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# Qualities and characteristics of applicants associated with successful matriculation to pediatric surgery fellowship training

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ABSTRACT

*Background:* Pediatric surgery (PS) is among the most competitive fellowship opportunities for general surgery residents. Prior investigations into factors associated with successful matriculation to PS have relied on surveys, which have inherent biases.
*Study design:* Data were extracted from the Electronic Residency Application System for applicants from 2012 to 2017 and analyzed after stratification by matriculation status.
*Results:* Data were gathered on a total of 444 applicants, of which 238 matriculated. The applicant pool was predominantly Caucasian (63.5%), largely graduated from US allopathic school (81%) and had a slight male predominance (54%), although the number of female applicants increased significantly over the study period. Attendance at a US allopathic medical school (OR = 4.55, $p < 0.001$), university-based general surgery training (OR = 3.02, $p < 0.001$) and training at institutions that offer PS fellowships (OR = 3.36, $p < 0.001$) were associated with matriculation. Matriculants had a higher quantity of peer reviewed publications (median 11 vs. 6, $p < 0.001$) and published in high impact factor journals ($p < 0.001$). A total of 65 applicants reapplied at least once, of whom 32% successfully matriculated.
*Conclusions:* PS applicants' medical school, residency, and research data points correlated with successful matriculation. These data may help guide general surgery residents and medical students aspiring to become pediatric surgeons.
*Type of study:* Prognosis study (retrospective)
*Level of evidence:* Level II

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Fellowship training has now become the most prevalent career path upon completion of a general surgery residency with nearly 80% of residents choosing to pursue some form of additional surgical training [1–2]. Among the many options available to general surgery graduates, Pediatric Surgery (PS) remains one of the most sought-after fellowships [3–5]. Candidates interested in training to become pediatric surgeons may apply for fellowship in PS programs designated by the Association of Pediatric Surgery Training Program Directors (APSTPD). The pediatric surgical match was established in 1992 and applications are currently submitted through the Electronic Residency Application Service (ERAS) [3]. There are currently 58 PS fellowships training programs (50 in the United States, 8 in Canada) recognized by the Accreditation Council for Graduate Medical Education (ACGME) and APSTPD, as well as Royal College of Physicians and Surgeons of Canada, and their graduates are eligible to sit for pediatric surgery board examinations [6–9].

Given a historically competitive application process, many have tried to elucidate factors associated with successful matriculation to PS fellowships to help guide prospective applicants. Most of these studies have utilized surveys or reviews of single-institution ERAS data, which do not capture the entire applicant pool and are therefore subject to inherent biases. These studies, however, demonstrated that correlations with "high-rank" on the match list were found for exceptional ABSITE scores, graduation from a US medical school, high quality of recommendation letters, AOA membership, and number of peer reviewed publications [3–5]. Our group previously used data from the ERAS to delineate factors associated with successful application to fellowship in Complex General Surgical Oncology (CGSO), which is yet another competitive fellowship after general surgery. ERAS national database allowed us to address the fundamental weakness that was found in previous single institution studies [10]. We utilized ERAS to gather objective data for PS applicants. Specifically, we aimed to provide a more complete and

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objective view of the applicants to PS fellowship training through the delineation of the applicant pool in general, as well as factors predictive of successful matriculation.

## 1. Methods

### 1.1. Data acquisition

The use of deidentified data was approved and released through an existing data sharing contract between the Association of American Medical Colleges (AAMC) and the National Institutes of Health (NIH). All applicant data originated from ERAS applications for PS fellowships for the 2012 through 2017 applications cycles. To maintain strict applicant privacy, all data were collected from ERAS directly by data operation specialists at the AAMC and deidentified prior to acquisition and use by our group.

