

Does Medical School Performance Predict Radiology Resident Performance?¹

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Rationale and Objectives. The authors performed this study to examine the relationship, if any, of a large number of measures of medical school performance with radiology residency performance.

Materials and Methods. Applications of 77 radiology residents enrolled from 1991 to 2000 were reviewed. Medical school grades, dean's letter summary statements, letters of recommendation, selection to Alpha Omega Alpha (AOA), and National Board of Medical Examiners (NBME) and U.S. Medical Licensing Examination (USMLE) Step 1 scores were recorded. Student *t* tests, analysis of variance, and correlation coefficients were used to examine the relationship between these measures of medical school performance and subsequent performance during radiology residency as determined by rotation evaluations, retrospective faculty recall scores, and American College of Radiology (ACR) and American Board of Radiology (ABR) examination scores. Resident performance was also correlated with prestige of the medical school attended.

Results. Preclinical grades of Honors or A; clinical grades of Honors or A in medicine, surgery, and pediatrics; and high NBME/USMLE scores strongly predicted success on the ABR written clinical examination but did not predict rotation performance. Most other measures of medical school performance, including outstanding Dean's letters and letters of recommendation, AOA selection during the senior year, and high medical school prestige did not predict high examination scores or superior rotation performance during residency.

Conclusion. Success on the ABR examination can be predicted by medical school success in preclinical courses, some clinical courses, and USMLE examination scores. Dean's letters, letters of recommendation, AOA selection during the senior year, and medical school prestige do not appear to predict future resident performance as reliably.

Key Words. Radiology residency performance, residency performance, American Board of Radiology Examination Scores, American College of Radiology Examination Scores, residency rotation performance.

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Radiology resident selection is vitally important both to residency training programs and to residency candidates entering the match. Resident selection committees have a responsibility to their departments to rank the applicants who are most qualified and best suited for that particular

program. The committees also have an obligation to the candidates, whose careers, lives, and families are greatly affected by the committees' decisions. These responsibilities demand fairness and due process toward each candidate.

Given the increasingly competitive pool of applicants, this is no small task. Accordingly, most radiology residency programs devote tremendous time and effort to ranking candidates. A variety of measures of medical school performance are considered. In one survey (1), more than 90% of program directors considered medical school grades and class rank to be very important factors,

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74% regarded selection to Alpha Omega Alpha (AOA) to be very important, and just more than 50% emphasized scores on the U.S. Medical Licensing Examination (USMLE).

Despite widespread use of this information in resident selection, few data indicate whether any of these measures of medical school performance predict a given candidate's subsequent success as a resident. The few published studies on this topic have reported conflicting results (2). For example, three studies (3–5) failed to find any correlation between USMLE scores and later residency performance, whereas two others (6,7) demonstrated a positive correlation. One study (8) showed that class rank based on medical school grades had a "modest" correlation with future residency performance; another (9) revealed that applicant rank order did not predict subsequent residency performance. Most of these published studies (and several others) have included small sample sizes and utilized only short-term follow-up, usually assessing resident performance solely during the 1st year of postgraduate training (7,8,10). Furthermore, limited data specifically address the assessment of future radiology residents. Only three of the previously cited studies (3,4,9) assessed the performance of medical students who subsequently entered radiology residencies, and each of these studies was limited in scope.

We performed this study to examine the relationship, if any, between a large number of measures of medical school performance and radiology residency performance. Our hope was to determine which elements of a medical student's application are most predictive of future success in a radiology residency. It might then be possible to give special consideration to these elements during resident selection.

MATERIALS AND METHODS

We reviewed the records of 77 residents who completed 4 years of training in our diagnostic radiology residency program between 1991 and 2000. Information from the residency application regarding medical school performance and data regarding subsequent residency performance were recorded.

Assessment of Medical School Performance

We recorded data from each resident's radiology residency application, including medical school transcripts, National Board of Medical Examiners (NBME) or USMLE Step 1 results, dean's letters, and letters of rec-

ommendation. Selection to AOA was noted, as well. We also recorded the perceived prestige of each resident's medical school (determined according to the *U.S. News and World Report* listing of best graduate schools in 2001). Finally, we noted whether the applicant attended a medical school located in the same general region (within the same state or neighboring states) as our program or had any other substantial connection to the region, such as a regional birthplace or college.

