Pathologist Workforce in the United States

I. Development of a Predictive Model to Examine Factors Influencing Supply

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• ***Context.***—**Results of prior pathology workforce surveys have varied between a state of equilibrium and predictions of shortage.**

Objective.—**To assess the current and future supply of pathologists, and apply a dynamic modeling tool for assessing the effects of changing market forces and emerging technologies on the supply of pathologists' services through 2030.**

Design.—**Data came from various sources, including the literature, College of American Pathologists' internal data, and primary research through custom-developed surveys for the membership and for pathology practice managers**

Results.—**Through 2010, there were approximately 18 000 actively practicing pathologists in the United States (5.7 per 100 000 population), approximately 93% of whom were board certified. Our model projects that the absolute and per capita numbers of practicing pathologists will decrease to approximately 14 000 full-time equivalent (FTE) pathologists or 3.7 per 100 000 in the coming 2 decades. This projection reflects that beginning in 2015, the numbers of pathologists retiring will increase precipitously, and is anticipated to peak by 2021. Including all types of separation, the net pathologist strength will begin falling by year 2015. Unless workforce entry or exit rates change, this trend will continue at least through 2030. These changes reflect the closure of many training programs 2 to 4 decades ago and the substantially decreased number of graduating residents.**

Conclusions.—**This comprehensive analysis predicts that pathologist numbers will decline steadily beginning in 2015. Anticipated population growth in general and increases in disease incidence owing to the aging population, to be presented in a companion article on demand, will lead to a net deficit in excess of more than 5700 FTE pathologists. To reach the projected need in pathologist numbers of nearly 20 000 FTE by 2030 will require an increase from today of approximately 8.1% more residency positions. We believe a pathologist shortage will negatively impact both patient access to laboratory services and health care providers' abilities to deliver more effective health care to their patient populations.**

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Since the early 1970s, several high-level analyses have assessed the manpower needs of pathologists either broadly as a specialty,[1–5] or more narrowly in the community practice setting,[6,7] also referred to as private practice. Two analyses[8,9] have examined single pathology subspecialty needs, and two[10,11] have focused in depth on academic health centers (AHCs) (see Table 1 for a complete list of acronyms). While not representative of the discipline as a whole, these surveys of AHCs accurately predicted overall manpower trends, especially in emerging subspecialty areas. Among the findings for these collected studies were predicted increases in numbers of PhD holders providing pathology services, more women and ethnic minorities serving as laboratory professionals, and a high number of pathologists leaving academic practice to enter private practice.

In 2009, the College of American Pathologists (CAP), anticipating that health care reform legislation would soon

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Table 1. Acronyms of Organizations Cited/Abbreviations

AAMC	Association of American Medical Colleges
AAPA	American Association of Pathologists' Assistants
ABP	American Board of Pathology
ACGME	Accreditation Council for Graduate Medical Education
AHC	Academic health center
AMA	American Medical Association
AOBP	American Osteopathic Board of Pathology
AP	Anatomic pathology
AP/CP	Anatomic and clinical pathology
ASCP	American Society for Clinical Pathology
C4C	Case for Change (College of American Pathologists)
CAP	College of American Pathologists
CP	Clinical pathology
DO	Doctor of osteopathic medicine
FREIDA	Fellowship and Residency Electronic Interactive Database
FTEs	Full-time equivalents
GME	Graduate medical education
IMG	International medical graduate
LCME	Liaison Committee on Medical Education
MD	Doctor of medicine
NRMP	National Resident Matching Program
PAs	Pathologists' assistants
PCS	Pathologist Characteristics Survey
PGY	Postgraduate year
PhD	Doctor of philosophy
RCPSC	Royal College of Physicians and Surgeons of Canada
RISE	Resident in Service Examination
USMG	US medical graduate

transform the delivery of health care in the United States, initiated a comprehensive evidence-based assessment of both current and future pathologist roles and services. Conducting a survey entitled Case for Change (C4C) to practicing pathologists, the CAP also examined emerging technologies, practice models, and the values the specialty brings to medicine. This survey was designed to provide data inputs for a comprehensive, scenario-based analysis of future stakeholder needs.

The overarching goal of the C4C was to identify the key trends influencing the current and future supply of and demand for pathologists. This "Pathologist Workforce" assessment enabled us to develop a flexible, interactive inventory-based model by which to predict across a wide range of variables and trends the state of the workforce (supply) and future manpower needs (demand) for key pathology subspecialties.

The questions we sought to answer were: (1) How many pathologists are there currently in the United States? (2) Will there be enough pathologists for future needs? (3) Will there be enough pathologist-hours across various pathology services and subspecialties to meet future demand? (4) What other workforces can help augment or even replace pathologists? And finally, (5) is there a looming deficit of practicing pathologists due to closure of training programs past and present, and retirement of our current workforce? In this article, we describe our findings on the supply side of the equation.

MATERIALS AND METHODS

Organization

We chose a committee consisting of CAP member pathologists practicing in diverse clinical environments. Members were sought with expertise and experience with workforce or population surveys. After an initial developmental period, the committee met weekly by phone call, and occasionally face-to-face, over a period of 18 months, before initiation of the analysis phase. Wherever possible, data from public and private resources were used, and where insufficient, focused surveys were conducted both among the membership and outside sources.

Design of Pathologist Supply Study

The study was organized in multiple phases: We (1) conducted a literature search to identify previous efforts to estimate the supply of physician pathologists; (2) studied various approaches used to estimate the supply of pathologists, and key data sources for information; (3) shortlisted approaches, based on logistical suitability to estimate pathologist supply and data availability; (4) gathered data from various sources: secondary research, CAP internal data, and primary research through custom-developed surveys for the membership and for pathology practice managers; (5) created a spreadsheet-based model structure to estimate the baseline supply of pathologists, using Microsoft Excel (Microsoft, Redmond, Washington); (6) developed an interactive dashboard for making changes to variables and incorporating revised supply information; (7) segmented the supply of pathologists into various service factors (roles)/subspecialties/practice settings; and (8) conducted scenario analyses to estimate how various variables can impact supply.