PS fellowship programs are approved by APSTPD as well as the ACGME and consisted of 50 American programs and 8 Canadian programs during our study period [7,8]. All approved programs (except The Hospital for Sick Children/Toronto and CHU Ste Justine/ University of Montreal in Canada) require the use of ERAS to apply for PS fellowship positions and, thus, all applicants to these programs from 2012 to 2017 were included in analysis. A total of 444 unique applicants were identified, and then stratified based on matriculation status (i.e. successful vs unsuccessful matriculation). To confirm that an ERAS applicant matriculated to a PS fellowship, applicant ID numbers from ERAS were cross-referenced with the rosters of the specified fellowship programs in GME Track. For applicants who applied more than once, only demographic and qualification from their most recent application were considered for analysis.

### 1.2. Definitions

#### 1.2.1. Residency type

Applicant demographics, medical school and residency characteristics, and publication data were collected by AAMC data specialists and provided to our group for additional analysis. General information on applicants' residency programs (whether US vs Canadian) and their affiliations was obtained from the American Medical Association's Fellowship and Residency Electronic Interactive Database (FREIDA) and matched to their ACGME Identification number. Residency programs are classified in FREIDA as university-based, community-based, or community-based/university-affiliated [9]. Residencies falling outside of these classifications are American Osteopathic Association programs, international residencies, and military programs and are denoted in a combined group labeled "Other." Residency programs were also classified by whether they had a PS fellowship. Institutional and hospital affiliation of an applicant's home residency program was determined based on FREIDA.

#### 1.2.2. Publication status

Published manuscripts authored by deidentified applicants were quantified, and the name and impact factor (IF) of each journal were recorded. A publication was counted for each applicant regardless of authorship position on a peer-reviewed scientific or clinical manuscript that was published, and articles with the status of "under review" or "accepted but not yet published" were excluded. Journal IFs were obtained from Thomson Reuters Journal Citation Reports for the year 2017 as calculated by Clarivate Analytics based on citations [11]. We adopted Wach et al. methods of quantifying academic productivity. Journals were ranked into academic tiers based on their IFs, with tier 1 assigned to low tier journals defined by IF <2.5, tier 2 assigned to midtier journals with IF 2.5-9.9, and tier 3 assigned to journals possessing an IF ≥10. The highest tier in which an applicant achieved publication was recorded as that applicant's impact tier. Individuals that did not have any publications listed were classified as Tier 0 [11].

### 1.3. Statistical analysis

Applicant characteristics were described and stratified according to matriculation status. Differences in characteristics were analyzed with Fisher's exact test and with odds ratios to demonstrate the association of potentially important factors on matriculation. Continuous variables were compared using the Wilcoxon rank sum test. The Cochran–Armitage trend test was applied to determine the significance of trends in publication in increasing impact factor journals on matriculation status as well as trends in numbers of applicants by sex over time. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC).

## 2. Results

### 2.1. Applicant characteristics

During the 6 years from 2012 to 2017, there were a total of 444 applicants to PS fellowship (Table 1). The average applicant age was 33.2 years. The applicant pool was more than half male (54%), primarily Caucasian (63.5%) either alone or in combination, with a large proportion of graduates from US allopathic medical school (81%).The matriculants during this time period were more likely to be male (59.7% vs. 48.1%; odds ratio: 1.60; 95% CI: 1.10–2.33; $p = 0.017$) and white vs. any other reported race or ethnicity (69.8% vs. 56.3%; odds ratio: 1.79; 95% CI: 1.21–2.64; $p = 0.0041$). There was an upward trend in the number of female applicants over the last three years, whereas the number of male applicants was static, and there was an overall relative increase in female applicants over all 6 years ($p = 0.0082$ by Cochran–Armitage test, Fig. 1). In 2017, the number of female applicants surmounted that of male applicants. Of the applicants who graduated from allopathic medical schools, 32.7% were AOA members. Applicants from University-based general surgery training programs comprised the largest proportion of the applicant pool (75.6%) and nearly half (46%) of the applicants completed their general surgery training at a site with a PS fellowship. Finally, most applicants likely undertook dedicated research time as 67% of applicants spent more than 5 years in general surgery training with a median of 7 years.

