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ORIGINAL ARTICLE

# Beyond the Red Line (BTRL): a course to provide the foundations for medical student surgical success in the operating room and beyond

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## Abstract

**Purpose** The surgery clerkship rotation is known to broaden anatomical understanding and enhance interest in surgical specialties, but little is known about effects of earlier pre-clinical surgical exposure. This study evaluates the impact of a hands-on surgical skills course on pre-clinical students' confidence in the operating room (OR), suturing, identifying basic surgical anatomy, and establishing surgical mentorship.

**Methods** Forty-six first-year medical students at an academic institution self-selected to participate in this IRB-approved course. This 3.5-day course was offered three times during an academic year. Students participated in a 2-day surgical education workshop taught by general surgeons and spent 1.5 days in the OR with a surgeon mentor. A 15-question 5-point Likert-scale pre- and post-survey was administered. Wilcoxon signed rank, Kruskal–Wallis, and Mann–Whitney tests were performed.

**Results** Students reported improved confidence with scrubbing, gowning, gloving, suturing, knot tying, basic surgical anatomy, and maintaining sterility in the OR after participation ($p < 0.05$). 90% of students reported increased confidence in scrubbing into an OR case ($p < 0.05$) and 81% were more confident in identifying a surgeon mentor ($p < 0.05$). There was no difference in confidence for scrubbing into a case or demonstrating suturing between students interested in surgical versus medical fields ($p = 0.26$, $p = 0.38$).

**Conclusion** Early surgical exposure improves students' confidence with skills training, hands-on OR experiences, and OR mentorship. This 3.5-day course provides an effective foundational introduction to surgical education for pre-clerkship students and improves overall confidence in the OR regardless of future residency interests.

**Keywords** Surgical education · Preclinical exposure · Surgical workshop

## Background

The surgical clerkship is a core academic experience for medical students which significantly impacts student career choices by cultivating interest in the surgical field [1–3]. In the previous decade, however, there has been a declining interest toward surgical careers [1, 4–9]. A 2021 report released by the American Association of Medical Colleges projects shortages of 15,800–30,200 in all surgical specialties by 2034 [8]. The literature has cited many reasons for this decline in interest, including but not limited to the difficulty of surgical training, demanding lifestyle, and challenges of balancing career and family life [1–6]. While the reason for declining interest is multifactorial, one factor is limited pre-clinical exposure to surgical careers. There has been a call for surgical departments to incorporate more exposure, and the literature has demonstrated that pre-clinical observership and simulation-based learning improved students' interest in surgical careers [6, 9–11]. However, there are limited data on the effects of pre-clinical basic surgical skills training, hands-on operating room (OR) experience, and mentorship combined approaches [12–14].

Medical school curriculum has transformed over the years to include more interactive clinical training with limited

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improvement in pre-clinical surgical training [4]. This has significant effects, as one study found that 59% of medical students already decided their career choices before the start of the third-year clinical rotations [5]. Additionally, the literature shows that the number of residency applications for a specialty correlates with the amount of early exposure to that field [11, 15]. It is, therefore, of the utmost importance to expose students to surgical careers earlier in their pre-clinical experience. Third-year medical students can be intimidated by the OR learning environment and fear of harming patients, affecting their participation and interest in surgery [16, 17]. Early exposure to basic surgical skills and OR etiquette outside of the clerkship rotation has been thought to promote confidence with these skills since performed in a low-stress, non-threatening environment.

Medical school education has transitioned from cadaveric dissections to other forms of anatomic teaching, including technology-based curriculum with a reduced amount of time spent on clinical anatomy. While technology-based anatomic learning is more commonly used due to reduced cost and improved availability, the literature demonstrates that cadaveric materials are the most valuable teaching resource for spatial awareness [18, 19]. Anatomic knowledge is crucial for the foundations of surgical education. Obtaining anatomic knowledge solely in the operating room during third-year clinical rotation does not provide adequate exposure to the students due to time and safety constraints.

