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# Transplant Surgery Pipeline: A Report from the American Society of Transplant Surgeons Pipeline Taskforce

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- BACKGROUND:** Transplant surgery fellowship has evolved over the years and today there are 66 accredited training programs in the US and Canada. There is growing concern, however, about the number of US-trained general surgery residents pursuing transplant surgery. In this study, we examined the transplant surgery pipeline, comparing it with other surgical subspecialty fellowships, and characterized the resident transplantation experience.
- METHODS:** Datasets were compiled and analyzed from surgical fellowship match data obtained from the National Resident Matching Program and ACGME reports and relative fellowship competitiveness was assessed. The surgical resident training experience in transplantation was evaluated.
- RESULTS:** From 2006 to 2018, a total of 1,094 applicants have applied for 946 transplant surgery fellowship positions; 299 (27.3%) were US graduates. During this period, there was a 0.8% decrease per year in US-trained surgical residents matching into transplant surgery ( $p = 0.042$ ). In addition, transplant surgery was one of the least competitive fellowships compared with other National Resident Matching Program surgical subspecialty fellowships, as measured by the number of US applicants per available fellowship position, average number of fellowship programs listed on each applicant's rank list, and proportion of unfilled fellowship positions (each,  $p < 0.05$ ). Finally, from 2015 to 2017, there were 57 general surgery residency programs that produced 77 transplant surgery fellows, but nearly one-half of the fellows ( $n = 36$  [46.8%]) came from 16 (28.1%) programs.
- CONCLUSIONS:** Transplant surgery is one of the least competitive and sought after surgical fellowships for US-trained residents. These findings highlight the need for dedicated efforts to increase exposure, mentorship, and interest in transplantation to recruit strong US graduates. (J Am Coll Surg 2021; ■:1–10. © 2021 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

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Formalized abdominal transplant surgery fellowship training was first organized by the American Society of Transplant Surgeons (ASTS) in 1980 with the development of educational training guidelines and a certification process for transplant surgery training programs.<sup>1</sup> Before this, training in transplant surgery occurred primarily as an unstructured apprenticeship, with trainees spending variable periods of time with emerging figures in the field.<sup>2</sup> During the past 4 decades, the training process has evolved with respect to program selection, experience requirements, and, most recently, the promulgation of training milestones and quality standards. Although transplant surgery applicants were historically chosen at the individual-program level, the ASTS formally entered the National

Resident Matching Program match in 2005 to standardize the application and selection process. In 2006, the ASTS began monitoring fellows' operative experience through periodic self-submission of operative logs, which transitioned to an electronic system in 2009. The first annual ASTS Fellows Training Symposium and Program Directors Conference was held in 2007. In 2008, the Academic Universe, an online curriculum for transplant surgery fellows focused on a breadth of topics germane to transplantation, was introduced. In that same year, the first fellow workload practice guidelines were developed, and these were later ratified in 2017 with the adoption of the ASTS managed time policy.<sup>3,4</sup> Today, this evolution has resulted in 66 well-structured accredited ASTS transplant surgery training programs, with 81.8% being multi-organ (kidney and liver) and 16.7% kidney only.<sup>5</sup>

Despite these advancements, there has been growing concern about the number of US-trained general surgery residents pursuing transplant surgery. This unease began in the late 1990s, when it was reported that 50% of all transplant surgery fellows were foreign medical graduates.<sup>1</sup> The problem was compounded further after recurring criticisms by general surgery residents who described a poor operative experience, lack of defined curriculum, overwhelming service requirements, and meager attending interactions on transplant surgery rotations.<sup>6</sup> These challenges, in combination with a limited supply of high-quality clinical and academic staff positions in the field, resulted in intense competition for jobs among the graduating trainees and further harm to the reputation of transplant surgery as a fruitful and meaningful career choice for trainees.

In 2018, the ASTS leadership established the Transplant Surgery Pipeline Taskforce. We envision the "pipeline" as the source of medical students and surgical trainees who develop a passion for our field and will become the transplant surgeons of the future. In his presidential address in 2011, Michael Abecassis warned our community of the "loss of luster" impacting our ability to attract the best young people into our field.<sup>7</sup> This work represents our initial efforts to understand these factors and serves as a position paper for efforts to address these concerns. Herein we describe the existing transplant surgery pipeline, comparing it with other surgical subspecialty fellowships, and examine factors associated with general surgery training programs and their potential influence on one's decision to pursue transplant surgery.