Model of Supply Analysis Chosen

The inventory-based model was selected from several common models for supply analysis. This model estimated the workforce by adding the net increase/decrease of pathologists per year to the current inventory of workforce (Figure 1). The key determinants of this model were (1) pathologists in the base year (2010), stratified by sex and age; (2) addition to pathology workforce per year after completion of training; and (3) separations from the workforce due to retirement, mortality, and others. Further, this model allows conversion of head count into full-time equivalents (FTEs) from the variation in working hours across age groups and sex. Certain historical trends (new pathology residents, mortality rates, and retirement patterns, etc) were presumed not to differ significantly from recent past trends, although the model is flexible and such changes can be programmed. Further, the current pathology educational system structure, and hence the supply of pathologists-in-training was assumed not to change significantly. Information on many variables was available through secondary sources and CAP internal data. Data on some variables (retirement patterns, working hours, non–board-certified pathologists) could be gathered only through survey.

We rejected a second commonly used method, the regression-based model, because it requires historic time-series data on supply and associated variables in order to project effectively the future supply. The historic data were sufficiently rigorous to support recognition of emergent events such as the compound impact of (1) postponed pathologist retirement into the early years of the present decade, (2) decreased residency program output, and (3) delayed workforce entry due to additional fellowship training, all of which contribute to the retirement cliff.

Our model estimates future workforce supply from analysis of relationships between historical supply and variables we believed might impact that supply, such as pathology resident enrollment and graduation rates, subspecialty selection, work hours, and aging of the workforce. We assumed that the future algebraic impact of these factors on workforce would not differ from that of the past.

Current Pool of "Active Pathologists"

The current pool of active pathologists includes all actively practicing pathologists (board certified and non–board certified) in the United States across all practice settings (hospital-based laboratories, independent laboratories, research, academia, etc).

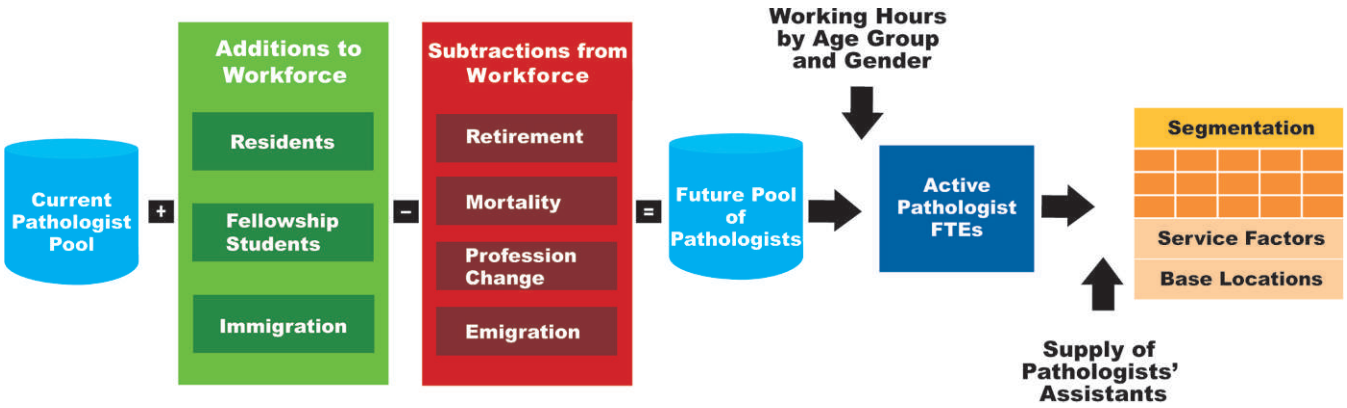

Figure 1. *Components of pathologist workforce supply in an inventory-based supply model. Abbreviation: FTEs, full-time equivalents.*

Pathologists were grouped by age clusters (<35, 35–44, 45–54, 55–64, 65–74, and >74 years), sex, and board certification (board certified or not certified) by the American Board of Pathology (ABP), the Royal College of Physicians and Surgeons of Canada (RCPSC), or the American Osteopathic Board of Pathology (AOBP). Pathologists' assistants (PAs), PhD holders who perform tasks that pathologists would otherwise perform, and nonpathologist doctors of medicine (MDs) practicing as pathologists are excluded from the term *active pathologist* as defined here; however, their work contribution was incorporated when comparing the supply-demand gap projections. The "active" designation also excludes pathologists who have retired or are trainees in residency or fellowship programs.

Among the data sources available to us, the US Census Bureau statistics do not stratify the specialty of pathology in its count of the medical workforce. The American Medical Association (AMA) provides the current count of physicians in the United States through its data licensees, including residents and fellows. Limitations from AMA data include difficulty in accounting for retirement, failure to respond to AMA surveys, and delayed reporting of mortality. Most information came from CAP internal sources or through primary research in the form of focus surveys.

Net Additions to the Workforce

"Net addition" to the workforce included trainees who have completed their residency and fellowship in the United States or in foreign institutions, and subsequently entered practice pathology in the United States. Medical school graduates included those from American allopathic medical schools, osteopathic medical schools, and non-American medical schools.

Medical Graduates Entering Pathology Residency Programs.—The data on filled residency positions in pathology were acquired from the Accreditation Council for Graduate Medical Education (ACGME)[12] with help from CAP and the National Resident Matching Program (NRMP),[13] 2005–2009. Each year's ACGME annual report listed the number of residents newly entering pathology training programs as postgraduate year 1 (PGY-1). Based on our understanding, every pathology residency program in the United States from which data were obtained for this study was ACGME accredited.

For the purposes of this study, "trainees" were defined as graduates from US allopathic medical schools, osteopathic medical schools, or non-US medical schools, including Canadian medical schools, international medical schools, and the now-defunct 5th Pathway Program (formerly designed for students who graduated from colleges and universities in the United States but attended medical schools outside the United States). Our model assumed that the current ratio of US medical graduates (USMGs) to "others" remained constant.

Resident Segregation by Type of Residency Programs (Anatomic Pathology/Clinical Pathology or Anatomic Pathology Only or Clinical Pathology Only).—Pathology residency programs offer 3 major tracks: combined anatomic pathology/clinical pathology (AP/CP), AP only, and CP only, and several minor tracks. These tracks differ in duration: "AP only" and "CP only" programs are of 3 years' duration, and combined AP/CP programs and the AP/neuropathology tract programs are of 4 years' duration. For this study, we used data for combined AP/CP programs and "AP- or CP-only" programs available for the year 2008 taken from a survey of 2512 residents in pathology programs conducted by the American Society of Clinical Pathology (ASCP).[14] At that time, the preponderance of residents were in the combined AP/CP program. In the absence of any other data, we have assumed for the purposes of this model that the ratio of AP/CP to AP to CP programs will remain constant during the period 2010–2030.[15]

Residency Positions Occupied, 2010–2030 (Baseline Scenario).—Residency positions have increased at a minor positive growth rate in the last few years, which for baseline projections we have calculated to be 0.1%. To create the baseline model, we have assumed that the short-term trend (2005–2009 from the NRMP) will continue through 2030 for the proportion of USMGs versus "others" among total enrolling residents.