One of the most influential factors in shaping students' interest in surgery is mentorship. Students who are more interested in surgery are more likely to report positive surgeon role models [1, 2, 4, 16]. Surgical mentorship that begins during 3rd-year clinical rotations does not sufficiently interest medical students in choosing a surgical career [4, 17]. Early surgical mentorship provides students with the opportunity to learn about the rewarding aspects of a surgical career while also gaining a realistic understanding of the career lifestyle. Establishing surgeon mentoring during pre-clinical years can be challenging, as pre-clinical students do not always have sufficient opportunities to interact with surgical faculty.

The purpose of this study was to describe and evaluate the effectiveness of the Beyond the Red Line (BTRL) program, a 3.5-day surgical training course implemented at a single academic institution for pre-clinical medical students. The goal of BTRL is to teach pre-clinical medical students the fundamental surgical skills and anatomic knowledge to be more confident crossing the red tape entering the OR and assist them with the development of surgical mentorship relationships.

## Methods

The Beyond the Red Line (BTRL) program was implemented at a single academic institution during the 2021–2022 academic year. Enrollment was limited to 229 first-year medical students. The course was offered during the school of medicine's student enrichment week (SER), where students are required to participate in a 3.5-day non-graded experience. Students rank the various enrichment experiences, and based off a lottery system are assigned to an activity. SER occurs four times during an academic year, and BTRL was offered as a SER experience 3 of these 4 times. Based off student ranking SER week experiences and random selection, up to 15 students were selected to participate in each BTRL session. A total of 46 first-year medical students participated. This study was approved by the Institutional Review Board and informed consent was obtained from all participants. Data were securely stored in an institutional REDCap database.

### Curriculum development and implementation

The BTRL program was designed by three faculty members of the department of surgery: the surgical clerkship director, associate clerkship director and director of the anatomy lab. The course curriculum was designed based off the most high-yield basic surgical content. The curriculum consisted of a 2-day in-person training in the cadaveric anatomy lab followed by 1.5 days of operating room exposure with an assigned surgeon mentor. Two board-certified general surgeons taught the 2-day training. Six sessions on OR sterility, suturing workshop, surgical instrumentation, basic surgical anatomy were conducted (Table 1).

Session 1 involved an in-depth lecture on OR etiquette and sterility. This was followed by student practice and subsequent demonstration of proper scrubbing, gowning, and gloving. Session 2 included a tutorial on suturing and knot tying methods. This was followed by student practice and subsequent demonstration of suturing techniques using suturing pads. Session 3 was a review of basic surgical instrumentation with discussion and demonstration of how these tools are utilized in the OR. Session 4 divided the 15 students into four groups to practice prepping and draping a soft-embalmed cadaver for various surgical cases. Session 5 divided the students into 2 separate groups in which they were taught clinically relevant abdominal and cardiothoracic anatomy on soft-embalmed cadavers by a board-certified general surgeon. Session 6 allowed individual student practice of suturing, stapling, and knot tying techniques on soft-embalmed cadaveric

**Table 1** BTRL program objectives

| Objectives | Curriculum time |
|---|---|
| Session 1: Demonstrate proper scrubbing, gowning, and gloving techniques and describe proper OR etiquette | 4 h |
| Wet and dry scrub techniques | |
| Gown and glove with the assistance | |
| Self-gown and glove | |
| Maintain a sterile field | |
| Describe members of the surgical team and their roles | |
| Deglove and break sterile field | |
| Session 2: Demonstrate proper suturing and knot tying | 4 h |
| Describe the different types of sutures and indications | |
| Simple interrupted suture | |
| Vertical mattress suture | |
| Horizontal mattress suture | |
| Interrupted deep dermal suture | |
| Subcuticular suture | |
| Instrument tying of suture | |
| One-handed knot tying | |
| Two-handed knot tying | |
| Session 3: Identify surgical instruments and demonstrate proper handling | |
| Needle drivers—Adson and Debakeys | 1 h |
| Mayo and iris scissors | |
| Hemostas and towel clamps | |
| Retractors—army/navy, ritch, sweetheart, appendiceal | |
| Cautery devices—bovie, bipolar, photoplade | |
| Suction cannulas—high capacity, pediatric | |
| Raytechs, lap pads | |
| Session 4: Demonstrate how to properly assist with prepping for a case | 1 h |
| Demonstrate proper draping techniques on soft-embalmed cadavers | |
| Demonstrate surgical prep application | |
| Apply Bovie pads, sequential compression devices, and Bair huggers | |
| Session 5: Identify basic surgical anatomy on soft-embalmed cadavers | 3 h |
| Abdominal: organs, vasculature, and innervations | |
| Cardiothoracic: organs, vasculature, and innervations | |
| Session 6: Practice suturing techniques on soft-embalmed cadavers | 3 h |
| Demonstrate basic suturing and knot tying | |
| Demonstrate skin stapling and removal technique | |