## METHODS

### Fellowship match analysis

The transplant surgery pipeline was evaluated using data from multiple sources. First, abdominal transplant surgery

match data from 2006 to 2018 were evaluated using publicly available match data from the ASTS. Second, surgical subspecialty fellowship match data for colorectal, pediatrics, critical care, vascular, thoracic, and surgical oncology were analyzed for comparison relative to transplant surgery. These data were obtained from the National Resident Matching Program (NRMP) yearly specialties matching service reports, which are available through the NRMP.<sup>8</sup> Applicants were analyzed based on the country in which they completed their surgical residency training. Although the ASTS match data stratified applicants as US, Canadian, and foreign graduates, the NRMP match data only stratified applicants as US and foreign graduates. For this analysis, US graduates were considered to be those that completed their surgical residency within the US, and foreign graduates completed their surgical residency in Canada and all other countries. These match data were used to evaluate trends in the transplant surgery match and relative fellowship competitiveness. Competitiveness among fellowships was analyzed by examining the number of applicants per available position, the number of rankings per applicant in the match, and by the proportion of unfilled fellowship positions.

### General surgery resident operative experience

The overall operative experience for general surgery residents in abdominal transplantation during their residency training was examined. Operative log data for US general surgery graduates are maintained by the ACGME, with aggregate data reportedly annually. The publicly available operative reports from 2000 to 2016 were reviewed (<https://www.acgme.org/Data-Collection-Systems/Case-Logs-Statistical-Reports>). The resident operative experience in abdominal transplantation is reported as both the net total experience and the proportion of total transplantations nationwide that involved general surgery residents. To calculate the latter, the total number of renal, liver, and pancreas transplantations was obtained from United Network for Organ Sharing database, with the annual time frame set as July 1 to June 30 to parallel the academic year for trainees. It was assumed that "significant participation" in a transplantation would occur for senior-level residents (R3 to R5) only, and not junior residents (R1 to R2), and that if a resident participated substantially in a transplantation, they would log the operation. Based on these assumptions, the proportion of the annual transplantations involving general surgery residents was estimated by taking the national total operative volume of renal, liver, and pancreas transplantations (per the ACGME case log data) and dividing it by a rolling 3-year average of the total national annual operative

volume of renal, liver, and pancreas transplantations (as per the United Network for Organ Sharing database).

### **Influence of transplant surgery program and rotation site on interest in transplant surgery fellowship**

Finally, graduate fellow data from 2015 to 2017 were obtained from the ASTS to evaluate an association between a resident's training program and their interest in transplant surgery. This analysis was limited to those residents who trained within the US. Any residency program without an ASTS-approved transplant surgery fellowship or an abdominal transplantation program was contacted to identify which transplantation program, if any, their trainees used for a transplant surgery rotation. An analysis was then performed to determine whether a particular surgical residency or transplantation training experience was more likely to place residents into the transplant surgery pipeline.

### **Statistical analysis**

Continuous data are reported as mean  $\pm$  SD. Categorical data are reported as n (%). Linear regression analysis was used to evaluate trends in the transplant surgery match over time. The coefficient of determination ( $R^2$ ), which ranges from 0 to 1, was used to measure goodness of fit. A value near 0 indicates poor fit and a value towards 1 indicates good fit. A one-way ANOVA for multiple comparisons with the Bonferroni post-hoc test was used for normally distributed data and ANOVA on ranks with the Dunn's post-hoc test was used for non-normally distributed data to determine differences between surgical subspecialty fellowships. The chi-square test was used for categorical data. A p value  $< 0.05$  was considered statistically significant. All statistical analyses were performed using JMP Pro, Version 12.0 (SAS Institute). This study was approved by Columbia University's IRB.

## **RESULTS**

### **Abdominal transplant surgery fellowship match**

From 2006 to 2018, a total of 1,094 applicants applied for 946 transplant surgery fellowship positions in the transplant surgery match. Among all applicants during this time period, 299 (27.3%) were US-trained residents and the remaining 795 (72.7%) were international medical school graduates. Overall, applicants successfully matched into 689 positions, filling 72.8% of all of the available transplant surgery fellowship positions. Of those who matched, 404 (58.6%) were international medical graduates and 285 (41.4%) were US-trained residents. During this time, 4.7% of US graduates did not match and 50.1% of international medical graduates did not match. The transplant surgery match trends are reported in [Table 1](#).

The proportion of US-trained general surgery residents applying and matching into transplant surgery was examined by linear regression analysis ([Fig. 1](#)). During the 13-year period, there was no overall change in the number of US-trained applicants applying to transplant surgery ( $p = 0.0652$ ); however, there was a 0.8% decrease per year in US-trained surgery residents matching into transplant surgery ( $p = 0.042$ ,  $R^2 = 0.323$ ). This translates to an overall 10.4% decrease during the 13-year period. This decrease occurred in spite of the fact that during this time, US-trained applicants were 20.4 times more likely to successfully match into transplant surgery than foreign-trained applicants (95% CI, 11.7 to 35.5;  $p < 0.001$ ).

### **National Resident Match Program fellowship comparison analysis**

The proportion of US-trained surgery resident applicants in transplant surgery was compared with other NRMP surgical subspecialty fellowships ([Fig. 2](#)). Fewer US-trained surgery residents applied to transplant surgery (28.0%  $\pm$  5.6%) compared with colorectal (70.2%  $\pm$  3.7%), pediatrics (79.1%  $\pm$  4.4%), critical care (72.3%  $\pm$  4.6%), vascular (68.5%  $\pm$  4.3%), thoracic (69.8%  $\pm$  3.6%), and surgical oncology (58.5%  $\pm$  7.2%) (each,  $p < 0.001$ ).

