

The Effects of Gender Stereotypes and Bias on the Developing Academic Surgeon

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Factors contributing to the underrepresentation of females in surgery, such as gender stereotypes and bias, are incompletely understood. The projects in this dissertation elucidate how negative stereotypes about women and gender bias in the training environment impact the professional development of aspiring academic surgeons.

First, a semi-structured interview methodology was used to explore how gender shapes experiences of surgery residents. This study, which was anchored to residents' self-identification with the surgical profession, found that fewer female residents self-identified as "surgeon" (11.1% versus 37.5%, $p < 0.01$). Residents felt that patients and physicians more frequently disregarded female residents' professional role ($p < 0.01$). Female residents more often reported aggressive behaviors from attendings, lack of mentorship, discomfort, feeling pressured to participate in unprofessional behaviors, and having difficulty completing tasks.

To explore these findings, a multi-center study was conducted using validated survey subscales to evaluate how gender bias in the training milieu is related to academic engagement. The association between perception of pro-male gender bias and career engagement differed significantly by gender (interaction p -value = 0.04); perceiving gender bias was associated with lower career engagement among women (coefficient -0.19; 95%CI -1.05, 0.66; $p = 0.64$) but higher career engagement among men (coefficient 0.75; 95%CI 0.1, 1.49; $p = 0.04$).

Finally, a multi-center randomized controlled trial determined how activating or protecting against stereotype threat affects technical skill performance, a key competency metric for

surgeons. The association between stereotype threat activation and Fundamentals of Laparoscopic Surgery (FLS) assessment score was similar in men and women (interaction p-value = 0.83). The association between stereotype threat activation and FLS scores differed by gender across levels of susceptibility to stereotype threat (interaction coefficient -35.2; 95%CI -60.8,-9.7; p=0.01). Higher susceptibility to stereotype threat was associated with lower FLS score among women who received a stereotype threat trigger (coefficient -9.9; 95%CI 21.3,-1.5, p=0.04). Among men with higher susceptibility to stereotype threat, evoking negative stereotypes about women was associated with higher FLS score (coefficient 5.2; 95%CI -7.9,18.3; p=0.42).

Gender bias and stereotypes influence the professional development of burgeoning academic surgeons. Academic institutions should mitigate factors that emphasize surgery as a masculine profession and impart coping strategies to female residents for gender-specific deterrents.

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Preface

I owe my success to the support of several individuals. Dr. Matthew Rosengart has approached my education with unbridled enthusiasm, inspiring me to derive meaning from every personal and professional endeavor. Dr. Matthew Neal identified my potential in the earliest phase of my training and has modeled for me ambition, work ethic, and academic commitment. Drs. Galen Switzer, Marie Norman, Leslie Hausmann, Giselle Hamad, and Kaleab Abebe have demanded excellence and invested themselves completely in my development. The work represented in this dissertation has been completed with enormous support from my program director, Dr. Kenneth Lee, the Chair of the Department of Surgery, Dr. Timothy Billiar, and my co-residents, especially Dr. Kristina Nicholson and Dr. Katherine Reitz. I am profoundly grateful to my mother who has loved me unconditionally and sacrificed so that I could live in the manner of my choosing. I am ineffably thankful to my husband, Micah, who has shared in my sorrows and joys, repaired all that I have broken, and has nurtured me in every pursuit. Finally, this dissertation is dedicated to my daughter, Sage, to whom I hope to impart the importance of never underestimating one's self.

1.0 Introduction

Diversity has the power to operationalize society by driving innovation and productivity.(R., 2009) Within medicine, leading organizations like the NIH have initiated programs to encourage the participation and retention of minorities.(Health, 2019) Unfortunately, diversity without inclusivity can prohibit social integration and detract from group cohesion with resulting detrimental effects.(Barak, 2015; Jackson SE, 1991) This absence of inclusivity may be responsible for the continued underrepresentation of women within many specialties—chief among them, academic general surgery.(Moore MD, 2018; R., 2009; Zhuge Y, 2011) Specifically, pro-male bias and negative stereotypes about women promote exclusivity(Casad BJ, 2016) and contribute to our failure to eliminate gender disparities in academic general surgery.

While there are relatively few studies that highlight the effects of gender-bias in academic surgery, comparative evidence from other stereotypically masculine fields demonstrates that pro-male bias influences career-related opportunities such as hiring and promotion.(Davison HK, 2000; Olian JD, 1988; Tosi HL, 1985) Negative stereotypes about women may serve as the basis for implicit and explicit biases in the workplace(Faigman DL, 2007) that impact performance evaluations and, subsequently, professional achievement. In business and operations management, for example, senior-level managers have significantly higher performance evaluations than women.(Lyness KD, 2006) The *shifting standards* phenomenon describes how these stereotyped judgements that men are more competent than women can reinforce gender imbalance.(Biernat M) Within surgery, similar factors likely contribute to the observation that although the percentage of females pursuing surgical specialties has increased, the ratio of women advancing to leadership positions has decreased over time.(Lyons NB, 2019; Sexton KW, 2012)

Despite literature demonstrating the presence of gender bias in academic surgery,(Seemann NM, 2016) a direct causal link between environmental bias and persistent underrepresentation of women has not been established. Rather, related research indicates that knowledge or perception of gender bias may be detrimental to women's professional development by activation of certain psychosocial constructs. In particular, gender bias may evoke negative stereotypes about women.(Ridgeway CL, 2004) Individuals who are sensitive to these stereotypes, i.e., exhibit high levels of gender stigma consciousness, may be more susceptible to *stereotype threat*, or the risk of reinforcing negative stereotypes associated with one's social group.(Pennington CR, 2016) While stereotype threat and gender bias are related, they are distinct in the sense that an individual who identifies as a member of a stigmatized social group may experience stereotype threat even in the absence of gender bias within their immediate work environment.(H. C, 2019) For these individuals, despite ostensible gender equality within the professional milieu, negative stereotypes from a larger cultural context may retain salience and contribute to worse performance.(Spencer SJ, 1999; Walsh M, 1999)

While previous investigations have demonstrated that being a member of an underrepresented group has psychological and professional consequences, mechanisms for these effects remain incompletely understood. In order to implement interventions that effectively mitigate the consequences of gender bias and stereotypes, it is imperative to identify factors that mediate the influence of these constructs. Ambient cues, for example, have been shown to reduce motivation to achieve by decreasing the degree to which one feels he/she fits in as a member of a professional community.(Cheryan S, 2009) These cues include leadership beliefs about inequalities in career advancement opportunities for underrepresented groups, which permeate through the environment and reinforce barriers to professional development faced by these

demographics.(Kluegel JR, 1986) Similarly, an administration's failure to recognize or arbitrate bias within the environment may cause underrepresented individuals to be more sensitive to experiences that confirm their stigmatized status within the field.(Purdie-Vaughns V, 2008) It is important to note, however, that the interplay between environmental and individual characteristics significantly contributes to whether a person exhibits a reactive or vulnerability response to bias and stereotypes.(Schmader R, 2008) Individual characteristics, such as resilience, can strengthen self-perception and self-efficacy thereby buffering one's susceptibility to negative stereotypes or bias.(Forbes CR, 2008) In contrast, stigmatized individuals who derive a greater sense of self-worth from their professional performance, i.e., domain identification, can exhibit increased vulnerability to negative stereotypes.(Woodcock A, 2012)

The projects described in this dissertation investigate how gender the experience of general surgery training and consider both environmental and individual factors that affect professional development. Our overarching hypothesis is that women who perceive bias favoring men and negative stereotypes about their gender suffer impaired career engagement and skill performance. To this end, we first establish that gender shapes the professional experiences of female and male residents. Our second project focuses specifically on how the association between perceived gender bias and career engagement differs among men and women. The last study demonstrates how triggering or protecting against stereotype threat influences skill performance differently based on resident gender. Collectively, these projects shed light on how perceived gender bias and negative stereotypes about women as an underrepresented group in surgery influence affective, cognitive, and behavioral factors that are integral to achievement for the developing academic surgeon.

2.0 A qualitative study of gender differences in the experiences of general surgery trainees

2.1 Introduction

An increasing number of women are becoming surgeons.(Davis EC, 2011; JA., 2008) Despite this increase, landmark studies have shown that female surgeons face unique challenges to professional advancement.(Dyrbye LN, 2011; Jena AB, 2015; Zhuge Y, 2011) Few studies have investigated gender-specific challenges before the transition to autonomous surgical practice. Higher attrition rates among female surgical residents(Khoussshal Z, 2017) contribute to under-representation of women in surgery and suggest that experiences during residency may differ by gender. Lower confidence in operative skill among women surgical residents(Flyckt RL, 2017; Fonseca AL, 2014) also supports gender-based differences among trainees. Research to date, however, has not explored the extent to which gender-divergent experiences within training occur or whether such differences interfere with the professional development of women surgical trainees.

It is important to consider whether women surgical residents encounter “gender-specific deterrent(s)”(Gargiulo DA, 2006) that could hinder their professional development. As a first step in investigating this issue, we interviewed surgical residents about gender-based challenges in training and the potential effects of these experiences on how they function as professionals and as surgeons. Our goal was to identify themes in their experiences that could help guide the discipline's larger discussion of diversity in surgical education.

2.2 Methods

This was a qualitative interview study(RF, 2017) to examine whether residents perceive gender differences in training and in their sense of professional identity. All general surgery residents in the University of Pittsburgh School of Medicine were eligible. There were no exclusion criteria. This study was approved by the Institutional Review Board at the University of Pittsburgh (PRO#17030607). Informed consent was obtained from all subjects before their participation.

We developed a semi-structured interview to explore residents' beliefs about the significance of (1) gender in the use of the professional title, (2) gender in patient care, and (3) gender in surgical training (Table 1). Interview questions were reviewed and approved by three experts in surgical education (K.A.H., G.G.H., and E.B.L.) and two in qualitative research methods (E.B.L. and M.E.H.). Prior to approval, interview questions were subjected to an iterative judgmental review process, first through independent assessment and then through group discussion. Once content experts agreed that there were no further ambiguities with respect to question relevance or definitions, the instrument was considered complete.(RA, 1990)

Table 1: Interview instrument

Item #	Closed-ended Questions**	Open-ended Questions or Question specific probes	Concepts addressed
1	Do you feel comfortable describing yourself as a “surgeon”?		Professional title, professional identity
2	Do you introduce yourself as “doctor” when addressing a patient?	<i>If resident identifies him/herself as “doctor”:</i> Do you think that identifying yourself as “doctor” affects the authority that you are perceived to have	Professional title, professional activity, patient care
3	Do you recall a specific time when a patient or attending referred to you by your first name?	<i>If resident recalls an experience:</i> If you can remember, how did this make you feel at the time?	Trainee’s experience of professional title
4	Do you think a provider’s gender factors into whether they are identified as a physician by a patient?	<i>If resident responds affirmatively:</i> If so, what are the barriers that might keep an individuals of a particular gender from being readily identified as a physician? Are there consequences with respect to the efficacy of care delivered if an individual’s role on the healthcare team is not accurately conveyed?	Trainee’s beliefs about credibility in patient care
5		In the past, when you have been in a formal professional setting outside of a clinical encounter (e.g., podium/poster presentation, grand rounds presentation, interview setting) how have you been addressed or introduced?	Professional title, professional activity
6		How does physician gender play a role in the development of an interpersonal relationship with patients?	Gender, patient care
7	Has there ever been a time when you believed that your gender affected the way that you were treated in training?	<i>If resident responds affirmatively:</i> Please describe this experience.	Gender, training
8	In the setting of surgical training and practice, are there physical or behavioral characteristics that confer advantages for a particular gender?	<i>If resident responds affirmatively:</i> What are some of these characteristics?	Gender, professional development
9	Have your emotions ever been mentioned during performance evaluations?	<i>If resident responds affirmatively:</i> Please describe these comments.	Gender stereo-typed traits, professional activities
10	Can you recall a recent experience with gender bias that affected your ability to deliver optimal patient care?	<i>If resident responds affirmatively:</i> Can you describe this experience? In what ways did it affect your ability to deliver care? How did this experience affect your relationship with other members of the healthcare team?	Gender, patient care

2.2.1 Procedure

Participants provided written informed consent before completing interviews. No incentives were provided for participation. Individual interviews were conducted and audio-recorded by a single individual (S.P.M.) who was trained in interviewing techniques. We chose peer interviewing with the hope that women and men would be candid (Byrne E, 2015) about the effects of gender on training. The semi-structured interviews began with yes or no questions about whether they introduce themselves as “doctor” when addressing patients and whether they feel comfortable describing themselves as a surgeon (Table 1, questions #1-2). These closed-ended questions served to anchor residents' subsequent discussions about professional identity, gender, and training. Following residents' responses to the initial interview questions, the interviewer asked open-ended questions intended to clarify each participant's narrative. These questions were related to how residents felt the use of a professional title might influence their interactions with patients or colleagues, gender-based challenges to being identified as a physician or delivering optimal patient care, and the influence of gender-specific stereotypes on professional activities and the training experience. Core questions 1-10 were asked of everyone. Additional probes were asked if the participant recalled an experience or answered affirmatively in response to a core question. Accuracy was assessed later by having a sample of 5 participants read through and confirm the content of his/her transcription.

2.2.2 Qualitative data coding

All participants were included in data analysis. Interviews were transcribed verbatim and then any identifiable content was redacted. The investigators (G.G.H., E.B.L., and S.P.M.)

developed a preliminary coding scheme by analyzing a subset of the interviews using inductive methods, that is, without an *a priori* or predetermined framework.(H, 2015) Recurrent themes were identified as recalled events, or experiences, as well as associated perceptions, or resident attitudes, about professional identity. These themes were categorized and further refined by comparisons across transcripts. Content experts (G.G.H., E.B.L., and S.P.M.) examined and revised the coding criteria with attention to clarity and relevance until a consensus was reached. Two coders (S.P.M. and K.J.N.) then coded the entire data set independently based on the revised index. Each interview transcript was considered a separate segment of text for coding purposes. Interrater reliability between coders was evaluated by calculating Cohen's kappa for each coded item (i.e., experience or attitude) using the entire data set. Values for coded data ranged from 0.63 to 0.83, with an average value of 0.75. Values ranging from 0.61 to 0.80 are interpreted as substantial, whereas values 0.81-1.00 indicate near perfect agreement.(ML, 2012) A framework for residents' experiences as they relate to professional identity and self-concept was developed.

