the demands on general cardiologists would be to shift care to primary care physicians as the "gatekeeper," a concept that has largely been rejected by patients and physicians. The impact of generalist vs specialist care has been examined in patients with unstable angina.[9] Patients with unstable angina treated by internists were less likely to receive effective medical therapy or revascularization and trended toward poorer outcomes. In addition, an "open-access" model for specialty care clinics is associated with dramatic declines in waiting times to these specialty clinics.[10] Indeed, this open access has been associated with a substantial decrease in urgent-care visits, reduced

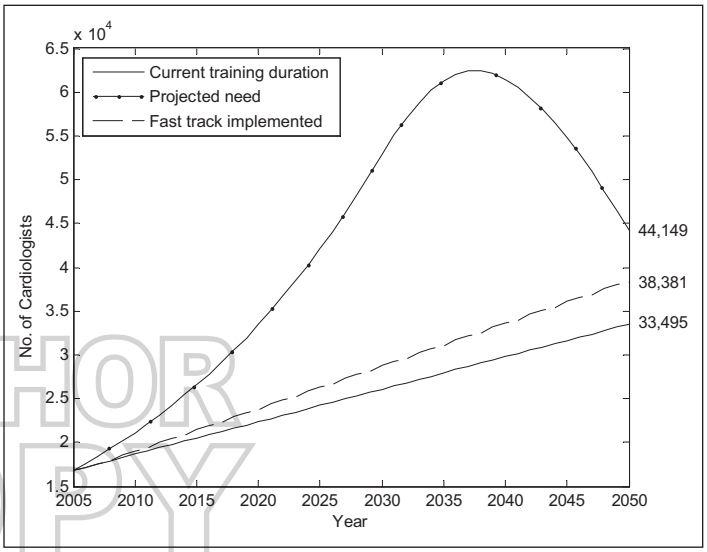

Figure 3. Projections of cardiology workforce (2005–2050). This model incorporates a decrease in heart disease prevalence by 0.58% per year from 2030 to 2040 and 0.39% per year from 2040 to 2050.

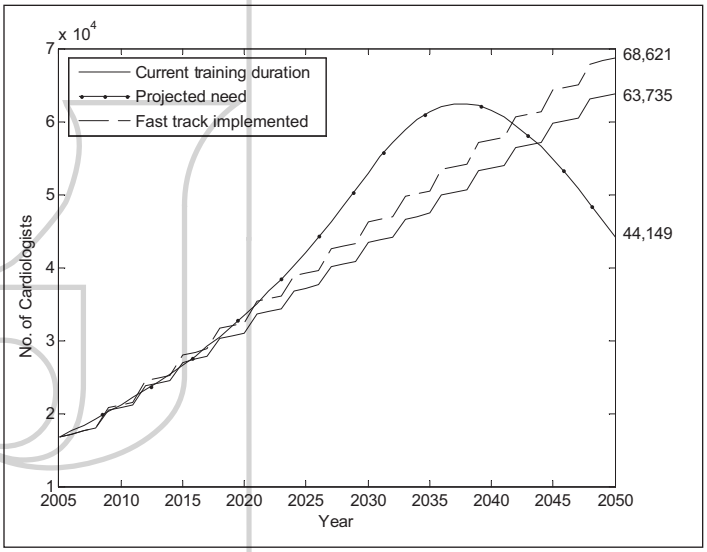

Figure 4. Projections of cardiology workforce (2005–2050).

number of hospital admissions, and shortened length of stays for patients with coronary heart disease.[11] Finally, in an era of increasing medical liability, it seems unreasonable to shift responsibility for patients with increasingly complex cardiovascular disease to primary care physicians.

Increasing the Numbers of General Cardiologists and Fast-Tracking. A 2005 survey of cardiology fellows indicated at least a quarter of respondents would like to see fast track training programs in such subspecialties as EP and interventional cardiology.[12] Three major reasons probably account for this preference. First, the development of advanced cardiovascular techniques led to the change in the

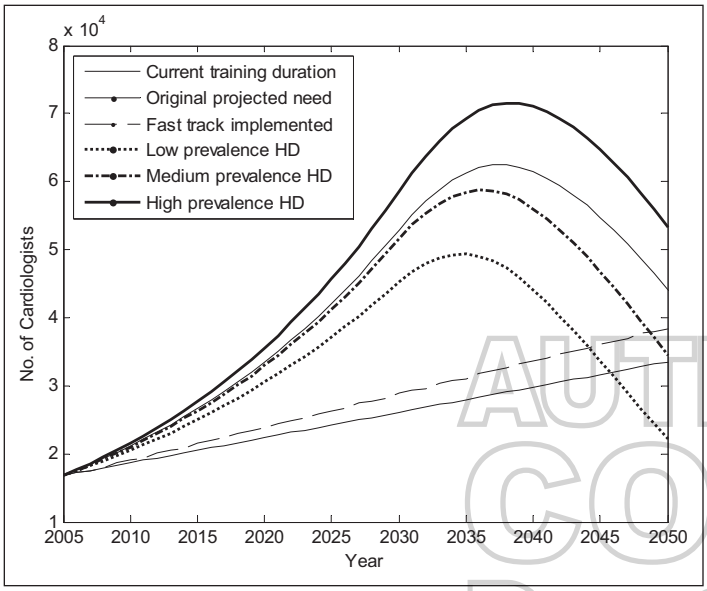

Figure 5. Sensitivity analysis of model varying heart disease (HD) prevalence.