tissue. During all six sessions, the staff surgeons provided the students personal feedback on their basic skills and were able to answer any questions. After completion of the 2-day course, students spent 1.5 days in the OR. Students were paired with a surgeon in various surgical specialties, based off their current surgical interest. If no surgical interest was identified, students were randomly assigned a surgeon. Establishment of mentorship was assessed with student confidence in interacting with surgeons and creating relationships for professional growth. Surgeon faculty that participated in the course were notified that this was more than a shadowing experience, were informed of the training that took place earlier in the week and were asked to actively involve students in the OR. Students scrubbed into OR cases, assisted with prepping, draping, retraction, suctioning, and sutured as their surgeons saw appropriate.

## Evaluation

Students were asked to complete an anonymous pre- and post- survey to evaluate the BTRL program based off their confidence with the learning objectives. The survey included a series of questions on demographics, current career interest, previous anatomy exposure, and 15 Likert-style

**Table 2** BTRL survey

| Rate the following statements. I am confident: | 1: Not at all confident | 2: Not very confident | 3: Neither | 4: Fairly confident | 5: Very confident |
|---|---|---|---|---|---|
| Demonstrating proper surgical scrubbing, gowning, and gloving technique | 1 | 2 | 3 | 4 | 5 |
| Demonstrating proper surgical timeout | 1 | 2 | 3 | 4 | 5 |
| Using CUS tool for communication | 1 | 2 | 3 | 4 | 5 |
| Identifying basic surgical instruments | 1 | 2 | 3 | 4 | 5 |
| Demonstrating simple interrupted suturing | 1 | 2 | 3 | 4 | 5 |
| Demonstrating vertical and horizontal mattress suturing | 1 | 2 | 3 | 4 | 5 |
| Demonstrating interrupted deep dermal suturing | 1 | 2 | 3 | 4 | 5 |
| Demonstrating subcuticular suturing | 1 | 2 | 3 | 4 | 5 |
| Demonstrating instrument tying of suture | 1 | 2 | 3 | 4 | 5 |
| Demonstrating two-handing tying of suture | 1 | 2 | 3 | 4 | 5 |
| Identifying general abdominal anatomy | 1 | 2 | 3 | 4 | 5 |
| Entering an OR | 1 | 2 | 3 | 4 | 5 |
| Shadowing a surgeon in the operating room | 1 | 2 | 3 | 4 | 5 |
| Scrubbing into an OR when asked | 1 | 2 | 3 | 4 | 5 |
| Identifying a surgeon with who I can mentor | 1 | 2 | 3 | 4 | 5 |

questions on confidence with basic surgical skills, sterility, and establishing surgical mentorship (Table 2). Likert-scale response options were '1: not confident, 2: not very confident, 3: neither 4: fairly confident, 5: very confident'. Students were given the same survey the day after completion of the BTRL program. Students were given up to one week to complete the post-survey. Survey responses were stored in a secure REDCap database.

## Statistical analysis

Descriptive statistics were used to analyze demographic data and career interest questions. Variables were analyzed for normality using the Shapiro–Wilk test. Visual histogram evaluation and non-parametric procedures were subsequently conducted. Change in survey responses were calculated as the difference between raw post-test and pre-test values. Pre- and post-test survey variables were analyzed using the Wilcoxon signed rank test. Rank differences between groups were assessed using the Whitney U and Kruskal–Wallis tests. Statistical analyses were performed in Excel. A $p$ value $< 0.05$ was considered as statistically significant.

