Predicting Resident Performance from Preresidency Factors: A Systematic Review and Applicability to Neurosurgical Training

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Key words
- Attrition
- Education
- Neurosurgery residency
- Recruitment
- Resident success

Abbreviations and Acronyms
AOA: Alpha Omega Alpha
CINAHL: Cumulative Index to Nursing and Allied Health Literature
GRADE: Grading of Recommendations Assessment, Development, and Evaluation
LOR: Letter of recommendation
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PRF: Preresidency factor
RS: Residency success
USMLE: United States Medical Licensing Exam

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BACKGROUND: **Neurosurgical educators strive to identify the best applicants, yet formal study of resident selection has proved difficult. We conducted a systematic review to answer the following question: What objective and subjective preresidency factors predict resident success?**

METHODS: **PubMed, ProQuest, Embase, and the CINAHL databases were queried from 1952 to 2015 for literature reporting the impact of preresidency factors (PRFs) on outcomes of residency success (RS), among neurosurgery and all surgical subspecialties. Due to heterogeneity of specialties and outcomes, a qualitative summary and heat map of significant findings were constructed.**

RESULTS: **From 1489 studies, 21 articles met inclusion criteria, which evaluated 1276 resident applicants across five surgical subspecialties. No neurosurgical studies met the inclusion criteria. Common objective PRFs included standardized testing (76%), medical school performance (48%), and Alpha Omega Alpha (43%). Common subjective PRFs included aggregate rank scores (57%), letters of recommendation (38%), research (33%), interviews (19%), and athletic or musical talent (19%). Outcomes of RS included faculty evaluations, in-training/board exams, chief resident status, and research productivity. Among objective factors, standardized test scores correlated well with in-training/board examinations but poorly correlated with faculty evaluations. Among subjective factors, aggregate rank scores, letters of recommendation, and athletic or musical talent demonstrated moderate correlation with faculty evaluations.**

CONCLUSION: **Standardized testing most strongly correlated with future examination performance but correlated poorly with faculty evaluations. Moderate predictors of faculty evaluations were aggregate rank scores, letters of recommendation, and athletic or musical talent. The ability to predict success of neurosurgical residents using an evidence-based approach is limited, and few factors have correlated with future resident performance. Given the importance of recruitment to the greater field of neurosurgery, these data provide support for a national, prospective effort to improve the study of neurosurgery resident selection.**

INTRODUCTION

The goal of neurosurgery training is to create independent practitioners with a skillset to diagnose and treat surgical ailments of the central and peripheral nervous system. In 2016, 342 U.S. medical students applied for 216 neurosurgical resident positions. Neurosurgery was the most competitive specialty based on board examination scores and number of programs ranked in order to match.[1] In the rapidly evolving climate of medicine, among one of the most sought after specialties, it is imperative for neurosurgery educators to recruit the best applicants.

However, recruitment is an inexact science. In various surgical subspecialties, many have shown limited ability to predict future resident performance.[2-4] Highly sought after applicants can become unfavorable trainees; likewise, unassuming candidates can blossom into stellar residents. In neurosurgery, the concern of attrition also remains, as a recent study reported 14% of 1361 matched neurosurgery applicants from 1990 to 1999 failed to complete residency.[5]

Several obstacles exist to improving resident selection. First, the ideal phenotype of a successful neurosurgical resident has not been crystallized. Proficiency in the operating room does not portend a desire to pursue research or leadership activities, just as research prowess may not translate to technical mastery. Second, while some

preresidency factors can be easily quantified, such as examination scores,[6] others are ambiguous, such as letters of recommendation,[7] interviews,[8] and leadership experience.[9] Third, most studies are small and restricted to a single institution and specialty, thus limiting generalizability. The one consistent theme is that prior examination performance correlates with future test performance[4,10]; however, examination proficiency might not predict clinical competency. Ironically, despite the complexities of recruitment, identifying clinical excellence can be intuitive, as one senior author describes, "I know it when I see it."[3]

In neurosurgery, the few existing studies on resident selection have sought to predict neurosurgeons who become employed by academic institutions,[11-15] rather than success in residency. These studies have focused on both preresidency and in-residency factors, such as neurosurgical board scores, publications or presentations, awards, and degrees.[11,12,14,16,17] Unfortunately, the neurosurgical literature sheds little light on predicting overall resident success. In contrast, the experience of other surgical subspecialties with the same question is much larger. By combining the work of all surgical subspecialties to generate study power, answers to these difficult questions may be found.