Noncompletion of Pathology Residency Training.—Some residents never complete training. Information on noncompletion was obtained from the ACGME annual *Data Resource Book*[12] and CAP internal data. For the purposes of creating the baseline for our model, we assumed that there is no difference in the noncompletion rate for USMGs and "others."

Sex of Trainees.—Data on sex composition were obtained from the earlier literature and during the past decade from recent ACGME data books.[12] We have assumed the current sex ratio will remain at the current levels through 2030.

Variables With Fellowship Programs.—In our model, residents who completed their general AP or CP training and then pursue fellowship programs are included in the total workforce counts only after completing all training. We have omitted those dermatopathology fellows who first completed dermatology residency because we cannot determine what effort they later devote to pathology or to their own clinically generated practice (see below).

We also assumed that a sudden change in the percentage of residents opting for fellowships may, over the short term (and transiently), influence additions to the workforce. To compute the fraction of pathology residents opting for fellowship positions, we relied on information reported as "intention to pursue fellowships" in the ASCP Resident In-Service Examination (RISE)[16] and AMA Fellowship and Residency Electronic Interactive Database (FREIDA) surveys[17] for residents' career plan. The latter online database covers 8700 graduate medical education (GME) programs from all specialties accredited by the ACGME.

Our model did not include calculation of pathologists who are currently in practice but may in the future decide to pursue fellowships and thus leave the workforce temporarily. Also, our

model did not differentiate between fellows in ACGME-approved versus nonapproved training programs, a differentiation we appreciated may have altered our calculations. For instance, residents in ACGME-approved programs (eg, cytopathology, dermatopathology, hematopathology, neuropathology) cannot bill as the responsible pathologist and thus are not considered to be practitioners, and hence are not included in tallies of active pathologists. Alternatively, residents in non–ACGME-approved programs (eg, surgical pathology, gastrointestinal pathology, gynecological pathology, uropathology) often may bill patients for their services as the responsible pathologist, are considered to be practitioners, and thus are included in tallies of active pathologists. We assumed that the percentage of residents planning to enter fellowship training is the same for males and females, and will remain constant for the duration of our projections.

It is common today for pathologists-in-training to pursue at least 1 year of fellowship in the course of their career, and sometimes more.[15] From the ASCP surveys conducted yearly, the intention to complete 1, 2, or 3 fellowships is assumed to be the percentage of residents who currently pursue these fellowships. We assumed that residents who enter 1 or more fellowships complete all the fellowship programs consecutively, without gaps and that the percentage of residents pursuing 1 or more fellowships in the future remains constant at the current levels.

The Intersociety Council for Pathology Information lists 39 areas of fellowship training,[18] which the ACGME groups into 11 categories.[12] The largest, "selective," is an aggregation largely from various AP subspecialties. Our model allows for shifts in the types of fellowships selected, but assumes graduating residents will continue their training with the same number of fellowships.

Separation From the Workforce

Separation from the workforce occurred largely from retirement and mortality. Less common reasons, which more often occur before entering the workforce, are change of specialty and emigration of pathologists who completed their residency training in the United States but owing to immigration rules, were required to return to their home countries. The percentage returning to their countries of origin after completion of pathology training was assumed to be the same as that for all other medical specialties.

Mortality.—The CAP membership statistics provide mortality data for pathologists. We used CAP historical data, collected yearly since 2000, to estimate the pathologist mortality rates in each age group. We chose mortality rates for the year 2009 as our index year to calculate the mortality rate across the age groups. We assumed that the mortality rate of pathologists will remain at current levels through our projection period.

Retirement.—Data from public domain sources on pathologists' retirement ages do not exist. We surveyed active pathologists who provided information on their intended ages of retirement. Two surveys were used: (1) planned retirement pattern of pathologists across age groups through the C4C Survey in 2010 (C4C-2010) and (2) Pathologist Characteristics Survey 2011 (PCS-2011). Pathologists provided responses about their planned age for part-time and full-time retirement, which we then stratified by respondents' ages. We assumed that pathologists' intended ages of retirement would be earlier than their actual ages of retirement, especially during times of an economic downturn.

We then adjusted for the differences between planned and actual retirement by using the Association of American Medical Colleges' (AAMC) patterns reported for male and female populations of physicians.[19] Applying the difference in cumulative probability of actual and planned retirement weighted against the size of their relative populations, adjusted for male to female ratio of the population, together with some subjective refinements, we derived the difference (in years) between the actual and planned retirement ages. The variance in "reported" versus "actual" retirement age is most likely due to pathologists in younger age cohorts, where a larger variance is expected.

Emigration.—Some international medical graduates (IMGs) emigrate after completing their residency training voluntarily and some involuntarily leave owing to visa requirements. A few leave later, seeking other job opportunities. We have assumed a constant rate for all the years in the future.[20] "J" visa émigrés are eligible to reapply to return after 2 years of living abroad.

Residents Taking Up Nonmedical Professions.—In addition to the residents who drop out during their program, some leave the medical profession after completing their training. The percentage has been sourced from the FREIDA database.[17]

Future Pool of Pathologists

The future pool of pathologists was calculated as the number of active pathologists in the base year plus annual future net additions minus separations from the workforce.

Full-Time Equivalent Calculation

The workforce component of our integrated model was based on the concept of the "pathologist FTE," which we defined as a pathologist working the usual number of hours a full-time pathologist normally works. Our FTE calculations compute the FTEs of active pathologists, based on the productivity variations of the pathology workforce across age groups and sex: [(Count of Active Pathologists in Various Age Groups) × (Work Hours of Active Pathologists per Week)]/(Average Working Hours of Pathologists) = FTE ratios across age and sex.

Analysis of C4C 2010 and PCS 2011 indicates that the average work hours of pathologists varies (though by small magnitude) across age groups, including sex and partial retirees.

