

The ACGME Duty Hour Standards and Board Certification Examination Performance Trends in Surgical Specialties

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Abstract

Background Duty hour limitations initiated by the Accreditation Council for Graduate Medical Education (ACGME) in 2003 could improve resident education in surgical specialties.

Objective The purpose of this study was to evaluate national surgical board examination performance and its relationship to the ACGME duty hour standards.

Methods In this retrospective cohort study, electronically published website content was evaluated for examination statistics for the 10 surgical boards in the American Board of Medical Specialties. To evaluate examination trends over time, we performed simple linear regression. We also performed interrupted time series analyses, using segmented logistic regression. The secondary analyses consisted of a χ^2 test of passing and failing examinees before and after 2003. All statistics used $\alpha = .05$.

Results There were 8 of 10 (80%) surgical boards with examinations that met inclusion criteria and a total of 72 482 unique examination results. Of the 16 examinations evaluated (50% written, 50% oral), 13 (81%) had either significant pass rate trends on regression analyses and/or a significant pre-post pass rate surrounding the initiation of the ACGME duty hour standards in 2003 in the secondary analysis ($P < .05$).

Conclusions There are both increasing examination pass rates and some downward trends in examination performance on surgical board examinations since the initiation of the ACGME duty hour standards in 2003. The etiology of these trends is unclear, but trends are important to know for individual examinees, residency training programs, and surgical boards.

Introduction

In July 2003, the Accreditation Council for Graduate Medical Education (ACGME) implemented the residency duty hour standards. Part of the rationale for limiting resident duty hours was the relationship between sleep and the quality of resident education. It was believed that duty hour limitations would enhance resident education.^{1,2} In surgical specialties, studies have shown the limits have improved resident attitudes regarding educational activities in surgical specialties; the limitation of duty hours has allowed for more independent content reading, literature review, conference preparation, and a sense of improvement in the effectiveness of the didactic curriculum.^{3,4}

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However, there are few studies evaluating the long-term impact of the ACGME duty hour standards on resident educational outcomes, including standardized test performance. The most comprehensive review of the literature identified 10 studies in surgical subspecialties evaluating performance on standardized tests, using a pre-post design comparison.⁵ Studies reported regional data or findings from single institution studies. In 1 study, intern performance on the American Board of Surgery In-Training Examination (ABSITE) improved in basic science, clinical management, and overall test scores. Second-year residents had higher basic science scores after the ACGME duty hour standards.⁶ In another study, performance on the ABSITE improved in the domains of basic science and overall test scores without a significant improvement in clinical management scores.⁷ For 6 of the remaining studies, board examination performance remained stable, and for 2 studies it declined after the implementation of the duty hour limits. There is a paucity of evaluation of standardized test performance at the national level with the exception of 1 study showing a recent decreasing trend in performance on the American Board of Surgery (ABS) Certifying Examination.⁸

The goal of this study was to describe the physician examinee performance trends on surgical specialty certifying examinations retrospectively with respect to the implementation of the ACGME duty hour standards in 2003. With local and regional improvement and the potential benefit of duty hour limitations leading to improved physician education, the hypothesis is that physician examinees have demonstrated increasing pass rate trends on board certification examinations after the implementation of the ACGME duty hour standards.

Methods

In this retrospective cohort study, the 24 medical specialty boards composing the American Board of Medical Specialties (ABMS) were evaluated. The ABMS is the organization involved in the development and utilization of standards for the ongoing certification and recertification of physicians for 24 medical specialty boards.⁹ In the ABMS, there are 10 primary surgical boards.

For each surgical board, the publicly available board website content was explored for descriptive statistics on certifying examinations. Board newsletters and other electronic publications were included in the search for examination statistics. Examination statistics were also found in published peer-reviewed manuscripts. Specialty board examinations were included in the primary analysis if electronic data were present for any 3 consecutive years after 2003. Subspecialty examinations were excluded from the analysis. Each member board with an examination satisfying inclusion criteria was contacted and each board agreed that electronically published pass rates were able to be quoted and used for research purposes. When available, subgroup examination results were included for first-time examinees or repeated-attempt examinees. Independent double entry and calculation were performed to ensure the accuracy of the extrapolated data. Cross-checking and validation between separate references was performed.

The primary analysis consisted of regression analyses. Simple linear regression was performed by using the examination year as the independent variable and the pass rate as the dependent variable. This regression occurred from the 2003–2004 to the 2010–2011 academic years. When available, subgroup examination trends were evaluated for first-time examinees or repeated-attempt examinees. Examinations were considered to have statistically significant pass rate trends if the 95% confidence interval of the slope of the regression line did not include zero. Examinations with significant pass rate trends were plotted to visually show these trends over time. A Pearson

What was known

Supporters of duty hour standards expected improvements in residents' educational outcome measures following their implementation.

What is new

Analysis of publicly reported board certification data shows both positive and negative trends in board pass rates under the duty hour limits.