2.2.3 Data analysis

As qualitative interviews were meant to explore a range of views, much of the data was not analyzed with bivariate statistics. There were, however, close-ended questions asked of all participants that were appropriate for statistical analyses aimed at determining between gender differences. Responses to these questions were analyzed using Fisher's exact tests in STATA 14. A p value <0.05 was considered significant. Prevalence data, for themes which emerged inductively from open-ended questioning, are presented with descriptive statistics.

2.3 Results

Forty-two (87.5% of total eligible) general surgery residents including 24 males and 18 females participated in this study ([Table 2](#)). Although there was no gender-based difference in the use of professional titles in self-introductions ($p = 0.32$), significantly fewer female residents were comfortable describing themselves as a “surgeon”: 11.1% *versus* 37.5%, $p < 0.001$.

Table 2: Participant demographics

Clinical postgraduate level (PGY)	Participants		Nonparticipants	
	Female	Male	Female	Male
1	3	4	0	0
2	3	4	0	0
3	2	4	0	0
4	0	2	0	4
5	2	4	0	0
Lab residents	8	6	0	2
Subtotal by gender	18	24	0	6
Total residents = 48	42		6	

2.3.1 Regard for professional titles

Both female and male participants reported that they felt patients more frequently dismissed female residents' professional title than male residents' (78.6% *versus* 11.9%, $p < 0.001$, [Table 3](#)).

Table 3: Regard for professional titles

A: Gender-based differences in resident experiences [*]			
	Residents' observations of females' experience n = 42 (%)	Residents' observations of males' experience n = 42 (%)	P value
Patients' disregard for resident's credentials	33 (78.6)	5 (11.9)	< 0.001
	Female reporter n = 18 (%)	Male reporter n = 24 (%)	
Physician [†] disregard for resident's credentials	10 (55.6)	2 (8.3)	< 0.001
B: Representative quotes			
Patients' disregard for resident's credentials	“During a particular rotation, I assisted on a case for a patient that was not on my service. The chief resident on that service was a female. Unfortunately, the patient and his son identified me as more of their go-to resident physician. On multiple times, I heard him say that he had not seen any doctors until either myself or the male attending would round on him even though the female chief resident had multiple times that day delivered our plan.” –Male, PGY 2		
Physician disregard for resident's credentials	“There was a specific instance recently where another resident called himself doctor and then introduced me by my first name. It stood out to me. It was very noticeable.” –Female, PGY2		

^{*}The number of participants whose responses were analyzed (i.e., n) varies for as some questions elicited responses that indicated all residents (regardless of their gender) agreed certain experiences occurred more commonly for one gender over the other. Other questions provoked responses from residents about their own experiences or experiences specific to their own gender. In these circumstances, the analysis was performed by participant gender (i.e., n = 18 for female residents, n = 24 for male residents).

[†]Indicates either an attending physician or a co-resident.

Residents felt that disregard for a resident's professional title devalued the achievement of attaining a medical degree. Representative quotes describing residents' experiences with use of their professional titles are presented in [Table 3](#). One woman resident stated that such experiences made her “feel like the (patients) don’t respect me and my knowledge especially when I have already introduced myself as doctor, which I always do. It indicates to me that they don’t respect me or my opinion as much.” Residents suggested that “the predominance of female-gender among support staff” might explain differences in patients' ability to recognize women as physicians. However, women also commonly experienced residents or attending physicians referring to them by their first name but introducing their male counterparts by their occupational title (55.6% *versus* 8.3%, $p < 0.001$, [Table 3](#)). A third-year woman resident reported that this behavior “automatically tells the patient that I am in a position of less authority. It tells the patient not to trust me as much and that I do not know as much.”

2.3.2 Perceptions, attitudes, and gender-based disadvantages

We asked our participants to reflect on the significance of gender to patient care and to surgical training, and these items resulted in reflections on perceptions, attitudes, and disadvantages of gender differences (Table 4). When discussing how gender might influence training experiences, significantly more residents perceived women but not men as being negatively stereotyped (81% *versus* 4.8%, $p < 0.001$), explaining that “men carry more confidence and women are much less confident.” Females were cast as lacking authority, being physically or emotionally weak, having low professional or societal worth, and being overly aggressive (when not described as meek). A higher percentage of female residents received criticism from attendings with respect to displaying confident behavior (56% *versus* 29%, $p < 0.001$). Subjects reported that such stereotypes might function as barriers to achievement and more commonly exist for females compared with males. One resident explained that she felt these stereotypes would “make me subject to scrutiny. My mistakes will be amplified based on the fact that I am female.” Residents also recognized that women were more often excluded from social networking than men.

More female residents reported experiencing feelings of lack of mentorship, discomfort, feeling pressured to accept or participate in unprofessional behaviors, having difficulty completing tasks, and having to adapt to overcome barriers. Nearly all the residents who communicated concern over barriers to career advancement were women. Only men described bias against the opposite sex and specific events that they perceived as undermining their female colleague's authority or potentially hindering their professional development.

Table 4: Perceptions, attitudes, and gender-based disadvantages

A: Gender-based differences in attitudes and experiences [*]			
	Residents' observations of female experience n = 42 (%)	Residents' observations of male experience n = 42 (%)	P value
Resident perceives attending's behaviors as preferential	0 (0)	10 (23.8)	—
Resident perceives gender stereotypes	34 (81.0)	2 (4.8)	< 0.001
Resident comments on gender-related training barriers	24 (57.1)	6 (14.3)	< 0.001
	Female reporter n = 18 (%)	Male reporter n = 24 (%)	
Resident is in the presence of lewd comments	13 (72.2)	6 (25)	—
Resident perceives aggression from support staff	9 (50)	1 (4.2)	—
Resident perceives aggression from attending surgeon	10 (55.6)	3 (12.5)	—
Resident receives encouragement from co-resident of same gender	6 (33.3)	0 (0)	—
Opposite-gender experiences gender-based disadvantage	0 (0)	11 (45.8)	< 0.001
Resident comments on lack of mentorship	8 (44.4)	0 (0)	—
Resident reports feeling uncomfortable	8 (44.4)	4 (16.7)	—
Resident feels pressured	5 (27.8)	2 (8.3)	—
B. Representative quotes			
Unprofessional behaviors: lewd remarks and attitudes perceived as aggressive	"Yes, (the introduction of sexual discourse) in the operating room has happened to me countless times. I think that part of it is about power and the aggressor, or inappropriate person, trying to assert their authority or develop some sort of power structure in the operating room to say 'I am in charge.'" female, PGY5		
Feelings of discomfort	"Additionally, there have been times when there were jokes at my expense when those things don't happen to the male residents. They seem to be more of participants rather than targets and that feels uncomfortable."—Female, PGY2		
Pressure to participate/accept unprofessional behaviors	"I think some of the talk is a little crude sometimes, to say the least. Sometimes I just ignore it. Sometimes I feel like I have to engage in it to some degree. I try to make one comment and then not participate anymore."—Female, lab		
Negative stereotypes associated with gender	"Men carry more confidence across all professional fields. Women are much less confident.... Some of us get mislabeled as a bitch when we are being confident and it becomes a negative connotation and then we kind of back off a little bit. I find it very interesting that men can act that way and it is perceived as positive and women do the same and it is perceived as negative."—Female, lab		
Feelings of exclusion or lack of mentorship opportunities	"Going into the lab and seeing particularly in research that all these people, almost certainly male, were heralded as these fantastic researchers.... It is because they were chosen to be that person and supported in that direction. This is not necessarily the case with female residents."—Female, lab		
Hardship or task interference	"Without question, I would be able to perform better without those interactions. The level of anxiety going into those operating rooms and appreciating that, that is just one of the attendings on one of my rotations but if that comes anywhere close to the type of biases that women have to put up with on a regular basis, then I don't know how they do it."—Male, PGY3		
Exhibiting adaptive behaviors to overcome barriers	"With patients, I have not always been someone that introduced myself as doctor and that is something I have adopted throughout residency... I think referring to myself by my first name probably led to some instances of confusion on the part of the patient about who I actually was and I found it more uncomfortable to then later in the conversation to be like 'No, I am one of your doctors.' Sort of, to make this clearer and say it up front."—Female, lab		
[*] The number of participants whose responses were analyzed (i.e., n) varies for as some questions elicited responses that indicated all residents (regardless of their gender) agreed certain experiences occurred more commonly for one gender over the other. Other questions provoked responses from residents about their own experiences or experiences specific to their own gender. In these circumstances, the analysis was performed by participant gender (i.e., n = 18 for female residents, n = 24 for male residents).			

Different themes regarding unprofessional behaviors emerged for females compared with males. Females recounted being in the presence of lewd remarks. Interestingly, women described either positive feelings of inclusion among their male peers and superiors or negative feelings of depreciation as a result of these experiences. For example, women endorsed changing their interpretations as they progressed through training. “In the beginning of residency, I thought, ‘I can participate in (this behavior),’ because I wanted so much to be accepted and liked. I think as I got older and more confident, I tried to identify and let people know that I thought their behavior was inappropriate.”

Both female and male residents felt that attendings of any gender preferred working with male residents. Women reported experiencing direct types of aggression (e.g., overt confrontation) as well as indirect forms (e.g., biased performance evaluations and asymmetrical opportunities) from attendings and support staff.

2.3.3 Female perceptions of self-worth

When asked about the significance of gender, women, but not men, reported feelings of reduced self-worth (Table 5). One female resident communicated, “I don’t feel like a real doctor but also I don’t feel like I am deserving to be called a doctor.”

Table 5: Explicit comments that indicate how women view themselves as professionals

Comments reflecting sense of professional self-worth
I don't feel like a real doctor but also I don't feel like I am deserving to be called a doctor.
There is this cultural expectation that a physician is male. I feel like it is an undercurrent of things happening for men and the relationships they are able to build. I do not necessarily get included in professional opportunities because I am not one of the boys.
I am told that I am too young and pretty to be a doctor. This tells me that the patient doesn't take me seriously. It is difficult for me to think of myself as a professional when I don't feel respected or when a patient addresses me as "girl".
I see every day how women are treated differently by hospital staff. This makes me wonder whether I am going to be able to rise up in this field with the way that people conceive women.
When an attending gives more autonomy to a male colleague of equal or lesser standing, it affects my interest in my work
I don't consider myself a person who is driven to achieve high levels of success.
I don't have the right to be respected for what I have done and what I have accomplished.
I feel unsure about using the title "doctor" because I feel a little uncomfortable asking someone to show deference to me.
Representative quotes are provided from all postgraduate levels, except year 4 as there were no female participants at this level. Given the number of female participants in the study, postgraduate level does not accompany the representative comment in order to preserve de-identification.

2.4 Discussion

This was a preliminary investigation into whether surgical residents, particularly women, experience gender-based challenges in the training environment that could affect their professional development. Themes that our participants raised suggest that the frequency of use of professional titles when patients and providers refer to surgical residents is gender-based and problematic for women in the context of caring for patients and learning to become surgeons. Participants' remarks indicated that an occupational title can evoke self-concept, that is, the mental image of oneself that has been constructed based on strengths, weaknesses, and status.(Ashforth BE, 1999) The fact that men and women exhibited similar preferences for the use of professional titles in self-introduction during patient encounters (question 1, [Table 2](#)), but significantly fewer women felt comfortable describing themselves as being surgeons (question 2, [Table 2](#)) may indicate absence of positive self-concept among female trainees.

Participants' interviews also contained themes of a highly sensitive nature that we did not expect. Participants reported gender-discrepant experiences (i.e., being in the presence of lewd remarks, interpreting others' behaviors as aggressive) in training that could disrupt their healthy maturation as a surgeon. These experiences caused female trainees to feel uncomfortable, pressured to accept unprofessional behavior, and disadvantaged and devalued more than their male counterparts. The finding that female residents experienced behaviors that might be interpreted by the receiver as aggression is consistent with the well-documented observation that women are at higher risk for workplace bullying than their male counterparts.(Einarsen D, 2003; Lee RT, 2011; Ling M, 2016) The finding that women more often felt devalued, expressed discomfort, felt pressure to accept unprofessional behaviors, and experienced task interference indicates that residents' reactions to certain experiences may provide insight into why gender is a risk factor for physician burnout.(Dimou FM, 2016) These attitudes were also expressed specifically in women's statements about their professional self-worth.

Professional identity, an essential component of the larger construct of self-concept, represents an individual's ability to integrate into their professional society and is crucial to achieving success.(DF, 2006; Markus H, 1987; S. V, 2009) In the realm of surgery, success requires more than mere technical proficiency—it is defined by nontechnical skills (e.g., behaviors that support surgical learning, motivation, and leadership)(Diperna JC, 2002) that shape reactions to challenging experiences. These skills can be collectively termed surgical competence, a reappropriation of the well-defined academic competence,(Neumeister KLS, 2006) and are necessary for the development of a surgeon's professional identity. A universal (but largely unspoken) surgical culture that includes aspects such as intimidation, competition, and sacrifice(Hill EJR, 2014) could serve as a possible barrier to the establishment of surgical

professional identity. Our findings suggest that aspects of surgical culture may be reflected in women's unique experiences during training. Although this study does not explicitly explore how differences in experiences affect the formation of professional identity, it does provide preliminary data suggesting an association may exist.

2.4.1 Limitations

As this was a preliminary study, it explored the perceptions and beliefs of general surgery residents of a single institution at a discrete point in their training with no control group for comparison. Our study could, however, be used to motivate future work investigating how gender might influence experiences of general surgery residents at different institutions and how these experiences are compared with those of trainees from other surgical and medical subspecialties.

In research of this nature, particularly when the material is sensitive, it is a standard to acknowledge the influence of the researchers; their relationship with the participants; and their role in the community from which the participants come.(McDermid F, 2014) We did not match the interviewer with the participant on the basis of gender. Previous investigations have shown that social identities, e.g., gender, race, sexual orientation, etc., may shape the interaction between interviewer and interviewee and affect data acquisition.(V.-T. J, 2017) Accordingly, women may have felt more comfortable in reporting certain experiences because the interviewer was also a woman. The role of the interviewer as a participant observer might result in participants emphasizing and elaborating themes of gender-based challenges to women surgical residents.(Purdie-Vaughns V, 2008) However, it is important to note gender is only a single parameter to consider; the intersectional effects of membership to multiple groups may further

complicate these dynamics. As such, it would not have been feasible to match each participant to an interviewer that identified similarly with respect to all salient social identities.⁵⁴ Therefore, since we were not able to control for these factors, matching the interviewer and participant by gender may have introduced more confounding rather than less. In spite of these limitations, the detail of information volunteered in the interviews provides insight into the experiences of women in training. Care was taken to reduce bias through training in interview techniques and piloting of questions to maximize objectivity. The authors acknowledge that even within general surgery residency, there is a hierarchy that may affect a participant's willingness to share. This limitation may have been reduced by the fact that the interviewer had entered into a nonclinical portion of residency dedicated to research and did not have a supervisory role over any of the participants.