### 2.2. Factors differentiating matriculants and nonmatriculants

Of the 444 applicants, 238 ultimately matriculated into PS fellowship programs. Over the 6-year study period, 65 applicants reapplied and of these, 21 (32%) ultimately matriculated. Comparing the matriculants to the nonmatriculants, we found a statistically significant difference in the proportion attending US Medical Schools (91.2% vs. 69.4%, $p<0.001$), training at University-based residency programs (84.9% vs, 65.1%, $p = 0.001$), and those completing general surgery training at a program with a PS Fellowship (59.7% vs. 30.6%, $p <0.001$) (Table 2).

Using number of publications as a surrogate to quantify research productivity, we found that matriculants had significantly more total number of publications than nonmatriculants (median 11 vs. 6, $p <0.001$, Fig. 2). Matriculants also tended to achieve publication in a high impact journal more frequently compared to nonmatriculants ($p <0.001$, Fig. 3).

## 3. Discussion

We objectively addressed the characteristics of the PS applicant pool, using the last six years of pooled, deidentified national data from AAMC/ERAS, and highlighted the importance of general surgery residency training at a university-based center and dedicated research time with quantitative and qualitative productivity. In the APSA Presidential address of 1995, Dr. Amoury presented the need for objective factors in selecting applicants that would replace the current pediatric surgeons [12]. Despite being a topic of interest for more than two decades, ambiguity remains given the heterogeneity of the match

**Table 1**
Demographics and residency attributes for all applicants in 2012–2017

| Characteristics ($n = 444$) | $n$ (%) | Nonmatriculants (%) | Matriculants (%) |
|---|---|---|---|
| **Sex** | | | |
| Male | 241 (54) | 99 (48) | 142 (60) |
| Female | 203 (46) | 107 (52) | 96 (40) |
| **Race/Ethnicity (Alone/Combination)** | | | |
| White | 282 (64) | 116 (56) | 166 (70) |
| Black/African American | 20 (5) | 13 (6) | 7 (3) |
| Asian | 71 (16) | 26 (13) | 45 (19) |
| Hispanic, Latino, or Spanish | 31 (7) | 19 (9) | 12 (5) |
| Other [a] | 71 (16) | 46 (22) | 25 (11) |
| **Medical Education** | | | |
| US Allopathic | 360 (81) | 143 (69) | 217 (91) |
| US Osteopathic | 7 (2) | 6 (3) | 1 (0.4) |
| Canadian | 26 (11) | 24 (12) | 2 (0.8) |
| International | 51 (22) | 33 (16) | 18 (8) |
| **AOA Membership** [b] | 97 (22) | 26 (18) | 71 (33) |
| **General Surgery Residency Attributes** | | | |
| University Affiliated | 336 (76) | 134 (65) | 202 (85) |
| Community Based-University Affiliated | 26 (6) | 16 (8) | 10 (4) |
| Community Based | | | |
| Other [c] | 41 (9) | 22 (11) | 19 (8) |
| | 81 (29) | 34 (17) | 7 (3) |
| **Children's Hospital Fellowship Affiliated Residency** | 205 (46) | 63 (31) | 142 (60) |

[a] Other includes American Indians, Alaska natives, non US citizens, Native Hawaiian; total number >444 because of combination of race/ethnicity
[b] Alpha Omega Alpha is an honor society for US allopathic schools and does not represent the entire population
[c] Other classification of residency includes American Osteopathic associated surgical programs, military based programs, International programs, unknown

process. The selection process varies from institution to institution and protection of identity of the applicants is of utmost importance, which previously impeded analysis at a national level. One of the salient features of the complexity as well as the competitive nature of the PS fellowship process is the relatively small pool of fellows and attendings at each fellowship-level institution. Most programs train one or two fellows at a time, sometimes selecting a new fellow only every other year. This highlights the importance of finding the "right fit" applicant individualized to each specific program.

The applicant characteristics that have been previously described in the literature were all based on single institution series or survey of applicants/program directors [12–14]. Our study contributes new knowledge by confirming these findings on a national level, across sites. Hirthler et al. demonstrated that matriculants were likely to hail from allopathic school within the United States. Similarly, general surgery residency training at a university-based center was shown to be highly significant between matriculants and nonmatriculants. Our study pointed out the low number of applicants and matriculants from osteopathic medical school. These findings have been consistent across the literature in the past couple decades, likely because of the competitive nature of PS and the inherent bias towards allopathic school education as well as surgical training at academic centers.