Limitations

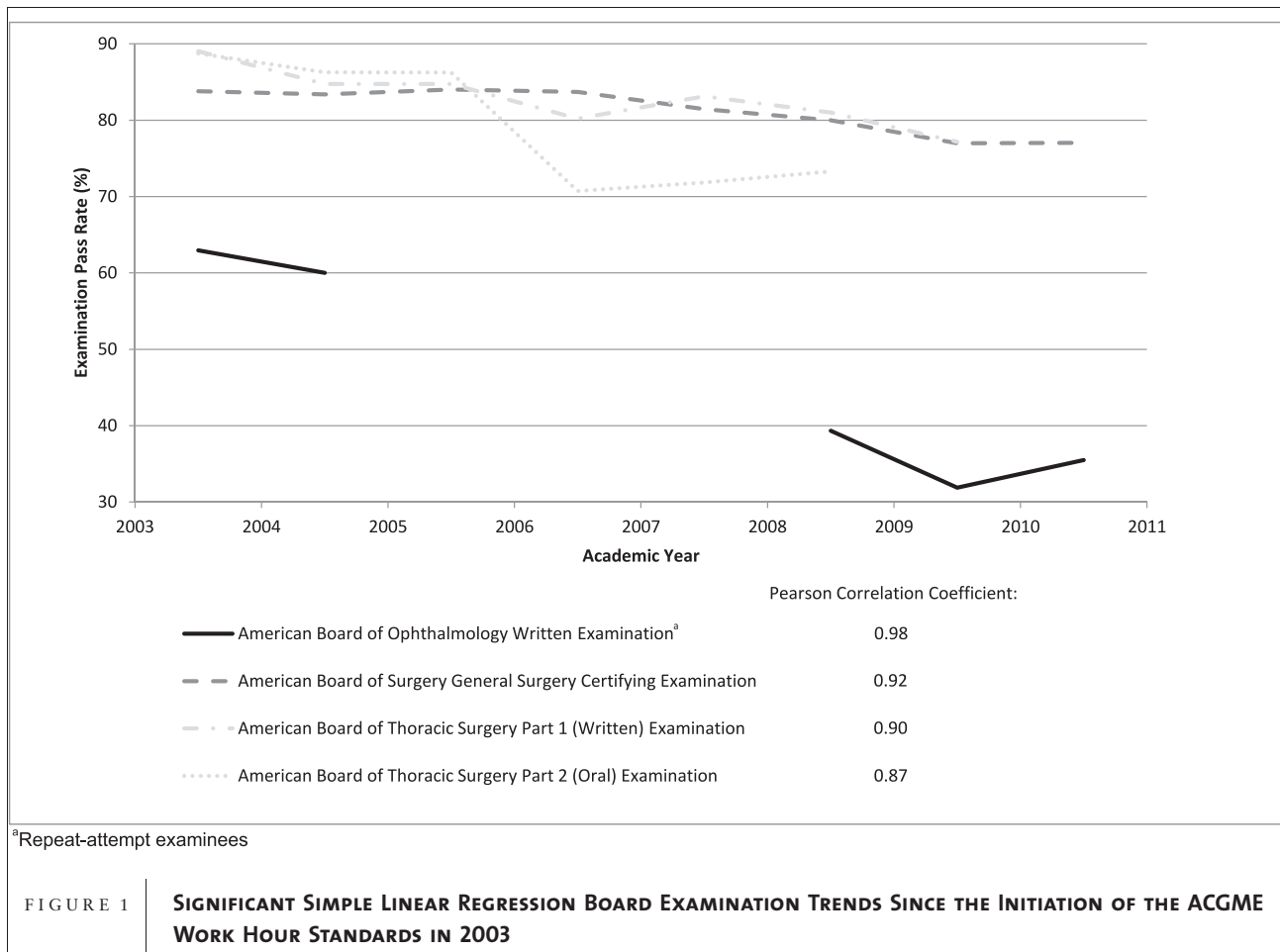
Lack of randomization, potential confounders, and missing data before 2003 complicates the analysis of trends.

Bottom line

Implementation of duty hour standards was associated with different trends in board examination performance across surgical disciplines. The results are relevant to examination preparation, curriculum development, and examination development.

correlation coefficient between pass rate and year was also performed for these examinations. To supplement the primary analysis, an interrupted time series using segmented logistic regression was performed to evaluate differences in pass rate trends leading to and subsequent to the ACGME duty hour standards.¹⁰ This method models the trend in pass rates before the introduction of standards and tests if the trend in pass rates will change after the standards are introduced.

The secondary analysis consisted of a pre-post design comparison of passing and failing examinee performance surrounding the initiation of the ACGME duty hour standards in 2003. The raw numbers of physician examinees that passed and failed each board-specific examination were obtained during data acquisition. Data were included between the 1995–1996 academic year and the 2010–2011 academic year; this time frame centers on the 2003–2004 academic year and the initiation of the ACGME duty hour standards. Board examinations were included in the secondary analysis if they satisfied criteria for primary analysis and if data were available before the 2003–2004 academic year. For each board examination that satisfied secondary analysis inclusion criteria, the total numbers of physician examinees that passed and failed before and after the initiation of the ACGME duty hour standards were compared with a $2 \times 2 - \chi^2$ test. An examination was considered to have statistically significant pass rate differences if the *P* value from the χ^2 test was $< .05$. All statistical tests were performed with Stata 11.1 statistical software (StataCorp LP, College Station, TX) except for the segmented logistic regression, which was performed with SAS version 9.2 (SAS Institute Inc, Cary, NC).



Abbreviation: ACGME, Accreditation Council for Graduate Medical Education.

Results

Of the 10 primary surgical boards of the ABMS, 8 specialty boards (80%) had at least 1 examination with publicly available electronic statistics satisfying the inclusion criteria: American Board of Neurological Surgery,^{11–20} American Board of Obstetrics and Gynecology,^{21–35} American Board of Ophthalmology,^{12–14,21,36} American Board of Orthopaedic Surgery,^{11,22–24,37–43} American Board of Plastic Surgery,^{11–13,24,44,45} American Board of Surgery,^{14,21–23,46–56} American Board of Thoracic Surgery,^{11,14,22,23,57} and American Board of Urology.^{12,13,21,24,58,59}

Physician examinee performance during the study period is given in TABLE 1. There were 16 unique board examinations that satisfied inclusion criteria. These included 8 (50%) written examinations and 8 (50%) oral examinations. Three (19%) of these examinations had first-time examinee performance and/or repeated-attempt examinee performance available for subgroup analysis. There was a total of 72 482 unique examination results that were included in the analyses, and the median number of

examinees per surgical board was 5031 (interquartile range [IQR], 3290–17 211).

Linear and segmented logistic regression results are given in TABLE 1. The simple linear regression analysis showed that 4 (25%) examinations had a linear regression line with a nonzero slope ($P < .05$). All 4 of these slopes were less than zero. Significant examination trends with the accompanying Pearson correlation coefficients are shown in FIGURE 1.