The themes in this study are robust and warrant further study. It is the authors' hope that understanding how experiences during training differ by gender might contribute to identifying discrete interventions that will improve surgical education.

2.4.2 Conclusion

Women surgical residents may suffer a number of barriers during training that interfere with self-identifying as surgeons. Future investigations are needed to determine how perceptions and behaviors contribute to overall self-image and confidence of the trainee and influence the development of professional identity.

3.0 Gender bias and career engagement among surgical residents

3.1 Introduction

Despite increased awareness of gender bias in professional settings, medicine⁵⁵ trails other fields in gender diversity.⁵⁶ Gender disparity is particularly pronounced within academic surgery: women represent less than 10% of full professors and only 22 department chairs in the United States and Canada.⁵⁷ Evidence indicates that pro-male bias depresses women's performance⁵⁸ in male-dominated professions.⁵⁹ If and how this bias affects healthcare providers remains to be characterized. This lack of information is a significant impediment to developing valid interventions that effectively address challenges to the promotion and retention of female surgeons. Here, we study how engagement, one component of career advancement, is influenced by pro-male bias during residency, a phase of profound personal and professional development.

Models of educational achievement, which are especially relevant to residency as a period of intensive training, have thoroughly investigated factors necessary for professional success. Professional success in academic surgery requires scholarly achievement,⁶⁰ demonstration of clinical/technical competence,⁶¹ and active social participation (e.g., membership in professional organizations).⁶² Psychosocial constructs, i.e., attitudes or behaviors that arise from interactions between an individual and his/her environment, both herald and reinforce professional success.⁶³ Importantly, previous studies emphasize one such construct, engagement, as integral to professional advancement.⁶¹ Existing literature, however, has shown that engagement is influenced by other psychosocial constructs including sense of belonging,⁶² resilience,⁶³ and ability to relate to one's profession (i.e., domain identification).⁶³ We propose that the association between

pro-male bias in the training environment and career engagement differs by gender and that this relationship is mediated by the aforementioned psychosocial constructs (Figure 1). These variables and the manner in which they are considered in this investigation are described in detail in the subsections that follow.

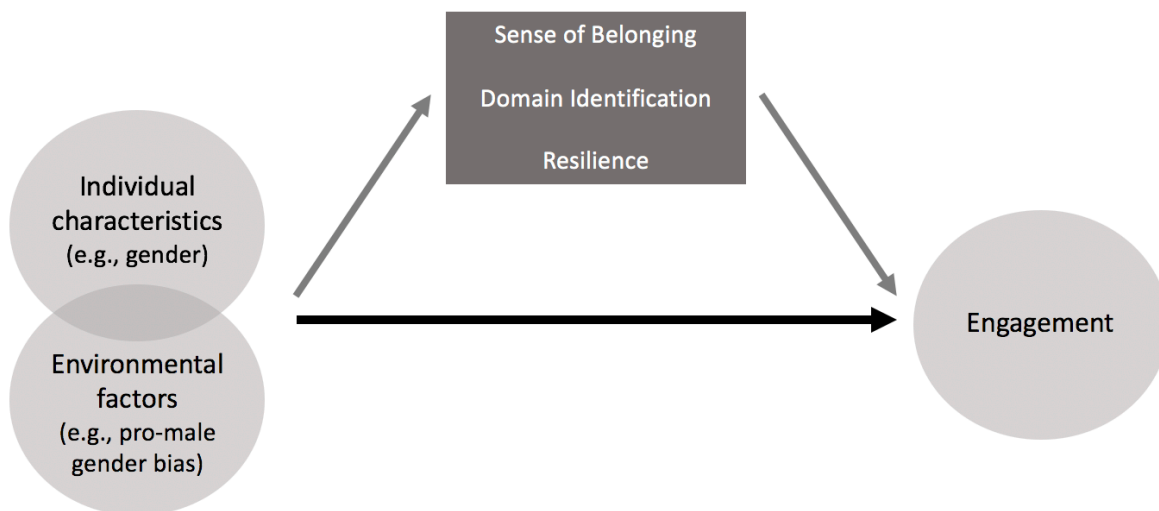


Figure 1: Paradigm delineating association between environmental factors and engagement

In this paradigm, we suggest that the influence of pro-male bias in the training environment on engagement is moderated by individual characteristics, and, in particular, a resident's gender. Additionally, we propose that sense of belonging, domain identification, and resilience are psychosocial constructs that may mediate this association.

3.1.1 Gender bias as an environmental stimulus

The underrepresentation of females in academic surgery exacerbates the already insufficient supply of surgeons tasked with caring for the US population.⁶⁴ In order to fulfill our obligation to patients, it is imperative that academic medical centers and training programs identify and mitigate factors that contribute to the attrition of all surgeons, but especially women,⁶⁴ who face unique gender-related challenges to career advancement.⁶⁵ Attrition, in general, has been

shown to be associated with job satisfaction,^{66, 67} commitment to the profession,⁶⁸ and intention to persist.^{69, 70} Characteristics of the work environment, and specifically those that affect interpersonal experiences, have been implicated in job satisfaction, commitment, and intention to persist.⁷¹ Investigations into discrete factors that influence these domains have shown that employee autonomy,⁷² equitable advancement opportunities,⁷³ and fairness in recognition for excellence all contribute.⁷⁴ As female gender has been associated with reduced operative autonomy,^{75, 76} significantly less compensation, and longer time to promotion within the field of surgery,⁷⁷ it is important to consider how bias favoring men underwrites factors that have been associated with attrition.

3.1.2 Career engagement as a predictor of professional success

Success as an academic surgeon requires one to excel with regard to scholarship, clinical reasoning and technical ability, and to be an active member of professional organizations. Given these varied responsibilities, it is useful to consider a construct that has been shown to predict achievement rather than to quantify each category of achievement separately. Engagement, defined for our purposes as self-directed and proactive career-related behaviors,⁷⁸ has been shown to predict advancement⁷⁹ and achievement.⁸⁰ It is characterized by residents' effort to involve themselves in activities that promote their professional development.⁸⁰

Institutional and environmental factors are important for facilitating engagement.⁸¹ In our study we are interested in assessing how engagement is affected by gender bias. If perceiving pro-male bias in the environment is associated with decreased engagement among female residents, it may also contribute to higher attrition rates in women compared to men. Studies in higher education substantiate this line of reasoning by demonstrating that engagement predicts student

persistence in school;⁸² insofar as engagement indicates the resident's commitment to the profession, increased engagement reflects decreased intent to withdraw from a career in surgery.

3.1.3 Sense of belonging

Vincent Tinto's *theory of student integration*, the foundation for much of the academic discourse pertaining to student achievement in the late 20th century, focuses on the concept that college students must transition from their pre-college communities and integrate themselves into their college communities in order to succeed. Similarly, during residency, surgical trainees must assimilate in such a way that they incorporate themselves into their professional community. Tinto's theory, however, has been criticized for failure to address environmental factors that may influence a student's ability to make this transition; because of their marginalized status, minority students may have negative experiences that hamper their integration.^{83, 84, 85} Thus, in order to fully appreciate the elements that impact professional success, we must understand not only how an individual's stigmatized status is emphasized by the training environment but also how related psychosocial determinants of achievement may mediate the association between this and engagement. Sense of belonging, one such determinant, describes the extent to which an individual feels accepted and valued such that they perceive themselves to be an integral part of their professional community.⁸⁶ Sense of belonging and engagement exist in a circular association; sense of belonging facilitates engagement^{87, 88} and increased engagement feeds back to reinforce sense of belonging.⁸⁹ By the same token, rejection and feeling as if one does not belong has been associated with reduced engagement.⁹⁰

3.1.4 Resilience

Resilience describes the ability to adapt when challenged with adverse circumstances.⁹¹ Whereas resilience was once believed to be an immutable and innate quality,⁹² longitudinal studies have demonstrated that children and adolescents brought up in stressful environments develop resilience and that this quality permits achievement and success.⁹³ Underrepresented individuals are at high risk for encountering adversity in the form of a discouraging or disruptive work environment due to social stigmas.⁹⁴ As a minority in a male-dominated profession, women in surgery face these challenges. Existing literature indicates that women who exhibit career resilience are able to employ coping strategies that allow them to overcome gender-related barriers, e.g., bias, and experience career success.⁹⁵ In this way, resilience may mediate the response of women to gender bias and facilitate engagement.

3.1.5 Domain identification

Domain identification describes the degree to which an individual identifies himself/herself by his/her relation to a profession. In this study, we consider the degree to which residents identify with the field of surgery. Domain identification can be particularly salient in environments where negative stereotypes are evident; evoking negative stereotypes has been shown to lead to domain disidentification.⁹⁶ Domain disidentification, in turn, has been associated with disengagement and reduced persistence within a field.²⁷ On the other hand, high domain identification has been shown to be predictive of women's engagement in STEM.⁹⁷ Although stereotypes about women are not the exposure of interest in this study, when pro-male gender bias is apparent in the training environment it is likely that residents are more cognizant of negative stereotypes. For this reason,

the mediating effect of domain identification is an important consideration. We anticipate that women residents who perceive pro-male bias in their environments will exhibit domain disidentification, i.e., lower domain identification, which will mediate the effect of bias on career engagement.

3.1.6 Study objectives

This multi-center study sought primarily to evaluate the association between gender bias and career engagement among trainees using survey methodology. We hypothesized that the association between perceiving pro-male gender bias in the training environment and career engagement would differ by gender. Specifically, we anticipated that there would be no association between perceiving pro-male bias and career engagement among men, but that among women, perceiving pro-male bias would be associated with reduced career engagement. As a secondary objective, we sought to perform exploratory analyses investigating whether the aforementioned psychosocial constructs mediated the association between pro-male bias and engagement.

3.2 Methods

3.2.1 Study setting and design

We conducted a survey-based investigation into the effects of gender bias on the career engagement of general surgery residents at three diverse academic campuses (Figure 2). IRB

approval was obtained at each participating institution (UW:STUDY00005154; UPMC:PRO18040386; UNC:Study#18-1921).

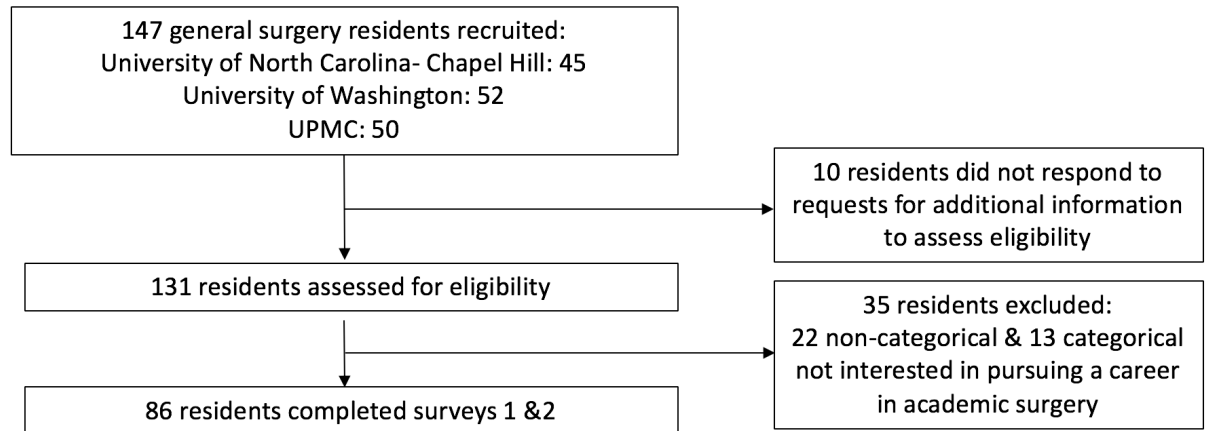


Figure 2: Flowchart detailing participant selection

3.2.2 Subjects

General surgery residents at UPMC (coordinating center), the University of North Carolina-Chapel Hill (UNC), and the University of Washington (UW) were recruited and completed an electronic pre-enrollment survey to determine study eligibility. General surgery residents who indicated on the enrollment questionnaire that they had completed undergraduate medical education in the United States and were interested in pursuing teaching/research as a principal component of their career (i.e., academic surgery)⁹⁸ were eligible for inclusion. Those who were not interested in pursuing a career in academic surgery, did not identify their gender as their biologic sex, or had entered surgery training after completing any amount of training in

another specialty were excluded. Eligible residents submitted written informed consent. We assigned each resident a unique alpha-numeric code for de-identification of serially collected data, the purpose of which was to blind the individuals conducting the study.

3.2.3 Survey instrument

Participants were asked to complete a survey comprised of 50 questions derived from validated scales assessing perception of gender bias, career engagement, susceptibility to stereotype threat, sense of belonging, resilience, and identification with the domain of surgery (see Appendix A). As this study analyzed data from a larger longitudinal study, we considered all the aforementioned constructs except susceptibility to stereotype threat, which will be discussed in detail in the third project.

Existing studies on surgery resident burn-out have shown that experiences during training can alter trainee motivation, job satisfaction, and quality of life over time.⁹⁹ Based on feasibility and previous studies investigating the effects of behavioral interventions on resident attitudes and perceptions,¹⁰⁰ we chose to administer the survey twice using a predetermined time frame of 5-6 months between surveys (Figure 3) to explore whether a change in response occurred over time. Residents had two weeks to complete each survey after it was delivered via a Qualtrics software generated link.