It was particularly notable that the number of female applicants in the pool has steadily grown over the past three years. In the last six years, there were more males than females matriculating despite the increase in the female applicant pool. A change was noticed in 2017, where there were more 21 female and 19 male matriculants. While the male to female ratio of medical students has achieved parity over the last decade, only 19% of all surgeons in the US are women [15]. This disparity is even more striking in pediatric surgery. Future studies will be necessary to demonstrate whether this trend in increasing female applicants to pediatric surgery results in gender parity within the specialty.

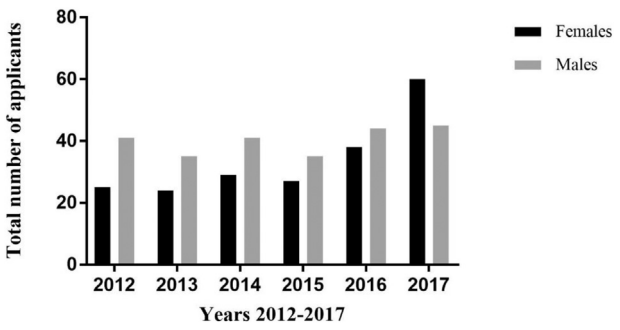


**Fig 1.** Trend in total number of male versus female applicants in years 2012–2017.

The competitive nature of the PS fellowship, reflected in ~58% match rate, necessitates a robust curriculum vitae from prospective applicants. A prior survey revealed that the number of first-author publication and basic research content were the top objective metrics in matriculant profiles, strongly suggesting the need for dedicated time away from clinical duties for research [4]. In our analysis, we assessed the number of combined, clinical and research, years spent in surgical residency for all the applicants. Applicants spent a median of 7 years in residency, with the mean number of hours spent in research nearly 700 more for matriculants than nonmatriculants. Not surprisingly, we found a clear difference between the median number of peer reviewed publications for matriculants and nonmatriculants. Little et al. showed that matriculants had nearly double the number of publications compared to the nonmatriculants [4]. In a more recent analysis of the three-year single institution cohort applying to Children's Mercy Hospital of Kansas, the authors showed similar trends in number of publications. They further showed that number of publications was significant factor whether an applicant matched in their top 10 versus top 3 choices [3].

The quality of research by the applicant can be measured by various methods like first authorship as well as publication in the type of journal. Impact factor of the scientific journals is one of the yardsticks used to gauge the quality of journals and thereby is a surrogate for the quality of research. Using highest impact factor accomplished by the

**Table 2**
Applicant characteristics associated with matriculation.

| Factor | Odds Ratio | 95% CI | p-value |
|---|---|---|---|
| US Allopathic School | 4.55 | 2.66–7.79 | <0.001 |
| AOA status[a] | 2.19 | 1.31–3.65 | 0.002 |
| University Based residency | 3.01 | 1.91–4.76 | 0.001 |
| Residency with pediatric surgery fellowship | 3.36 | 2.27–4.98 | <0.001 |

[a] AOA status designation only applies to US allopathic school only, $n = 360$.

