Original Investigation

Factors Determining Scientific Paper Productivity by Neuroradiology Fellows

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Rationale and Objectives: We sought to determine (1) whether United States Medical Licensing Examination (USMLE) scores predict academic productivity in neuroradiology fellows as measured by publications and citations, and (2) what factors predict such productivity.

Materials and Methods: We reviewed the USMLE scores, gender, medical school location attended, publication record before and during fellowship, fellowship evaluation ratings and subsequent practice site (private vs academic) of neuroradiology fellows from 2004 to 2014 to determine relationships with publications and citations after fellowship. Spearman's correlation and Poisson regression analyses were performed to assess the association between these factors and quantity of publications and citations per year after fellowship.

Results: USMLE scores and fellowship evaluation scores correlated inversely with radiology publications and citations. There were strong correlations between publication records before or during fellowship and after fellowship. Fellows from international medical schools, with PhD degrees, and those fellows proceeding to academic practice had more publications before or during and after neuroradiology fellowship.

Conclusions: The best predictors of whether a graduating neuroradiology fellow will publish and have high citation rates is prior publication record, a PhD degree, and staying in academics. USMLE scores and evaluations during the fellowship were inversely correlated with publication measures of academic productivity.

Key Words: Fellowship; productivity; USMLE; neuroradiology.

INTRODUCTION

Components of the United States Medical Licensing Examination (USMLE) are taken at various stages in a medical trainee's career and are one way that residency and fellowship applicants, in most medical specialties, are evaluated and ranked (1). Step 1 of the test is essentially a general medical knowledge test and is usually taken after the second year of medical school for American students. International graduate students applying to American training programs typically take Step 1 as the first part of the USMLE, but it can also be taken years after their medical school training. American students usually take the two components of Step 2 of the USMLE, Clinical Knowledge and Clinical Skills, in their final year of medical school. Most Accreditation Council for Graduate Medical Education (ACGME) residency programs require passing Steps 1 and 2 before acceptance. However, Step 3, a test of patient management and decision-making, can be taken during internship or residency, although it is usually completed before the end of postgraduate training. All of the Steps are offered to international medical graduates at any time during their medical career.

A previous publication reported that the USMLE Steps 1 and 2 were correlated with core competency evaluations of neuroradiology fellows (2). It was concluded that there is justification for using USMLE scores as part of the screening or acceptance criteria for evaluating neuroradiology fellowship candidates. However, the criteria for judging a successful graduate of a neuroradiology fellowship program may extend beyond the fellowship itself. Passing the neuroradiology subspecialty boards after fellowship is not considered a good marker for career success because the pass rate is so high. Subspecialty certification scores are unlikely to tease out the relationship between "success" and USMLE scores because the examination scores are no longer provided to fellowship programs with a numerical value, just pass or fail.

Given that the USMLE scores also do not predict who goes into academics and who goes into private practice, we sought to assess the USMLE's ability to predict academic productivity of the graduated neuroradiology fellows. To that end, we looked at paper productivity (as far as publications and citations) before, during, and after completion of a neuroradiology fellowship. We sought to determine whether USMLE 1 and 2 scores would predict publication rates and citation rates. We hypothesized that paper productivity **before** fellowship would

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most closely approximate productivity **after** fellowship, even when both private practice and academic physicians were included. We also sought to assess the predictive index of fellowship evaluations and medical school location (American vs international) attended for manuscript productivity.

METHODS

This study was approved by the Institutional Review Board, was Health Insurance Portability and Accountability Act compliant, and informed consent to review fellows' USMLE scores was waived.

The application records of 76 neuroradiology fellows at our institution from 2004 to 2014 were reviewed. There were no USMLE scores on four fellows, two from the military and two lost to follow-up, leaving 72 fellows (51 men and 21 women) for analysis. Sixty fellows had records for all three USMLE scores (Step 1, Step 2 Clinical Knowledge, and Step 3) available; the rest ($n = 12$) merely had Step 1 and Step 2 scores. Four fellows who did not have any USMLE score available were excluded from the study. Among these four, two were from the military and two had scores lost to follow-up.