The relative competitiveness of transplant surgery compared with the other NRMP surgical subspecialty fellowships was then determined using 3 complementary approaches. First, the number of US applicants per available fellowship position was calculated ([Fig. 3A](#)). There were significantly fewer US-trained applicants per available position for transplant surgery (0.32  $\pm$  0.04 applicants per position) compared with colorectal (0.95  $\pm$  0.06;  $p < 0.001$ ), pediatrics (1.46  $\pm$  0.18;  $p < 0.001$ ), vascular (0.71  $\pm$  0.06;  $p = 0.005$ ), thoracic (0.69  $\pm$  0.19;  $p = 0.02$ ), and surgical oncology (0.9  $\pm$  0.59;  $p = 0.004$ ). The number of US-trained applicants per available fellowship position was similar between transplant surgery and critical care (0.55  $\pm$  0.1;  $p = 0.474$ ). Second, the average number of fellowship programs listed on each applicant's rank list was examined ([Fig. 3B](#)). There were significantly fewer rankings per US-trained applicants in the transplant surgery match (6.1  $\pm$  1.2 rankings per applicant) compared with the colorectal (12.9  $\pm$  1.3), pediatrics (29.2  $\pm$  3.0), vascular (10.9  $\pm$  1.3), thoracic (10.8  $\pm$  3.4), and surgical oncology match (11.3  $\pm$  0.9) ( $p < 0.001$  for each comparison). The number of rankings per US-trained applicant in the transplant surgery match was similar to that for critical care (5.2  $\pm$  1.9). Third, the proportion of unfilled fellowship positions was evaluated ([Fig. 3C](#)). Transplant surgery had a significantly larger percentage of unfilled fellowship

**Table 1.** Transplant Surgery Fellowship Match Trends

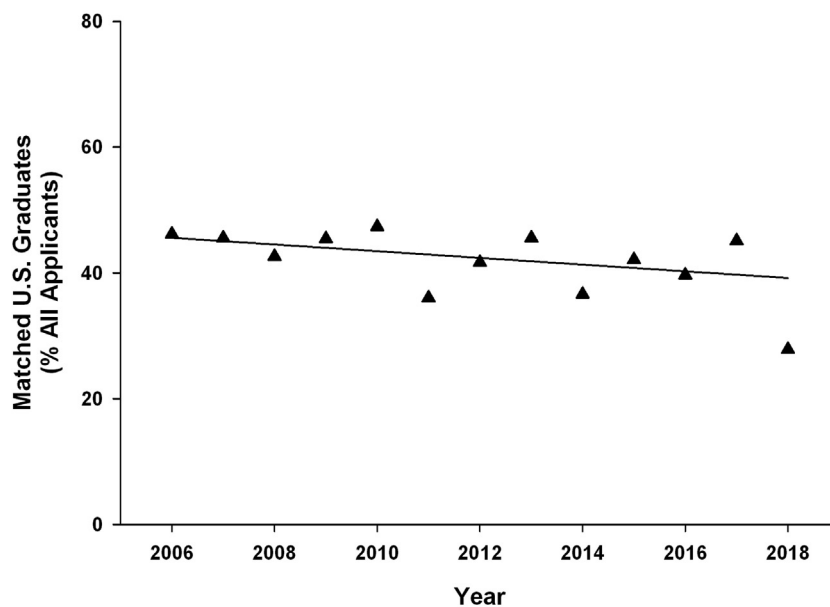
Year	Available positions, n	Positions filled, %	Applicants, n	Applicants		Matched applicants, n	Matched applicants	
				US graduates, %	Foreign graduates, %		US graduates, %	Foreign graduates, %
2006	60	65.0	52	40.4	59.6	39	46.2	53.8
2007	67	72.0	69	31.9	68.1	48	45.5	54.5
2008	65	65.0	64	28.1	71.9	42	42.6	57.4
2009	78	71.0	86	29.1	70.9	55	45.4	54.6
2010	71	74.0	96	29.2	70.8	53	47.3	52.7
2011	79	77.0	94	23.4	76.6	61	36.0	64.0
2012	72	69.0	80	26.3	73.8	50	41.7	58.3
2013	84	73.0	116	25.9	74.1	61	45.5	54.5
2014	73	71.0	98	20.4	79.6	52	36.6	63.4
2015	70	81.4	81	29.6	70.4	57	42.1	57.9
2016	77	75.3	89	30.3	69.7	58	39.6	60.4
2017	74	68.9	75	32.0	68.0	51	45.1	54.9
2018	76	71.0	94	18.1	81.9	61	27.8	72.2

positions ( $27.4\% \pm 4.5\%$ ) compared with colorectal ( $1.3\% \pm 1.3\%$ ), pediatrics ( $0.8\% \pm 1.2\%$ ), vascular ( $8.3\% \pm 4.1\%$ ), and surgical oncology ( $0.5\% \pm 0.9\%$ ) ( $p < 0.001$  for each comparison). There was a similar proportion of unfilled fellowship positions in critical care ( $p = 1.0$ ) and thoracic surgery ( $p = 0.275$ ) compared with transplant surgery.