The segmented regression analyses showed that 7 (44%) examinations had a change in trajectory after the initiation of the ACGME duty hour standards. Four examinations had an upward deflection in trajectory, while 3 examinations had a downward deflection in trajectory. These 7 examination trends are shown in FIGURE 2.

The results of the secondary analyses are given in TABLE 1. There were significant differences in $2 \times 2 - \chi^2$ tests comparing passing and failing examinees before and after 2003 on 8 (50%) of the examinations. The magnitude and direction of the 8 statistically significant certifying

TABLE 1 EXAMINATION PASS RATE TRENDS BEFORE AND AFTER THE INITIATION OF THE ACCME WORK HOUR STANDARDS

| Board and Examinations | Year | | | | | | | | | | | | | | P Value ^a | P Value ^b | P Value ^c | | |
|---|--|------|------|------|------|------|------|------|------|------|------|------|------|------|----------------------|----------------------|----------------------|------------------|-------|
| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | | | 2009 | 2010 |
| | The American Board of Neurological Surgery | | | | | | | | | | | | | | | | | | |
| Written Examination | | | | | | | | | | | | | | | | | .89 | .08 | .84 |
| Pass (n) | ... | ... | ... | ... | ... | ... | 428 | 366 | 496 | 457 | 463 | 531 | 534 | ... | ... | ... | | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | 70 | 109 | 32 | 68 | 88 | 86 | 102 | ... | ... | ... | | | |
| Oral Examination | | | | | | | | | | | | | | | | | .97 | .88 | .06 |
| Pass (n) | ... | ... | ... | ... | ... | ... | 163 | 131 | 157 | 126 | 129 | 119 | 133 | ... | ... | ... | | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | 17 | 30 | 20 | 20 | 20 | 27 | 22 | ... | ... | ... | | | |
| The American Board of Obstetrics and Gynecology | | | | | | | | | | | | | | | | | | | |
| Principal Written Examination | | | | | | | | | | | | | | | | | >.99 | .03 ^d | .54 |
| Pass (n) | ... | ... | ... | ... | 1195 | 1214 | 1154 | 1075 | 1154 | 1125 | 1129 | 1070 | 1226 | 1164 | 1192 | ... | | | |
| Fail (n) | ... | ... | ... | ... | 415 | 389 | 361 | 426 | 371 | 415 | 442 | 474 | 385 | 402 | 338 | ... | | | |
| Principal Written Examination ^e | | | | | | | | | | | | | | | | | .74 | <.001 | <.001 |
| Pass (n) | ... | ... | ... | ... | 1106 | 1103 | 1037 | 989 | 979 | 995 | 981 | 941 | 988 | 1018 | 1012 | ... | | | |
| Fail (n) | ... | ... | ... | ... | 146 | 114 | 132 | 189 | 131 | 183 | 180 | 212 | 155 | 164 | 141 | ... | | | |
| Principal Oral Examination | | | | | | | | | | | | | | | | | .10 | .64 | .02 |
| Pass (n) | ... | ... | ... | ... | ... | 1214 | 1132 | 1119 | 1225 | 1050 | 1187 | 1067 | 1072 | 1056 | 1117 | 1074 | | | |
| Fail (n) | ... | ... | ... | ... | ... | 188 | 201 | 166 | 223 | 194 | 205 | 187 | 194 | 191 | 211 | 207 | | | |
| The American Board of Ophthalmology | | | | | | | | | | | | | | | | | | | |
| Written Examination | | | | | | | | | | | | | | | | | .50 | .34 | .001 |
| Pass (n) | ... | ... | ... | ... | ... | ... | 431 | 419 | 434 | 459 | ... | ... | ... | 459 | 435 | 454 | | | |

TABLE 1 CONTINUED

| Board and Examinations | Year | | | | | | | | | | | | P Value ^a | P Value ^b | P Value ^c | | | | | | |
|---|------|------|------|------|------|------|------|------|------|------|------|------|----------------------|----------------------|----------------------|------|------|------|------|-------|--|
| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | | | | 2007 | 2008 | 2009 | 2010 | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | 227 | 209 | 202 | 184 | ... | ... | ... | 160 | 193 | 179 | | .54 | N/A | N/A | |
| Written Examination ^e | | | | | | | | | | | | | | | | | | | | | |
| Pass (n) | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 389 | 399 | 394 | | | | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 52 | 80 | 70 | | | | | |
| Written Examination ^f | | | | | | | | | | | | | | | | | | <.01 | .98 | <.001 | |
| Pass (n) | ... | ... | ... | ... | ... | ... | 133 | 121 | 119 | 102 | ... | ... | ... | 70 | 36 | 60 | | | | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | 73 | 81 | 70 | 68 | ... | ... | ... | 108 | 113 | 109 | | | | | |
| Oral Examination | | | | | | | | | | | | | | | | | | .72 | .03 | <.001 | |
| Pass (n) | ... | ... | ... | ... | ... | ... | 456 | 437 | 410 | 314 | ... | ... | 215 | 422 | 428 | 457 | | | | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | 85 | 55 | 83 | 84 | ... | ... | 51 | 88 | 121 | 104 | | | | | |
| Oral Examination ^e | | | | | | | | | | | | | | | | | | .56 | N/A | N/A | |
| Pass (n) | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 185 | 355 | 363 | 361 | | | | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 38 | 70 | 95 | 78 | | | | | |
| Oral Examination ^f | | | | | | | | | | | | | | | | | | .48 | N/A | N/A | |
| Pass (n) | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 30 | 67 | 65 | 96 | | | | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 13 | 18 | 26 | 26 | | | | | |
| The American Board of Orthopaedic Surgery | | | | | | | | | | | | | | | | | | | | | |
| Part I (Written) Examination | | | | | | | | | | | | | | | | | | .51 | .01 | <.001 | |
| Pass (n) | ... | ... | ... | ... | 616 | 607 | 637 | 628 | 645 | 590 | 647 | 641 | 610 | 643 | 628 | ... | | | | | |
| Fail (n) | ... | ... | ... | ... | 162 | 182 | 168 | 132 | 92 | 113 | 94 | 87 | 105 | 76 | 151 | ... | | | | | |