The main search technique for publications and citation numbers was Google Scholar cross-referenced to Scopus and PubMed. Publications and citations were separated into those in Radiology versus all topics in the literature to assess impact in radiology. We separated Radiology from clinical journals because often trainees publish papers in medical school and before residency that are not in the radiology literature. We studied these parameters corrected for years after fellowship. The corrected total number of publications and citations after fellowship were used as end points for judging academic productivity.

Other variables that were studied included the gender of the fellow and whether, after they left the fellowship program, they entered a private or academic practice. We also explored the variables comparing those with medical degrees (MD, DO) versus those who had additional Doctor of Philosophy (MD, PhD) degrees. Because we only had 2 DOs in the cohort, we did not separate them from MD fellows. However, we did examine those who matriculated to the fellowship after a diagnostic radiology residency in our host program versus those who came from an outside radiology residency. The fellows were also categorized by cumulative fellowship evaluation scores and ranking and whether they matriculated from an international or American medical school.

The fellows were evaluated quarterly during their fellowship by neuroradiology faculty based on the E*Value evaluation program (E*Value, Advanced Informatics, Minneapolis, MN) whose questions corresponded with the six core competencies (medical knowledge, patient care, communication, practice-based learning, system-based practice, and professionalism) espoused by the ACGME. These scores were based on a 5-point scale. Each faculty member ($n = 15$) was asked to evaluate each fellow at quarterly intervals for their ACGME-accredited fellowship year.

The cumulative mean score of the fellows during their fellowship year (4 evaluations × 27 items from the E*Value × 15 evaluators = 1620 scores) was used to assess the fellow in the neuroradiology fellowship program. Each fellow was also ranked from best to worst each year to keep variable measures from year to year controlled. Thus, the cumulative mean score and the annual ranking of the fellow were used as variables for clinical performance during the fellowship. Only 3 of the 28 questions were directly related to research skills (Questions 3, 16, 27 of Appendix S1).

The E*Value survey questions used to evaluate the neuroradiology fellows are found in Appendix S1.

Descriptors for quantity of publications and USMLE scores were presented in median and interquartile range. Spearman's correlation and Poisson regression analyses were performed to assess the association between USMLE scores and quantity of publications and citations. With the evidence of overdispersion in the publication quantity data, negative binomial models with robust variance estimates were used to estimate the predictability of USMLE scores, E*Value scores, and ranking on the productivity. All the models were adjusted for medical school attended and practice area. The years after fellowship were incorporated as exposure variables in the model. Gender, medical school, residency program, and ultimate practice setting variables were also analyzed. Separate analyses were performed on the fellows who practice in academics after graduation. Statistical significance was defined at $P < 0.05$. All analyses were done using Stata 12 (StataCorp LP, College Station, TX).

RESULTS

Seventy-two fellows were included in the study. The characteristics of these participants are seen in Table 1 and show a large percentage (34.7%) of international medical graduates.

Seventy-one fellows provided USMLE 1, 67 provided USMLE 2, and 61 provided USMLE 3 scores. Four of the 12 fellows who did not provide USMLE 3 scores did not remain in the United States for postfellowship practice. One fellow provided USMLE 2 but not USMLE 1 scores.

There was no difference between genders in quantity of publications or citations (all areas of medicine or radiology) (Table 2). Fellows who graduated from international medical schools (11.9 mean radiology publications, and 13.6 all publications) had over twice the mean number of publications as American graduates (mean 5.1 and 6.8, respectively) ($P < 0.05$) but no difference in citations. In addition, the ones who went into academic practice had significantly more publications before, during, and after the fellowship than those who subsequently went into private practice ($P < 0.001$).

Six fellows had PhD degree and all practiced in academic area. They had significantly more publications and citations than those without PhD degree (Table 2). Compared to the 36 fellows without PhD degree but practicing in the academic arena, the six fellows with PhD degree also had more publications in all topics (21.7 vs 13.0, $P = 0.025$) and