Performance in five preclinical (anatomy, biochemistry, pathology, pharmacology, and physiology) and five clinical (medicine, surgery, pediatrics, obstetrics and gynecology, and radiology) courses was reviewed. Students were placed into one of two categories: those who received grades of "Honors" or "A," and those who did not. No data were recorded for the five applicants who attended a medical school in which only passing or failing grades (without the Honors or A designation) were assigned.

As mentioned, the NBME and USMLE Step 1 scores were recorded. Because these two examinations employ different scoring systems, the results for each were recorded separately. A normalized scoring system was also devised so that scores for each examination could be considered together.

Dean's letters were sorted into one of two categories: those in which the word "outstanding" was used in the summary statement or in which the overall tone indicated superlative medical school performance, and those in which the tone reflected less than outstanding performance. Twenty-nine of the 67 available dean's letters were classified as indicating outstanding performance.

Three letters of recommendation were evaluated for each resident. These letters were sorted into one of two categories: those describing the student as the best candidate in his or her class or as one of the best students with whom the author had interacted, and those that were positive but did not describe the resident in such glowing terms.

We categorized each resident's medical school by placing it into one of three categories: (a) elite schools (ranked 1–12 according to the *U.S. News and World Report* survey), (b) competitive but not elite schools (ranked 13–50 according to the *U.S. News and World Report* survey), and (c) all other schools.

Assessment of Radiology Residency Performance

Residency performance was assessed in three ways: (a) by a review of rotation evaluation forms, (b) by a sur-

vey of three faculty members regarding resident performance, and (c) by American College of Radiology (ACR) in-training examination scores during the first three years of residency and the American Board of Radiology (ABR) written clinical examination score during the 4th year of residency.

The method utilized for considering the rotation evaluation forms has been described previously (9). Briefly, evaluation forms were obtained for each resident throughout his or her residency at the conclusion of each 3–4-week subspecialty rotation. Usually, the rotation directors or the faculty members who had the most contact with the resident completed that resident's evaluation form. Although residents were subjectively evaluated in a number of categories, we chose to record data from two categories applicable to every rotation: general knowledge and overall performance. *General knowledge* consisted of an assessment of general medical and radiology knowledge as it related to the specific rotation. Overall performance reflected a broad impression of how the resident performed during the rotation. No specific criteria were available to guide the faculty members in their evaluations. A mean score from all evaluation forms was calculated for each resident in general knowledge and overall performance for each year of residency; these scores were assumed to reflect the resident's performance during that year of residency. Because two different evaluation forms were employed during the study period (a five-point scale from 1991 to 1995 and a four-point scale from 1995 to 2000), we created a normalized *z*-score for the evaluation form ratings so that the two types of evaluation forms could be combined.

Three senior faculty members with expertise in three different subspecialty areas performed the retrospective evaluation of residents. A four-point grading scale was used. The faculty members were asked to assess residents in the same two categories that were used on the rotation evaluation forms (general knowledge and overall performance). The faculty members were also asked, however, to evaluate the residents in an additional category: interpersonal skills. We added this additional category because we believed that an assessment of interpersonal skills might reflect more closely measures of performance used during some medical school clinical rotations.

At our institution, 1st-, 2nd-, and 3rd-year residents regularly take the ACR examination. The overall number of answers correct, percentage scores, and percentile scores for this examination were recorded for each resident. With the exception of 1991 and 1992, the 4th-year

residents did not take this examination. Because the number of 4th-year ACR examination scores was very small ($n = 11$), these results were not included in our analysis. We also recorded the overall scores for the ABR written clinical examination.

Statistical Analyses

The measures of medical school performance were compared with the measures of radiology residency performance. Given the variety of data acquired for this study, a number of different statistical methods were employed.

Medical school performance in the five selected preclinical and clinical courses was compared with the radiology residency rotation evaluation scores and the retrospective faculty evaluation scores by using Student *t* tests (for independent samples). For each of the 10 assessed preclinical and clinical courses, we compared rotation evaluation scores and retrospective evaluation scores in general knowledge and overall performance and retrospective evaluation scores in interpersonal skills for those residents who received grades of Honors or A with those residents who did not. Student *t* tests were also used to determine whether those who received grades of Honors or A had higher ACR and ABR scores than those who received lower grades.

Student *t* tests were employed to determine whether any difference existed in rotation evaluation scores, retrospective evaluation scores, ACR examination performance, and ABR examination scores between residents who had outstanding dean's letters versus residents who did not.