T A B L E 1 CONTINUED

| Board and Examinations | Year | | | | | | | | | | | | P Value ^a | P Value ^b | P Value ^c | | | | |
|--|------|------|------|------|------|------|------|------|------|------|------|------|----------------------|----------------------|----------------------|------|------|-------|------|
| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | | | | 2007 | 2008 | 2009 | 2010 |
| Part II (Oral) Examination | | | | | | | | | | | | | | | | | .96 | .13 | .846 |
| Pass (n) | ... | ... | ... | 639 | 621 | 631 | 563 | 594 | 645 | 593 | 596 | 584 | 621 | 602 | ... | ... | | | |
| Fail (n) | ... | ... | ... | 75 | 104 | 76 | 52 | 104 | 52 | 63 | 66 | 85 | 74 | 78 | ... | ... | | | |
| The American Board of Plastic Surgery | | | | | | | | | | | | | | | | | | | |
| Written Examination | | | | | | | | | | | | | | | | | .06 | <.001 | .40 |
| Pass (n) | 236 | 222 | 358 | 225 | 186 | 190 | 177 | 178 | 191 | 195 | 189 | 207 | 204 | 195 | 201 | 201 | | | |
| Fail (n) | 46 | 38 | 62 | 40 | 56 | 51 | 53 | 36 | 46 | 48 | 48 | 44 | 39 | 35 | 33 | 33 | | | |
| Oral Examination | | | | | | | | | | | | | | | | | .70 | .27 | .14 |
| Pass (n) | 194 | 220 | 205 | 358 | 227 | 182 | 173 | 169 | 162 | 198 | 180 | 189 | 209 | 164 | 178 | 178 | | | |
| Fail (n) | 57 | 48 | 40 | 60 | 52 | 54 | 33 | 40 | 41 | 43 | 49 | 41 | 47 | 46 | 43 | 43 | | | |
| The American Board of Surgery | | | | | | | | | | | | | | | | | | | |
| General Surgery Qualifying Examination | | | | | | | | | | | | | | | | | .94 | .02 | .35 |
| Pass (n) | ... | ... | ... | ... | ... | 1017 | 964 | 993 | 999 | 985 | 972 | 1010 | 989 | 1022 | 1102 | 1102 | | | |
| Fail (n) | ... | ... | ... | ... | ... | 270 | 321 | 275 | 288 | 262 | 296 | 283 | 272 | 340 | 276 | 276 | | | |
| General Surgery Certifying Examination | | | | | | | | | | | | | | | | | .001 | .48 | .08 |
| Pass (n) | ... | ... | ... | ... | ... | 969 | 983 | 1019 | 1044 | 1093 | 1089 | 1027 | 1032 | 882 | 869 | 869 | | | |
| Fail (n) | ... | ... | ... | ... | ... | 199 | 201 | 197 | 208 | 208 | 212 | 234 | 258 | 264 | 259 | 259 | | | |

| T A B L E 1 | | CONTINUED | | | | | | | | | | | | | | | | | | |
|--|------|-----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|----------------------|----------------------|----------------------|--|
| | | Year | | | | | | | | | | | | | | | | | | |
| Board and Examinations | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | P Value ^a | P Value ^b | P Value ^c | |
| | | | | | | | | | | | | | | | | | P Value ^a | P Value ^b | P Value ^c | |
| The American Board of Thoracic Surgery | | | | | | | | | | | | | | | | | | | | |
| Part 1 (Written) Examination | | | | | | | | | | | | | | | | | <.01 | .98 | .15 | |
| Pass (n) | ... | ... | ... | ... | ... | ... | 155 | 133 | 146 | 139 | 139 | 142 | 133 | 111 | 98 | ... | | | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | 23 | 22 | 18 | 25 | 25 | 35 | 27 | 26 | 29 | ... | | | | |
| Part 2 (Oral) Examination | | | | | | | | | | | | | | | | | .03 | .03 | <.001 | |
| Pass (n) | ... | ... | ... | ... | ... | ... | 162 | 117 | 150 | 113 | 138 | 116 | 125 | 118 | ... | ... | | | | |
| Fail (n) | ... | ... | ... | ... | ... | ... | 9 | 21 | 19 | 18 | 22 | 48 | 49 | 43 | ... | ... | | | | |
| The American Board of Urology | | | | | | | | | | | | | | | | | | | | |
| Qualifying Examination | | | | | | | | | | | | | | | | | .08 | .15 | <.001 | |
| Pass (n) | 263 | 256 | 270 | 290 | 249 | 377 | 270 | 252 | 263 | 269 | 244 | 259 | 246 | 267 | 256 | 271 | | | | |
| Fail (n) | 56 | 80 | 68 | 62 | 96 | 77 | 59 | 55 | 54 | 30 | 34 | 26 | 32 | 27 | 27 | 30 | | | | |
| Certifying Examination | | | | | | | | | | | | | | | | | .96 | <.001 | <.001 | |
| Pass (n) | 252 | 244 | 261 | 247 | 290 | 288 | 262 | 245 | 255 | 249 | 211 | 257 | 249 | 233 | 233 | 237 | | | | |
| Fail (n) | 74 | 69 | 55 | 58 | 47 | 43 | 15 | 36 | 25 | 13 | 16 | 26 | 22 | 18 | 16 | 21 | | | | |

Abbreviations: ACGME, Accreditation Council for Graduate Medical Education; N/A, not applicable.

^a Result of a simple linear regression analysis testing for a nonzero slope from 2003–2011.