Special Considerations

Derivation of Non–Board-Certified Pathologist Workforce.—There are no national data indicating the number of non–ABP-certified pathologists. To estimate this, we investigated the state licensure databases from North Carolina and New York, which are open to public review. We identified all allopathic physicians and doctors of osteopathic medicine (DOs) who self-declared as being in the practice of pathology, including any of the 21 areas of pathology listed, which included AP/CP, AP, CP or combinations with blood banking/transfusion medicine, neuropathology, dermatopathology, forensic pathology, hematopathology, immunopathology, molecular genetic pathology, chemical pathology, cytopathology, medical microbiology, pediatric pathology, and selective pathology.

We excluded all persons with out-of-state primary addresses. The resulting list was cross-referenced against the ABP's master list of board-certified pathologists.

Work Hours.—We assumed in this model that both "Variation in average working hours by age and sex of pathologists" and "Average working hours per week among pathologists" will remain constant at current/historic values through 2030.

Extender's Supply: Pathologists' Assistants.—*Total Current Pool*.—We considered the total count of active PAs to include those certified by the ASCP Board of Certification (formerly, the ASCP Board of Registry) and those who are not certified. From our surveys, opinions of team members, and interviews with executives of the American Association of Pathology Assistants (AAPA) and others, we found that the definition of PAs has in the past included various levels of support personnel, often with limited responsibilities and generally on-the-job training. In this analysis, PAs are classified as certified or noncertified.

Count of Certified PAs.—The ASCP Board of Certification commenced certification for PAs in 2005. Individuals who were members of AAPA before 2005 were "grandfathered" by the ASCP as being certified. The count of board-certified PAs through 2004, obtained directly from the ASCP, was 735. From 2005 thru 2010, the ASCP certified another 711 persons, for a total baseline count of 1441.

Steps to Count the Current Number of Noncertified PAs.—There exist no statistics on the number of non-ASCP certified PAs.

We estimated this number through an indirect survey-based approach. In the C4C-2010 and PCS-2011, respondents were asked to provide the number of pathologists and PAs working in their respective practice settings. From those data we calculated an average industry-level pathologist to PA ratio. To estimate the total 2010 PA workforce in units of FTE, we multiplied the overall practice pathologist to PA ratio by the total current supply of FTE pathologists. We did not ask respondents to report whether or not the PAs were ASCP certified. To enable us to stratify PA calculations by ASCP certification, we subtracted from the total PA headcount for 2010 the number of PAs registered as being ASCP certified, the difference being those PAs who were not ASCP certified.

Conversion of PA Headcount to FTE Pathologists.—Physicians' assistants cannot replace pathologists completely, but can be viewed as performing under supervision a portion of FTE work that a pathologist might otherwise perform, specifically the professional activity of gross examination and dissection of specimens. To render coherency in modeling this fractional FTE effort, we have assumed PA supply should be representative of pathologists supply. A short survey of pathology practice managers asked the following: (1) number of PAs employed in their particular setting and (2) number of pathologists required to replace the work effort performed by these PAs. From this, we calculated the required replacement factor, assuming that (1) the replacement factor does not vary with certification status of PAs, and is constant for both certified and noncertified PAs; and (2) the replacement factor will remain constant until 2030 (CAP survey with practice managers, conducted on 11 practices).

Growth in PA Numbers.—Both certified and noncertified PAs add to the annual pool of US PAs. For the baseline estimates, we have not made additions to the noncertified pool, although some are undoubtedly added annually. Reasons why this pool is not expected to increase significantly are that (1) laboratory and hospital administrations prefer to hire certified PAs; and (2) pathologists supervising work by others that requires technical knowledge, skill, and independent judgment are more confident in certified PAs. For baseline purposes, we used the statistics on certified PAs added to the PA workforce obtained from ASCP. In 2009 and 2010, 104 new PAs were certified by the ASCP Board of Certification. We assumed this growth rate to be constant through 2030.

Literature Research: Methodology

Exhaustive research was conducted on the topic by scanning journal aggregators and other information sources. Relevant key words were used (workforce analysis, demand, supply, pathologists, physicians, projected, etc) to identify studies on this topic. From the citations in these studies, which identified primary sources of information, where pertinent, we contacted the relevant organizations though e-mail and telephone—without disclosing client identity and study details—to obtain access to or inquire about alternative sources of information. We used the findings of these reports and articles (cited herein) in constructing our model.

RESULTS

Current State of the Pathologist Workforce

As of the index year (2010), there were 17 986 active US pathologists (an estimated 17 570 FTEs), of whom 16 657 are board certified (see Table 2 for a breakdown of categories).

Currently, approximately 75% of active pathologists are 45 years or older and 41% are 55 years or older (Figure 2), which is older than nearly all other specialties.[21]

The average pathologist works 49.2 hours per week, a number similar to 25 years ago.[22] Both men and women work roughly the same hours, exclusive of time away for family leave. Broken into decade-long intervals, the average number of hours worked varies from a low of 45.0 for women aged 55 to 64 years to a high of 51.2 hours per week for men 35 to 44 years of age.

Part-time work effort, regardless of age bracket, is approximately 30 hours per week (range, average of 26–34 hours by decades of age). Below age 55 years, 4% of pathologists work part-time. Between the ages of 55 to 63 years, 7% of pathologists work part time, rising to 19% between ages 65 and 74 years.

Pathologists, whether in private practice or in an academic setting, have approximately 8 weeks annually of time offered for vacation and/or professional leave time, including postgraduate education, plus another 2 weeks allocated to sick leave or designated holiday days. The average pathologist was sick only 2 days during the year. Pathologists younger than 45 years used less vacation and continuing medical education leave (average 7 weeks) than pathologists older than 45 years (10+ weeks).

Review of data from 2 state medical boards (North Carolina and New York, see "Materials and Methods") indicates that approximately 7% (~1254) of all active pathologists in those states lack board certification. In North Carolina, 34 of 745 licensees (4.5%) self-identifying as pathologists were not certified by the ABP (which includes internists involved in laboratories, pathologists in research who did not take board examinations, failed board examinations, etc). Similarly for 821 licensees listed by the New York State Medical Board, 66 (~8%) were non-ABP board certified. Our M1 team members agreed that 7% was a reasonable estimate figure for the percentage of non-ABP board-certified physicians serving as pathologists. Generalizing from this, we estimate that there are 1254 physicians currently serving as non–board-certified active pathologists.