Student *t* tests were also used to determine whether residents who had received the highest-scored letters of recommendation had higher rotation evaluation scores, retrospective evaluation scores, or ACR/ABR scores than those who did not.

Additionally, Student *t* tests were used to determine whether residents who had been selected to AOA as medical students had better radiology rotation or retrospective faculty evaluation scores or scored more highly on the ACR/ABR examinations than those who had not been selected.

Finally, Student *t* tests were used to compare the rotation and retrospective evaluation scores and the ACR/ABR examination scores of residents who did and residents who did not have any substantial connection to our region.

Table 1
Preclinical Grades versus Performance on ACR or ABR Examination

Course	ACR 1st-Year Percentile	ACR 2nd-Year Percentile	ACR 3rd-Year Percentile	ABR 4th-Year Score
Anatomy				
Honors	72.1 [18, 25.0]	71.3 [17, 21.4]	68.0 [18, 23.8]	583 [17, 46.7]
No honors	52.1 [27, 25.9]	47.8 [26, 24.3]	53.0 [25, 21.1]	543 [30, 48.5]
<i>P</i>	.01	.002	.04	.01
Biochemistry				
Honors	64.4 [18, 22.8]	66.4 [18, 20.0]	67.3 [18, 23.4]	591 [18, 29.9]
No honors	55.4 [27, 31.1]	49.2 [25, 30.0]	53.5 [24, 24.7]	540 [28, 52.4]
<i>P</i>	.271	.03	.075	<.001
Pathology				
Honors	67.9 [22, 24.0]	64.7 [22, 26.4]	70.6 [22, 23.0]	587 [23, 45.0]
No honors	54.2 [28, 29.0]	50.3 [26, 27.1]	49.8 [26, 21.7]	535 [29, 45.7]
<i>P</i>	.079	.070	.002	<.001
Pharmacology				
Honors	66.7 [27, 23.9]	64.9 [26, 25.3]	65.9 [28, 22.1]	576 [27, 41.8]
No honors	52.9 [24, 28.8]	47.7 [23, 26.8]	51.4 [21, 25.1]	540 [26, 55.1]
<i>P</i>	.067	.03	.04	.01
Physiology				
Honors	69.2 [19, 22.1]	70.8 [19, 20.0]	68.3 [19, 25.6]	582 [18, 36.4]
No honors	52.9 [28, 29.4]	46.1 [26, 26.4]	52.0 [26, 22.0]	543 [31, 54.8]
<i>P</i>	.04	.001	.03	.005

Note.—Bold type demarcates statistically significant comparisons ($P < .012$). Number of comparisons and standard deviation, respectively, are in brackets.

Correlation coefficients were obtained to compare the number of medical school Honors or A grades with the rotation and retrospective evaluation scores and with the ACR/ABR examination scores. They were also used to compare NBME and USMLE scores with radiology residency rotation and retrospective evaluation scores and to compare NBME/USMLE and ACR/ABR examination scores with one another. For this last analysis, NBME scores, USMLE scores, and combined, normalized USMLE/NBME scores were all compared with the number correct, percentage correct, and percentile scores on the ACR examination and with the overall ABR examination scores. (It should be remembered that, in general, correlation coefficients of 0.8–0.9 are considered to be notable in laboratory research, but correlation coefficients of 0.2–0.4 are considered to be notable in social science [behavioral] research.)

We used an analysis of variance to compare medical school prestige with subsequent resident performance as assessed by means of rotation and retrospective evaluation scores and ACR/ABR examination scores.

Given the large number of comparisons in this study, we were concerned about the possibility of fortuitously significant results. Therefore, for each test, a Bonferroni

adjustment was performed. This adjustment lowers the P value that is necessary to reach statistical significance based on the number of comparisons that are made for each test. For the tests performed in our study, the Bonferroni adjustments lowered the threshold P values for determining significance from .05 to .012 or .016.

RESULTS

Preclinical Medical School Grades as Predictors of Radiology Residency Performance

Residents who had received Honors or A grades in any of the assessed preclinical courses performed statistically significantly better on the ABR written clinical examination than those who did not (by means of 39–52 points), with P values of .005 or less for each comparison (Table 1).