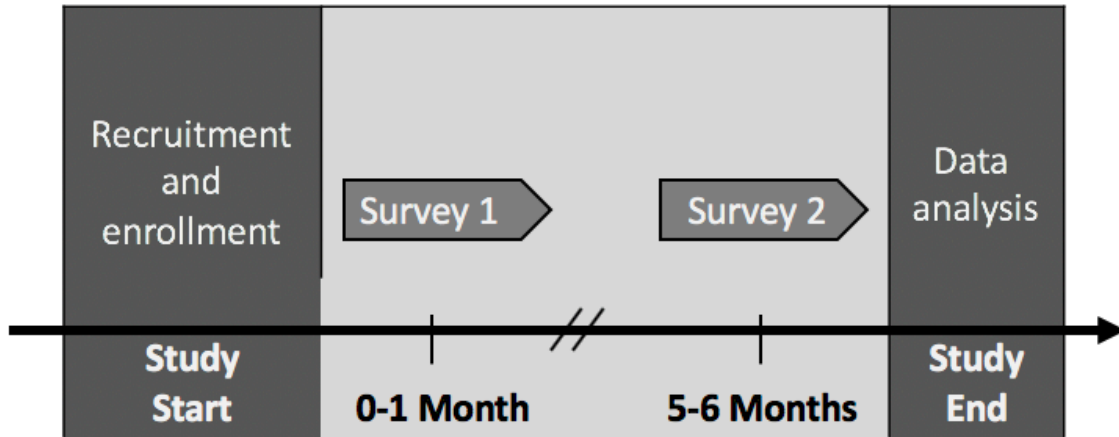


Figure 3: Study timeline

Seven items adapted from the Employee Environment Diagnostic Survey (EEDS)¹⁰¹ were used to measure the exposure of interest, a resident's perception of pro-male gender bias in their environment. Items in this scale assessed gender-based differences with regard to fairness of opportunities, support, and recognition within the work environment. Nine items adapted from the Career Engagement Scale (CES)¹⁰² assessed a resident's degree of engagement, the primary outcome of interest. As engagement itself is a complex concept influenced both by environmental cues, as well as, characteristics intrinsic to the individual,¹⁰³ we chose to incorporate additional psychosocial constructs into the survey instrument. Factors that have been shown to contribute to career engagement include sense of belonging to one's environment, identification with one's professional domain, and resilience, which were evaluated as mediating variables by responses to Sense of Belonging Index (SOBI: 7-items),¹⁰⁴ Domain Identification Measure (DIM: 7 items),¹⁰⁵ and the Connor-Davidson Resilience Scale (CD: RISC; 10-items),¹⁰⁶ respectively. Rationale for each of these scales is provided in the subsections that follow.

Subscales consisted of 7-10 items, each of which was graded on a Likert scale from 1-5, with 1 indicating the lowest and 5 the highest intensity of response. On the initial survey, five questions assessed resident demographics including age, race, sex, marital status, and post-graduate training level. Categories for age included <25 years old (yo), 25-29 yo, 30-34 yo, 35-39 yo, ≥40 yo. Participants were asked to identify their race as Caucasian, Black/African-American, Asian, Native Hawaiian or Pacific Islander, or Other.¹⁰⁷ Options for sex included Male or Female. Participants could indicate that they were married, widowed, divorced, separated, or never married. Residents were asked to classify their post-graduate year (PGY) as PGY-1, PGY-2, PGY-3, PGY-4, PGY-5, or Lab (i.e., exempt from clinical responsibilities and pursuing protected academic time).

3.2.3.1 Perception of gender bias in the environment

Various survey instruments exist to assess employees' perceptions and attitudes regarding their work environment. Some instruments, such as the Index of Organizational Reactions¹⁰⁸ and Worker Opinion Scale,¹⁰⁹ interrogate factors that contribute to job satisfaction including supervision, amount of work, and quality of the individual's relationship with his/her colleagues. In contrast, the goal of EEDS is not to measure job satisfaction *per se* but to assess particular work environment characteristics that relate to job satisfaction, institutional commitment, and intention to leave, all of which are, in turn, related to engagement. The full scale includes five subscales that assess 1) supervisor relations, 2) equity and fairness of the work environment, 3) co-worker relations, 4) job-person match, and 5) personal control of the job. This investigation adapted questions from the equity and fairness subscale. The EEDS survey was considered appropriate for this study because it evaluates a variable that is theorized to *influence* factors that have been shown to be related to engagement and attrition.

3.2.3.2 Career engagement

During residency, trainees pursuing careers in academic surgery are expected to be self-directed with respect to their learning and required to assume responsibility for their own clinical and academic development.^{110, 111} Thus, professional success requires proactive behaviors, i.e., career engagement. There are several instruments that measure distinct components of career engagement such as planning¹¹² and networking.¹¹³ Assessing each of these behaviors separately, however, is of limited utility, especially since others have shown that individuals are participating in multiple behaviors simultaneously.^{114, 115} Rather, it is more appropriate to employ a general metric of career engagement to evaluate theories related to environmental factors.^{116, 117} For these reasons, we have selected the CES as a measure of proactive behaviors necessary for success in academic surgery. The items in the CES scale were adapted to reflect behaviors related to research and scholarly endeavors, which are particularly important for the academic surgeon-in-training. Moreover, commitment to research facilitates excellence in other aspects necessary for success as an academic surgeon. Specifically it promotes 1) clinical competence through acquisition of knowledge with regard to ever-evolving evidence-based medicine, and 2) integration into professional communities.

3.2.3.3 Sense of belonging

Sense of belonging requires an individual to 1) view that his/her contributions are needed, and 2) feel that he/she fits in with other members of their group.¹¹⁸ As hierarchy is emphasized in surgical culture, residents may not feel that their input is valued.¹¹⁹ This, however, does not necessarily preclude a sense of belonging. Devaluation may be sanctioned as a rite of passage, thereby increasing sense of belonging, and its downstream effects of engagement and persistence.¹²⁰ For this reason, we have chosen to evaluate sense of belonging with a scale that

focuses on the degree to which a resident feels he/she fits in as a member of the surgical community rather than an instrument that also includes one that assesses the extent to which a resident might feel his/her input is appreciated.

3.2.3.4 Resilience

Resilience itself is a multi-faceted construct that varies in response to the type of stress and context within which that stress is encountered.⁹¹ In light of this it is not surprising that many of the scales that assess resilience^{121, 122 123, 124} are inconsistently used, not well validated, and, therefore, not generalizable.¹²⁵ CD-RISC was developed with an emphasis on the role of resilience in modulating mental health.¹²⁶ It has been shown to be valid in the general population. The creators of CD-RISC argue for implementing the scale in studies high-risk, high-stress occupations and in evaluating interventions aimed at promoting resilience. For these reasons, we have selected this scale as an assessment of general surgery trainees' resilience.

3.2.3.5 Domain identification

Prior to the development of the DIM, domain identification had been reported using surrogates such as grades, course enrollment, and college entrance scores.¹⁰⁵ Aronson et al. had assessed domain identification using two Likert-scale type questions evaluating perceived math ability and importance of math.¹²⁷ The DIM was developed for use in a generalized population with applicability to a variety of domains. To our knowledge, it is the most suitable scale to evaluate domain identification in this study.

3.2.4 Outcomes and statistical analysis

The Likert scores for each item within a psychosocial domain subscale were summated to yield a total continuous subscale score. Internal consistency of each subscale was determined using Cronbach's alpha with acceptable values ranging from 0.7-0.9.¹²⁸ T-tests were used to determine whether mean responses to subscales for survey 1 or 2 differed by gender. Paired T-tests were used to assess whether survey responses differed over a 6-month period. As the initial survey was administered at the beginning of the academic year, first year residents may not have had the opportunity to be fully immersed in their training environment. For this reason, the responses to the second survey likely provide a better assessment of residents' perspectives on their training environment. As such, primary and exploratory analyses were performed using responses to survey 2 subscales.

Our primary outcome of interest was career engagement as measured by the CES. We modeled the association between pro-male bias as measured by the EEDS score and career engagement using linear regression incorporating an interaction term between gender and EEDS score. This model was adjusted for study site and post-graduate training level. To avoid sampling bias and accurately reflect resident population demographics, we utilized a post-stratification weighting adjustment¹²⁹ based on participant gender and race using national data¹³⁰ in our analyses. Our rationale in using this adjustment stemmed from the fact that although the distribution of residents within each residency program did mirror national resident demographics with approximately 30% of residents being female, the proportion of residents who chose to participate in this study and were female was 50%. Therefore, our unadjusted data may represent an oversampling of women residents. We recognize that there are limitations of weighting. Namely, weighting effectively reduces signal from female participants' data, thereby potentially

biasing results toward the null. Additionally, weighting adjustments introduce difficulty in interpreting standard errors. Finally, weighting was based on national data from American Board of Surgery categorical resident demographics from 2008; weighting may have been inaccurate due to outdated demographic data, combining population information for both community and academic training programs, and arbitrarily considering some demographic features but not others (e.g., race and sex but not socioeconomic or marital status).¹²⁹ For these reasons, sensitivity analyses were performed to compare differences between results using weighting adjustment and non-adjusted data.

3.2.4.1 Exploratory analyses

Previous investigations have demonstrated the important of sense of belonging, resilience, and domain identification in intentions to persist. Exploratory analyses were aimed at determining whether the effect of gender bias on career engagement via these constructs differed by gender (Figure 4). As with primary outcomes of interest, sensitivity analyses were used to determine whether weighting adjustment contributed to differences in results compared to using non-adjusted data.

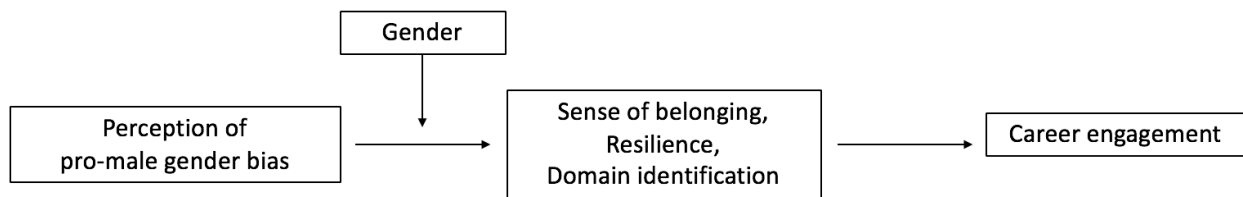


Figure 4: Exploratory analyses evaluating moderated mediation

Sense of belonging, resilience, and domain identification were incorporated as mediators into models assessing how gender moderated the association between perception of pro-male gender bias and career engagement.

3.3 Results

Of 112 eligible general surgery residents, eighty-six (77%) completed the both surveys (Table 6).

Table 6: Participant demographics

Variable	Participants N=86, n (%)
Post-graduate year (PGY)	
PGY-1	15 (17)
PGY-2	18 (21)
PGY-3	11 (13)
PGY-4	11 (13)
PGY-5	10 (12)
Lab	21 (24)
Sex	
Male	43 (50)
Female	43 (50)
Race	
Caucasian	57 (66)
Black/ African-American	6 (7)
American Indian or Alaska Native	0 (0)
Asian	16 (19)
Native Hawaiian or Pacific Islander	0 (0)
Other	7 (8)
Marital status	
Married	40 (47)
Single	46 (53)
Site	
UPMC	38 (44)
University of North Carolina-Chapel Hill	31 (36)
University of Washington	17 (20)

Survey response data is presented in Table 7. The association between EEDS and career engagement differed significantly by gender (interaction p-value=0.04); there was no significant association among women between the EEDS subscale and career engagement subscale scores (coefficient -0.19; 95%CI -1.05, 0.66; p=0.64) while men who had higher scores on the EEDS

subscale had higher scores on the career engagement subscale (coefficient 0.75; 95% CI 0.1, 1.49; $p=0.04$; Figure 5). These results were similar to those yielded by using data that had not been weight-adjusted to reflect national resident demographics. Specifically, the association between EEDS score and career engagement continued to differ significantly by gender (interaction p -value=0.02). There was no significant association between EEDS score and career engagement among women (coefficient -0.29; 95% CI -1.13, 1.08; $p=0.07$). Among men, EEDS score was positively associated with career engagement score (coefficient 1.01; 95% CI 0.22, 2.25; $p=0.02$).

Table 7: Survey responses

Subscale	Females Mean (SD)	Males Mean (SD)	Between gender difference (p-value)	Cronbach's alpha
Career engagement				
Survey 1	15.28 (5.44)	15.45 (5.45)	0.89	0.87
Survey 2	15.39 (5.52)	15.19 (6.09)	0.87	0.85
Between survey difference (p-value)	0.80	0.97		
Perception of gender bias				
Survey 1	10.58 (2.39)	10.65 (2.20)	0.89	0.83
Survey 2	10.67 (2.85)	10.50 (2.11)	0.77	0.82
Between survey difference (p-value)	0.63	0.67		
Sense of belonging				
Survey 1	13.00 (2.98)	13.08 (2.88)	0.91	0.87
Survey 2	12.75 (2.92)	13.28 (3.06)	0.42	0.85
Between survey difference (p-value)	0.25	0.19		
Identification with the domain of surgery				
Survey 1	8.65 (2.71)	8.71 (2.58)	0.91	0.80
Survey 2	8.84 (2.99)	8.53 (2.31)	0.60	0.82
Between survey difference (p-value)	0.16	0.57		
Resilience				
Survey 1	10.59 (2.83)	9.98 (1.75)	0.24	0.86
Survey 2	12.19 (3.08)	10.86 (1.68)	0.02	0.86
Between survey difference (p-value)	<0.01	<0.01		

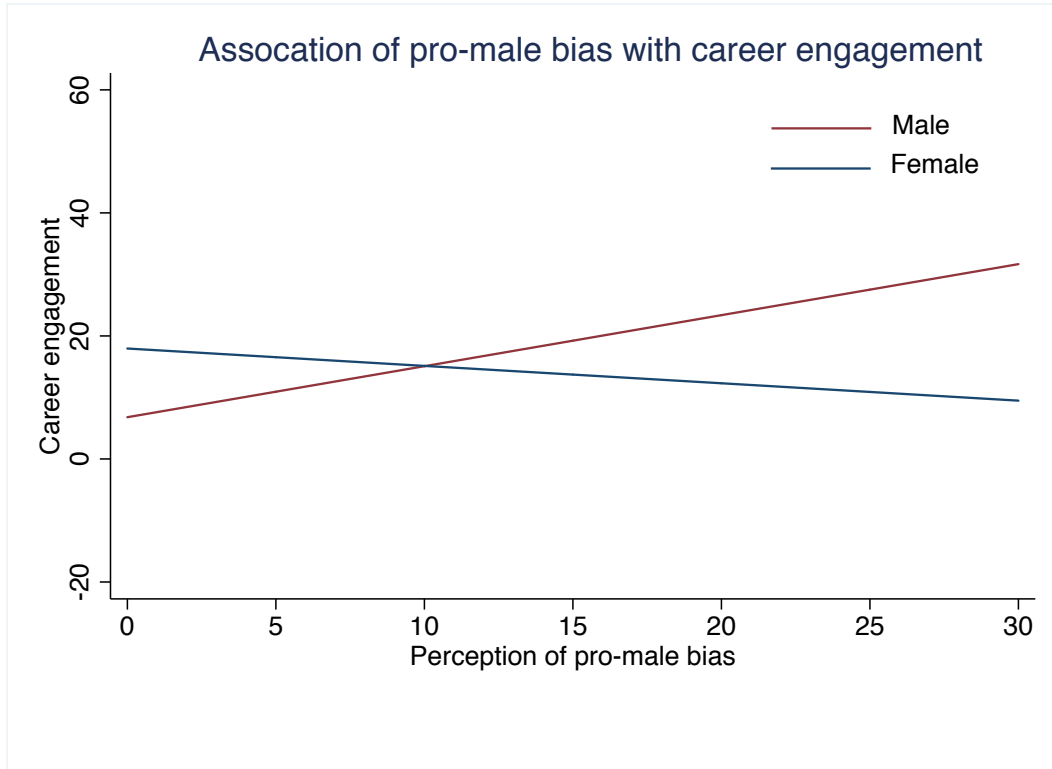


Figure 5: Association between perception of gender bias and career engagement differs across gender

Among males, higher perception of pro-male gender bias as measured by the Employee Environment Diagnostic Survey (EEDS) score is associated with higher career engagement as assessed by the Career Engagement Survey (CES) score. This relationship is reversed for women; higher EEDS score is associated with lower CES score among female residents.