Table 2. Calculation of Active Pathologists in the United States

Total CAP membership	17 873
Junior members	−3335
Emeritus members	−3353
Members abroad	−330
Active CAP practicing pathologists in USA	= 10 855
ABP living board-certified pathologists[a]	23 012
Calculated ABP active board-certified pathologists[b]	17 926
Estimated émigrés[c]	1044
Calculated active ABP pathologists in USA	16 657
Estimated non–board-certified active pathologists	+1254
Calculated total active pathologists in USA, to April 2010	= 17 911
Calculated total active pathologists in USA, at December 2010	17 986

Abbreviations: ABP, American Board of Pathology; CAP, College of American Pathologists; USA, United States of America.

[a] Includes retirees and persons living abroad, including Canada (courtesy of American Board of Pathology).

[b] Assumes the same ratio of retirees to total members less residents for ABP and CAP.

[c] Estimates a 2-fold higher rate than for the 2.95% who become CAP members.

Annual Additions to Workforce

Residents.—In 1926, there were few (approximately 10) training programs in pathology in the United States. This grew dramatically from the early 1940s to 1963 when there was a maximum of approximately 700 programs. Creation of the Residency Review Committee at ACGME at that time

led to a sharp decline, commonly through consolidation, to approximately 150 programs in 2000. The number of programs then stabilized, although we understand that some smaller programs are considering termination with the current harsh economics. The maximum number of residents in all programs collectively was approximately 3600 in 1971. After a dip in the 1980s, a second peak occurred in about 1994 with 3200 residents,[23] tapering off since about 2005 to today's level of approximately 2400 positions (for 2013, there are 583 openings of which 562 are filled for a 4% vacancy rate) (S.B-S., from NRMP, written communication, March 2013).

We estimate that of 626 residents matriculating in 2006, only approximately 570 would complete their 3-year AP or CP program in 2009 or 4-year AP/CP program in 2010. This 9% dropout is due to a change of program type, dismissal, withdrawal, etc, across the 4 years. Approximately 2.0% drop out between years 1 and 2; approximately 4.7%, between years 2 and 3; and the remainder (2.3%), later.

Fellows.—There are currently 954 ACGME-accredited fellowship positions in the United States (Table 3); 717 are filled.[12,18] We have no information on nonaccredited programs. This is well in excess of the estimated 570 pathology residents graduating per year. Selective pathology is the largest group (153 filled); this includes a host of general surgical pathology fellows or fellows in general pathology with an emphasis on a subspecialty, for example, gastrointestinal pathology. Specific specialties with filled positions are cytopathology (138 fellows), hematopathology (135 fellows), and dermatopathology (84 fellows). Overall occupancy of these fellowship programs is 75%, ranging from a high of 88% in hematopathology to a low of 49% in pediatric pathology. Development of ACGME-accredited informatics fellowships has only been announced recently.

The surplus of available positions is explained in part by the multiplicity of fellowships taken by a substantial minority of graduating residents. From the number of graduates from basic AP/CP programs and their declared fellowship intent, we estimated that the average resident will extend training with fellowships for an additional 1.2 years, reflecting the algebra of supernumerary fellowship enrollments. Nearly all fellows, including those in ACGME-accredited programs, will provide some, but variable, degrees of patient care, and very likely, most in non-ACMGE programs will actually function for a portion of the year in a junior staff capacity. However, the net addition of FTE effort was considered as not significantly affecting the overall available workforce, as the additional FTE effort from this professional pool is likely to remain stable.

Presently, 41% of the currently filled 84 ACGME-approved dermatopathologist fellow positions include fellows who trained initially as dermatologists (direct survey), a percentage that is slightly lower than all practicing dermatopathologists, including those trained in past years.[24] This potential new FTE pool has not been included in the workforce model, as the percentage effort ultimately devoted to dermatopathology is unknown. Their contribution to both supply and demand is presumed to remain as at present.

Subtractions From the Workforce

Emigration.—Based on an estimated 570 graduates from AP/CP or AP or CP programs annually, with 33% matriculating from international medical schools,[12] and 20% subsequently out-migrating,[20] we calculate that about

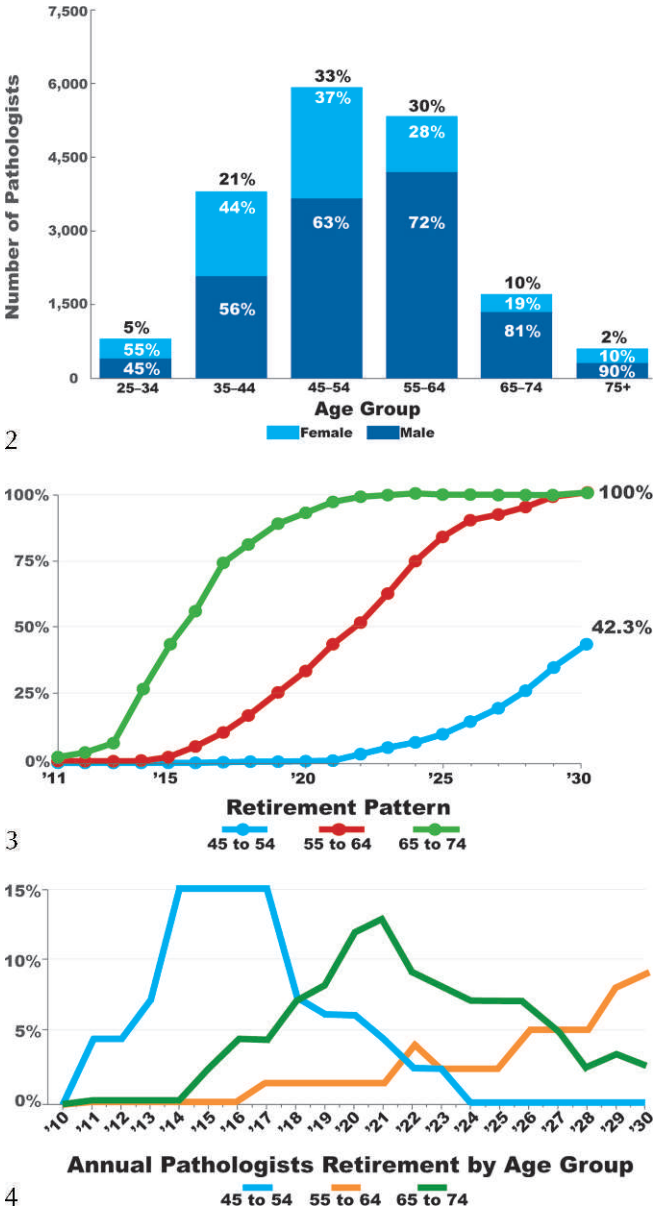

Figure 2. *Age and sex distribution of pathologists in the US workforce (2009–2010).*

Figure 3. *Pathologist retirement patterns across age groups from 2010 projected through 2030.*

Figure 4. *Pathologist retirement patterns across age groups. Low retirement after 2027 is caused by few pathologists in older groups left to retire, and pathologists in the younger groups having just begun to retire.*

6.5% (approximately 37) of residents will leave the United States annually.