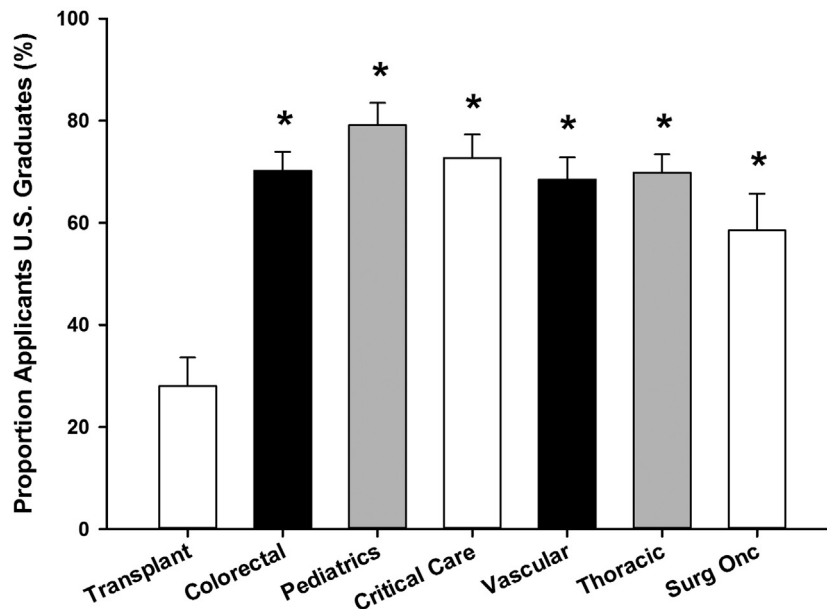
#### General surgery resident operative experience

The operative experience of general surgery graduates in abdominal transplantations during clinical training was

examined. Based on ACGME operative log data, trends in surgical resident experience for renal, liver, and pancreas transplantation from 2000 to 2016 are depicted in Figure 4. Surgical residents participated during this time period in a mean  $\pm$  SD of  $6.0 \pm 0.3$  renal,  $1.0 \pm 0.1$  liver, and  $0.3 \pm 0.1$  pancreas transplantations. When considering this as a proportion of all renal, liver, and pancreas transplantations performed nationally, residents participated in  $39.6\% \pm 2.6\%$  of all renal,  $17.6\% \pm 2.3\%$  of all liver, and  $26.1\% \pm 3.6\%$  of all pancreas transplantations.



**Figure 1.** The number of US-trained general surgery residents matching ( $0.8\%$ ,  $p = 0.042$ ;  $R^2 = 0.323$ ) into transplant surgery has declined steadily from 2006 to 2018.



**Figure 2.** Fewer US-trained general surgery residents apply to transplant surgery than to all other surgical fellowships using National Resident Matching Program. \* $p < 0.05$  compared with transplant surgery by ANOVA with Bonferroni post-hoc test.

### Influence of transplant surgery program and rotation site on interest in transplant surgery fellowship

Finally, the association between a surgical resident's training program and where they did their transplant surgery rotation with an interest in pursuing transplant surgery was explored. From 2015 to 2017, the 77 US graduates who matched into transplant surgery fellowship came from only 57 US general surgery training programs. During this same time period, there was an average of 248 ACGME-accredited general surgery programs in the US, such that only 23.3% of all US programs produced transplant surgery fellows. Of these 57 general surgery residency programs, 16 programs (28.1%) produced nearly one-half ( $n = 36$  [46.8%]) of all transplant surgery fellows (Fig. 5A). In addition, of these 57 programs, 26 (45.6%) had an associated ASTS-accredited transplant surgery fellowship program and produced a mean  $\pm$  SD of  $1.58 \pm 0.76$  fellows per program compared with the remaining 31 programs without an associated ASTS-accredited transplant surgery fellowship, which produced  $1.16 \pm 0.45$  fellows per program ( $p = 0.007$ ).