Honors or A grades in preclinical courses were sporadically related to success on the ACR examination. Residents who, as medical students, received Honors in the anatomy course subsequently performed significantly better on the 1st- and 2nd-year ACR examinations (Table 1). Residents who received Honors in the pathology course subsequently performed better on their 3rd-year ACR ex-

Table 2
Clinical Grades versus Performance on ACR or ABR Examination

Course	ACR 1st-Year Percentile	ACR 2nd-Year Percentile	ACR 3rd-Year Percentile	ABR 4th-Year Score
Medicine				
Honors	67.2 [25, 24.1]	64.8 [25, 25.2]	66.3 [25, 24.3]	583 [25, 44.6]
No honors	57.8 [33, 28.0]	53.2 [32, 26.2]	55.5 [31, 24.2]	544 [33, 48.7]
<i>P</i>	.186	.097	.102	.003
Obstetrics-gynecology				
Honors	70.6 [25, 24.4]	66.3 [24, 24.7]	62.5 [28, 23.5]	572 [24, 43.7]
No honors	55.1 [29, 26.1]	53.7 [29, 25.7]	56.3 [25, 26.1]	554 [30, 52.5]
<i>P</i>	.028	.077	.371	.177
Pediatrics				
Honors	66.9 [25, 24.0]	66.0 [24, 22.2]	58.9 [26, 26.1]	584 [24, 45.1]
No honors	58.3 [31, 29.0]	53.2 [32, 28.1]	61.9 [28, 24.5]	543 [32, 49.2]
<i>P</i>	.238	.072	.668	.002
Radiology				
Honors	60.9 [22, 28.4]	59.8 [21, 27.8]	63.6 [23, 26.8]	567 [23, 51.7]
No honors	61.5 [13, 26.6]	49.3 [13, 25.5]	50.2 [12, 24.0]	549 [13, 55.3]
<i>P</i>	.949	.281	.156	.326
Surgery				
Honors	68.2 [32, 21.6]	67.3 [31, 23.0]	67.5 [33, 20.1]	583 [30, 38.9]
No honors	55.8 [25, 29.6]	49.4 [25, 25.1]	50.0 [23, 27.3]	540 [27, 49.0]
<i>P</i>	.087	.008	.01	.001

Note.—Bold type demarcates statistically significant comparisons ($P < .012$). Number of comparisons and standard deviation, respectively, are in brackets.

amination. Those residents with Honors in the physiology course performed better on their 2nd-year ACR examination. Mean ACR examination scores were higher for students who received Honors in all other preclinical courses, but none of these other differences was statistically significant.

In contrast, no consistent, statistically significant differences in radiology rotation performance were found between residents who received preclinical Honors or A grades and residents who did not. Also, residents who received Honors or A grades in any one of the five selected preclinical rotations did not receive statistically significantly higher retrospective evaluation scores from two of the three faculty members. Interestingly, residents who received an Honors grade in anatomy, biochemistry, and physiology received statistically significantly higher scores from the third faculty member in the category of general knowledge, and residents who received an Honors grade in anatomy also received statistically significantly higher scores according to the third faculty member in the category of overall performance. These findings suggest that the criteria used by this faculty member were more consistent with the criteria used to grade medical students

in the preclinical courses than with those employed by the other two faculty members.

Clinical Medical School Grades as Predictors of Radiology Residency Performance

Residents who obtained Honors or A grades in medicine, pediatrics, or surgery achieved significantly higher ABR scores (by means of 39–43 points), with P values less than .005 (Table 2). In comparison, residents who obtained an Honors or A in the obstetrics and gynecology clerkship and the radiology elective did not subsequently attain statistically significantly higher ABR examination scores.

Residents who received Honors or A grades in their clinical courses did not consistently perform statistically significantly better on the ACR examination, although two relationships were identified (Table 2). Residents who received an Honors or A grade in surgery had statistically significantly higher 2nd- and 3rd-year ACR examination scores than residents who did not. The mean ACR examination scores during each year were higher for residents receiving Honors or A grades for all but two of the other comparisons, but none of these other differences was statistically significant.

Residents who received grades of Honors or A in any of their clinical courses did not perform statistically significantly better on rotation or retrospective evaluation forms.

Correlation between Number of Preclinical or Clinical Honors or A Grades and Residency Performance

Residents who received more Honors or A grades in the preclinical and clinical medical school courses also performed better on the ACR examination during their 2nd and 3rd years and scored higher on the ABR written clinical examination than those residents who received fewer such grades. No correlation was found with the 1st-year ACR examination. Residents who received more Honors or A grades did not receive higher rotation evaluation scores (with the exception of the overall performance category in the 3rd year) or retrospective evaluations (with the exception of one evaluator's general knowledge category).

