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Identification of Factors Associated with Hematology-Oncology Fellow Academic Success and Career Choice

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Abstract
Factors affecting hematology-oncology trainees' academic success and career choices have not been well characterized. We performed a retrospective study of 57 hematology-oncology fellows trained at Mayo Clinic between 2008 and 2017 in an attempt to identify factors associated with success during fellowship and with career choice (academic versus private). Sex, age, residency quality, and letters of recommendation indicating a "top" applicant were not associated with hematology or oncology in-training examination (ITE) scores, research productivity (abstracts/publications during fellowship), or career choice (academic versus private). Fellows with higher United States Medical Licensing Examination (USMLE) scores were more likely to perform well on ITE, but examination scores did not predict academic productivity or academic versus private career choice. More academically productive fellows were more likely to choose academic careers. Both ITE scores and productivity were associated with receipt of national and/or institutional awards. Finally, fellows who were non-US citizens and/or international medical graduates (IMG) had higher academic productivity both pre-fellowship and during fellowship and as per the observations above were more likely to choose academic careers. In conclusion, predictors of superior knowledge differ from predictors of academic productivity/career choice, and it is important to take multiple factors into account when selecting candidates most likely to succeed during fellowship.

Keywords Hematology · Oncology · Fellowship · Medical education · Outcomes

Introduction

Fellowship education in hematology-oncology is intended to provide graduates with the skills, knowledge, and attitudes necessary to pursue successful careers in clinical care and academic research [1]. The fellowship application is a rigorous process during which applicants' curricula vitae are reviewed by educational committees looking to select those applicants best suited to the fellowship class at a particular institution. Committees review multiple aspects of applicants' records including—but not limited to—medical school transcripts, United States Medical Licensing Examination (USMLE) step 1, 2, and 3 scores, residency "performance" (often based on an internal medicine program director's letter of recommendation and additional faculty letters of recommendation), and research productivity. Applicants chosen for interviews are then further stratified on the basis of interpersonal interactions with fellowship program directors (PDs), members of the selection committee, and current hematology/oncology fellows.

Prior work has identified determinants of hematology-oncology trainees' post-fellowship career pathways with respect to practice setting and patient distribution [2]. However, despite the extensive fellowship review and selection process, there are few studies characterizing the relationship between pre-fellowship variables reviewed during the selection process and subsequent fellowship outcomes, including performance on examinations during fellowship, academic productivity during fellowship, and ultimate choice of career. Work in other

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specialties has demonstrated that residents planning to apply to fellowships often doubt that they are preparing their applications correctly and that residents believe fellowship directors in their field of intent are the most reliable at providing fellowship-related information [3].

We believe that it is important to investigate associations between pre-fellowship and in-/post-fellowship markers of success for several reasons. We would like to provide prospective fellowship applicants with a better understanding of the factors most likely to influence individual domains of future success, give internal medicine PDs information on which to help focus mentoring and career development discussions during residency for those IM residents planning careers in hematology/oncology, and augment the ability of hematology/oncology fellowship selection committees to have truly evidence-based discussions about fellow selection. As such, we performed a retrospective review of several years of our prior fellowship trainees to identify determinants of success across several domains.

Methods

Data Collection

The Mayo Clinic Rochester Hematology/Oncology fellowship is a three-year ACGME-accredited fellowship which accepts between eight and ten categorical fellowship applicants per year. Fellows complete all training required for both hematology and medical oncology board eligibility within 3 years and have the option of continuing with the program for a fourth year to receive advanced subspecialty and/or research training. After receiving approval from the Mayo Clinic Institutional Review Board, study personnel performed a retrospective review of the records of all past Mayo Clinic Rochester hematology/oncology graduates meeting inclusion criteria. Inclusion criteria were as follows: matriculation to the fellowship program between 2008 and 2014 and subsequent graduation by June 2018 (fellows matriculating after 2014 were not included as this would not have allowed for complete data collection for those choosing to complete a fourth year of training).

Pre-fellowship data collected included age, sex, program start year, visa status (J1, H1B, permanent resident or US citizen), medical school including medical school location (United States or International), residency program, USMLE step 1, 2 clinical knowledge (CK), and 3 scores, number of fellowship letters of recommendation stating the applicant was "top" or "top 5%" of their residency class and/or amongst those residents that the letter-writer had mentored, number of abstracts presented prior to fellowship, and number of first-author peer-reviewed publications prior to fellowship. Numeric placement on our program's fellowship rank list was also included. In-fellowship and post-fellowship data collected included in-training examination (ITE) scores for both hematology and medical oncology each year of fellowship, number of abstracts presented during fellowship, number of first-author peer-reviewed publications during fellowship, awards received during fellowship (institutional, national, both, or neither), and post-fellowship career choice (academic or private practice).