## Results

Of the 46 first-year medical students who enrolled and participated in the BTRL program, 19 identified as male, 27 female, and 0 as other. 44 students (96%) completed both the pre and post-test survey, and the other two students (4%) were excluded from study due to incomplete surveys. In the pre-survey results, 32 (72%) stated interest in pursuing a career in a surgical specialty, 1 (2%) in OB-GYN and the

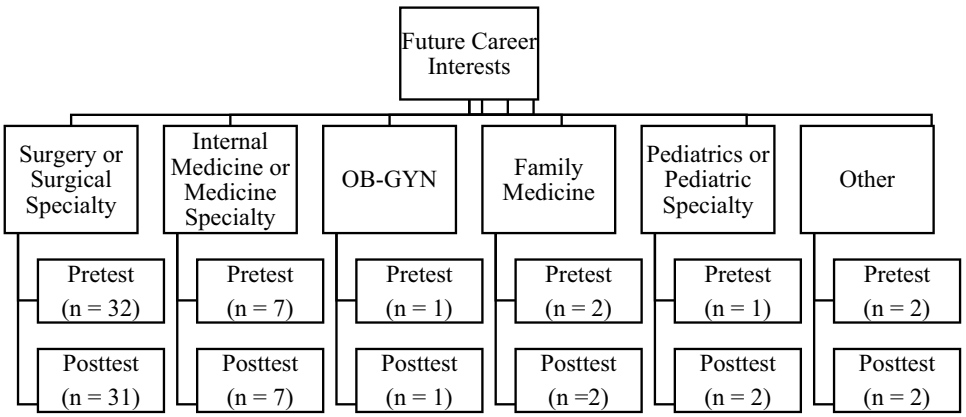


**Fig. 1** Future career interests of BTRL students

remaining 11 (26%) in several medical specialties (Fig. 1). Fifty percent of students stated they had taken an anatomy lab prior to medical school.

Table 3 shows the differences in perceived student confidence with learning objectives before and after the course. Statistically significant improvements in confidence were observed for all questions ($p < 0.001$) including scrubbing, gowning and gloving, various suturing methods, instrument tying, two-handed tying, identifying abdominal anatomy, scrubbing in for an OR case, and identifying a surgeon mentor. A mean increase of $2.0 \pm 1.3$ was observed for all questions. Students reported greatest improvement in confidence for subcuticular and deep dermal suturing (97% and 93%, respectively) and lowest level of improved confidence with identifying general abdominal anatomy (75%). Most students were more confident scrubbing in the OR (91%) and in identifying a surgeon mentor (82%) after completion of the course.

When comparing students with reported interest in a surgical specialty ($n = 33$) versus medical specialties ($n = 11$), there were no statistically significant differences in confidence for scrubbing techniques, identifying basic surgical instruments, demonstrating simple interrupted, vertical and horizontal mattress, and deep dermal suturing, demonstrating instrument and knot tying, and identifying general abdominal anatomy ($p > 0.05$). Students not interested in a surgical specialty were as confident scrubbing in an OR case ($p = 0.26$) and establishing surgeon mentorship ($p = 0.31$) as those interested in a surgical specialty. However, after completing the BTRL program, students not interested in surgery reported greater improved confidence with shadowing a surgeon in the operating room ($p = 0.02$) (Table 4).

Students who identified as male ($n = 17$) and female ($n = 26$) were equally as confident shadowing a surgeon in the operating room ($p = 0.63$) and identifying a surgeon mentor ($p = 0.71$). Additionally, there was no difference in confidence with demonstrating proper surgical scrubbing ($p = 0.12$) or identifying basic surgical instruments ($p = 0.06$). Male and female students were just as confident with simple interrupted ($p = 0.13$), subcuticular ($p = 0.14$), and vertical and horizontal mattress ($p = 0.66$) suturing. However, female students reported lower improved confidence with deep dermal suturing ($p = 0.01$) and two-handed suture ($p = 0.03$) tying than male students (Table 5).

Confidence scores were evaluated between students who had ($n = 22$) and had not ($n = 22$) previously completed anatomy and physiology courses. No differences in confidence were observed for identifying basic abdominal anatomy ($p > 0.05$).