3.3.1 Exploratory analyses

The effect of perceiving pro-male gender bias on career engagement via sense of belonging differed by gender (p -value= 0.04; Figure 6). In males, the total effect of pro-male bias on career engagement was increased by sense of belonging. In females, however, perceiving pro-male bias was associated with a significant decrease in sense of belonging, which resulted in a nonsignificant decrease in the total effect of pro-male gender bias on career engagement. These results did not differ when using data without weighting adjustment.

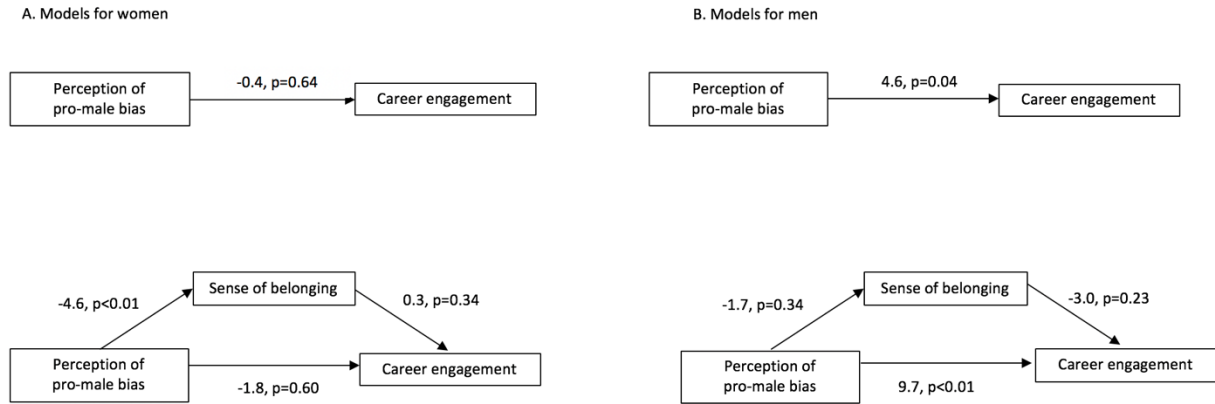


Figure 6: Association of perception of pro-male gender bias and career engagement as mediated by sense of belonging for women (panel A) and men (panel B)

The effect of perceiving pro-male gender bias on career engagement via resilience differed by gender (p -value= 0.02; Figure 7). For males, the association between perceiving gender bias and engagement was mediated by resilience. Perceiving gender bias was associated with a non-significant increase in resilience; resilience was associated with a significant increase in career engagement. In females, resilience did not mediate the association between pro-male bias and career engagement. Results were similar when using data without weighting adjustment.

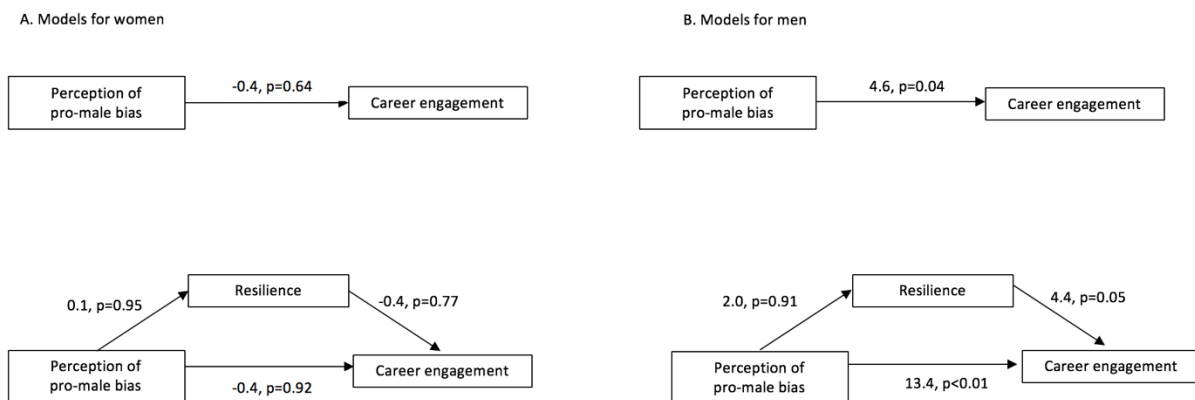


Figure 7: Association of perception of pro-male gender bias and career engagement as mediated by resilience for women (panel A) and men (panel B)

The effect of perceiving pro-male gender bias on career engagement via domain identification differed by gender (p-value= 0.01; Figure 8). For males, perceiving gender bias was associated with an increase in domain identification, which was associated with an increase in career engagement. The effect of perceiving pro-male gender bias on career engagement increased when mediated by domain identification. Among women, mediation via domain identification yielded a nonsignificant decrease in the association between perception of pro-male bias and career engagement as perception of pro-male bias was negatively associated domain identification. There were no differences in results when using data without weighting adjustment.

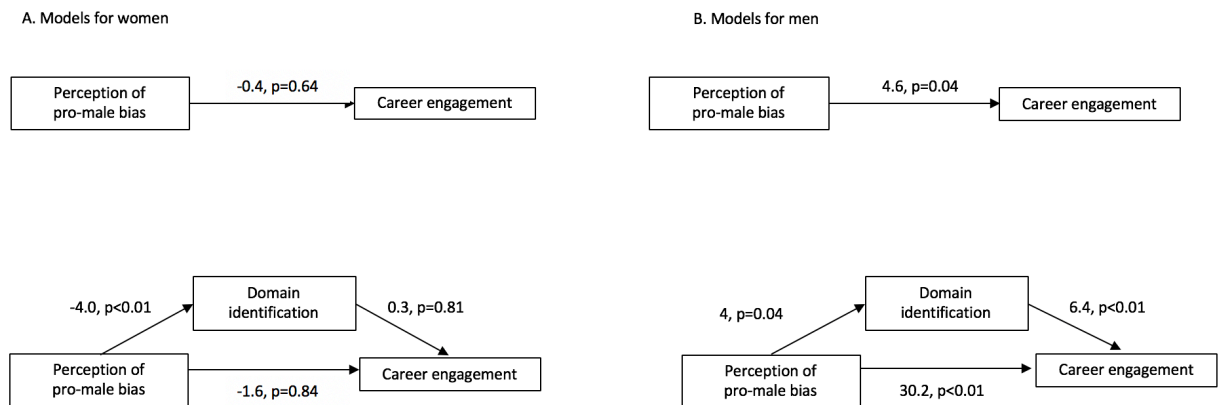


Figure 8: Association of perception of pro-male gender bias and career engagement as mediated by domain identification for women (panel A) and men (panel B)

3.4 Discussion

Although the underrepresented status of women in academic surgery is widely recognized,^{55, 56} contributing elements are complex. This study is among the first to explore how

the perception of pro-male bias in the training environment is associated with resident engagement, a key contributor to professional success.¹⁰³

Gender bias within the work environment may influence women's underrepresentation in surgery. We have shown that experiencing bias favoring men is associated with higher career engagement among men. Although no significant association was noted between perceiving pro-male bias and career engagement among women, the direction of the data in women was opposite to that for men. Others have proposed that reduced engagement may contribute to poor academic performance,¹⁰³ burnout, and attrition among women in academic medicine.¹³¹ Because engagement appears to be malleable,¹³² engagement may exist as a potential for targeted interventions aimed at cultivating professional development. Further studies delineating gender-based differences in engagement are necessary to determine whether and how interventions aimed at promoting engagement may be beneficial for women training to become academic surgeons.

Additional investigations are necessary to establish the mechanisms by which bias challenges professional efficacy and engagement. As a first step, we evaluated sense of belonging, resilience, and domain identification as possible mediators. Our results indicate that sense of belonging may have mediated the association between the perception of pro-male bias and engagement differently for men and women. For women, recognizing bias favoring men was associated with a reduced sense of belonging, which accounted for modestly lower engagement. Women who perceive pro-male bias in the training environment may find it more difficult to integrate with the surgical community.^{83, 84, 85} If feelings of rejection and reduced sense of belonging result, this may motivate the female trainee to withdraw her commitment and engage less in endeavors related to professional development.⁹⁰

We expected that for men, sense of belonging would mediate and strengthen the association of pro-male bias with engagement, reasoning that perceiving favoritism might increase one's sense that he fits in with other surgeons. Although the total effect was augmented by sense of belonging, we were surprised to find that 1) pro-male bias was negatively associated with sense of belonging, and 2) sense of belonging was negatively associated with engagement. It is difficult to argue that being given a gender-based advantage would lead to feeling *less* accepted. One could imagine, however, that in a culture that valorizes masculinity, men who deviate in any way from traditionally masculine qualities might experience conflict, and, consequently, reduced belonging.¹³³ This mechanism for reduced belonging may be similar to those responsible for observations by The American Psychological Association and others that masculine ideology has negative effects on males' mental health.¹³⁴ Although in our study, reduced sense of belonging for men is associated with a positive outcome of increased engagement, there are detrimental effects that we do not consider. Training programs should recognize that gender bias can thwart the psychological development of both men and women, which can have unforeseen ramifications for professional development.

In the second arm of the mediation pathway between pro-male bias and engagement among men, sense of belonging had an inverse relationship, albeit non-significant association, with engagement. While others have not found this negative relationship, it has been noted that sense of belonging more strongly predicts persistence in STEM for women compared to men.¹³⁵ We speculate that absence of gender bias *against men* may promote a confidence among male residents such that they believe they can overcome challenges. For women, on the other hand, pro-male bias may increase awareness of negative stereotypes which can, in turn, elicit feelings that obstacles are insurmountable, i.e., fixed mindset. Studies have shown that emphasizing that ability is plastic

and can be improved over time debunks a fixed mindset and increases sense of belonging.¹³⁶ In this way belonging has two interrelated components. Social belonging is influenced by gender identity and can be influenced by pro-male bias in the training environment.¹³⁷ Ability belonging describes an individual's belief that he/she fits in intellectually.¹³⁸ For men, threats to ability belonging may be soluble if males interpret the message of pro-male bias as representing the field's confidence in their ability. For women, pro-male bias may impede social belonging and further diminish ability belonging. One possible explanation for the inverse relationship between sense of belonging and career engagement among men seen in our study is that diminished social belonging could paradoxically motivate increased engagement behaviors encouraged by self-assurance and ability belonging. As the sense of belonging scale used in this study does not distinguish between types of belonging, future studies are needed to investigate how these different facets of belonging mediate the association between individual and environmental factors and professional outcomes.

Interventions that build resilience have been suggested for promoting engagement.²⁶ Resilience describes the capacity to resist adverse psychological ramifications precipitated by stressful circumstances.¹³⁹ In theory, teaching women to harness this individual characteristic may afford protection against the damaging effects of gender bias. Although women had higher scores for resilience compared to men, degree of resilience did not mediate the relationship between bias and engagement. This result was surprising in view of data from others demonstrating the importance of resilience for achievement among minority groups that may experience bias.^{140, 141} Severe adversity, however, may overwhelm the defense that resilience offers in spite of seemingly high levels of resilience.^{93, 142} Similarly, research on burnout suggests that individual factors, such as resilience, may be insufficient to contest situational and organizational factors,¹⁴³ such as bias. For these reasons, interventions to encourage resilience may not effectively mitigate the

ramifications of gender bias on career engagement. It is, however, important to consider that different forms of adversity almost certainly exist and resilience may continue to be protective if the degree of adversity encountered is endurable. This may be one explanation for the observation in our study that resilience positively mediates the association between pro-male bias and engagement among male residents.

Domain identification is an important factor for professional success. Studies from academia have shown that higher domain identification is positively associated with task commitment, performance, and motivation.¹⁰⁵ Among men, we found that perceiving pro-male bias bolstered domain identification, which contributed to higher scores on the career engagement subscale. Although domain identification was also positively related to engagement for women, because bias favoring men negatively influenced domain identification, an overall inverse, albeit minimal and non-significant effect, was seen between perception of gender bias in the environment and career engagement among women. Since domain identification indicates that the individual places great value on performance in that particular domain, it follows that one's self-worth also relies on performance within the domain.¹⁴⁴ When identifying with a domain challenges an individual's self-worth, a decrease in domain identification is obligatory for preserving self-worth.¹⁴⁵ Our first study, which demonstrated that women reported weakened self-worth in response to perceiving pro-male bias and negative stereotypes about women, is consistent with our findings in this investigation.

3.4.1 Limitations

There are several limitations worth addressing. First, the subscales used in this study were validated for demographics other than surgical residents. While only minor adaptations were made

to the language of items within the subscales, questions may have been received and interpreted differently by surgical trainees thereby compromising the assessment of a given psychosocial construct. Additionally, the subscale to evaluate the perception of pro-male gender bias was developed in concert with other subscales as part of the larger EEDS instrument. Selecting part of the EEDS instrument may have altered the validity of the subscale. Further investigations are necessary to evaluate the subscale used in this investigation especially with regard to its relation to the other scales used in our combined survey instrument. We were insufficiently powered for this study given that the data presented here was part of a larger longitudinal investigation based on alternate outcomes. Finally, our study incorporated only two time-points for survey data; administering surveys at additional points over time would strengthen our ability to determine changes in subscale responses during training.

3.4.2 Conclusion

Pro-male gender bias affects career engagement differently depending on gender. Further studies are needed to elaborate on these relationships and whether sense of belonging, domain identification, and resilience may mediate these associations. Elucidating how these constructs promote or deter the professional development of surgeons-in-training, and, particularly, women is necessary for encouraging inclusivity, retention, and advancement in academic surgery.