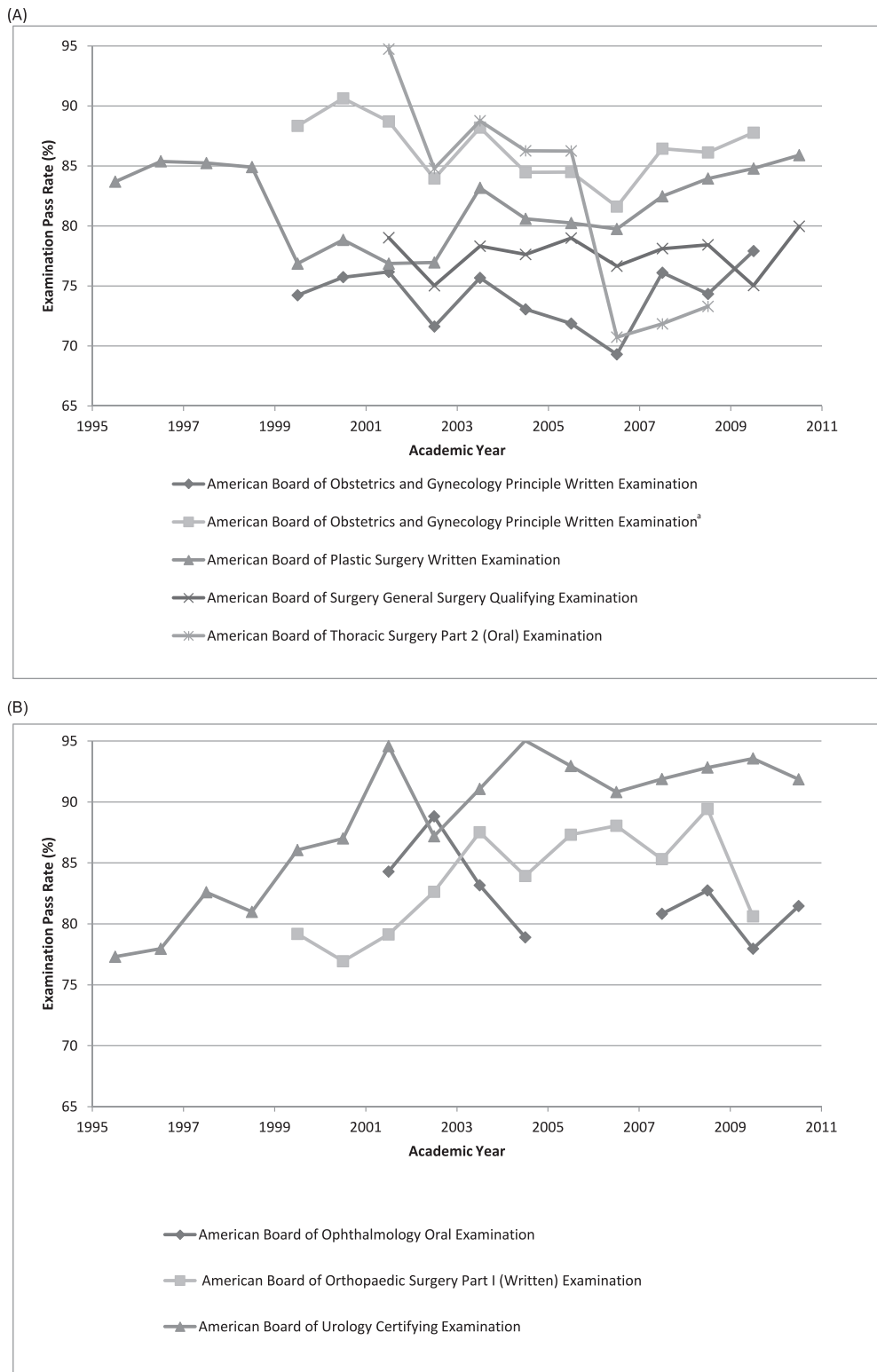
^b Result of segmented regression analysis testing during the study period.

^c Result of a χ^2 test of passing and failing examinees between 1993–2002 and 2003–2011.

^d Bolded values signify $P < .05$.

^e First-attempt examinees.

^f Repeated-attempt examinees.



^aFirst-attempt examinees

FIGURE 2

SIGNIFICANT INCREASING (A) AND DECREASING (B) SEGMENTED REGRESSION BOARD EXAMINATION TRENDS SURROUNDING THE INITIATION OF THE ACGME WORK HOUR STANDARDS IN 2003

Abbreviation: ACGME, Accreditation Council for Graduate Medical Education.

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examinations are presented in TABLE 2. Secondary analyses showed that there were 5 examinations with lower pass rates after 2003 and 3 examinations with higher pass rates after 2003. The median absolute difference in pass rates was 7.6% (IQR, 4.7%–9.4%).

Overall, there were 13 (81%) examinations that had either a significant pass rate trend on regression analyses and/or a significant pre-post pass rate surrounding the initiation of the ACGME duty hour standards in 2003 in the secondary analysis ($P < .05$). The American Board of Thoracic Surgery Part 2 (Oral) Examination had decreasing results on the simple linear regression analysis, segmented regression analysis, and χ^2 analysis ($P < .05$).

Discussion

Our findings show that most certifying examinations had either a significant pass rate trend since 2003 on regression analyses and/or a significant pre-post pass rate surrounding the initiation of the ACGME duty hour standards in 2003. However, none of the data from the simple linear regression analyses satisfied our study hypothesis that duty hour limits would improve performance on the surgical certification board examination. On the contrary, data for 4 certification board examinations showed significant decreasing rate trends since 2003 on simple regression analysis. All of these trends are fairly consistent, with Pearson correlation coefficients > 0.80 . The decrease on the ABS General Surgery Certifying Examination is consistent with the findings of a prior study.⁸ That study examined 2006–2010, evaluating only first-time examinees, and did not use linear regression.