Dean's Letter Summary Statements as Predictors of Radiology Residency Performance

No statistically significant differences were found between mean rotation evaluation scores in any year or retrospective faculty recall scores for those residents who had received dean's letter summary statements listing them as outstanding medical students versus those who had not. Also, no statistically significant differences were found between the ACR/ABR written examination scores for residents who had received outstanding dean's letter summary statements and the scores for residents who had not. An overall trend was found, however, toward better performance (albeit not statistically significant) on the standardized radiology tests by those residents who had received outstanding dean's letters.

Letters of Recommendation as Predictors of Radiology Residency Performance

No statistically significant differences were found between the mean rotation evaluation scores in any year or retrospective faculty scores for those residents who had received the most outstanding letters of recommendation and the evaluation scores of those who had not. Residents who had received the most outstanding letters of recommendation did consistently attain higher mean ACR and ABR scores in comparison to those who had not received such letters. These differences were not great, however, and none reached statistical significance.

Selection to AOA as a Predictor of Radiology Residency Performance

Selection to AOA during the senior year of medical school did not predict subsequent success during the radiology residency. Selection to AOA during the senior year did not reliably predict higher rotation or retrospective evaluation scores or greater ACR examination success in any year of residency (Table 3). Whereas mean ABR examination scores were higher for senior AOA students than for those who were not selected to AOA (600.7 vs 557.8, respectively), large standard deviations occurred, and this difference did not reach statistical significance.

Mean ABR examination scores for those residents who were selected to AOA during their junior year were also higher than those of residents who were not selected to AOA in their junior year, although the difference was not as great as that between the senior-year AOA and the non-AOA groups and, again, was not statistically significant. In contrast, a few sporadic statistically significant associations were found between selection to AOA during the junior year and ACR examination success (Table 3). Selection to AOA during the junior year predicted statistically significantly higher percentile scores, but not percentage correct or number correct, for the 1st-year ACR examination. Selection to AOA during the junior year also was associated with statistically significantly higher percentile scores and percentage correct, but not with number correct, on the 2nd-year ACR examination. Selection to AOA during the junior year was not predictive of 3rd-year ACR examination success using any measure. No statistically significant differences were found in mean rotation evaluation scores for any year or in retrospective faculty evaluation scores between those residents selected to AOA during their junior year of medical school and those who were not selected.

NBME/USMLE Scores as Predictors of Radiology Residency Performance

Many statistically significant correlations were found between performance on the NBME or USMLE examination and subsequent written examination scores during radiology residency (Table 4). Whereas NBME scores for the period 1991–1996 did not correlate with ACR examination scores for any year, they did statistically significantly correlate with ABR written examination scores. The USMLE scores for the period 1997–2001 statistically significantly correlated with every measure of performance on 1st- and 3rd-year ACR examinations, two of the three measures of performance on the 2nd-year ACR

Table 3
AOA Selection versus Scores on ACR or ABR Examinations

Examination	Junior-Year AOA		Senior-Year AOA	
	Yes	No	Yes	No
ACR				
1st year				
No. correct	334.1 (.672) [16, 29.4]	330.1 [32, 34.0]	340.9 (.430) [8, 41.1]	330.9 [38, 30.4]
Percentage correct	56.4 (.067) [16, 5.0]	53.6 [32, 4.6]	54.8 (.946) [8, 5.7]	54.6 [38, 4.8]
Percentile	73.2 (.013) [17, 18.6]	56.1 [34, 28.4]	62.8 (.657) [8, 31.9]	58.1 [41, 26.3]
2nd year				
No. correct	373.9 (.059) [15, 28.1]	353.9 [24, 37.5]	388.3 (.48) [6, 31.0]	356.7 [31, 35.2]
Percentage correct	62.4 (.014) [17, 4.4]	58.5 [26, 5.1]	61.2 (.527) [7, 4.0]	59.8 [34, 5.5]
Percentile	73.6 (.007) [17, 23.5]	52.7 [31, 24.9]	60.9 (.780) [8, 21.0]	58.0 [38, 28.0]
3rd year				
No. correct	403.9 (.036) [16, 40.9]	378.5 [21, 30.2]	392.0 (.985) [4, 11.5]	392.4 [31, 38.0]
Percentage correct	66.1 (.112) [18, 5.5]	63.6 [27, 4.9]	64.8 (.952) [5, 2.5]	65.0 [38, 5.3]
Percentile	68.4 (.081) [19, 23.6]	55.9 [30, 24.1]	60.4 (.820) [7, 25.4]	62.7 [40, 23.7]
ABR	579.7 (.108) [17, 43.2]	556.4 [33, 50.0]	600.7 (.032) [7, 29.5]	557.8 [41, 49.6]