The paramount importance of selecting qualified neurosurgery residents was the impetus for this investigation. A systematic review of published studies among neurosurgery and all surgical subspecialties was performed to correlate both objective and subjective preresidency factors (PRFs) with measures of residency success (RS). We sought to answer the following two questions. First, can objective PRFs predict RS? Second, can subjective PRFs predict RS?

Considering the existing data, we hypothesized that there would be both objective and subjective PRFs associated with RS.

MATERIALS AND METHODS

Electronic Literature Search

A formal systematic review was undertaken in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[18] Titles and abstracts were identified through querying of the electronic databases PubMed, ProQuest, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Embase. Articles published in peer-reviewed, English-language journals or books from 1952 to November 2015 were considered. The starting year of 1952 was selected because the National Resident Matching Program was established in that year.[19] The MEDLINE search terms included MeSH terms. Searches were performed using keywords, such as predict/prediction, resident/residents, performance, success, student, and applicant. The initial query of PubMed was as follows: *(predict*[tiab] OR factor*[tiab]) AND residen*[tiab] AND (perform*[tiab] OR success*[tiab] OR select*[tiab]) AND (student*[tiab] OR applicant*[tiab])*, with a filter for English results only. The initial query of CINAHL was as follows: *Success AND residency; apply related words, publish date 1952-present, English language, peer reviewed, exclude medline records.*

Study Selection

Inclusion criteria were agreed upon by all authors. Observational studies were included if they reported an association between objective or subjective PRFs with outcomes of RS. Several key definitions were agreed upon:

1. Preresidency factor (PRF): A PRF was operationally defined as any applicant information known to a residency selection committee before final applicant ranking.
2. Residency success (RS): An outcome of RS was operationally defined as any comprehensive measure of a resident's performance either during residency or afterward. A successful resident was defined, at minimum, to have completed neurosurgical residency, passed requisite board examinations, and gained a favorable evaluation by faculty members. By anchoring the definition of a successful resident between all studies, we attempted to standardize our principle outcome. Naturally, this definition varied between study and metric. Thus, specific definitions of RS were determined by the individual study itself.

Ideally, the current systematic review would include only studies of neurosurgery applicants and residents; however, this was not a viable option because of the limited available research. Considering this absence, and in an initial attempt to best answer the question empirically, the systematic review was expanded to all surgical subspecialties. It was determined by all authors that the similarities between each surgical sub-specialty in desired work ethic, integrity, technical skill, leadership, and communication outweighed the many differences. By combining efforts of these surgical subspecialties, worthwhile information of use to neurosurgical educators could be gleaned. The systematic review was restricted to: general surgery, orthopedic surgery, otolaryngology, cardiothoracic surgery, vascular surgery, ophthalmology, urological surgery, and obstetrics and gynecology.

Strict exclusion criteria were imposed. Studies were excluded if they were not in any of the a priori defined surgical subspecialties. Procedural specialties, such as anesthesia, critical care, or emergency medicine were not included. Studies that evaluated factors not available at the time of applicant ranking were excluded. In addition, studies were excluded if their outcome of residency success was restricted to the first or second year of residency for lack of relevance to the desired outcome of a successful resident.[20,21] In addition, studies were excluded if the outcome was completion of residency only, with no measure of performance.

Two authors (P.D.K. and S.L.Z.) independently reviewed all identified studies for relevance. Any disagreements were settled by discussion among authors, with inclusion of a third author (A.Y.K.) as necessary. Additional studies were identified through the review of references cited in selected articles and were evaluated for inclusion using the aforementioned procedures.

Data Extraction and Quality Assessment

A standardized data extraction spreadsheet was used to collect all study data. Data were initially extracted by one author (S.L.Z.) and confirmed by an additional author to ensure accuracy (A.Y.K., P.J.M., M.C.D., J.A.M.). Thus, each included article was reviewed independently by 2 authors. Observational publications included were all initially classified as low quality of evidence. For each of the questions, Grading