Segmented regression is an excellent method to evaluate outcomes after an intervention.¹⁰ This method of regression evaluates the deflection in performance in the setting of established trends. For example, the 4 examinations in FIGURE 2A have upward deflections after the initiation of the ACGME duty hour standards. These examinations, while not having significant positive slopes on simple linear regression, do show a clear change in trend after 2003. These examinations, therefore, are consistent with the study hypothesis, as the downward trends before 2003 were blunted after the initiation of the ACGME work hour standards. In FIGURE 2A, a notable visual difference in performance between all examinees and first-attempt examinees is seen in the American Board of Obstetrics and Gynecology Principal Written Examination. First-attempt examinees outperform the population of examinees that include repeated test-takers.

In FIGURE 2B, there are 3 examinations with downward deflections after the initiation of the ACGME duty hour standards in 2003. The American Board of Urology

Certifying Examination most notably shows an interesting phenomenon. The examination trends appear to be increasing before 2003. After 2003, the trend still increases, but at a decreasing rate. The ceiling of performance is theoretically 100%, but this examination shows a unique finding possible with segmented regression analyses that directly contrasts the χ^2 results. In contrast, the ABS Certifying Examination, while having a clear decreasing pass rate on linear regression, has a segmented regression that suggests there is no significant trend change since 2003. This suggests the downward trend started before 2003, and that it is unclear how this trend was affected by the ACGME duty hour standards. With missing data before 2003, some of the trends from the period before the implementation of the ACGME duty hour standards may not be representative.

There were 8 examinations with significantly different pass rates on secondary analysis. The pass rate changes are mixed. The increase in pass rates seen for the American Board of Orthopaedic Surgery Part I (Written) Examination and the American Board of Urology Qualifying Examination and Certifying Examination are consistent with our hypothesis. The temporal nature of these conclusions is also consistent. These changes, however, are not associated with linear changes in pass rates from the simple linear regression analysis. The decreases in pass rates seen in the secondary analyses are inconsistent with our hypothesis. Interestingly, the χ^2 analyses demonstrate some potential bias introduced by repeated-attempt examinees. While first-attempt examinees have higher performance after 2003, repeated-attempt examinees, in direct contrast, have lower performance after 2003 on the American Board of Ophthalmology Written Examination.

Overall, there was only 1 examination that was statistically significant on the simple linear regression analysis, the segmented regression analysis, and χ^2 analysis. The American Board of Thoracic Surgery Part 2 (Oral) Examination has a decreasing pass rate on simple linear regression since 2003, and in the segmented analysis, it has a pass rate that is lower after 2003, compared with data from earlier years.

The results of our study of national performance on surgical board certification examinations are consistent with the published literature of studies using data on local and regional performance. The most complete review of the literature on educational outcomes surrounding the initiation of the ACGME duty hour standards identified 9 studies assessing board examination performance in surgical specialties. Two studies reported an improvement in performance surrounding the initiation of the ACGME duty hour standards. Five studies showed no change, and 1 study found a decrease in standardized examination

TABLE 2 PASS RATE DIFFERENCES ON BOARD EXAMINATIONS SURROUNDING THE INITIATION OF THE ACGME WORK HOUR STANDARDS

| Medical Board and Examination | Before the ACGME Work Hour Standards | After the ACGME Work Hour Standards | Difference in Pass Rate |
|---|--------------------------------------|-------------------------------------|-------------------------|
| The American Board of Obstetrics and Gynecology | | | |
| Principal Written Examination ^a | 87.9 | 85.5 | -2.4 |
| Principal Oral Examination | 86.1 | 84.6 | -1.5 |
| The American Board of Ophthalmology | | | |
| Written Examination | 66.1 | 70.9 | 4.8 |
| Written Examination ^b | 62.2 | 47.3 | -14.9 |
| Oral Examination | 86.4 | 80.9 | -5.5 |
| The American Board of Orthopaedic Surgery | | | |
| Part I (Written) Examination | 79.4 | 86.0 | 6.6 |
| The American Board of Thoracic Surgery | | | |
| Part 2 (Oral) Examination | 90.3 | 79.2 | -11.1 |
| The American Board of Urology | | | |
| Qualifying Examination | 80.1 | 88.9 | 8.8 |
| Certifying Examination | 84.0 | 92.5 | 8.5 |

Abbreviation: ACGME, Accreditation Council for Graduate Medical Education.

^a First-attempt examinees.

^b Repeated-attempt examinees.

scores after the implementation of the duty hour standards.⁵

The segmented regression analyses and secondary analyses are more powerful from a statistical standpoint. The linear regression analyses can have only a maximum of 8 data points for seeing any linear trends in examination pass rates since 2003 and do not consider trends before 2003. In contrast, the segmented logistic regression analyses and secondary data analyses account for temporal relationships and for thousands of physician examinees across more years. Using multiple statistical approaches allows for a more robust evaluation of the data as opposed to any method alone.

Our study has several limitations. There was a considerable amount of missing data, particularly before 2003, and this makes it difficult to assess the impact of ACGME duty hour standards on the trajectory of pass rates with the segmented logistic regression and also limits conclusions that can be drawn from secondary analyses. Additionally, having first-attempt performance would make for a more homogenous sample, as including repeated-attempt examinee data adds bias to the examination results. If the data supported our study hypothesis, there would also be higher pass rates for repeated-attempt

examinees and total examinees. There is evidence that performance for repeated-attempt examinees has worsened since 2003, as demonstrated on the American Board of Ophthalmology Written Examination. Having a randomized prospective design would minimize the bias, but is not possible with board examination data. Finally, retrospective studies are more difficult for drawing cause-and-effect conclusions from the data. At the same time, the methods used in this study are the most appropriate way to show temporal differences surrounding the initiation of the ACGME duty hour standards.

The causes of the trends in board examination performance in the specialties in our study are unclear. Examinee performance is complex and can be affected by the quality of the candidates, improved surgical curricula, and the attractiveness of specialties. Trends in medical school applicants' grade point average, United States Medical Licensing Examination performance, and the competitiveness of surgical specialties represent an area that should be examined in future research in this domain.