4.0 The effect of stereotype threat on skill performance of surgical residents

4.1 Introduction

Gender stereotypes have been shown to impair the performance of underrepresented groups.³ This is proposed to occur through the activation of stereotype threat, a phenomenon that describes the risk of reinforcing a negative stereotype about the group with which an individual identifies.¹⁸ Susceptibility to stereotype threat requires that an individual have knowledge of a negative stereotype, identify strongly with the stereotyped group, and be concerned with achievement in the domain regarded by the stereotype (e.g., surgery).^{146, 147} Stereotype threat can be activated by explicitly indicating low performance in one group compared to another (i.e., women versus men)¹⁴⁸ or by raising awareness of underrepresented status,¹²⁷ and is particularly salient in competitive high-pressure situations, such as surgical residency, in which an individual has great personal motivation to excel.¹⁴⁶

Stereotype threat contributes to measurable differences in technical skill performance by depleting executive function and siphoning attention away from the task at hand.⁴ For surgeons, professional performance includes assessments of technical ability. Importantly, technical performance is becoming the dominant metric by which surgeon competence and achievement is judged both by patients and hospital systems.⁵⁻⁷ In fact, The American Board of Surgery now requires that surgeons achieve a passing score on the Fundamentals of Laparoscopic Surgery (FLS) exam, an assessment of laparoscopic skill. Here we study how technical skill performance is influenced by negative stereotypes against women during residency, a phase of profound personal and professional development.

Specifically, this multi-center study sought to investigate if gender moderated the association between evoking negative stereotypes about women and skill performance. We hypothesized that triggering stereotype threat would affect FLS score differently in women compared to men. We anticipated that women who were provided with data indicating that women have inferior technical skill performance than men would score worse than women who were presented with data suggesting no gender-based difference in performance. We expected that intervention would not be associated with difference in FLS score among men.

4.2 Methods

4.2.1 Study setting and design

We conducted a multi-center randomized trial to study the effect of stereotype threat activation on the technical skill performance of general surgery residents at three diverse academic campuses (Figure 9). General surgery residents at UPMC (coordinating center), the University of North Carolina-Chapel Hill (UNC), and the University of Washington (UW) were recruited and enrolled as previously described in our second project. Participants included in this study completed the survey-based study in the previous project, which evaluated the association between gender bias and career engagement. IRB approval was obtained at each participating institution (UW: STUDY00005154; UPMC: PRO18040386; UNC: Study#18-1921). This trial was registered under ClinicalTrials.gov identifier NCT03623009.

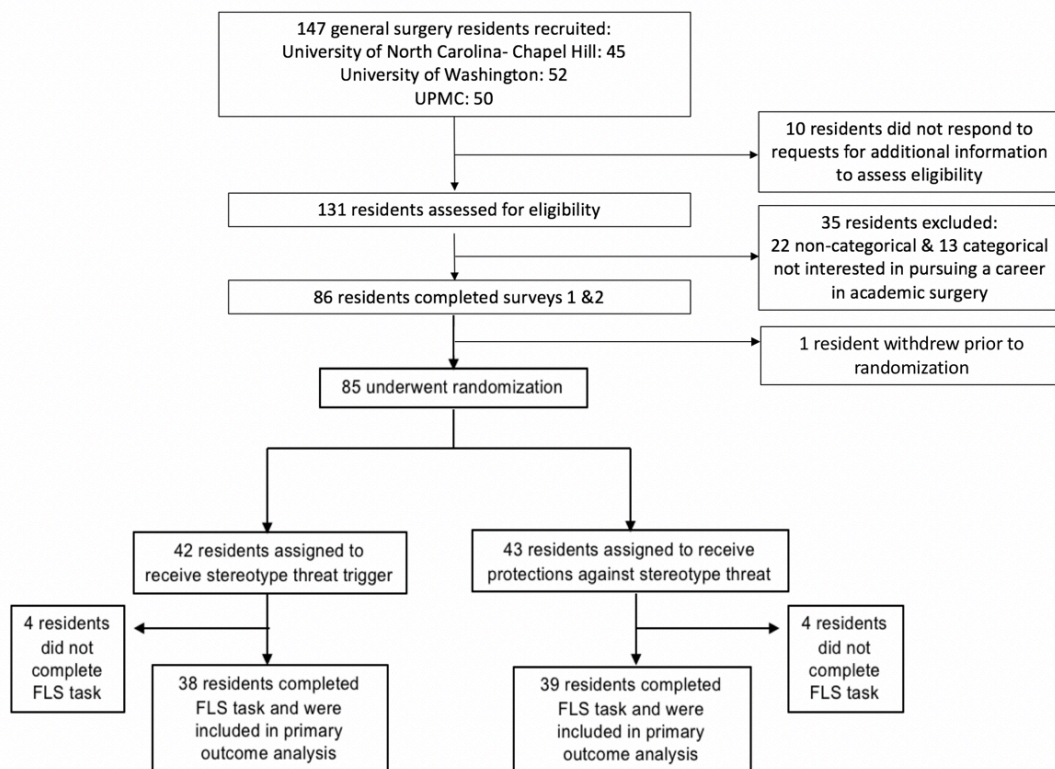


Figure 9: Study design

Of the 147 residents recruited, 85 met eligibility criteria and underwent randomization. Residents who completed the Fundamentals of Laparoscopic Surgery (FLS) tasks were included in the primary outcome analysis.

4.2.2 Study instruments and interventions

Residents were randomized 1:1 to receive either a female-focused stereotype threat trigger (i.e., women are negatively labeled) or protection against stereotype threat in a permuted block design stratified by study site, post-graduate level, and gender. At study outset, participants were informed that the objective of this investigation was to explore how the surgical training environment affects surgical skill performance. In an effort to enhance validity and promote spontaneous behavior, detailed information regarding the study's purpose of investigating the effect of stereotype threat activation on skills performance was not proffered;¹⁴⁹ instead, residents

were told that they would be given reading material prior to completing the FLS assessment in order to assess how their performance would change if their focus was distracted immediately before completing a technical skill (i.e., distributive task processing). After the investigation was complete, participants were debriefed by the primary investigator; interventions, study intent, and results were disclosed in an open-forum using PowerPoint slide presentation.

Adapting a validated method of activating or protecting against stereotype threat,¹⁵⁰ intervention A was meant to trigger stereotype threat among women by asking participants to read the abstracts of two articles that evoked negative stereotypes of women by reporting that women performed worse with regard to laparoscopic skills than men. Intervention B was meant to protect against stereotype threat by asking participants to read two abstracts that debunked negative stereotypes about women by reporting no gender-based differences in laparoscopic skills performance. Residents were not aware that these abstracts served as the manipulation. Intervention abstracts were altered from originals^{151, 152} using Adobe® Photoshop® (Appendix B, Appendix C). Article title, authors, and journal volume, issue, and page number data were obscured so as to prevent participants identifying the article or recognizing that the content and findings were modified to suit the intervention arm. Although no formal pilot testing was performed to evaluate resident responses to the interventions, previous experiments have demonstrated that reading material claiming inferior performance by a stereotyped group compared to a non-stereotyped group triggers stereotype threat for individuals that identify as the stereotyped group with consequent worse performance on math assessments.¹⁵³ Being told that men and women perform similarly well on a task, on the other hand, has been shown to protect women against stereotype threat activation and result in improved performance.²⁰

According to the randomization assignment, articles were placed in a sealed envelope labeled with the participant's study code and provided to each participant just prior to administration of the technical skills assessment. Residents were asked to read the abstracts and summarize the main conclusion in one sentence. An investigator reviewed the sentences for concordance with study findings as a way of determining that residents had understood the message of the abstracts. Immediately after the interventions, the subjects completed the FLS assessment (task-portion), a standardized and validated simulation-based assessment of laparoscopic ability,¹⁵⁴⁻¹⁵⁷ followed by a survey evaluating psychosocial constructs germane to professional achievement (Appendix A) in-person in the testing center. This survey was composed of validated subscales (described previously for our second project) assessing sense of belonging (SOBI), resilience (CD-RISC), and identification with the domain of surgery (DIM).¹⁰⁴⁻¹⁰⁶ In addition to these survey subscales, this study utilizes data from the Social Identities and Attitudes Scale (SIAS)¹⁵⁸ which evaluates susceptibility to stereotype threat. Susceptibility to stereotype threat is discussed in detail in the subsection that follows.

No resident was compensated for their participation. FLS exams were administered by two proctors certified by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), who were blinded to the participants' intervention arm. Exams were sent to SAGES for scoring under the residents' deidentified participant code and returned to the central site coordinator. Residents understood that their score was for study purposes alone and could not be used for FLS certification. Proctors and SAGES were compensated for their involvement in exam administration and scoring.

4.2.2.1 Susceptibility to stereotype threat

Although environmental factors like gender bias have been shown to create barriers for the achievement of women in STEM fields,¹⁹ how an individual internalizes and interprets these stimuli determines the degree to which negative consequences occur.¹⁴⁸ We consider bias favoring men in the surgical training environment to be a manifestation of negative stereotypes about women surgeons. Our first study showed that female residents who perceived pro-male bias were acutely aware of these stereotypes. In order for a woman to be sensitive to the effects of these stereotypes, she must both derive her identity from *being a woman*, and recognize the negative stereotype that is being suggested by an environmental cue (i.e., gender stigma consciousness).^{148,}
¹⁵⁸ To our knowledge, the only survey instrument with validated subscales for both gender identity and gender stigma consciousness is the Social Identity and Attitudes Scale (SIAS). In addition to the scales assessing sense of belonging, resilience, and domain identification, nine items from the SIAS scale assessed susceptibility to stereotype threat based on the degree to which an individual identifies their gender as a defining aspect of their social identity and the extent to which they recognize negative stereotypes about their gender.¹⁵⁸

4.2.3 Outcomes and statistical analysis

Our primary hypothesis was that the association between intervention arm and FLS score would vary by gender. Specifically, we anticipated that, when female-focused stereotype threat (i.e., evoking a negative stereotype about women) was activated, women but not men would have reduced performance such that gender-based differences in FLS score would be more pronounced.

Although there is limited data with regard to differences in performance of men and women on FLS assessment, women have been shown to perform worse than men on the Fundamentals of

Endoscopic Surgery (FES) skills assessment,¹⁵⁹ a simulation based technical skills assessment similar to the FLS.¹⁶⁰ It is important to note that the designation of endoscopic surgery by SAGES refers to procedures using an endoscope, a flexible tube containing a light source and camera that is used to evaluate the gastrointestinal tract. Laparoscopic surgery, on the other hand, describes is a minimally invasive technique using a fiber-optic instrument that is inserted through the body wall and allows visualization of organs. Although etymologically laparoscopic surgery refers only to procedures involving abdominal organs (*lapara* (abdomen/flank) + *scopein* (watch)), this terminology practically refers more broadly to any surgical procedure involving the laparoscope.¹⁶¹ As laparoscopic techniques are quickly replacing more invasive, i.e., open, approaches,¹⁶² the FLS is a more appropriate measure of surgical skill. Additionally, the FES assessment was only added as a requirement for American Board of Surgery certification in 2018, which was after this study was designed and IRB approvals were obtained.¹⁶³

The primary outcome of FLS score was assessed as a continuous value. We modeled the association between intervention arm and FLS score using linear regression incorporating an interaction term for gender and adjusting for site and training level. Details for range of score for surgery residents in general and how the FLS exam is assessed are considered proprietary and were not released to study investigators by SAGES. This study was originally powered to detect an overall difference in FLS performance between intervention arms; a minimum sample size of 84 residents was calculated to detect a 20-point difference in FLS score at 80% power, alpha=0.05, and counting for 10% drop-out after randomization and prior to FLS task completion.³³ To adequately power a test of the moderating effect of gender on intervention arm, our primary hypothesis, we would have needed to increase this sample size by a factor of four.

4.2.3.1 Post-hoc and exploratory analyses

Psychosocial constructs (i.e., susceptibility to stereotype threat, sense of belonging, resilience, and identification with the domain of surgery) that were considered in post-hoc and exploratory analyses were evaluated using previously validated subscales consisting of 7-10 items, each of which was graded on a Likert scale from 1-5, with 1 indicating the lowest intensity of response. The scores from items within a psychosocial domain were summated to yield a total continuous subscale score.

The intended purpose of incorporating the SIAS scale was to evaluate post-hoc whether susceptibility to stereotype threat moderated the effect of the interaction between gender and intervention arm on FLS score. We modeled whether the 2-way interaction effect between gender and intervention arm changed over values for susceptibility to stereotype threat (i.e., a three-way interaction between intervention arm, gender, and susceptibility to stereotype threat) since individuals who are more sensitive to the effects of stereotype threat may have different psychological responses to its activation compared to those who are less sensitive.

As sense of belonging, domain identification, and resilience have been associated with gender-based differences in performance, we performed exploratory analyses interrogating whether these construct mediated the association between intervention-type and FLS score in either men or women using linear mediation models. We expected that these psychosocial constructs would serve as strong mediators and account for a significant portion of the association between activation of stereotype threat and skill performance. The moderating effect of gender was retained in these exploratory analyses regardless of whether the effect of intervention on FLS score differed significantly by gender. We recognize that a moderated mediation model is not typically utilized if the association between the independent (i.e., intervention arm) and dependent

variable (i.e., FLS score) does not significantly vary over the level of the moderator variable (gender). However, because we were underpowered to see moderating or interaction effects, these interactions may have only been insignificant because of insufficient sample size. For this reason, exploratory analyses incorporating moderated mediation were deemed to still be informative. STATA15 was used for all analyses. A p-value ≤ 0.05 was considered significant.

4.3 Results

Of 85 residents randomized, 77 (91%) completed the study. Three residents in the intervention A arm and four residents in the intervention B arm were unable to schedule their FLS exam during the periods of time when the study proctor was available to administer exams. One resident in the intervention A arm arrived to his scheduled FLS exam but was paged to attend to clinical responsibilities prior to receiving the intervention.

4.3.1 Primary outcomes

Although the mean score was lower for women compared to men in both intervention A (367 ± 152 vs. 423 ± 148 ; $p=0.12$) and intervention B (328 ± 168 vs. 400 ± 142 , $p=0.08$) these differences were not statistically significant (Figure 10). Intervention group was not associated with FLS score (coefficient 31.4; 95% CI -37.9, 100.7; $p=0.37$) but female sex was associated with decreased FLS score (coefficient -65.5; 95% CI -131.5, 0.42; $p=0.05$). The association between intervention group and FLS score was similar in men and women (p-value for interaction 0.83).

