The PreOp Program: Intensive Preclinical Surgical Exposure is Associated With Increased Medical Student Surgical Interest and Competency

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OBJECTIVE: As medical students' interest in surgical fields wanes, we investigated the impact of a preclinical surgical exposure program on students' attitudes toward pursuing surgical careers.

DESIGN: This is a prospective longitudinal study of PreOp, a preclinical rotation-based surgical exposure program for first-year medical students, from 2013 to 2017. Surveys assessed PreOp rotation quality, students' surgical interest, and students' self-reported preparedness for the surgical clerkship. Surgery clerkship grades were obtained as a measure of surgical competency and compared to class-wide peers. Match data was collected and compared to class-wide peers as well as historical norms.

SETTING: NewYork-Presbyterian Hospital/Weill Cornell Medicine, New York, NY; tertiary care center.

PARTICIPANTS: Fifty-four PreOp students from 2013 to 2017.

RESULTS: Fifty-four PreOp participants were recruited. After completing the PreOp program, 66.7% of PreOp students reported being very likely to apply into a surgical field compared to 29.4% when they started medical school. Ultimately, 71.4% of PreOp students versus 21.7% of non-PreOp class-wide peers matched into surgical fields ($p < 0.001$). From the preceding 5 match years before PreOp implementation, 21.4% of all students matched into surgical fields compared to 25.6% of all students after PreOp was started ($p = 0.26$). In terms of preparedness, 75% of PreOp students reported feeling more prepared for the third-year surgery clerkship than their non-PreOp peers after the second year of medical school. PreOp students were significantly more likely than non-PreOp class-wide peers to receive honors in the surgery clerkship when controlling for cumulative clerkship GPA ($p = 0.012$, adjusted odds ratio = 5.5 [95% confidence interval 1.5-22.1]).

CONCLUSIONS: Hands-on preclinical surgical exposure was associated with student-reported increased surgical interest that was maintained longitudinally and reflected in significantly increased surgical matches relative to non-PreOp class-wide peers. This study uniquely demonstrates that participation in PreOp was also associated with increased self-reported surgical preparedness and

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significantly higher surgery clerkship grades relative to overall academic performance. (J Surg Ed 76:1278−1285. © 2019 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: Surgical education, medical student education, curriculum development, skill development, preclinical, surgical exposure

COMPETENCIES: Practice-Based Learning and Improvement, Patient Care

INTRODUCTION

Early surgical exposure has been historically neglected during the nonclinical years of medical school. More recently, there has been a move to consolidate the preclinical years and incorporate clinical activities such as office preceptorships and student clinics in order to provide students with earlier hands-on patient care opportunities.[1-8] Given the nature of the different specialties, however, the majority of this preclinical exposure falls within the purview of internal medicine with persistently minimal preclinical surgical exposure.

This lack of exposure is concerning given the steady decline in medical students pursuing surgical careers. While 11% of all US medical students applied into general surgery in 1984, this number fell to 6.5% in 2014.[9] Such statistics are problematic as current forecasts predict that surgeon supply will fall by 18% between the years 2009 and 2028.[10]

Recent studies have demonstrated the significant role of the negative surgical stereotype in deterring medical students from pursuing surgical careers; in general, students perceive surgeons as competitive and intimidating, making this career option both unappealing and unrealistic.[11,12] However, these negative perceptions can be directly addressed with early medical student participation in surgical interest groups. Preclinical surgical exposure programs have a positive impact on students' attitudes toward surgical culture and confidence about their role within the operating room (OR).[9,13-17] Moreover, students report increased enthusiasm about surgery if actively engaged through hands-on participation during these programs.[18-21] These results suggest that targeting interested students for surgical training earlier in their medical education may enhance their preparedness as third-year clerks, then as residents, and ultimately as junior attending surgeons—a sort of "trickle-up" effect.[22] Therefore, the preclinical years may be an opportune time to pique interest in surgery and initiate earlier skills acquisition.

This study was designed to evaluate an intensive preclinical surgical exposure program ("PreOp") that provides quality-controlled surgical attending mentorship, skills workshops, and hands-on OR time to first-year medical students. It uniquely follows student participants longitudinally throughout medical school and the match in order to investigate the program's influence on surgical interest, confidence, and competence.

MATERIAL AND METHODS

This is a prospective institutional review board-approved study performed as a collaboration between Weill Cornell Medicine and the Department of Surgery at New-York-Presbyterian Hospital.