Statistical Analysis

We assessed all associations in SAS 9.4. Spearman's correlations were used to test between two continuous or two ordinal variables. For a continuous outcome variable and binary predictor variable, we employed Student's *t* tests for a difference-of-means analysis, and analysis of variance models when the predictor was multinomial (citizenship status). For the reverse (binary outcome associations with continuous predictors), logistic regression was performed.

Results

Fellow Characteristics

Fellows' demographic characteristics prior to fellowship matriculation are shown in Table 1 (A). Thirty-eight fellows (66.7%) were male and the median age at the start of fellowship was 30 years (range 27–37). 45.6% of fellows were United States (US) citizens, 21.1% held J1 visas, 19.3% were permanent US residents, and 14% held H1B visas. 49.1% attended medical school in the USA and the remainder attended international medical schools. Median USMLE step 1, 2CK, and 3 scores are shown in the table. The median number of abstracts prior to fellowship was 2, and the median number of peer-reviewed publications was 1.

Academic and other accomplishments during fellowship and ultimate career choice (academic versus private practice) are shown in Table 1 (B). Median in-training examination (ITE) scores in years 1, 2, and 3 are shown for both hematology and oncology; scores increased over time for both. Fellows produced a median of two abstracts during fellowship (range 0–10) and a median of two peer-reviewed publications (range 0–11). 28.1% of fellows received a national award, 8.8% an institutional award, and 14% received both national and institutional awards. Thirty fellows (52.6%) entered academic medicine and 47.4% went into private practice.

Associations Amongst Pre-fellowship Variables

Relationships between pre-fellowship variables are shown in Table 2 (A, B), with statistically significant associations indicated by values and non-significant associations indicated by

Table 1 (A) Pre-fellowship demographics and accomplishments. (B) Accomplishments during fellowship and career choices

	N (%)	Median (range)
A		
Sex		
M	38 (66.7%)	
F	19 (33.3%)	
Age at start of fellowship		30 (27–37)
Visa status		
US citizen	26 (45.6%)	
Permanent resident	11 (19.3%)	
H1B	8 (14.0%)	
J1	12 (21.1%)	
Medical school location		
United States	28 (49.1%)	
International	29 (50.9%)	
USMLE step 1		244 (190–271)
USMLE step 2 CK		252 (220–278)
USMLE step 3		233 (192–258)
Abstracts pre-fellowship		2 (0–9)
Publications pre-fellowship		1 (0–6)
B		
Hematology, year 1 ITE		513 (332–719)
Hematology, year 2 ITE		634 (349–800)
Hematology, year 3 ITE		647 (411–800)
Oncology, year 1 ITE		485 (324–739)
Oncology, year 2 ITE		654 (437–800)
Oncology, year 3 ITE		709 (549–800)
Abstracts during fellowship		2 (0–10)
Publications during fellowship		2 (0–11)
Awards during fellowship		
None	28 (49.1%)	
Institutional	5 (8.8%)	
National	16 (28.1%)	
Institutional and national	8 (14.0%)	
Career choice		
Academic	30 (52.6%)	
Private practice	27 (47.4%)	

X. There was no association between sex, age, or citizenship status and either numbers of letter of recommendation in the "top" category or scores on USMLE 1 or USMLE2 CK scores; there was a positive association between non-US citizen status and higher scores on USMLE 3 ($p = 0.03$). Sex and age were not associated with number of abstracts or publications prior to fellowship, but non-US citizens were more likely to have both more abstracts and more publications prior to fellowship ($p = 0.02$ and $p = 0.03$, respectively). Similarly, there was no association between USMLE step 1, 2, or 3 scores and number of abstracts pre-fellowship, though there was a positive association between USMLE 1 and 2 scores and more publications prior to fellowship. Those who had attended international (non-US) medical schools were more likely to have both more abstracts as well as more publications prior to fellowship ($p = 0.0002$ and $p = 0.0005$, respectively). Those who attended US medical schools were more likely to have higher scores on USMLE Step 3 ($p = 0.0003$) but this association was not significant for steps 1 and 2.