Retirement.—Currently, 94% of pathologists work full time. The average age at which pathologists reported they planned to retire is at 66.5 years, which is nearly 5 years later than 20 years ago.[22] Many shift to part-time work 2.7 years earlier (at age 63.8 years) (Figure 3). During recent times, pathologists older than 55 years have reported their planned retirement age will rise by about 4 years from age 67 to 71 years. Based on the latter retirement age for the groups 45 to 54 and 55 to 64 years of age, by 2015 the number retiring will rise to about 470 per year, peak at about 810 in year

Table 3. ACGME-Approved and Filled Pathologist Fellowship Positions (2012–2013)[a]				
Programs 2012–2013	No. of Programs	Filled Positions	Approved Positions	Vacancy, %
Hematopathology	85	135	154	12
Molecular genetic pathology	34	45	53	15
Cytopathology	92	138	167	17
Selective pathology	69	153	187	18
Dermatopathology	54	84	105	20
Blood bank/transfusion medicine	48	51	79	35
Neuropathology	33	42	72	42
Microbiology	13	10	19	47
Forensic pathology	34	39	76	49
Pediatric pathology	27	19	39	51
Chemical pathology	2	1	3	67
Pathology informatics	New			
Total	**143**	**717**	**954**	**25**

Abbreviation: ACGME, Accreditation Council for Graduate Medical Education.

[a] Courtesy of Linda Thorsen, MA, executive director for the ACGME, Pathology Residency Committee.

2021, and then decrease, but even by 2030, the anticipated separations will still exceed the workforce additions by almost 50% (a deficit rate of 264 per year).

After 2025 there is some fluctuation in the rates of pathologist retirement, owing in part to the currently older pathologists having completed their retirement, to pathologists between 55 and 64 years of age having largely retired, while with some uncertainty those currently aged 45 to 54 years will just have begun their retirement (Figure 4).

From the planned retirement patterns, approximately 4700 pathologists will leave the workforce during 2010–2020; and an additional 5700 pathologists, between 2021 and 2030.

Special Considerations

Sex.—With time, women have increasingly chosen careers in pathology. The percentage of women occupying positions in US pathology residency training programs was 46% in 2002–2003, and has been between 49% and 53% since 2004. These figures are dramatically higher than the 14% reported from Canadian programs in 1981[25] and the "high teen" range reported in the early 1990s from academic health centers in the United States.[11]

Maternity leave averaged 14.5 weeks. Approximately 4/5 of men younger than 44 years took paternity leave, but for a shorter duration, generally about 2 to 4 weeks. Once through residency training and in practice, during the childbearing years, the overall average working hours spent by women in the age category of 44 years or younger was slightly lower than for men (49.2 hours/week versus 51.0 hours/week, respectively), but was slightly greater for women among pathologists aged 45 years or older (49.3 hours/week versus 48.7 hours/week, respectively). The variables of family leave and differences of hours worked, being determined as having a low impact on the FTE supply of pathologists, were excluded from the model.

Pathologists' Assistants (Pathology Extenders).—Similar to all specialties constituting medicine, PAs enable pathologists to provide patient care more efficiently. Currently, 62% of PAs have baccalaureate or masters of science degrees. About 41% work in community hospitals, 26% with private groups, and 24% in AHCs. Ninety-six percent of PAs are involved in preparation of smaller pathology specimens and grossing of larger specimens. Additional activities include preparation of specimens for frozen section analysis (67% of PAs) and supporting ancillary functions (photography, 80% of PAs; biorepository activities, 23% of PAs). On a daily basis, the typical PA spends most time on performing gross examination (5 hours), autopsy prosection (½ hour), and supervision (1 hour) among other services. In AHCs, PAs, by assisting in grossing, also help residents from exceeding their allowable duty hours.

The central tendency of PA work effort was 41 to 45 hours per week (46% of all PAs), 31 to 40 hours per week (31% of all PAs), and 46 to 50 hours per week (13%). Five percent each were at the extremes.

The programs leading to certification by the Board of Certification of the ASCP currently graduate a net of about 104 PAs a year, which has been constant for some years, although this may well change in the future. This number includes the net number leaving the field each year as dropouts or through retirement. The higher counts noted earlier reflect grandfathering of an additional 134 PAs in 2007 and 158 PAs in 2008. Through 2010, we estimate there are 1441 certified PAs.

In addition, many PAs are noncertified: some trained before certification began. Others are PAs who have limited responsibilities and have chosen not to become certified. From surveys, we estimate there are slightly more than 3000 noncertified PAs, that is, about twice as many as the certified group.

From the PCS-2011, a single PA can effectively support about 4 to 6 pathologists, depending on the type of practice and assigned duties (AHC, 0.18 PA per pathologist; core laboratory, 0.17 PA per pathologist; research laboratory, 0.10 PA per pathologist; and autopsy center, 0.45 PA per pathologist). The C4C indicates slightly higher ratios, with 1 PA supporting 3 to 4 pathologists.

PhD Holders (Clinical Scientists).—Based on the C4C-2010 survey only, there are 1028 PhD holders working in pathology laboratories for a ratio of about 1 PhD holder per 8 pathologists. We are unable to estimate the growth rate of PhD holders. From limited surveys, approximately 39% of their efforts are expended in clinical pathology, 19% in directing the medical laboratories, 15% signing out cases, 9% in applied clinical research, and the rest in providing consultations, biorepository management, and to a lesser extent, in teaching and research.