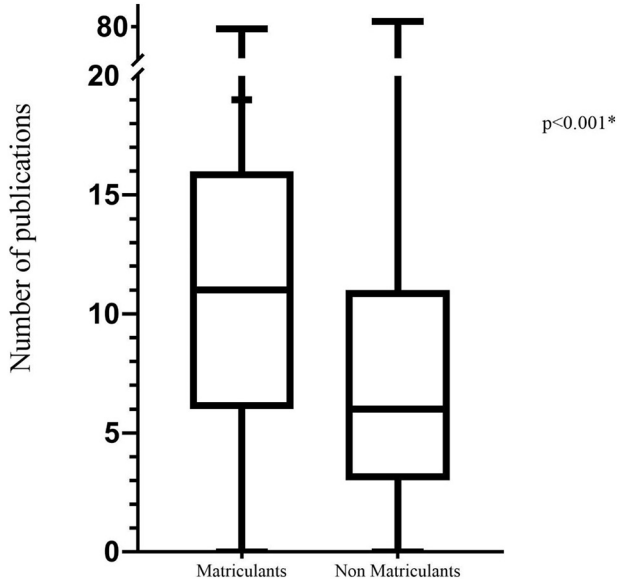


**Fig 2.** Quantity of published scientific manuscripts per applicant stratified by matriculation status. *Boxes represent lower quartile, median and upper quartile while whiskers represent range. *P value represents statistical difference between the median number of publications in matriculants vs. nonmatriculants.*

applicant, the results showed that most applicants were able to produce research in midtier journals and that more matriculants achieved higher tier journals as compared to nonmatriculants. This surrogate method of measuring quality validates the role it plays in the selection process.

Reapplying for a fellowship position is common in fields that carry low match rates. There have been no previous reports of reapplicant success data in the literature. In our unique study, we found that the reapplicant match rate is about one-third over the last six years. This is important information to counsel applicants as they go through residency as well as fellowship decisions. Anecdotally, applicants unsuccessful in first attempt often look for fellowships such as pediatric critical care, minimally invasive surgery, other nonaccredited fellowships or engage in scientific work in the "year off"; however, there have been no studies reported in the literature to best guide the unsuccessful applicant toward matriculation.

The biggest limitation in this study was the nature of the deidentified, pooled data. Another inherent limitation was the exclusion of two Canadian programs (The Hospital for Sick Children/Toronto and CHU Ste Justine/ University of Montreal in Canada) that offer two spots every other year, whose data were missed since they do not utilize the ERAS application process. This study was also unable to capture the programs that dropped out of match to accept fellows outside of match

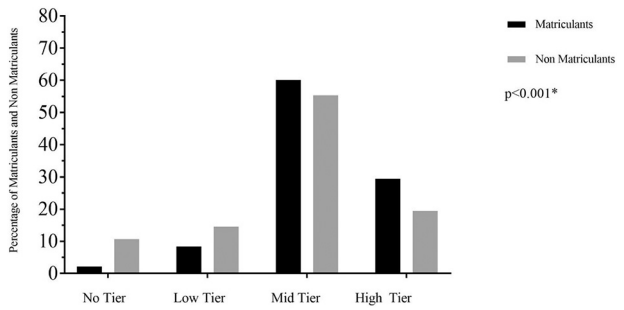


**Fig 3.** Comparison of achievement of publication in highest impact factor journal according to the matriculation status. *No tier = No publication, or journal with no impact factor. Low tier = Journals with impact factor <2.5. Midtier = Journals with impact factor 2.5–9.9. High tier = journals with impact factor > or =10. *P value signifies the statistical difference in matriculants vs nonmatriculants over the tiers.*

process. One of the foremost markers of research success is first authorship, which could not be discerned with deidentified data. ABSITE scores are another objective metric that may play a significant role in the interview or match process. This information was not retrieved in our database and hence could not be evaluated. There are other intangible factors such as the interview process, letters of recommendation, presentations at national meetings, and connections with leaders in the field that may play a pivotal role in a successful match. These could not be studied using this national database and require a survey of the program directors.

## 4. Conclusion

Overall, in this unique study utilizing the ERAS database we examined the overall PS applicant pool's characteristics and factors leading to matriculation. Education at US allopathic medical school followed by training at University-based center, especially one with PS fellowship site was associated with matriculation. Further, matriculants had a greater number of total publications and tended to be published in higher impact factor journals. These factors can guide in counseling and career planning for future general surgery residents interested in pursuing PS. More up to date program director survey would be needed to further understand the interview process and study additional factors that lead to matriculation.

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## IRB approval

This study utilized the collaboration with ERAS/AAMC with NIH to use deidentified pooled data only, as such it was exempt from IRB approval.

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