Associations Between Pre-fellowship Variables and In-fellowship Variables

Associations between pre-fellowship variables and in-fellowship variables are demonstrated in Table 3. Neither sex, age, nor the number of "top" letters of recommendation was associated with ITE scores in hematology or oncology, the number of abstracts or publications during fellowship, or career choice. Higher USMLE step 1 scores were significantly associated with higher scores on hematology ITE (years 1, 2, and 3) as well as higher scores on oncology ITE but only in year 2. Higher USMLE step 2 CK scores were significantly associated with higher scores on hematology ITE (years 1, 2, and 3) and higher scores on oncology ITE in years 1 and 2. Higher USMLE step 3 scores were only associated with higher scores on oncology ITE in year 1. Higher USMLE step 3 scores were associated with fewer number of abstracts during fellowship ($p = 0.004$) but there was otherwise no association between USMLE scores and number of abstracts or publications in fellowship or career choice.

Higher number of abstracts pre-fellowship was associated with higher scores on oncology ITE (year 2), more abstracts and publications during fellowship, and academic career choice. Higher number of publications pre-fellowship was associated with higher scores on hematology ITE (years 1 and 2), oncology ITE (year 2), and choice of an academic career, but was not associated with having more abstracts or publications during fellowship.

Non-US citizen status was significantly associated with higher scores on hematology ITE (year 2), oncology ITE (years 2 and 3), more abstracts and publications during fellowship, and choice of an academic rather than a private practice career. Attending an international medical school rather than a US medical school was also associated with higher scores on oncology ITE (year 2), more abstracts in fellowship, and choice of an academic career.

With respect to awards received during fellowship, there was no association between sex, age, USMLE step 1, 2, or 3 scores, or number of "top" letters of recommendation and receipt of awards (either institutional, national, or both) during fellowship. However, there were significant associations between non-US citizenship status, attendance at an international medical school, and higher numbers of abstracts and publications prior to fellowship and receipt of awards.

Table 2 (A) Associations amongst demographic factors and pre-fellowship variables. (B) Associations amongst pre-fellowship variables

Pre-fellowship variable						
Demographic variable	USMLE 1	USMLE 2 CK	USMLE 3	LOR top	Abstracts pre-fellowship	Pubs pre-fellowship
Sex	X	X	X	X	X	X
Age at matriculation	X	X	X	X	X	X
Citizenship status	X	X	0.03	X	0.02	0.03
Med school US or int	X	X	0.0003	X	0.0002	0.0005
Later pre-fellowship variable						
Early pre-fellowship variable		LOR top	Abstracts pre-fellowship		Pubs pre-fellowship	
USMLE 1		X	X		0.02	
USMLE 2		X	X		0.01	
USMLE 3		X	X		X	

Association Between In-fellowship Variables and Outcomes

As seen in Table 4, higher scores on hematology ITE in years 1 and 3 were significantly associated with a higher number of publications during fellowship but not with number of abstracts during fellowship nor with academic versus private career choice. There were no associations between hematology ITE score in year 2 or oncology ITE scores in any year and number of abstracts or publications during fellowship or with career choice. Higher numbers of abstracts and publications during fellowship were significantly associated with receipt of awards as well as with a higher likelihood of choosing an academic career.

Discussion

We assessed pre-fellowship and in-fellowship variables from a cohort of hematology/oncology fellows who matriculated to our fellowship program between 2008 and 2014 and found several associations between individual variables and academic and career outcomes. The most striking findings included significant associations between (1) pre-fellowship and intra-fellowship examination scores, (2) pre-fellowship and intra-fellowship academic productivity, (3) pre- and intra-fellowship academic productivity and the choice of an academic career, and (4) non-US citizenship status and attendance at an international medical school and subsequent academic productivity and choice of an academic career.

This is the first such study characterizing the association between pre-fellowship and intra-fellowship/post-fellowship success across multiple domains. We believe that, based both on previous reports in the literature as well as a degree of common sense, none of these findings are particularly surprising. Although the breadth of prior work examining factors affecting success of fellow-level trainees is limited, there is more with regard to predictors of success in residency. One Mayo Clinic-based study of urology residents found that several factors including higher USMLE step 2 CK scores, lack of negative interview comments, and honors in clinical clerkships were associated with improved "quality scores" during residency (as scored by program leadership) [4]. For general surgery residents, higher USMLE step II scores have been

Table 3 Associations between pre-fellowship and in-fellowship variables

	In-fellowship variable								
Pre-fellowship variable	Heme ITE Y1	Heme ITE Y2	Heme ITE Y3	Onc ITE Y1	Onc ITE Y2	Onc ITE Y3	Abstracts in fellowship	Publications in fellowship	Career acad/private
Sex	X	X	X	X	X	X	X	X	X
Age at matriculation	X	X	X	X	X	X	X	X	X
Citizenship status	X	0.047 (I)	X	X	0.01 (I)	0.01 (I)	0.002 (I)	0.03 (I)	< 0.001 (I)
Med school US or int	X	X	X	X	0.02 (I)	X	0.004 (I)	X	< 0.001 (I)
USMLE 1	0.007	0.004	0.006	X	0.01	X	X	X	X
USMLE 2 CK	0.007	0.001	0.01	0.003	0.02	X	X	X	X
USMLE 3	X	X	X	0.02	X	X	0.004	X	X
LOR Top	X	X	X	X	X	X	X	X	X
Abstracts pre-fellowship	X	X	X	X	0.046	X	0.002	X	0.005
Publications pre-fellowship	0.04	0.02	X	X	0.002	X	X	X	0.048