Of the 57 residency programs, 12 programs had residents complete their transplant surgery rotation at an outside institution (the location of the transplant surgery rotation for 3 programs was unable to be verified), and the remainder had their residents rotate at their home institution. Accounting for the fact that some residents trained at their home institution and others trained at outside institutions, 48 unique transplant surgery rotation sites were

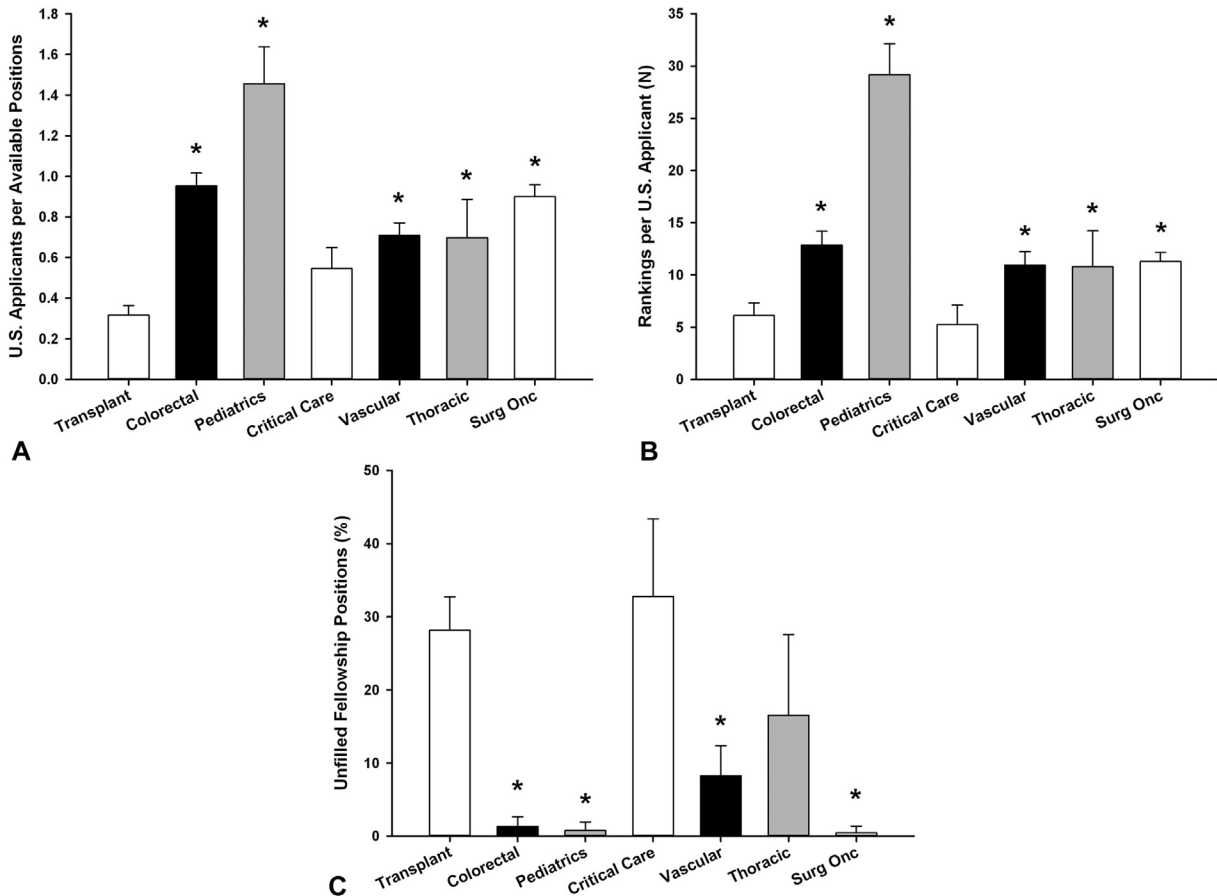
identified for this cohort. Of the 48, nineteen (39.6%) transplant surgery rotation sites produced 45 (60.8%) of the transplant surgery fellows (Fig. 5B).

### DISCUSSION

This work serves as the first publication from the ASTS Pipeline Taskforce and aims to examine and characterize the transplant surgery pipeline. We found that US-trained graduates make up a small proportion of both applicants and matched fellows in transplant surgery. We also demonstrate that transplant surgery is one of the least sought after and least competitive fellowships for US general surgery graduates among other surgical fellowships. To explore the motivations behind these observed phenomena, our data suggest it might be due to resident exposure and limited participation in transplantations. We also observed that the location of a residents' transplant surgery rotation influences their decision to pursue a career in transplant surgery.

Our data demonstrate that abdominal transplantation is not a highly sought after career choice for US general surgery graduates. Not only do US graduates make up the minority (27%) of the transplant surgery applicant pool, but the number of US trainees matching into transplant surgery is decreasing by nearly 1% per year. This number is even more striking in comparison with the next lowest proportion of US applicants, which is surgical oncology, at 59%. Not only is there low interest among US graduates, but transplant surgery is also one of the





**Figure 3.** Transplant surgery is one of the least competitive surgical fellowships. Relative competitiveness of the National Resident Matching Program surgical subspecialty fellowships was compared by examining (A) the number of US applicants per available position, (B) the number of rankings per US applicant, and (C) the proportion of unfilled fellowship positions. \* $p < 0.05$  compared with transplant surgery by ANOVA on ranks with Dunn's post-hoc test or ANOVA with Bonferroni post-hoc test where appropriate.