The PreOp Program

The PreOp program is an intensive surgical exposure program for first-year medical students that was piloted in 2013-14 and continues as an established elective.[22] This study will reflect data collected from 2013 to 17 academic years. Interested first-year medical students applied to PreOp and a subset was selected to participate. An equal number of surgical attending mentors were recruited across a variety of surgical specialties (Supplemental Table 1).

The PreOp model was specifically designed to provide increased surgical exposure for preclinical medical students via OR- and clinic-based rotations with attending mentors as well as a parallel surgical skills curriculum. During PreOp's pilot year, students spent 1 month with each of the 10 mentors for a total of 10 one-month rotations. During the subsequent years (2014-17), per student request, PreOp adopted a new scheme with 5 two-month-long rotations instead to maximize time with each mentor. Clinical rotations were supplemented with a surgical skills curriculum (Supplemental Table 2), focusing on basic surgical skills (e.g., sterile technique, suturing, and knot-tying) as well as more advanced techniques (e.g, electrosurgery, laparoscopic surgery, and robotic surgery).

Longitudinal Study

PreOp students were consented to participate in a longitudinal study at the time of recruitment. Nine students from the pilot cohort (class of 2017), 10 students from the 2014 to 15 cohort (class of 2018), 15 students from the 2015 to 16 cohort (class of 2019), and 20 from the 2016 to 17 cohort (class of 2020) were included. PreOp students completed regular postrotation surveys detailing their experiences. For comparison as part of a PreOp quality control initiative, non-PreOp first-year students participating in a traditional surgery interest group were

also surveyed at the end of the pilot year regarding their experiences. This traditional surgery interest group offers monthly surgical shadowing and one surgical skills session per year.

In order to evaluate the extent to which PreOp participation influenced student specialty interest longitudinally, PreOp students completed baseline surveys, post-PreOp, and post-second-year surveys reporting specialty preference. Surveys obtained after the third-year clerkships were excluded due to low response rates. Match outcome data was obtained for PreOp students and compared to non-PreOp class-wide peers from 2017 to 2018. Overall match data from 2017 to 2018 was also compared to match data from the 5 years before PreOp implementation (2012-2016).

In order to assess whether PreOp participation influenced student surgical confidence, PreOp students were asked to report their feeling of preparedness for the surgery clerkship after their second year. Subsequently, deidentified clerkship grades were collected from the registrar as a proxy for surgical competency. A cumulative third-year clerkship grade point average (GPA) was calculated for each student excluding the surgery clerkship grade, with honors assigned a value of 4.0, high pass assigned 3.0, and pass assigned 2.0. Surgical clerkship grades were then compared between PreOp students and non-PreOp class-wide peers when controlling for cumulative clerkship GPA.

Data analysis

PreOp student data collected from the sequential cohorts was combined to increase the sample size for analysis. Sample sizes were adjusted to reflect survey response rate. Descriptive statistics (including median, interquartile range [IQR], frequency, and percent] were calculated to characterize the study sample, where applicable. Chi-square tests, Fisher's exact tests, and nonparametric Mann-Whitney U tests were used for the statistical comparisons in the results section, as appropriate, based on the type of data being analyzed. Multivariable logistic regression analysis was utilized to evaluate the effect of PreOp participation status (i.e., PreOp versus non-PreOp) on surgical clerkship grade status (i.e., honors versus nonhonors distinction in the surgery clerkship; binary outcome variable), while controlling for cumulative clerkship GPA (surgery clerkship GPA was excluded from this variable). A 2-sided p value of <0.05 was considered statistically significant for all tests. Ninety-five percent confidence intervals (95% CI) were calculated for all proportions of interest to assess the precision of the obtained estimates. Statistical analyses were performed using SPSS Version 22 (IBM, Armonk, New York) and R version 3.5.1 (Vienna, Austria).

RESULTS

A total of 54 PreOp students were recruited to participate in the study between the years 2013 and 2017. Baseline information was available for 51 PreOp students (Table 1). Demographic information (e.g., age, gender, and race) was not collected to maintain anonymity per our institutional review board.

Baseline Surgical Interest

At the start of medical school, 15 (29.4%) PreOp students reported that they were very likely to apply into surgery while 20 (39.2%) reported a moderate likelihood of applying into surgery (Table 1). When asked about specialty preference, 34 (66.7%) PreOp students reported that a surgical field was their first-choice specialty (Table 1).