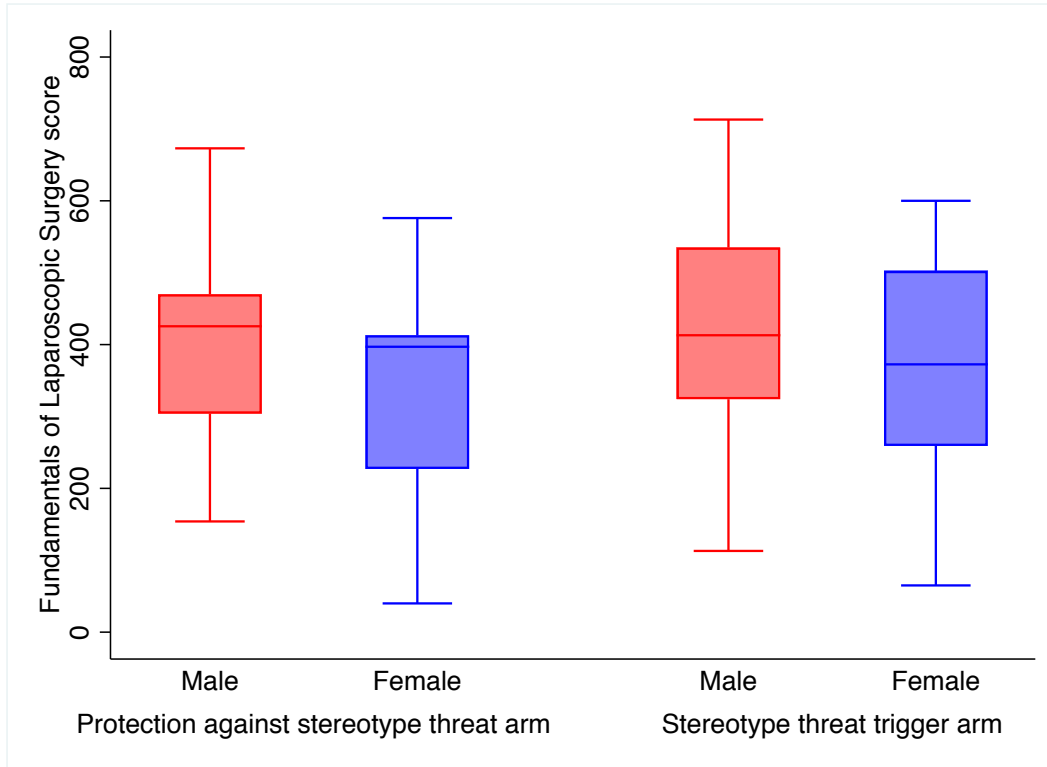


Figure 10: Fundamentals of Laparoscopic Surgery scores for residents by gender and intervention arm

4.3.2 Post-hoc and exploratory analyses

Survey response data are presented in Table 8. The association between stereotype threat activation and FLS score differed by gender across levels of susceptibility to stereotype threat (interaction coefficient -35.2; 95% -60.8, -9.7; $p=0.01$; Figure 11). Among women who received a trigger of stereotype threat, higher susceptibility to stereotype threat was associated with lower FLS score (coefficient -9.9; 95% CI—21.3, -1.5; $p=0.04$). In contrast, there was no significant association between susceptibility to stereotype threat and FLS score among women who received protection against stereotype threat (coefficient 12.0; 95% CI-9.0, 33.0; $p=0.24$). Among men with higher susceptibility to stereotype threat, evoking negative stereotypes about women was not significantly associated with FLS score (coefficient 5.2; 95% CI -7.9, 18.3; $p=0.42$). In contrast,

among men who read abstracts indicating that male and female residents perform equally well on laparoscopic skills assessments, higher susceptibility to stereotype threat was associated with lower FLS score (coefficient -8.2; 95% CI -17.0, -0.68; $p=0.05$).

Table 8: Survey response data

Subscale	Males		p-value	Females		p-value
	Intervention A Mean (SD)	Intervention B Mean (SD)		Intervention A Mean (SD)	Intervention B Mean (SD)	
Susceptibility to stereotype threat	19.73 (5.67)	19.25 (7.51)	0.82	17.47 (5.84)	17.64 (4.21)	0.92
Sense of belonging	16.86 (5.63)	17.65 (6.60)	0.67	16.52 (6.55)	16.89 (5.67)	0.18
Resilience	15.32 (5.40)	14.60 (4.82)	0.66	19.26 (8.53)	20.06 (6.12)	0.75
Domain identification	13.58 (5.26)	11.9 (3.65)	0.25	13.05 (5.05)	14.41 (5.32)	0.44

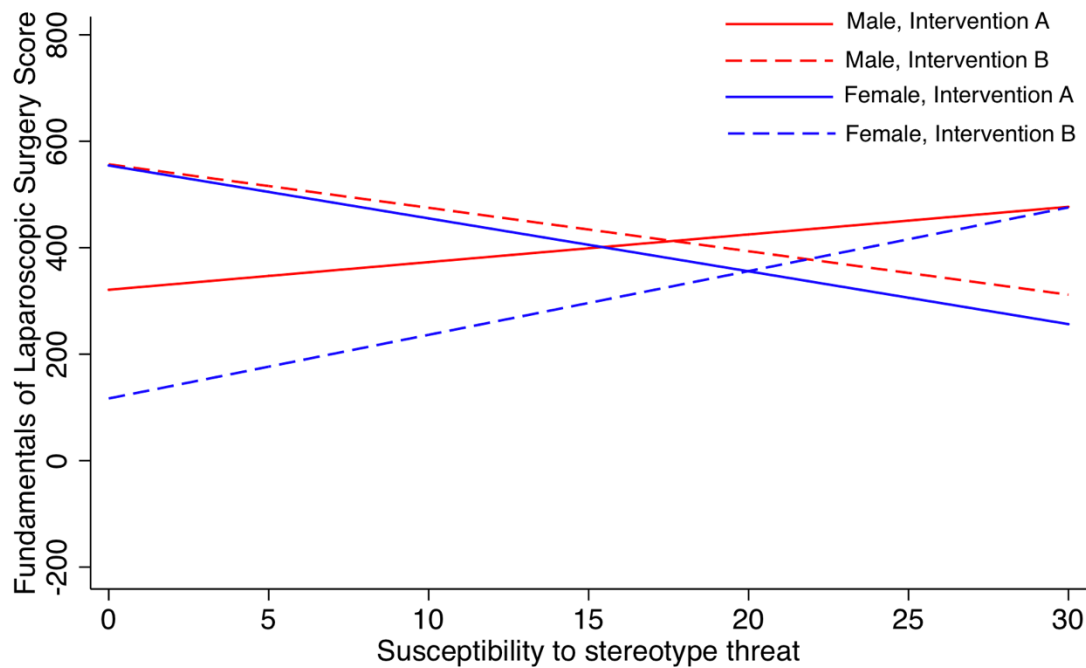


Figure 11: Gender based differences in Fundamentals of Laparoscopic Surgery score as susceptibility to stereotype threat varies

For women, sense of belonging may have mediated the effect of triggering stereotype threat on FLS score as there was a nonsignificant decrease in the association between intervention group and FLS score. Triggering stereotype threat was significantly and negatively associated with sense of belonging. Sense of belonging was significantly positively associated with FLS score. Sense of belonging did not mediate the association between intervention group and FLS Score among men.

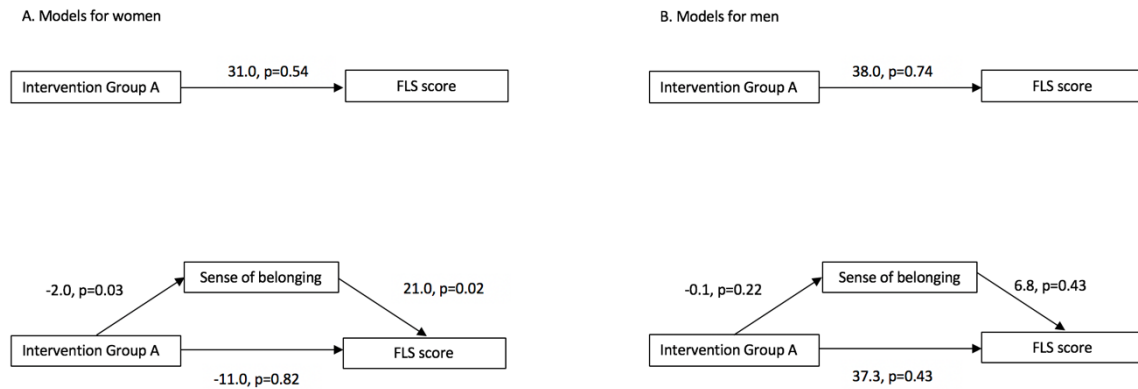


Figure 12: Association of Intervention Group A and Fundamentals of Laparoscopic Surgery (FLS) as mediated by sense of belonging for women (panel A) and men (panel B)

Resilience did not mediate the association between intervention group and FLS score among women or men as the total effect of intervention group on FLS score was the same as its direct effect for both genders (Figure 13).

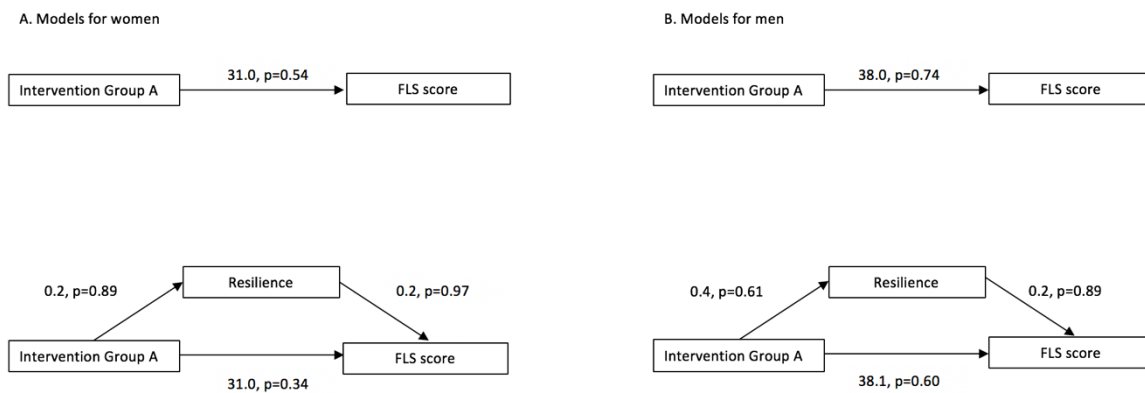


Figure 13: Association of Intervention Group A and Fundamentals of Laparoscopic Surgery (FLS) as mediated by resilience for women (panel A) and men (panel B)

For women, domain identification may have mediated the effect of triggering stereotype on FLS score as there was a modest non-significant decrease in the total effects of intervention a on FLS score (Figure 14). Activation of stereotype threat was non-significantly associated with a decrease in domain identification. Domain identification was non-significantly positively associated with FLS score. Domain identification did not mediate the association between intervention group and FLS Score among men (Figure 14).

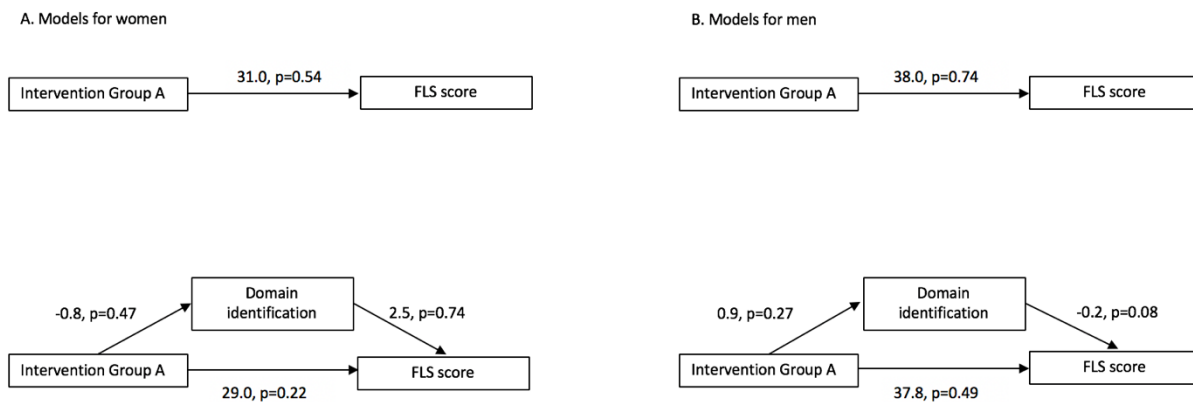


Figure 14: Association of Intervention Group A and Fundamentals of Laparoscopic Surgery (FLS) as mediated by domain identification for women (panel A) and men (panel B)

4.4 Discussion

To our knowledge, this is the first multi-center randomized controlled study to explore how stereotype threat activation affects technical skill performance among general surgery trainees. The association between intervention group and FLS score was similar in men and women. However, among women with higher susceptibility to stereotype threat, evoking negative stereotypes about women was associated with lower FLS scores. These findings suggest that the

operative performance of stigmatized individuals may suffer if they are exposed to negative stereotypes about the group with which they identify.

A substantial body of research has demonstrated that gender stereotypes can decrease professional performance of women.³ While previous studies have illustrated the consequences of gender stereotypes on promotion¹⁹ and opportunities,²³ a causal link between stereotype threat activation and technical skill performance among female general surgery residents has not been established. Our finding that intervention arm alone was not associated with differences in FLS score between men and women is consistent with previous studies that have been unable to identify gender-based differences on FLS or other laparoscopic skills metrics.¹⁵² This observation oversimplifies the reaction to stereotype threat given that it does not take into account that stereotype threat impacts stigmatized individuals differently.^{96, 164} Rather, understanding one's reaction to stereotype threat requires consideration of psychological factors.²⁵ One such factor that influences the relationship between performance and stereotype threat is susceptibility to stereotype threat. Susceptibility to stereotype threat requires both that an individual is cognizant of gender stigma (i.e., gender stigma consciousness) and identifies as the stereotyped gender.^{124, 158} We show that reminding women who exhibit higher susceptibility to stereotype threat of negative gender stereotypes reduces performance on the FLS exam. This result corresponds with data previously published⁹⁶ indicating that underrepresented demographics express increased anxiety about their abilities in a manner that may reduce performance. Given that technical skill performance is requisite to ascertaining surgical competence, efforts to reduce the effect of negative gender stereotypes are paramount to the success of women in academic surgery.