When comparing students between session 1 ($n = 16$), session 2 ($n = 14$), and session 3 ($n = 14$), there was no difference in confidence in demonstrating proper surgical scrubbing, gowning and gloving technique, scrubbing into an OR case, identifying basic abdominal anatomy, demonstrating all suturing and knot tying methods, and establishing surgeon mentorship ($p > 0.05$).

**Table 3** Baseline, post-test, and change scores on the BTRL confidence survey, $N = 44$*

| Survey question | Students with improved confidence after BTRL (%) | Baseline confidence scores, mean (SD) | Post-test confidence scores, mean (SD) | Change in confidence scores, mean (SD) |
|---|---|---|---|---|
| Using CUS tool for communication | 91 | 1.6 (0.9) | 4.1 (0.9) | 2.6 (1.1) |
| Identifying basic surgical instruments | 89 | 1.9 (0.8) | 3.8 (0.8) | 1.7 (1.1) |
| Identifying general abdominal anatomy | 75 | 2.9 (1.2) | 4.2 (0.8) | 1.2 (1.0) |
| Entering an operating room | 86 | 2.6 (1.3) | 4.7 (0.7) | 2.0 (1.3) |
| Shadowing a surgeon in the operating room | 75 | 3.1 (1.3) | 4.6 (0.6) | 1.4 (1.2) |
| Scrubbing into an operating room when asked | 91 | 2.1 (1.2) | 4.7 (0.6) | 2.6 (1.3) |
| Identifying a surgeon mentor | 82 | 2.4 (1.2) | 4.0 (1.0) | 1.6 (1.5) |
| Demonstrating | | | | |
| Proper surgical scrubbing, gowning, and gloving technique | 91 | 2.0 (1.0) | 4.6 (0.5) | 2.5 (1.1) |
| Proper surgical timeout | 91 | 1.5 (0.7) | 4.0 (0.9) | 2.4 (1.1) |
| Simple interrupted suturing | 86 | 2.4 (1.3) | 4.5 (0.6) | 2.0 (1.3) |
| Vertical and horizontal mattress suturing | 91 | 1.6 (0.9) | 4.1 (0.9) | 2.4 (1.3) |
| Interrupted deep dermal suturing | 93 | 1.4 (0.8) | 3.9 (0.9) | 2.4 (1.2) |
| Subcuticular suturing | 97 | 1.4 (0.6) | 3.7 (0.9) | 2.3 (1.1) |
| Instrument suture tying | 84 | 2.2 (1.3) | 4.4 (0.8) | 2.0 (1.4) |
| Two-handing suture tying | 84 | 2.0 (1.2) | 4.0 (0.9) | 2.1 (1.4) |

*All changes were significant at $p < 0.001$

**Table 4** Differences in confidence survey change scores by specialty interest, mean (SD)

| Survey question | Non-surgical ($n=11$) | Surgical ($n=33$) | $p$ value |
|---|---|---|---|
| Demonstrating proper surgical scrubbing, gowning, and gloving technique | 2.8 (0.8) | 2.4 (1.2) | 0.40 |
| Demonstrating proper surgical timeout | 2.8 (1.1) | 2.3 (1.0) | 0.13 |
| Using CUS tool for communication | 2.3 (1.3) | 2.7 (0.9) | 0.37 |
| Identifying basic surgical instruments | 1.9 (1.1) | 1.7 (1.1) | 0.58 |
| Demonstrating simple interrupted suturing | 1.9 (1.2) | 2.0 (1.4) | 0.91 |
| Demonstrating vertical and horizontal mattress suturing | 2.5 (1.2) | 2.5 (1.2) | 0.97 |
| Demonstrating interrupted deep dermal suturing | 2.2 (1.2) | 2.5 (1.2) | 0.33 |
| Demonstrating subcuticular suturing | 2.3 (1.0) | 2.3 (1.1) | 0.77 |
| Demonstrating instrument suture tying | 2.4 (1.2) | 1.8 (1.4) | 0.23 |
| Demonstrating two-handing suture tying | 2.4 (1.5) | 1.8 (1.4) | 0.24 |
| Identifying general abdominal anatomy | 1.4 (0.9) | 1.2 (1.0) | 0.41 |
| Entering an operating room | 2.3 (0.8) | 1.7 (1.3) | 0.06 |
| Shadowing a surgeon in the operating room | 2.2 (1.1) | 1.1 (1.1) | 0.02 |
| Scrubbing into an operating room when asked | 3.3 (0.7) | 2.3 (1.4) | 0.26 |
| Identifying a surgeon mentor | 2.2 (1.4) | 1.4 (1.5) | 0.20 |