Surgical Exposure Quality

A total of 172 postrotation evaluations were collected from 54 PreOp students (Table 2). PreOp students shadowed a median 1.5 days (IQR 1.0-2.0) with each mentor per month, observing a median 1.5 surgeries (IQR 1.0-3.0) per month. PreOp students reported scrubbing into cases during 98 rotations (57.0%). PreOp students had the

TABLE 1. Baseline PreOp Student Data (n = 51)

Prior Surgical Exposure	
No prior surgical exposure	9 (17.6%)
Research	13 (25.5%)
Shadowing	32 (62.7%)
Volunteering	11 (21.6%)
Likelihood of matching into surgery	
Very likely	15 (29.4%)
Moderately likely	20 (39.2%)
Undecided	15 (29.4%)
Moderately unlikely	1 (2.0%)
Very unlikely	0 (0%)
First-choice specialty preference	
Any surgical field*	34 (66.7%)
General surgery (or general subspecialty†)	14 (27.5%)
Neurosurgery	7 (13.7%)
Obstetrics/gynecology	1 (2.0%)
Ophthalmology	1 (2.0%)
Orthopedic surgery	4 (7.8%)
Otolaryngology	3 (5.9%)
Urology	4 (7.8%)
Undecided	7 (13.7%)
Other	10 (19.6%)

* Surgical field here includes all specialties recognized by the American College of Surgeons including obstetrics/gynecology, ophthalmology, otolaryngology, and urology.
† General subspecialty refers to the related fields of plastic surgery, pediatric surgery, cardiothoracic surgery, and vascular surgery.

TABLE 2. PreOp Rotation Quality Assessment

Number of rotation evaluations collected	172
Median total days (IQR) with mentor/month*	1.5 (1.0-2.0)
Median surgeries (IQR) observed/month*	1.5 (1.0-3.0)
Skills performed per rotation	
Any skill in the OR including foley placement, prepping	102 (59.3%)
Scrubbing and gowning	98 (57.0%)
Suturing	44 (25.6%)
Knot-tying	28 (16.3%)
Teaching modality for performed skills per rotation (n = 102†,‡)	
PreOp mentor	70 (68.6%)
PreOp skills session	38 (37.3%)
Surgery resident	14 (13.7)
Confidence level performing skills in OR per rotation (n = 102†)	
Very confident	29 (28.4%)
Moderately confident	55 (53.9%)
Neutral	13 (12.7%)
Moderately not confident	5 (4.9%)
Not confident	0 (0%)
Student-perceived mentor willingness to answer questions per rotation	
Very willing	145 (84.3%)
Moderately willing	7 (4.1%)
Neutral	5 (2.9%)
Not available	15 (8.7%)
Quality of rotation per student evaluation	
Excellent	93 (54.1%)
Good	47 (27.3%)
Average	11 (6.4%)
Fair	2 (1.2%)
Poor	4 (2.3%)
Not available	15 (8.7%)
Quality of mentor per student evaluation	
Excellent	125 (72.7%)
Good	24 (14.0%)
Average	8 (4.7%)
Fair	0 (0%)
Poor	0 (0%)
Not available	15 (8.7%)

*This data is reported as median per month rather than per rotation because rotations varied in duration.
†This reflects the total rotations in which students performed any hands-on skill in the operating room (OR).
‡Teaching modalities per rotation are not mutually exclusive.

opportunity to suture during 44 (25.6%) rotations and tie knots during 28 (16.3%) rotations. PreOp students reported feeling either very confident (28.4%) or moderately confident (53.9%) with skill performance such as preoperative prepping, foley catheter placement, scrubbing, suturing, and knot-tying. Positive PreOp student evaluations of both rotation and mentor (as excellent versus nonexcellent) were significantly more likely if students were allowed to scrub into cases ($p < 0.001$ and $p < 0.001$, respectively) and suture ($p < 0.001$ and $p = 0.010$, respectively).

Non-PreOp students in the traditional surgery interest group were also surveyed regarding their first-year surgery exposure (n = 9). In addition to spending significantly less time shadowing per month than PreOp students during the pilot year ($p = 0.001$), non-PreOp students were significantly less likely to scrub in ($p < 0.001$) and none were allowed to suture or tie knots.

Specialty Interest

Specialty interest data was available from 15 PreOp students after the first year of medical school and 17 PreOp students after the second year of medical school due to limited response rates. Following the first year of medical school, 10 of 15 (66.7%) PreOp students reported being very likely to apply into a surgical field compared to 15 of 51 (29.4%) at the start of medical school (Fig. 1). After the second year of medical school, 8 of 17 (47.1%) PreOp students reported being very likely to apply into a surgical field (Fig. 1).