Conclusion

Overall, the initiation of the ACGME duty hour standards has been associated with both positive and negative

changes in certifying board examination pass rates across surgical disciplines and in both the written and oral examinations. The results of this study are important for individual physician examinees, surgical training programs, and surgical boards. The findings may be relevant to examination preparation by individuals, curriculum development by training programs, and examination development by surgical boards.

References

- 1 Accreditation Council for Graduate Medical Education: *Duty Hours Subcommittee Report*. Chicago, IL: Accreditation Council for Graduate Medical Education; 2002.
- 2 Philibert I, Friedmann P, Williams WT; ACGME Work Group on Resident Duty Hours, Accreditation Council for Graduate Medical Education. New requirements for resident duty hours. *JAMA*. 2002;288(9):1112–1114.
- 3 Basu CB, Chen LM, Hollier LH Jr, Shenaq SM. The effect of the Accreditation Council for Graduate Medical Education Duty Hours Policy on plastic surgery resident education and patient care: an outcomes study. *Plast Reconstr Surg*. 2004;114(7):1878–1886.
- 4 Barden CB, Specht MC, McCarter MD, Daly JM, Fahey TJ III. Effects of limited work hours on surgical training. *J Am Coll Surg*. 2002;195(4):531–538.
- 5 Fletcher KE, Reed DA, Arora VM. Patient safety, resident education and resident well-being following implementation of the 2003 ACGME duty hour rules. *J Gen Intern Med*. 2011;26(8):907–919.
- 6 Schneider JR, Coyle JJ, Ryan ER, Bell RH Jr, DaRosa DA. Implementation and evaluation of a new surgical residency model. *J Am Coll Surg*. 2007;205(3):393–404.
- 7 Durkin ET, McDonald R, Munoz A, Mahvi D. The impact of work hour restrictions on surgical resident education. *J Surg Educ*. 2008;65(1):54–60.
- 8 Falcone JL, Hamad GG. The American Board of Surgery Certifying Examination: a retrospective study of the decreasing pass rates and performance for first-time examinees. *J Surg Educ*. 2012;69(2):231–235.
- 9 The American Board of Medical Specialties. American Board of Medical Specialties, 2006–2011. <http://www.abms.org>. Accessed May 3, 2011.
- 10 Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther*. 2002;27(4):299–309.
- 11 American College of Surgeons. Ten specialty boards report accomplishments and plans: part I. *Bull Am Coll Surg*. 2003;88(3):34–43. http://www.facs.org/fellows_info/bulletin/2003/boardspt10303.pdf. Accessed April 12, 2012.
- 12 American College of Surgeons. Ten specialty boards report accomplishments and plans: part I. *Bull Am Coll Surg*. 2004;89(3):24–32. http://www.facs.org/fellows_info/bulletin/2004/tenspecialty0304.pdf. Accessed April 12, 2012.
- 13 American College of Surgeons. Ten specialty boards report accomplishments and plans: part I. *Bull Am Coll Surg*. 2005;90(3):19–27. http://www.facs.org/fellows_info/bulletin/2005/tenspecialtyboards0305.pdf. Accessed April 12, 2012.
- 14 American College of Surgeons. Ten specialty boards report accomplishments and plans: part II. *Bull Am Coll Surg*. 2006;91(4):41–54. http://www.facs.org/fellows_info/bulletin/2006/tenspecialtyparttwo0406.pdf. Accessed April 12, 2012.
- 15 Day AL. *American Board of Neurological Surgery Newsletter*. No. 22. 2004. http://www.abns.org/content/newsletter_info_22_pr.asp. Accessed April 12, 2012.
- 16 Chandler WC. *American Board of Neurological Surgery Newsletter*. No. 23. 2005. http://www.abns.org/content/newsletter_info_23.asp. Accessed April 12, 2012.
- 17 Solomon RA. *American Board of Neurological Surgery Newsletter*. No. 24. 2006. http://www.abns.org/content/newsletter_info_24.asp. Accessed April 12, 2012.
- 18 Batjer HH. *American Board of Neurological Surgery Newsletter*. No. 25. 2007. http://www.abns.org/content/newsletter_info_25.asp. Accessed April 12, 2012.
- 19 Barrow DL. *American Board of Neurological Surgery Newsletter*. No. 26. 2008. http://www.abns.org/pdfs/newsletter_info_26.pdf. Accessed April 12, 2012.
- 20 Barrow DL. *American Board of Neurological Surgery Newsletter*. No. 27. 2009. http://www.abns.org/pdfs/newsletter_info_27.pdf. Accessed April 12, 2012.
- 21 American College of Surgeons. Ten specialty boards report accomplishments and plans: part II. *Bull Am Coll Surg*. 2003;88(4):37–58. http://www.facs.org/fellows_info/bulletin/2003/tenspecialty0403.pdf. Accessed April 12, 2012.
- 22 American College of Surgeons. Ten specialty boards report accomplishments and plans: part II. *Bull Am Coll Surg*. 2004;89(4):40–59. http://www.facs.org/fellows_info/bulletin/2004/tenspecialty0404.pdf. Accessed April 12, 2012.
- 23 American College of Surgeons. Ten specialty boards report accomplishments and plans: part II. *Bull Am Coll Surg*. 2005;90(4):27–40. http://www.facs.org/fellows_info/bulletin/2005/tenspecialtyboards0405.pdf. Accessed April 12, 2012.
- 24 American College of Surgeons. Ten specialty boards report accomplishments and plans: part I. *Bull Am Coll Surg*. 2006;91(3):29–39. http://www.facs.org/fellows_info/bulletin/2006/tenspecialtypartone0306.pdf. Accessed April 12, 2012.
- 25 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. 2000–2001;27:1–6. <http://www.abog.org/publications/2000-2001dip.pdf>. Accessed April 12, 2012.
- 26 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. 2001–2002;28:1–6. <http://www.abog.org/publications/2001-2002dip.pdf>. Accessed April 12, 2012.
- 27 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. 2002–2003;29:1–6. <http://www.abog.org/publications/2002-2003dip.pdf>. Accessed April 12, 2012.
- 28 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. Fall 2004;30:1–6. <http://www.abog.org/publications/2003-2004dip.pdf>. Accessed April 12, 2012.
- 29 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. Fall 2005;31:1–7. <http://www.abog.org/publications/2004-2005dip.pdf>. Accessed April 12, 2012.
- 30 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. Fall 2006;32:1–6. <http://www.abog.org/publications/2005-2006dip.pdf>. Accessed April 12, 2012.
- 31 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. 2006–2007. http://www.abog.org/publications/DIPLOMATE-MOC_FINAL%20formatted%20version2007.pdf. Accessed April 12, 2012.
- 32 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. Summer 2008;34:1–7. <http://www.abog.org/publications/2008dip.pdf>. Accessed April 12, 2012.
- 33 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. Fall 2009;35:1–8. <http://www.abog.org/publications/ABOG2009.pdf>. Accessed April 12, 2012.
- 34 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. Summer 2010;36:1–7. <http://www.abog.org/publications/ABOG2010.pdf>. Accessed April 12, 2012.
- 35 American Board of Obstetrics & Gynecology. *The A.B.O.G. Diplomate*. Summer 2011;37:1–7. <http://www.abog.org/publications/ABOG2011.pdf>. Accessed April 12, 2012.
- 36 American Board of Ophthalmology. Examination statistics 2012. <http://abop.org/about/examination-statistics>. Accessed April 10, 2012.
- 37 American Board of Orthopaedic Surgery. *The ABOS Diplomate*. February 2005. <https://www.abos.org/documents/2005%20Diplomate%20Copy1.pdf>. Accessed April 10, 2012.
- 38 American Board of Orthopaedic Surgery. *The ABOS Diplomate*. February 2006. <https://www.abos.org/documents/2006%20Diplomate.pdf>. Accessed April 10, 2012.
- 39 American Board of Orthopaedic Surgery. *The ABOS Diplomate*. April 2007. <https://www.abos.org/documents/2007Diplomate.pdf>. Accessed April 10, 2012.
- 40 American Board of Orthopaedic Surgery. *The ABOS Diplomate*. January 2008. <https://www.abos.org/documents/ABOSDiplomate-1.pdf>. Accessed April 10, 2012.
- 41 American Board of Orthopaedic Surgery. *The ABOS Diplomate*. January 2009. <https://www.abos.org/documents/Diplomate-2009-Final.pdf>. Accessed April 10, 2012.
- 42 American Board of Orthopaedic Surgery. *The ABOS Diplomate*. April 2010. <https://www.abos.org/documents/ABOSDiplomate-2010-3.pdf>. Accessed April 10, 2012.
- 43 American Board of Orthopaedic Surgery. *The ABOS Diplomate*. February 2011. <https://www.abos.org/documents/ABOSDiplomate-2011-1.pdf>. Accessed April 10, 2012.
- 44 American Board of Plastic Surgery Inc. *Annual Newsletter to Diplomates*. January 2005. https://www.abplsurg.org/documents/Final_ABPS_Newsletter_Jan_2005.pdf. Accessed April 28, 2012.
- 45 American Board of Plastic Surgery Inc. Examination statistics 2012. https://www.abplsurg.org/documents/Exam_Stats_2012.pdf. Accessed April 28, 2012.