**Table 5** Sex differences in confidence survey change scores, mean (SD)

| Survey question | Women ($n=26$) | Men ($n=17$) | $p$ value |
|---|---|---|---|
| Using CUS tool for communication | 2.9 (0.9) | 2.1 (1.1) | 0.02 |
| Identifying basic surgical instruments | 2.0 (1.1) | 1.4 (1.1) | 0.06 |
| Identifying general abdominal anatomy | 1.4 (1.1) | 1.0 (0.9) | 0.25 |
| Entering an operating room | 2.2 (1.3) | 1.9 (1.4) | 0.57 |
| Shadowing a surgeon in the operating room | 1.5 (1.2) | 1.2 (1.2) | 0.63 |
| Scrubbing into an operating room when asked | 2.6 (1.3) | 2.5 (1.3) | 0.79 |
| Identifying a surgeon mentor | 1.7 (1.6) | 1.5 (1.4) | 0.71 |
| Demonstrating | | | |
| Proper surgical scrubbing, gowning, and gloving technique | 2.7 (1.1) | 2.2 (1.0) | 0.12 |
| Proper surgical timeout | 2.8 (0.9) | 1.8 (1.0) | 0.001 |
| Simple interrupted suturing | 2.2 (1.2) | 1.6 (1.3) | 0.13 |
| Vertical and horizontal mattress suturing | 2.5 (1.3) | 2.4 (1.3) | 0.66 |
| Interrupted deep dermal suturing | 2.8 (0.8) | 1.8 (1.3) | 0.01 |
| Subcuticular suturing | 2.4 (1.1) | 2.1 (0.9) | 0.14 |
| Instrument suture tying | 2.1 (1.5) | 1.8 (1.2) | 0.43 |
| Two-handing suture tying | 2.4 (1.2) | 1.6 (1.5) | 0.03 |

## Discussion

Traditionally, medical school curriculum has not provided adequate early exposure to surgical careers, as pre-clinical years have mainly focused on lecture-style education. While there has been a shift to incorporate more clinical-based experiences earlier in training, surgical curriculum is still lacking during first- and second-year training [4]. Bernholt et al. found that only approximately one-third of institutions have some type of exposure to surgical education within pre-clinical curriculum [5]. Less time is being spent on anatomic dissection as in previous decades and there is reduced access to cadaveric dissections [18, 19]. The literature demonstrates that surgical mentorship improves student interest in surgical careers. However, one of the biggest barriers to surgical mentoring is time constraints and accessibility of surgeon mentors [1, 2, 4, 16]. With these changes in medical education, it is imperative that medical students get early surgical exposure to anatomy, surgical skills, and mentorship to improve their confidence, improve understanding of a surgical lifestyle and foster interest for a career in surgery.

The Beyond the Red Line (BTRL) program at our institution provided first-year medical students with a 3.5-day structured surgical training event to give students the early anatomy and surgical exposures that they have been lacking. After completing the course, students with surgical interest as well as those interested in medical careers reported improved confidence with skills training, hands-on OR experience, and mentorship ($p > 0.05$) indicating that this program was useful for all students regardless of career choice.

Students who were not interested in surgical careers did report greater improved confidence with shadowing a surgeon in the operating room ($p = 0.02$). The reason for this result could be that students not interested in surgery may not have had significant previous exposures to shadowing in the OR or have preconceived notions about surgeons prior to BTRL. The literature shows that pre-clinical exposure to surgery improves perceptions of surgeons, and after pre-clinical exposure, students are less likely to find surgeons as intimidating [20]. Students who are interested in surgery may have had previous exposure, creating higher confidence with shadowing a surgeon mentor in the OR prior to BTRL. Additionally, this study found that both students interested in surgery and not interested in surgery had similar confidence in establishing mentorship ($p > 0.05$). While there is not a significant amount of literature on this, Braun et al. found that surgeons are able to create positive teaching environments for all students, irrespective of surgical interest [21].