Match results were obtained and combined for the class of 2017 and 2018, including 14 PreOp students and 166 non-PreOp students who had completed the match (Table 3). Overall, 10 (71.4%) PreOp students matched into surgical fields including obstetrics and gynecology, with 2 (14.3%) matching in general surgery. In contrast, 36 (21.7%) non-PreOp students from the class of 2017 and 2018 matched into surgical fields, with 4 (2.4%) matching into general surgery. PreOp students were significantly more likely to match into a surgical field compared to their non-PreOp class-wide peers ($p < 0.001$). Between 2012 and 2016, prior to PreOp implementation, 103 of 481 (21.4%) students matched into surgical fields. In comparison, from 2017 to 2018 after PreOp was introduced, 46 of 180 (25.6%) of all students matched into surgical fields ($p = 0.26$).

Surgical Preparedness and Competence

The majority (75.0%) of PreOp students who had completed second year (n = 16) reported feeling more prepared than their non-PreOp peers for the third-year clerkship.

Surgery clerkship grades were obtained for the classes of 2017 and 2018 (who had fully completed clerkships) as a measure of surgical competence. Data was available for 19 PreOp students and 174 non-PreOp students (Table 4). Median cumulative clerkship GPA (excluding the surgery clerkship grade) for non-PreOp class-wide peers was 3.50 (IQR 3.00-3.67), compared to 3.40 (IQR 2.92-3.67) for PreOp students ($p = 0.440$). Eleven of 19 (57.9%) PreOp students received an honors grade in surgery compared to 65 of 174 (37.4%) non-PreOp students, with the Fisher's exact test demonstrated a trend

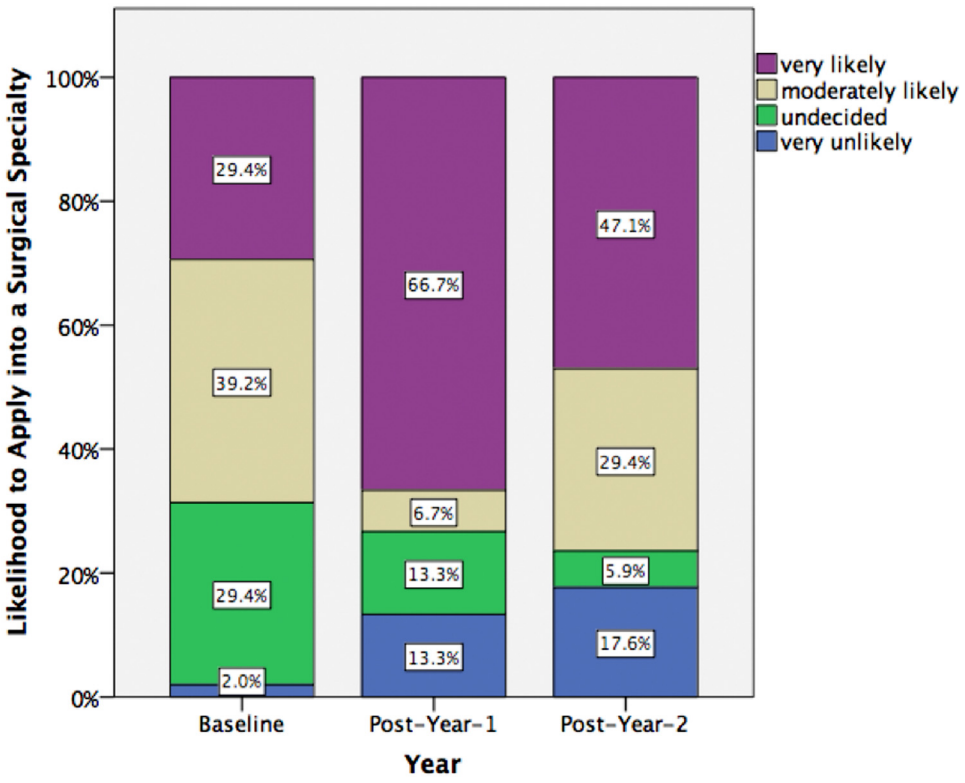

FIGURE 1. PreOp Students' self-reported likelihood to apply into a surgical specialty stacked bar graphs demonstrate PreOp students' self-reported likelihood to apply into a surgical specialty at multiple time points including at baseline (n = 51), after completing PreOp (postyear-1; n = 15), and after the second year of medical school (postyear-2; n = 17).

towards statistical significance (p = 0.090). PreOp participation was statistically significantly associated with an increased likelihood of receiving an honors grade in the surgery clerkship when controlling for cumulative GPA (p = 0.012; adjusted OR = 5.5 [95% CI 1.5-22.1]) via logistic regression, however.