- 46 American Board of Surgery. General surgery examination statistics 2012. <http://home.absurgery.org/default.jsp?statgeneral>. Accessed April 10, 2012.
- 47 American Board of Surgery. Vascular surgery examination statistics 2012. <http://home.absurgery.org/default.jsp?statvasc>. Accessed April 10, 2012.
- 48 American Board of Surgery. Pediatric surgery examination statistics 2012. <http://home.absurgery.org/default.jsp?statped>. Accessed April 10, 2012.
- 49 American Board of Surgery. Surgical critical care examination statistics 2012. <http://home.absurgery.org/default.jsp?statcrit>. Accessed April 10, 2012.
- 50 American Board of Surgery. Surgery of the hand examination statistics 2012. <http://home.absurgery.org/default.jsp?stathand>. Accessed April 10, 2012.
- 51 Lewis F. Report of the American Board of Surgery. *Arch Surg.* 2007;142(9):904–906.
- 52 Lewis F. Report of the American Board of Surgery January 2008. *Arch Surg.* 2008;143(8):809–812.
- 53 Lewis F. Report of the American Board of Surgery. *Arch Surg.* 2009;144(6):591–593.
- 54 American Board of Surgery. *ABS News*. Summer 2004. <http://www.absurgery.org/xfer/newslet2004sum.pdf>. Accessed April 12, 2012.
- 55 American Board of Surgery. *ABS News*. Summer 2005. <http://www.absurgery.org/xfer/newslet2005sum.pdf>. Accessed April 12, 2012.
- 56 American Board of Surgery. *ABS News*. Summer 2006. <http://www.absurgery.org/xfer/newslet2006sum.pdf>. Accessed April 12, 2012.
- 57 ABTS examination statistics, 5-year pass rate, certification, 2012. <https://www.abts.org/sections/Certification/index.aspx>. Accessed April 10, 2012.
- 58 American Board of Urology. Qualifying (Part 1) Examination, American Board of Urology aggregate examination statistics, reports and statistics. <http://www.abu.org/downloads/Part1ExamStats.pdf>. Accessed April 12, 2012.
- 59 American Board of Urology. Certifying (Part 2) Examination, American Board of Urology aggregate examination statistics, reports and statistics. <http://www.abu.org/downloads/Pt2ExamStats.pdf>. Accessed April 12, 2012.