There was no difference between students identifying as male versus female when comparing improved confidence with many learning objectives. Interestingly, female students reported less improved confidence with using CUS (communication, uncomfortable, safety) tool and demonstrating proper surgical time out compared to males ($p < 0.05$). These results could reflect that female students felt less confident communicating in the OR, as the literature reports women are more likely than men to experience less respect, feeling unheard, or perceived negatively for speaking up in the OR [22]. These are factors that can lead to women not feeling confident to speak up in the OR.

Review of clinically relevant abdominal anatomy was useful to all students regardless of previous anatomic exposure and knowledge. This could be because undergraduate anatomy courses provide general anatomy, whereas BTRL provides broad clinically relevant surgical anatomy. Additionally, anatomy is taught on soft-embalmed cadavers, which many students, even most medical students, have not had the opportunity to learn from in undergraduate anatomy courses.

Comparisons between the three BTRL sessions showed there were similarities in improved confidence between the groups, irrespective of which session they were in. This decrease the possibility of other external factors, such as student interest group events or other electives impacting student confidence a throughout the academic year.

BTRL shares similarities with Cloyd et al.'s "Operating Room Assist" program, where first-year medical students were taught basic surgical skills and then participated in OR cases. However, this program did not include an anatomy component or utilize cadavers to practice suturing, stapling, and draping techniques. Additionally, the primary focus of this paper was on students' evaluation of scrub nurse and attending as role models as well as the attending and scrub nurse's evaluation of the student involvement in OR cases, while BTRL focuses more on the student perspective [14].

Schoeb et al.'s "Feel like a Surgeon" program demonstrated that exposure to basic surgical skills on cadavers improves student comfort, which aligns with our results. They found that their program had little significant effect on the number of students interested in surgical careers [13]. Similarly, BTRL was also successful at improving student confidence in the OR and with basic surgical skills; however, there was not an increase in the number of students interested in surgical careers (Fig. 1). One student transitioned from interest in surgical career to a non-surgical career after completing BTRL. The literature demonstrates that other pre-clinical exposure events had similar results, with decrease in number of students interested in surgical careers [4, 11]. This is likely because these events provide students with a realistic view of a surgical career and the stressors and challenges of the field.

With the lack of surgical education during pre-clinical curriculum, there has been a push to incorporate more extracurricular surgical education through suture workshops and simulation learning. Beyond the Red Line (BTRL) offered first-year medical students' comprehensive exposure to surgical skills that successfully improved confidence in the OR. Similar programs should be implemented at other academic institutions to help stimulate interest in surgical specialties.

The authors recognize there are several limitations to the study. All data submitted were limited to pre- and post-intervention surveys. Self-reporting has its limitations and biases. A significant number of students who participated in this program had prior interest in surgical careers, which could be a factor affecting confidence levels with learning objectives, as they may have previous experiences that improved confidence. There are no data on students' proficiency with basic surgical skills, identifying basic abdominal anatomy, and identifying surgical instrumentation. The students who participated in the program were selected based on voluntary interest, therefore allowing for selection bias. The program did not include the surgeon mentor's evaluation of student performance and participation in the OR. This is a weakness in our study, as we do not know what level of engagement and participation students had in the OR and if this

could have affected their perceived versus actual observed confidence.

Our results provide important data on the efficacy of a newly implemented surgical exposure course for pre-clinical students. Future studies will evaluate student performance in the OR and proficiency with the learning objectives of the course in the upcoming academic years through surveys for surgeon mentors and OR staff as well as gradings on suturing skills and clinical anatomy knowledge. Based on the feedback given by students asking for more time spent in the OR, changes to BTRL course have been made for the subsequent academic years and comparisons will be made. Long-term studies will evaluate how this early exposure BTRL course affects academic performance in clinical years and match rates.

## Conclusion

Overall, the Beyond the Red Line surgical course successfully provided students with skills training, hands-on OR experience, and mentorship. Other academic programs should consider implementation of similar programs to improve pre-clinical students' confidence in surgical settings and ultimately enhance students' surgical experiences in medical school.

**Data availability** Not applicable.

### Declarations

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

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