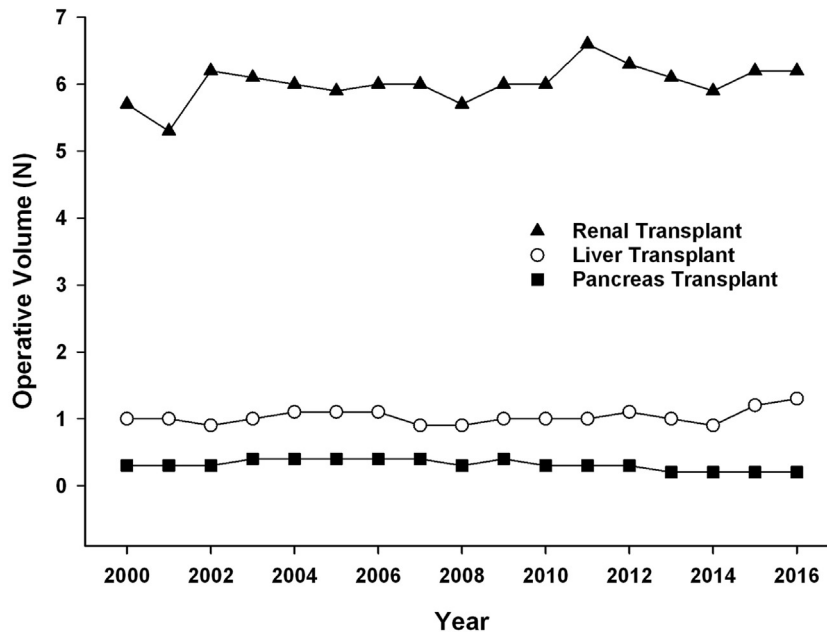
least competitive fellowships compared with other NRMP-based fellowships across a number of metrics. A recent ASTS workforce study demonstrated that 89% of attending transplant surgeons in the US completed residency training in the US.<sup>9</sup> This is in sharp contrast to our finding that 42% of the transplant surgery fellows completed their general surgery training in the US.

Lifestyle is often blamed as a significant detractor for surgical residents pursuing a career in transplantation. Several studies have characterized the work-life balance of transplant surgeons, with transplant surgeons working, on average, 65 to 69 hours per week.<sup>9-12</sup> Many of these hours working can be spent during inconvenient hours or while on call, with transplant surgeons having the highest number of nights on call per week, higher than any surgical subspecialties.<sup>10,13</sup> Not surprisingly, burnout is high among transplant surgeons and is estimated at 40% of faculty.<sup>10,14</sup> In addition, more than one-third of transplant surgeons meet criteria

for depression, and nearly two-thirds report home-work conflicts.<sup>10</sup> Recent work by the ASTS Fellowship Training Committee found that 23% of transplant surgery fellows experience burnout and are at increased risk of committing a medical error and consideration of leaving fellowship.<sup>15</sup>

In spite of the long and erratic work hours, the work of transplant surgeons is rewarding and fulfilling. In an American College of Surgeons survey of nearly 8,000 surgeons, transplant surgeons were among the highest of the surgical subspecialties for overall satisfaction with career and specialty.<sup>16</sup> The degree of career satisfaction among transplant surgeons is twice that of a general surgeon and only second behind pediatric surgeons.<sup>10</sup> Transplant surgeons seem to lead meaningful and productive lives outside of the hospital, with 88% of both men and women attending transplant surgeons being married, and 90% of men and 65% of women having children.<sup>9</sup> It is therefore imperative for transplant surgeons to engage and foster a relationship with surgical





**Figure 4.** The national general surgery resident operative experience in abdominal transplant surgery domains. Graduating surgical residents participated in a mean  $\pm$  SD of  $6.0 \pm 0.3$  renal,  $1.0 \pm 0.1$  liver, and  $0.3 \pm 0.1$  pancreas transplantations during their surgical training.