DISCUSSION

PreOp, an intensive surgical exposure program for preclinical medical students, objectively provided higher quality, more hands-on exposure than traditional shadowing modalities. Moreover, PreOp also successfully stimulated surgical career interest. Though this

TABLE 3. PreOp Versus Non-PreOp Class-wide Combined Match Results from the Classes of 2017 and 2018

	PreOp (N, [%])	Non-PreOp Class-wide Peers (N, [%])
Students applying and matching	14	166
Match specialty:		
Any surgical field*	10 (71.4%)†	36 (21.7%)†
General surgery	2 (14.3%)	4 (2.4%)
Neurosurgery	1 (7.1%)	1 (0.6%)
Obstetrics/gynecology	2 (14.3%)	11 (6.6%)
Ophthalmology	1 (7.1%)	4 (2.4%)
Orthopedic surgery	2 (14.3%)	9 (5.4%)
Otolaryngology	0 (0%)	4 (2.4%)
Plastic surgery	1 (7.1%)	1 (0.6%)
Urology	1 (7.1%)	2 (1.2%)

*Surgical field here includes all specialties recognized by the American College of Surgeons including obstetrics/gynecology, ophthalmology, otolaryngology, and urology.
†Chi-square analysis: p < 0.001.

TABLE 4. PreOp Versus Non-PreOp Class-wide Clerkship Performance

	PreOp	Non-PreOp Class-wide Peers
Students completing clerkships	19	174
Median cumulative third-year clerkship GPA (IQR)*	3.40 (2.92-3.67)	3.50 (3.00-3.67)
Surgery Clerkship Grades† (N, [%])		
Honors	11 (57.9%)	65 (37.4%)
High Pass	2 (10.5%)	66 (37.9%)
Pass	6 (31.6%)	43 (24.7%)
Fail	0 (0%)	0 (0%)

GPA, grade point average calculated with exclusion of the surgery clerkship grade.
*Mann-Whitney U analysis: p = 0.440.
†Fisher's exact analysis: p = 0.090.

paradigm has been described previously,[9,13,15-17] our longitudinal study uniquely reports actual match outcomes. PreOp participation was associated with increased matches into surgical fields relative to baseline surgical interest and class-wide non-PreOp peers. When comparing overall class-wide surgical matches before and after PreOp introduction (2012-2016 versus 2017-2018) to minimize selection bias, we report a 4.2% increase in surgical matches after PreOp introduction. While this is not statistically significant, this still represents a notable increase given that PreOp students represent only 7.8% of the class of 2017 to 2018. This increase suggests that PreOp has the potential to increase surgical matches beyond the number of students who historically would have matched into surgical fields at baseline.

Generating student interest through programs like PreOp is critical given the national decline in surgery residency application rates, especially in general surgery. While the reasons for this decline are likely multifactorial, previous studies suggest that it may be largely attributed to negative stereotypes of surgical culture as intimidating and unwelcoming.[11,13,15] Strong surgical mentorship, a component of the PreOp program that especially resonated with students, is integral in dispelling these beliefs.

Demystifying the OR also requires that students feel more comfortable performing in this unfamiliar environment. Our results uniquely demonstrate how participation in PreOp enhanced students' self-reported preparedness to perform surgical skills. This subjective measure of confidence was further reflected in objective measures of competence, as PreOp students were significantly more likely to receive an honors grade in the surgery clerkship compared to non-PreOp class-wide peers when controlling for overall clerkship academic performance. Programs like PreOp may therefore have the potential to combat the issue of resident preparedness by initiating earlier training of surgeons, leading to a potential "trickle-up" effect.[22]

Limitations

Since surgical interest was a prerequisite to applying into the PreOp program, we cannot exclude selection bias in our analysis of PreOp student longitudinal interest and ultimate match results relative to class-wide peers. Analysis of match results was therefore also performed relative to historical controls to minimize the impact of selection bias.

Post-clerkship surveys were excluded from analysis due to low response rates; therefore, this study is unable to take into account the impact of the surgical clerkship experience on longitudinal surgical interest and match results. Sample size was inherently limited given PreOp cohort size and imperfect survey response rate, such that nonresponse bias cannot be excluded.

CONCLUSIONS

PreOp offered consistently higher quality and more hands-on preclinical surgical exposure in comparison to traditional surgical shadowing. Student participation in PreOp was associated with increased interest in surgery that was maintained longitudinally and resulted in significantly increased rates of surgical matches compared to non-PreOp class-wide peers. Moreover, our results uniquely demonstrate that participation in PreOp was associated with significantly increased surgical competence as measured in surgical clerkship grades. Similar programs are readily implementable throughout the country and may address the national problem of surgeon shortages by enhancing student recruitment to surgical careers.

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SUPPLEMENTARY INFORMATION

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jsurg.2019.03.019.