Modeling

The first prediction of our model is a major "retirement cliff" showing first in 2015, with the retirees exceeding the

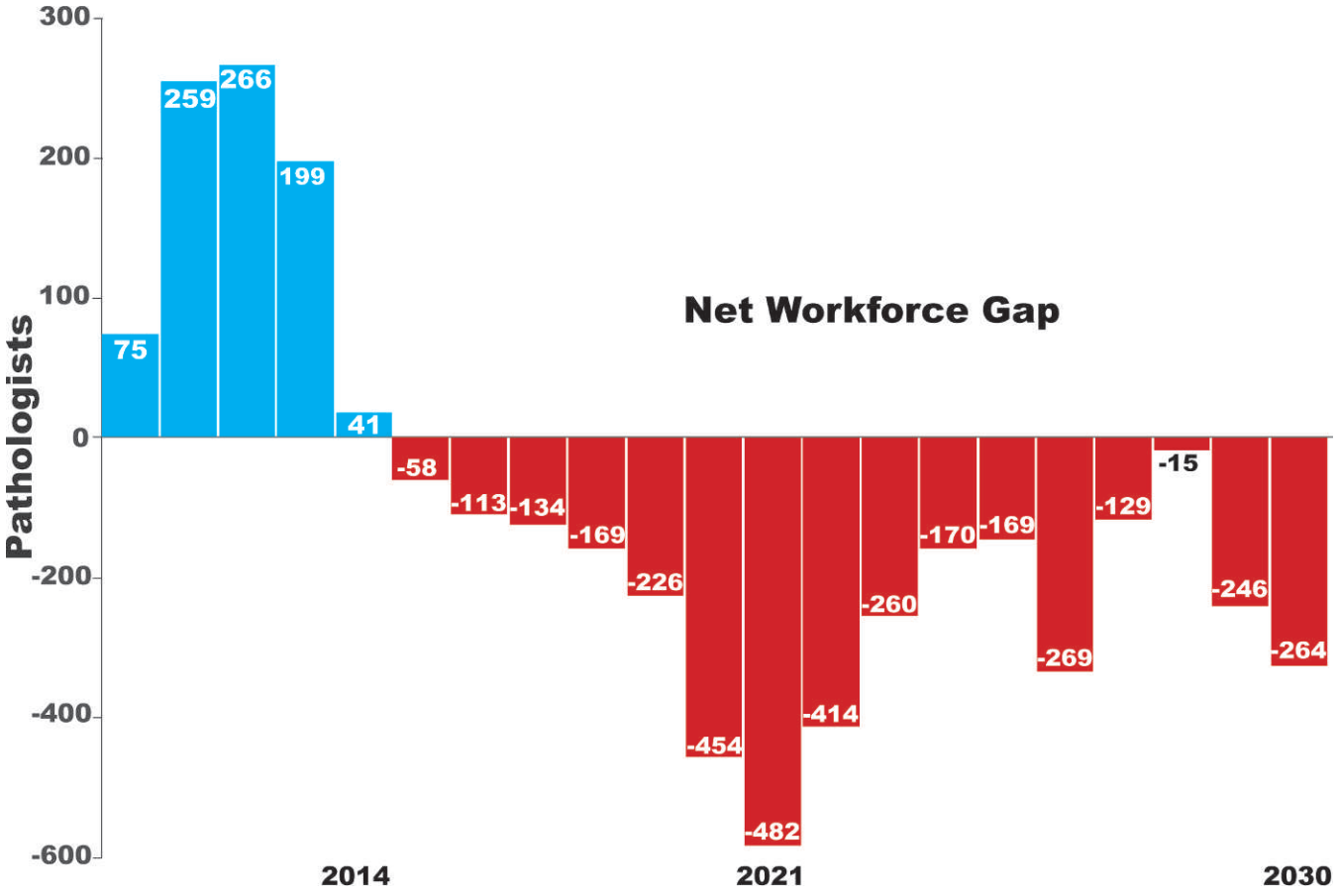

Figure 5. *Net changes to pathologist workforce (headcount), based on year-to-year additions to the workforce less withdrawals/retirements. It does not include the anticipated additional numbers needed due to changes in demand, that is, from population growth and other factors (see Figure 6).*

number of pathologists entering the workforce throughout the extent of this model (Figure 5).

Using all of the data given above, the assumptions derived from our work, and presuming no intervening changes in workforce supply, the second prediction of our model is that our discipline's workforce will begin to fall within the next 2 years, and by the year 2030 it will have dropped by an FTE count of approximately 3500 to just shy of 14 000 (3.74 per 100 000 population), presuming no intervening changes occur.

Working with just the supply side of the model, altered projections can be forecasted from supply-side scenarios. The key variable is funding of US allopathic pathology residency training positions. If for example, the overall funding to support pathology residency programs is cut and 10% of the positions are transferred permanently to programs in other specialties, the overall pathologist FTE count will fall to about 10 550 by 2030.

The third prediction of our model considers that the demand for pathologist FTE effort will not remain constant over time, but will increase. Based simply on population growth and medical usage by an aging population in the United States, the number of FTE pathologists required by 2030 will increase substantially to nearly 20 000 in absolute numbers (5.29 per 100 000 population), leading to a projected gap of about 5700 pathologists by the year 2030 (Figure 6). Filling this gap will require a total of 8.1% new residency training positions per year starting immediately. If the goal were simply to maintain the supply of pathologists in 2030 at the same level as in 2010, a 5.5% year-on-year growth of residency positions would be required from 2013 to 2030. These demand-side considerations will be reported in a separate forthcoming article.

COMMENT

Pathologists are central to bringing the understanding of disease and disease mechanisms to bear on patient

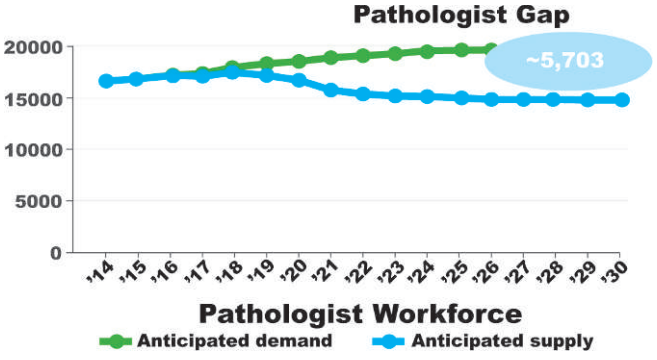

Figure 6. *The gap in pathologist workforce between supply available and numbers needed is widening continuously, in part owing to additional demand factors.*

diagnosis and management. The CAP, as part of a long-range vision to help transform its specialty and prepare for the future, undertook a comprehensive survey of pathology workforce supply and demands and population needs in the United States, with the goal of developing a dynamic modeling tool that could be easily updated, and be sufficiently flexible to predict pathologist needs in any particular subspecialty area.