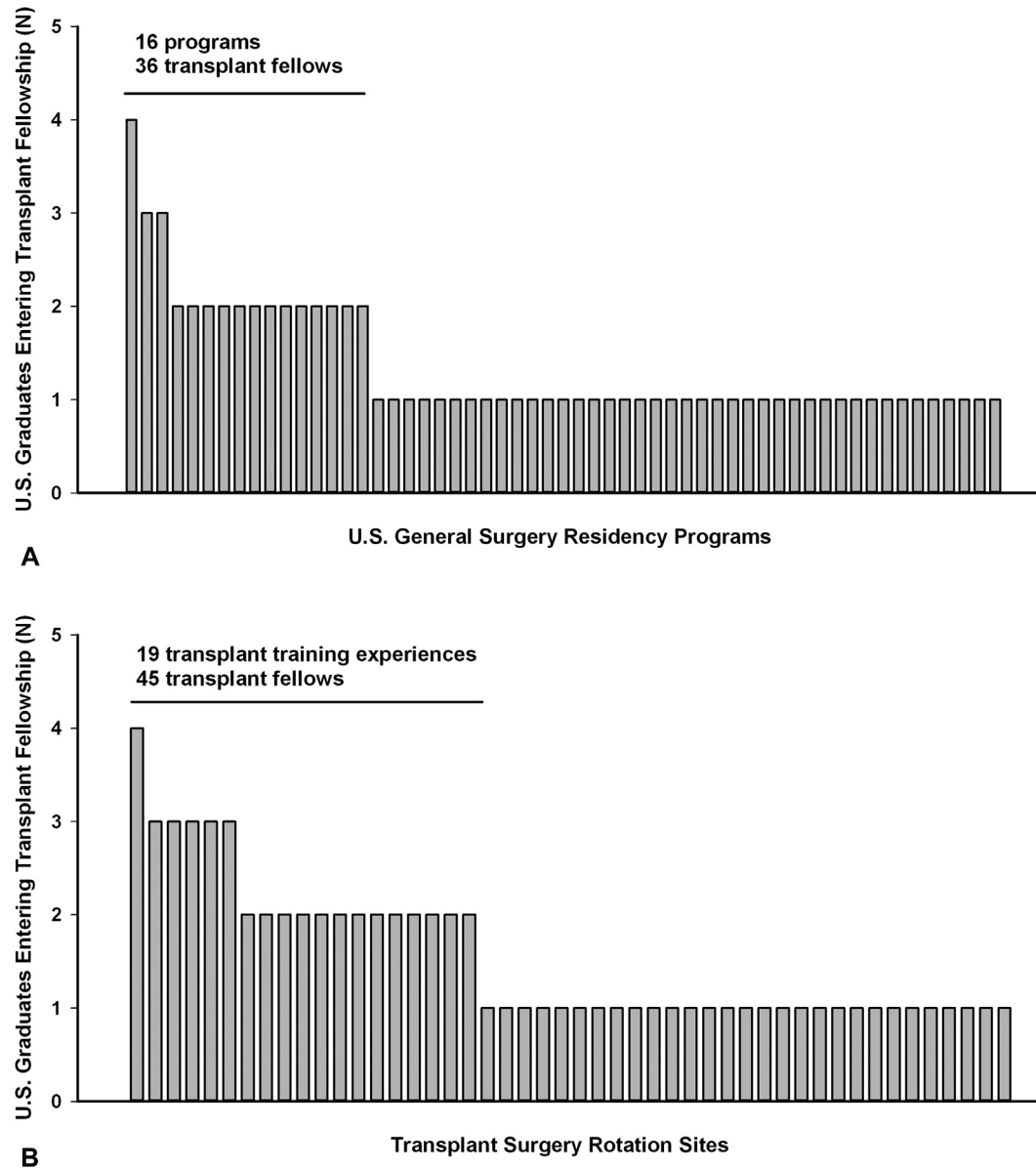
residents not only in the clinical capacity, but also to model the real-life, day-to-day human factors that might be at the forefront of a surgical resident's mind as they consider a career in transplant surgery. Finally, mentorship should extend to the academic realm to pique the scholarly interests of future transplant surgeons. One of the unique aspects about transplant surgery is that the majority (79%) of transplant surgeons work in an academic setting, and the majority (75%) of general surgeons work in private practice.<sup>9,17</sup> This predominant academic environment provides the transplant surgeon with an avenue for the development of novel scientific ideas stemming from clinical insight.

Most transplant surgeons develop an interest in transplantation during their second or third year of general surgery training.<sup>18,19</sup> Despite a concerted effort, in part, by the ASTS Fellowship Training and Curriculum Committee, ASTS Fellowship Directors, and the ASTS senior leadership to identify and institute a corrective plan of action, the Resident Review Committee changed the transplantation requirement for general surgery residents from a formal transplant surgery "rotation" to an "experience" in 2011.<sup>6,18</sup> Currently, transplant surgery is an essential content area for general surgery residency training, with an experience in solid organ transplantation being required by the American Board of Surgery and specific topics being included in the Surgical Council on Resident Education curriculum.<sup>20,21</sup> Historically, reasons why surgical residents view their transplant surgery rotation negatively include poor operative experience and lack of a defined curriculum,

coupled with overwhelming service responsibilities, poor integration of the resident into the transplantation team, and meager attending interaction.<sup>6,22</sup>

In a study of 101 US general surgery residency program directors, 92% offered a formal transplantation rotation. However, many did not have a transplantation program at their home institution, rather relying on relationships with nonintegrated hospitals to provide this experience.<sup>18</sup> This is concerning, as some believe that visiting residents are not provided an equivalent educational experience as the residents of the home institution.<sup>22,23</sup> Although the majority of the transplant surgery fellows ( $n = 62$  [83.8%]) in our analysis completed their transplantation training rotation at their home institution, 12 (16.2%) had their experience at an outside institution, suggesting the value and potential influence of this away rotation on one's future career choice. However, the burden of maintaining an away rotation, coupled with perceived low educational benefits, has led many program directors to conclude that transplant surgery should not be a mandatory component of general surgery training.<sup>18,23</sup>