Table 4 Associations between In-Fellowship Variables and Outcomes

	In-Fellowship productivity/career outcome		
In-fellowship quantitative	Abstracts in fellowship	Publications in fellowship	Career acad/private
Heme ITE Y1	X	0.006	X
Heme ITE Y2	X	X	X
Heme ITE Y3	X	0.05	X
Onc ITE Y1	X	X	X
Onc ITE Y2	X	X	X
Onc ITE Y3	X	X	X
	Outcome		
In-fellowship scholarship	Career acad/private		
Abstracts in fellowship	0.01		
Publications in fellowship	0.046		

correlated with improved performance on the surgical ABSITE scores (equivalent to ITE examinations for residents and fellows), and the number of honors grades received in third-year medical student rotations was associated with improved competency-based evaluations during surgical residency [5, 6]. USMLE examination scores have also been associated with ITE performance in obstetrics-gynecology residents, emergency medicine residents, and dermatology residents [7–9].

There are few studies specifically examining determinants of success in hematology-oncology fellows. Of the few studies we could identify, one found that hematology and oncology in-service examination scores were stronger predictors of a passing score on the hematology and medical oncology boards, respectively, than program director assessment of competency [10], but this study did not assess additional factors which could have contributed such as prior USMLE scores, letters of recommendation, and citizenship/visa status and did not assess fellows' career choices and future academic pursuits. Another study found that specific factors including completion of a clinical project, faculty mentorship, and obtaining independent career development funding were correlated with predictors of an academic career pathway after fellowship [11], but this study did not examine factors associated with objective academic success such as ITE scores.

It is important to address the key role we found for non-US citizenship and international medical graduate (IMG) status as factors associated with higher academic productivity both pre-fellowship and during fellowship. IMGs make up approximately 25% of the US physician workforce [12]. In the 2017 hematology-oncology fellowship match (2018 start date), 26.5% of positions were filled by non-US citizen international graduates and another 6.6% by US citizens graduating from non-US medical schools [13]. Prior work has shown that neuroradiology fellows who are graduates of international medical schools were more academically productive during fellowship than those who were graduates of US medical schools, and additional work has suggested improved clinical outcomes for patients of doctors graduating from international medical schools who were not US citizens at the time they entered medical school [14, 15]. Despite this, IMGs often find it challenging to gain acceptance to US-based residency programs and must often work harder to "prove themselves" especially those hoping to later match at competitive fellowship programs. Therefore, we were not surprised to observe that non-US citizens and IMGs were more academically productive prior to fellowship; research publications have been associated with IMG success in acquiring fellowship spots and may serve as a "ticket" into fellowship [16].

This study was carried out at a large academic program with unique geographic and practice characteristics which may limit the generalizability of our findings. A large proportion of our fellows are academically productive prior to fellowship, which is not an element universal to all programs, and therefore the association between pre-fellowship and intra-fellowship productivity may not be entirely generalizable. Furthermore, those fellowship programs which take limited numbers of non-US citizens and/or IMGs may not find these particular citizenship and training location associations applicable to their own programs. Additionally, the associations between IMG status and success are not necessarily generalizable to non-hematology-oncology training programs given that a study of gastroenterology fellows at our institution found negative associations between IMG status and performance ratings [17].

Overall, we believe our findings to be somewhat unsurprising as they demonstrated that past success in one domain (test-taking or academic productivity) predictive of future success in the same domain. Those who performed well on tests in the pasts are likely to continue to do so in the future, and similarly, those who were more productive prior to fellowship are more likely to continue to be productive in fellowship and choose

academic careers. Additionally, those fellows who are non-US citizens and/or IMGs were more likely to be academically productive before and during fellowship and choose academic careers. There are multiple potential positive implications for the inclusion of academically impressive non-US citizens/IMGs as members of fellowship classes both from an academic/research standpoint and from a contribution to diversity in the US physician workforce [18]. We hope that these observations provide evidence-based guidance for aspiring hematology-oncology fellows, IM program directors, and mentors across a variety of spectrums.

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