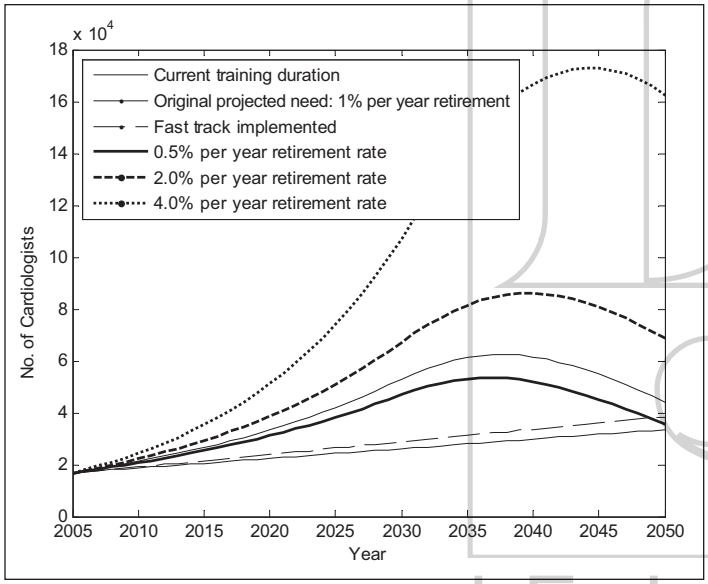

Figure 6. Sensitivity analysis of model varying cardiologist retirement rates.

traditional 2-year training program to the current system of 3- or 4-year durations. Second, 21% to 32% of current EP and interventional training programs require an additional 2 years of training after the traditional 3 years of general cardiology.[12] Finally, in 2003 the average graduating medical student loan debt was between $100,000 and $135,000. Even after adjustment for inflation, this constitutes an increase of more than 150% since 1984.[13]

This model reveals that fast-tracking will increase the number of general cardiologists trained without significantly increasing the number of EP and interventional subspecialists. Assuming no change in the number of total general cardiology fellows allowed, fast-tracking will help reduce the predicted shortage by adding 1396 general cardiologists by 2020. Fast-tracking, while streamlining the training of EP and interventional cardiologists, would allow a 2-year dedicated timeframe for training in the specific subspecialty.

Initial talks have taken place with the American Board of Internal Medicine about shortening internal medicine residencies and allowing residents to enter cardiovascular disease fellowships after their second year; however, major changes to the structure of medical residencies will need to be completed before this can be implemented. Thus, the concept of fast-tracking proposed here may be a first, albeit small, step to offset the impending shortage of general cardiologists. Another interesting approach would be to allow the number of general cardiology positions to rise and fall along with the size of the general population.

Sensitivity Analyses of HD Prevalence and Retirement Rates. The low and high HD prevalence projections were based on the work of Foot and colleagues[7] that examined population projections. These researchers found the low estimates were "unduly pessimistic" and the high estimates, based on high immigration assumptions, were "unsustainable." In addition, they reported that these HD projections were relatively insensitive to absolute population numbers, reflecting the fact that HD is an older person's disease. It is worrisome that, even with the lowest HD prevalence estimates, a shortfall of general cardiologists is still predicted. In addition, even with an unreasonably low rate of retirement of 0.5% per year, a shortfall of general cardiologists is projected during the peak of need.

Limitations

This model assumes that it is possible to have a varying number of fellows per year in a training program. This would make clinical service coverage very difficult for programs with fewer numbers of fellows per year. In addition, this model assumes that there is a certain amount of Graduate Medical Education funding available in 3-year aliquots. This is required because the number of fellows per year is not constant. If it is assumed that an institution receives a certain amount of money for a trainee and if EP or interventional subspecialty cardiologists require 2 years rather than 3 years of general cardiology training, then more money (or program slots) has been freed up for additional general cardiology trainees. By removing these

subspecialty fellows from the pipeline, the Graduate Medical Education funding is theoretically freed up for incoming general cardiology fellows. However, an additional revenue stream would be needed to fund the 2-year EP and interventional fellowships.

Most important, modeling such a complex, nonlinear US health care system is fraught with difficulty. In 1980, the Graduate Medical Education National Advisory Committee (GMENAC)[14] concluded that by 1990 the supply of cardiologists would exceed demand by 100%; in its 1985 to 1986 update, the GMENAC concluded that by 2000, the supply of cardiologists would exceed demand by 110%.[15] The Institute of Medicine issued strong warnings when they predicted a surplus of physicians in their 1996 report.[16] They recommended no new osteopathic or allopathic medical schools be opened, residency positions be limited, the numbers of international medical graduates be limited, and replacement funding be given to institutions that provided indigent care. It is interesting to compare the predictions set forth in the present study to those of another predicting a general physician shortage.[17] In 2005, there were 802,230 active physicians[18] and 16,800 general cardiologists. Thus, general cardiologists comprised 2.094% of the active physicians in practice in 2005. Cooper and associates[17] reported that in 2020 there would be a projected demand of 1,164,700 physicians. Thus, using this same percentage of general cardiologists, the projected demand for general cardiologists would be 24,389 in 2020 based on the work of Cooper and colleagues. The model proposed herein, however, suggests that there will be a much higher demand for general cardiologists (n=33,459 in 2020). Caution must be taken to apply the same percentage of subspecialists required to the overall predicted physician demand by Cooper and colleagues. This is especially true given that the aging demographics of the baby boomer population will likely increase the percentage of cardiologists needed as a proportion of the total physician population. Nonetheless, despite a decline in the number of total US medical graduates and those matching in internal medicine, my model predicting impending shortages in general cardiologists may quite simply be wrong.

Conclusions

There is evidence of an impending shortage of general cardiologists that will peak in 2038, reaching only 46.5% (n=33,409 fewer cardiologists) of the projected need. This is the result of factors that include declining numbers of US medical graduates and those matching in internal medicine residencies and patients having increasingly complex cardiovascular disease that requires the care of multiple, distinct cardiovascular specialists.

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