This study raises the question as to why abdominal transplantation is not an attractive field for US graduates. The findings herein have prompted the ASTS Pipeline Taskforce to invest efforts into mixed-methods approaches to better understand the motivators behind this observation. Curiously, we found that there are a number of unfilled training programs each year, which prompts the reassessment of the supply and demand of transplant surgeons. Are there



**Figure 5.** Exposure to transplant surgery during general surgery residency influences a surgical resident's interest in transplant surgery. From 2015 to 2017, the 77 US graduates who matched into transplant surgery fellowship came from 57 unique US general surgery training programs. (A) Of these 57 programs, 28.1% ( $n = 16$ ) produced 46.8% ( $n = 36$ ) of the transplant surgery fellows. (B) Of these 57 programs, 48 unique transplant surgery rotation sites were identified. Of these 48 rotation sites, 39.6% ( $n = 19$ ) produced 60.8% ( $n = 45$ ) of the transplant surgery fellows.

currently too many training programs? Although we advocate for more US resident interest in transplantation, the job market must be able to accommodate these trainees, in both the quantity and scope of positions available. Given the intensity of fellowship, which for most fellows includes liver transplantation, many graduates want to pursue a job that allows them to perform these operations. Of the 66 ASTS-accredited programs, only 17% are kidney-only

training tracts, and the remaining 83% include liver training as well. Although our findings describe the potential supply of transplant surgeons, future work is needed to develop a better understanding of the demand.

Moving forward, the ASTS Pipeline Taskforce encourages active efforts at the program level to improve the resident experience. The Taskforce recently added 3 resident membership positions, as well as the development of a

student/resident Transplant Advisory Board. Recommendations to facilitate trainee recruitment into transplantation include clearly outlining educational objectives, establishing a level-appropriate operative experience, designating a transplant surgeon to work with the program director to oversee the education of surgical residents, creating a feedback system for resident progress, and ensuring visiting residents receive an equal experience to other rotating residents.<sup>22,23</sup> Establishment of a formal system to enable resident and medical student participation in organ procurements, which is lacking in most residency programs, could also improve residents and surgical educators view of the transplant surgery rotation.<sup>24</sup> There is opportunity for the ASTS and its established curricula to incorporate into resident education and training schema. Finally, and most importantly, transplant surgeons need to be ever cognizant of their influence on surgical residents, as earlier work has shown that surgical role models and mentors have substantial impact on one's interest in a field, although most are unaware of the magnitude of their influence.<sup>25</sup>

There are several limitations of our study. First, we were unable to separate Canadian graduates from graduates of other countries. Although ASTS match data stratify applicants as US, Canadian, and foreign graduates, the NRMP match stratifies applicants as only US and foreign graduates. Second, we were only able to analyze those fellowships under the NRMP match and were not able to access match data for the programs under the auspices of The Fellowship Council (ie advanced gastroenterology, bariatric, flexible endoscopy, hepatopancreaticobiliary, and minimally invasive surgery). Third, the operative volume data are aggregate national data and, as such, we are unable to make conclusions about individual programs or trainees, impairing any conclusions on how a specific resident's experience or a programs volume influenced their interest in transplantation. Finally, we recognize that this study is limited to characterizing the pipeline and only provides early insights into why this phenomenon is occurring. Future work by the ASTS should aim to explore resident motivations behind why trainees are not pursuing transplantation. In addition, this analysis does not explore the fellowship training experience and how that can impact the pipeline. There is concern about jobs in transplant surgery, and both fellowship and career factors of transplant surgeons must be studied in future work to not only better understand the pipeline into transplant surgery, but to more completely characterize the transplant surgery workforce and its needs.

## CONCLUSIONS

The data reported herein represent a concerted effort by the ASTS Pipeline Taskforce to characterize and better

understand the driving factors behind resident interest in transplantation. Our findings support what many have suspected—transplant surgery is one of the least sought after and least competitive fellowships for US general surgery graduates. Based on the findings herein, and as a first step toward combating the issues uncovered, the Taskforce has developed efforts to raise awareness and increase residents' interest in transplant surgery. A collaboration with the "Behind the Knife" podcast created a 6-part series about transplantation to educate an audience that consists primarily of medical students and surgical residents about the field of transplantation. Second, the ASTS Pipeline Award was established to honor an individual who has shown dedication to the transplant surgery experience of students and residents with the first recipient being awarded in 2020. Finally, the Pipeline Taskforce has appointed 2 resident and 1 student members to the Taskforce to provide a voice for those individuals the field is trying to attract. At this juncture, we as a transplant surgery society have a great opportunity to invest in the future of our field, not only in the excitement of xenotransplantation, artificial organs, and novel immunosuppression, but equally as importantly in the people who will follow in our footsteps to care for the transplantation patients of the future.

## Author Contributions

Study conception and design: Quillin, Cortez, Emond, Segev

Acquisition of data: Quillin, Cortez

Analysis and interpretation of data: Quillin, Cortez, Dageforde, Watkins, Collins, Garonzik-Wang, Glorioso, Tevar

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