Note.—Bold type demarcates statistically significant comparisons ($P < .016$). P values are in parentheses; number of comparisons and standard deviation, respectively, are in brackets.

Table 4
Correlation Coefficients of Scores on NBME or USMLE with Scores on ACR or ABR Examination

Examination	NBME 1991–1996	USMLE 1997–2001	Normalized 1991–2001
ACR			
1st year			
No. correct	0.514 (.029) [18]	0.605 (.002) [24]	0.563 (.000) [42]
Percentage correct	0.508 (.032) [18]	0.612 (.001) [24]	0.553 (.000) [42]
Percentile	0.504 (.033) [18]	0.626 (.000) [30]	0.585 (.000) [48]
2nd year			
No. correct	0.175 (.136) [17]	0.552 (.041) [14]	0.454 (.010) [31]
Percentage correct	0.418 (.095) [17]	0.593 (.006) [20]	0.478 (.003) [37]
Percentile	0.431 (.085) [17]	0.515 (.007) [26]	0.471 (.001) [43]
3rd year			
No. correct	0.442 (.066) [18]	0.822 (.001) [12]	0.507 (.004) [30]
Percentage correct	0.497 (.036) [18]	0.665 (.001) [22]	0.584 (.000) [40]
Percentile	0.361 (.141) [18]	0.527 (.007) [25]	0.460 (.002) [43]
ABR	0.614 (.005) [18]	0.824 (.000) [24]	0.725 (.000) [42]

Note.—Bold type demarcates statistically significant comparisons ($P < .016$). P values are in parentheses; when P is listed as .000, $P < .001$. Number of comparisons is in brackets.

examination, and ABR written examination scores. The normalized NBME/USMLE scores for the period 1991–2001 statistically significantly correlated with every measure of performance on 1st-, 2nd-, and 3rd-year ACR examinations and with the ABR written examination scores.

Correlation coefficients were high for these comparisons. This was especially true for the comparisons of

USMLE and normalized NBME/USMLE scores with ABR examination scores, in which the correlation coefficients were 0.824 and 0.725, respectively. The P values for these comparisons were very low ($< .001$).

In contrast, no statistically significant positive correlations were found between NBME and USMLE examination scores and radiology rotation evaluation scores in

either category or for any year. Also, no correlations were found between NBME and USMLE examination scores and retrospective evaluation scores.

Medical School Prestige as a Predictor of Radiology Residency Performance

Medical school prestige (according to the *U.S. News and World Report*) did not predict subsequent radiology residency performance. Specifically, there was no significant correlation between the ranking of a resident's medical school and his or her rotation evaluation scores during any year of residency or with the retrospective faculty evaluations. One-way analysis of variance also failed to detect any statistically significant difference among the mean rotation evaluation scores in any year or in either category for residents from "elite", "competitive", or other medical schools. Additionally, no correlation was found between the ranking of a resident's medical school and his or her subsequent ABR written examination or ACR examination scores during any year of residency.

Geography as a Predictor of Radiology Residency Performance

Residents with ties to the geographic region in which our residency program is located performed better during the early and late years of radiology residency as assessed by rotation evaluation scores. Residents who had attended college or medical school or who had previously lived in our geographic region had higher mean rotation evaluation scores for overall performance in the 1st and 4th years than those who did not. No other statistically significant relationships regarding geography were found.

DISCUSSION

The purpose of our study was to determine if, at our institution, specific elements of a medical student's residency application can predict his or her future performance as a resident. If so, we might then emphasize these elements in our resident selection process. We found that residents who had received Honors or A grades in the five preclinical medical school courses sporadically performed statistically significantly better on their ACR in-training examinations and performed substantially better on their ABR written clinical examinations than those residents who had not. Residents who had received Honors or A grades in several of the assessed clinical courses (medicine, pediatrics, and surgery) also did substantially better on their ABR examination than those who had not.