With our model, we have been able with some precision to address specific concerns about the workforce. Of the 36 specialty groups tracked by the AAMC, pathologists have the second highest percentage of active practitioners aged 55 or older.[21] The pathologist retirement cliff, forecast earlier,[26] is beginning. The pathology residents trained in the 1970s have practiced for some 40 years and are now beginning to retire; current training programs are insufficient to make up the shortfall. With new technologies and other new areas of endeavors opening, the coming demand for pathologist services will greatly exceed the supply. Based on a diminished supply and taking into account a greater demand based solely on general US population growth with a greater portion of the population reaching senior years, our analysis forecasts that a substantial gap will develop, upwards of 30% of the available supply relative to estimated demand for pathologists' services.

Strengths

There are multiple strengths to this study. Studies of the pathology workforce supply have been projected before, but not at this level of detail. The studies reported earlier,[10,11] while large in scope, were unable to comprehensively survey the entire specialty. Our study tried to account for and quantify as many variables as possible that are associated with the pathologist workforce supply, including (1) additions to the workforce in terms of residents, fellows, and IMGs; (2) separations from the workforce in the form of retirement, death, and emigration; and (3) the supply of extenders (PAs and PhD holders). We also were able to identify variables which, while present, were of much more limited influence (in particular, work effort as a function of sex or age). Building our model from previously available and primary research allowed us to be explicit in our methodology and made our model more robust.

Limitations

Despite best attempts, there are limitations to this study. Some data gaps outlined below hopefully can be improved in future studies.

Number of Non–Board-Certified Pathologists.—From limitations of available data, we estimate that about 7% (1254) of active pathologists are not ABP board certified. Further work is needed to determine if this is an accurate estimate for the United States, and why the rate is this high. Questions include: What numbers represent MD clinicians, most likely board certified in other specialties, who are working in blood banking or transfusion medicine, clinical laboratories, or in other specialized fields of pathology such as microbiology? What numbers are trained pathologists who never obtained board certifications and are now working in academic health centers or in the research industry in administrative or scientific positions? Of a greater health care concern, are licensed physicians who have failed the ABP certifying examinations practicing as pathologists, possibly in physician-owned in-office laboratories, where the prerequisite of certification could be left to the discretion of the owners of the practice?

Entry to the Workforce of Dermatopathologists From Dermatology.—Annually, about 34 dermatologists complete their training to become dermatopathologists. We cannot assess what workforce contribution this group brings, without a better understanding of what portion of their effort is subsequently devoted to practice as dermatopathologists, and what percentage of their work is derived from their own or their immediate group's practice as dermatologists.

In-Office Laboratory.—The in-office anatomic pathology laboratory, that is, "pod labs," about which we have few data, is a sensitive issue that has been under a cloud of regulatory and legal agency review. The more common areas involve dermatopathology, gastrointestinal pathology, and uropathology. While we do know that the pathology services provided for these laboratories are often done by board-certified pathologists, we do not know to what extent. Few practices are willing to reveal details of their operations or finances, but their advertisements indicate clearly they are thriving. Highly sensitive details needed to relate these practices to the workforce model would include volumes of specimens generated and time spent by pathologists in these practices.

International Medical Graduates.—International medical graduates comprise a substantial portion of pathology trainees and subsequently the workforce. With current visa rules, it is unclear what proportion of IMGs who come for purposes of residency training are required by law to return to their home countries, and what proportion ultimately return to join the permanent workforce. With the global economy changing currently, we also do not know how many IMGs in the workforce later decide to permanently leave the United States and seek employment in another country. Information specific to pathology residency is not captured by the information sources known to us. We have based our model on research,[20] which states a 20% rate, but caution that the authors' statement is not referenced by any independent data and cannot be verified.

Availability of information was also limited for international pathologists who completed their residency training in other countries and have migrated to the United States for pathology practice. Our model has a placeholder for this variable.

Pathologists' Assistants.—Pathologists' assistants play a critical role in the functioning of today's pathology laboratories and for that reason were included in this analysis of pathologist workforce supply. The word "extender" is used purposefully. While PAs can be seen to some extent as replacing certain work that the pathologist might otherwise do, to a large extent, they extend what pathologists perform, and are essential as the requirements for a comprehensive examination of a specimen become far more complex. For example, in the 1960s, the usual workup of a breast lumpectomy specimen consisted of 1 or 2 slides being prepared from the tumor mass, and possibly a slide or 2 of the nontumorous region and a closest margin. Today, the same specimen workup routinely incorporates specimen radiographs, gross photographs, extensive inking, detailed correlation maps made of the gross findings and radiologic findings, fixing of the entire specimen in formalin, blocking and mapping the entire specimen for microscopic examination (requiring often 25 to 60 blocks), and preparing key areas for the biorepository. All of this requires substantial

work. All of these procedures require substantial time and effort, and explains the pathologist–pathologists' assistant partnership in dealing with the new world of complexity. In this analysis, we have examined the ratio of anatomic pathologists to pathology extenders, but we are unable to measure precisely what work the pathologist does that is actually replaced by the pathology assistant.

PhD Holders (Clinical Scientists).—Clinical scientists with PhD degrees participate integrally in the operation of the laboratory. A detailed study, like ours done for pathologists, is needed to analyze this segment of the workforce, including its various training programs.

SUMMARY AND THE FUTURE

As medicine rapidly changes, we see rapidly evolving demands for pathology services. In part, some of the services will be related to a larger population and also to the aging of so-called baby boomers, whose health care needs will significantly add to an already stressed health care system. In addition to areas now covered, we foresee the introduction of new and enhanced services, including genomic (precision) medicine and bioinformatics, outcome assessment/utilization management, in vivo microscopy, biorepository management, preventative health management, and provider consults. Our analysis shows that current numbers of pathologists completing training programs are substantially inadequate to compensate for the numbers of pathologists retiring in the next decade and a half. There is also great concern about the recent closure of several training programs, lack of funding for current seats, and health care reform that might broadly cut financial support for medical education, affecting all specialties including pathology.

The model we have developed provides a robust tool to analyze and quantify workforce data from which thoughtful decisions can be made. The model's supply-side analysis displays the variables that have been considered, which are critical, and how they could be changed to assure sufficiency of the pathologist workforce. The companion report on the demand side will analyze current specialty and subspecialty needs, and explore workforce demand as new testing modalities are introduced and new forms of testing are integrated into patient care.

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Note: Several references are published yearly, but the URL is listed generally only once. The ACGME annual *Data Resource Book* from 2002–2007 is available only in print; volumes thereafter are available only in electronic form.

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