In all but two other instances, residents who had received Honors or A grades in any of the other preclinical or clinical courses had higher mean 1st-, 2nd-, and 3rd-year ACR and ABR examination scores than those who did not receive these grades, but none of these other differences was statistically significant. Finally, we also found that NBME/USMLE scores correlated strongly with both ACR examination and written clinical ABR examination scores.

The reasons for these correlations are not obvious, but they may reflect that excellent test-taking skills during medical school are likely to be rewarded with good grades and high examination scores. These skills are likely to persist into residency. Our results suggest that residency programs value success on written examinations, then preclinical grades, some clinical grades, and USMLE scores should be emphasized in the resident selection process.

These results echo those of previous studies in other specialties that showed correlations between medical school board examinations and subsequent board certification examinations, including those for orthopedic surgery, dermatology, preventive medicine, and internal medicine (11). In the radiology literature, however, these results differ from those recently reported by Gunderman and Jackson (4), who did not detect any association between NBME scores and ABR written or oral examination scores. We suspect that the discrepant results may be caused by differences in methods. Gunderman and Jackson were interested primarily in determining whether the few residents in their series who failed the ABR written or oral examination were more likely to have performed poorly on the NBME examination; those authors did not find this to be the case. Our study, however, did not consider failure rates but, instead, calculated correlation coefficients, and during the time period that we studied, none of our residents failed the written ABR examination.

The most important result of our study may be the lack of any identifiable predictive value demonstrated by several measures of medical school performance. Outstanding dean's letters, superior letters of recommendation, AOA selection during the senior year, and medical school prestige did not consistently predict subsequent residency performance to a statistically significant degree as assessed by radiology rotation evaluations, retrospective faculty evaluations, and to a slightly lesser extent, ACR/ABR written examinations. Therefore, we believe that these elements of the residency application may be overemphasized.

Selecting residents with a greater likelihood for success on clinical rotations would be beneficial, but no measures of medical school performance have yet been identified that can predict radiology rotation performance. Our results also indicate that a medical student who excels at a less prestigious medical school is just as likely to excel during his or her radiology residency as a student with similar credentials from an elite medical school.

We were surprised to learn the role of geography. Residents with a connection to our state, or to our neighboring states, performed better both early and late in their residency. This may be because such residents adapt more quickly to residency in a familiar environment and have more external support later in the residency, when stress again peaks.

Our study has a number of strengths, including its size (9 years of resident data) and its breadth. To our knowledge, no other such study has examined as many elements of the medical student application or measured resident performance as extensively.

Our study also has a number of important limitations. Despite its size and breadth, it remains relatively small, consisting of data regarding only 77 residents. If more resident data had been included, more of our comparisons might have yielded statistically significant results. The study also is limited by predominantly subjective evaluations of resident performance and rating scales that attempt to quantify dean's letters and letters of recommendation. It is also limited by its homogeneous study population. All residents in the study were enrolled in a single, highly competitive residency program. A multi-institutional study, which would include a more diverse population, might provide stronger statistical results for specialty-wide application. The present single-institutional study may provide lessons only for the residency selection process at our institution or at similarly competitive programs. Additionally, we did not assess the relationship of oral ABR examination performance to medical school performance. Because only a very small number of our residents did not pass the oral ABR examinations outright, we did not believe that oral ABR scores would be a reliable discriminator. Nonetheless, future investigations might be able to assess the relationship between medical school performance and oral ABR examination perfor-

mance. Finally, because of the large number of statistical comparisons, fortuitously significant results are possible. Statistical adjustments were performed with this pitfall in mind.

In summary, our detailed analysis has shown that of all the elements available from residency applications, pre-clinical grades of Honors or A in anatomy, biochemistry, pathology, pharmacology, and physiology; clinical grades of Honors or A in surgery, medicine, and pediatrics; and high NBME/USMLE scores strongly predict higher scores on the ABR written examination in clinical radiology and, occasionally, predict superior performance on the ACR in-training examination. Outstanding dean's letters, superlative letters of recommendation, AOA selection during the senior year, and medical school prestige do not appear to predict residency success as reliably when assessed using any of our measures. Unfortunately, none of the elements from medical student applications predict superior residency performance as assessed by rotation evaluation forms or faculty retrospective evaluations.

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