Interestingly, among men with higher susceptibility to ST, there was a non-significant positive (i.e., upward) directionality with regard to FLS score when presented with negative

stereotypes about women. While not reaching statistical significance, it is worth noting that this observation is consistent with data from others demonstrating that men exhibit improved performance when told that women perform worse compared to when they are told that no difference in performance exists.²⁰ This phenomenon has been referred to as *stereotype lift*¹⁶⁵ and is theorized to occur because men perceive an indirect advantage as a result of the negative labeling of women.¹⁶⁶ Gender stereotypes that potentially contribute to worse performance among women and better performance among men may ultimately influence gender-based disparities in professional success.

Previous studies have demonstrated that negative stereotypes may contribute to the underrepresentation of women in surgery by influencing psychological constructs associated with self-perception and self-efficacy.²⁵ Sense of belonging, is one such construct and describes the degree to which an individual feels valued by and integrated into their professional community. While the influence of belonging has not been studied in surgical trainees, studies from higher education have indicated its importance for intentions to persist in academic endeavors among minorities.²⁶ In this study, we observed a nonsignificant decrease in the coefficient for the association between triggering stereotype threat and FLS score among women, which may indicate that sense of belonging mediates this relationship. While our second study investigated a different exposure and outcome of interest, the result of this third study mirrors this finding insofar as we noted an inverse relationship between pro-male bias and career engagement. For men, on the other hand, our findings for this study were incongruent with those of our second study; sense of belonging did not mediate the association between intervention group and FLS score for men. We were surprised that sense of belonging did not mediate an improved score on the FLS among men after they were presented with a negative stereotype about women. Perhaps we would have

appreciated this relationship if we had explicitly referenced positive stereotypes about men rather than suggesting a negative stereotype about women. Further studies are necessary to investigate how sense of belonging affects performance and professional success differently for men and women and whether different environmental cues affect men's and women's sense of belonging to different degrees. Moreover, if sense of belonging mediates the effect that negative stereotypes about women have on the performance of female surgery residents, it may also be associated with other metrics of professional success, and, by extension, persistence in the field.

Resilience has been identified as a quality that buffers against stereotype threat activation. In this study, however, resilience did not have a mediating effect on the association between female-focused stereotype threat activation and FLS performance for either men or women. In comparison, although resilience also did not mediate the association between pro-male bias and engagement for women, in our second study resilience may have mediated this relationship among men. These differences suggest, first, that there are different types of resilience, and, second, that the degree to which resilience is protective is situationally dependent. Broadly, resilience has been categorized as cognitive, emotional, or physical.¹⁶⁷ Resilience has also been classified with respect to specific outcomes; for example, academic resilience is defined by academic achievement in the face of adversity.¹⁶⁸ It may be that bias and stereotype threat activate cognitive and emotional resilience to different extents with different consequences for engagement versus technical skill performance. The scale used to assess resilience in this study does not distinguish between types of resilience. Another factor to consider is that this study investigated the effect of stereotype threat activation as an acute stressor. Both acute and chronic exposure to stereotype threat have been shown to account for gender discrepancies in achievement.¹⁶⁹ The relative strength of acute versus chronic effects and how acute on chronic activation influences outcomes, however, are

understudied. Our first two studies suggest that negative stereotypes about women are pervasive in the surgical training environment. In situations such as this, where a chronic social stressor is present, women may develop an enduring and maladaptive response that erodes the influence of resilience thereby rendering it inconsequential.¹⁷⁰

In women, domain identification has been shown to both influence vulnerability to stereotype threat and to diminish as a result of stereotype threat activation. For example, in a study of secondary students' math performance, women who identified strongly with the domain of mathematics were more susceptible to the effects of stereotype threat activation on mathematic assessment score than women who had low domain identification.¹⁷¹ Our study, however, focused not on the moderating influence of domain identification, but rather on whether this psychosocial construct mediated the response to a trigger of stereotype threat. Others have shown that over time and in response to sequential stereotype threat activation, individuals disidentify from a domain.^{172,}¹⁷³ Since, as we observed in our first study, negative stereotypes about women are apparent in the surgical training environment, we viewed our intervention A as presenting an acute on chronic exposure. We expected an inverse association between stereotype threat activation and domain identification as female residents disidentify from the domain of surgery to preserve self-worth. Domain identification did not appear to mediate the association between evoking negative stereotypes about women and FLS score for men. Unlike for women, there is little evidence to substantiate that domain identification among men changes *in response to* gender stereotypes. Similar to the data for women, however, several studies that suggest domain identification *moderates* men's reactions to positive male stereotypes. When exposed to these stereotypes, males with higher domain identification have improved performance and those with lower domain identification have worse performance. Perhaps factors that contribute to development and

plasticity of domain identification differ between men and women. Additionally, it is important to consider that academic surgery describes a profession with two distinct subdomains: scholarly activity and clinical competence. The DIM, which was used in this study, does not distinguish between these subdomains. It is possible that male participants pursuing a career in academic surgery identify more as scholars than as clinicians. In this case, testing the association between a positive stereotype about clinical performance and evaluating its effect on FLS score may not have revealed the mediating effect of domain identification as well as testing the association between research-related positive stereotypes and metrics of scholarly productivity (e.g., awarded grants/funding). By the same token, it may be that because women are underrepresented both in clinical and academic subdomains within surgery, a mediating effect of domain identification was observed in both this and the previous project. Further studies are necessary to both investigate factors that facilitate or impede domain identification and to delineate how identifying with different subdomains within the field of surgery can contribute to professional development.

4.4.1 Limitations

There are several limitations. First, while our sample size was sufficient to determine an overall difference between intervention groups in FLS scores, we were underpowered to study effect modification or interactions. Contamination¹⁷⁴ that resulted from residents recognizing the purpose of activating stereotype threat (i.e., failure of planned deception) and developing a reactive, rather than vulnerability, response⁵⁹ may have biased our results toward the null. Indeed, during debriefing, several women commented that suggesting women performed worse than men motivated them to achieve higher scores. Similarly, the intent of these interventions may have been transparent for discerning residents; in this situation, participants may have less seriously

considered the FLS tasks and their performance such that the expected strain on executive functioning purported to occur during stereotype threat activation would not occur. While there is precedent for comparing performance after a trigger of stereotype threat activation versus an intervention aimed at protecting against stereotype threat (i.e., after indicating equal performance between stigmatized and non-stigmatized groups), we recognize that merely calling attention to gender may have inadvertently activated stereotype threat in the non-trigger intervention arm. Accordingly, a more robust experimental design may have been to compare an intervention that evoked negative stereotypes about women with one that did not mention gender or surgical performance at all. Finally, as our comparisons relied on responses to stereotypes about women, we were not able to observe differences that would occur after introducing stereotypes about men, positive or otherwise.^{165,166} We did not perform pilot testing of the intervention materials, which would have better characterized this variability in response. As there are no metrics by which to evaluate degree to which training environments perpetuate negative stereotypes about women, we could not account for how ambient cues and organizational policies may have influenced intervention effect.¹⁷⁵

4.4.2 Conclusion

Stereotype threat may affect technical skill performance among women pursuing careers in academic surgery. As technical performance is key to demonstrating surgical competence, these negative stereotypes may have significant ramifications for the professional development of female surgical trainees. Academic institutions should focus efforts both on mitigating factors within the training milieu that emphasize surgery as a masculine profession and on imparting coping strategies to female residents for gender-specific deterrents such as negative stereotypes.

Further investigations are necessary to elucidate whether psychosocial constructs such as sense of belonging, domain identification, and resilience mediate the response to negative stereotypes, and, if so, how these constructs may be leveraged for interventions aimed at improving professional development.

5.0 Conclusion

Diversity in the medical workforce is fundamental to scientific discovery and providing optimal patient care. Findings from organizational science highlight the benefit of multiple perspectives, a corollary of diversity in the professional environment, for problem-solving.¹⁷⁶ Studies within medicine have yielded similar results.¹⁷⁶ Gender diversity, in particular, contributes to higher quality scholarship and better clinical outcomes.¹⁷⁷ Unfortunately, despite a resounding commitment to gender parity from scientific and medical communities, women remain underrepresented in many health-related professions. In traditionally male dominated fields, such as general surgery, gender-based stereotypes may hamper work-force diversity by negatively influencing the retention and promotion of women.¹³ Recognizing that psychological, social, and cultural elements impact career pursuits,^{178, 179} the National Institutes of Health's Enhancing Diversity Initiative advocates for investigations that address 1) how bias and stereotype threat encourage homogeneity, and 2) interventions to mitigate these effects.¹⁸⁰ The studies described in this dissertation are aligned with this initiative, establish the role of pro-male bias and negative stereotypes about women in the professional development of academic surgeons-in-training, and provide a platform that informs interventions aimed at creating a more gender-inclusive ethos.

In the first project, we explored whether bias and stereotypes modify the experiences of men and women during residency. Although these issues have drawn increased interest,¹⁸¹ especially in the period of the #MeToo movement,¹⁸² few studies investigate their relevance to the surgical training environment. Our first project demonstrated that both female and male residents reported bias favoring men and recognized negative stereotypes about women surgeons. In association with these findings, female trainees were less comfortable identifying themselves as

surgeons and more frequently described negative consequences to their professional development (e.g., hardship or task interference, lack of mentorship). While there were several limitations inherent to the qualitative single-center nature of this study, the results were useful insofar as they substantiated that gender-related bias and stereotypes are associated with disparate experiences between men and women and revealed that women attributed feelings of diminished professional self-worth to these. Considering this observation within a *social cognitive theory* framework emphasizes that behaviors that facilitate or impede learning are dynamic and develop as a result of the interaction between a person and their environment.⁴⁸ In this way, reflexive self-definitions such as those that are associated with one's professional identity may fluctuate in response to environmental triggers such as negative stereotypes or bias.¹⁸³ Accordingly, individuals may be inclined to disengage from career related endeavors as a protective mechanism in order to preserve self-worth.¹⁸⁴ This may be one possible mechanism for the increased levels of attrition among female compared to male residents.³² The resulting inability to retain women within the specialty reinforces gender imbalance.

Our second project aimed to expand upon the findings in our first study by testing the association between perceiving gender bias in the training environment and career engagement. Professional achievement after residency results from patterns of action that reflect degree of engagement.¹⁸⁵ Perceiving pro-male bias was associated with increased career engagement among men. We were not able to appreciate a significant association between perceiving pro-male bias and career engagement among women. Engagement is a complex construct with cognitive and behavioral components. Additional studies are necessary to thoroughly assess the association between gender bias and engagement among women. Although we evaluated career engagement using an adaptation of a previously validated survey subscale, appropriate and specific metrics for

engagement in academic general surgery are lacking and have hampered progress in creating effective interventions.¹⁸⁶ Thus, there is an opportunity for future studies, first, to identify these metrics, and, second, to evaluate the efficacy of behavioral interventions aimed at improving retention among women in academic general surgery through increased engagement.

Our final project demonstrated that when negative stereotypes about women are evoked, women residents with higher susceptibility to stereotype threat performed worse on a measure of technical competence. Although others have demonstrated the effect of stereotype threat on performance for women in STEM,¹⁸⁷ to our knowledge we are the first to assess this relationship in general surgery trainees using a validated assessment of technical skill. While the FLS, a simulation-based evaluation of surgical competency, has been shown to reflect operative ability among trainees,¹⁸⁸ it is unclear whether triggers of stereotype threat have a measurable effect on surgical outcomes or the degree to which this effect persists in more seasoned surgeons. There is some evidence to support that female surgeons have fewer postoperative complications, mortality, and readmissions relative to their male colleagues.¹⁸⁹ The tangible consequences of stereotype threat on patient care require further investigation.

In an effort to understand contributing psychological factors, we surveyed residents with regard to parameters that have been shown to influence engagement. These included sense of belonging, resilience, and domain identification. Our second study demonstrated that sense of belonging and domain identification may possibly mediate the association between gender bias and career engagement differently for men than women. In our third study, though we did not observe that any of these constructs mediated the association between evoking a negative stereotype about women and FLS score among male residents. Additional investigations are needed to determine how sense of belonging and domain identification can alter the effect of

environmental stimuli relating to gender stereotypes and bias, and whether this results in ramifications for the professional development of surgeons in training.

Resilience was another psychosocial construct considered in the exploratory analyses of projects two and three. We failed to detect mediating effects of resilience in these studies. This may have been in part due to a limited sample size. We must, however, also consider that resilience is multi-factorial¹⁹⁰ and/or may not be the panacea to social adversity that it is touted to be. It is conceivable that women who pursue careers in surgery have successfully entered into the field because of high resilience. This quality, however, may be less useful for persisting thereafter. Prior to implementing interventions aimed at increasing resilience,¹⁹¹ future investigations are required to parse the specific aspects of resilience that confer protection to stereotypes and bias and the circumstances in which these function.

The projects discussed in this dissertation are limited in that they do not address how being a member of multiple underrepresented demographics compound the effect of bias and negative stereotypes.¹⁹² Simplifying these studies to focus specifically on women, typically the most well represented minority demographic, has allowed us to more easily identify threats to professional identity at the expense of underestimating the influence of intersectionality. Recognizing the heterogeneity of effect that intersectionality confers is paramount to designing successful interventions that benefit all underrepresented groups.

In addition to the concrete primary outcome of technical skill performance, this study also considered the influence of stereotype threat activation on psychosocial determinants of success as secondary outcomes. Others have demonstrated that diminished sense of belonging may contribute to the underrepresentation of women in traditionally male-dominated fields.¹¹⁶ Further

investigations are needed to determine how sense of belonging and other psychosocial parameters moderate responses to stereotype threat.

The work described in this dissertation has gone beyond demonstrating the existence of gender disparities in surgery, which has long affected the landscape of medical training; it has shed light on the mechanisms by which gender bias and stereotypes cause underrepresentation of women. Interventions that effectively promote the recruitment and retention of female surgeons should target outcomes such as engagement and skill performance by addressing both environmental and individual factors.

Appendix A Survey questions

Gender bias in the environment adapted from the employee environment diagnostic survey (EEDS)

1. Does gender bias favoring men exist in the surgical training environment (i.e., residency)?
2. To what degree are men offered institutional support more often than women?
3. To what degree are men evaluated more fairly than women?
4. To what degree are women discouraged from making their own work decisions?
5. To what degree are operative opportunities offered more frequently to men compared to women?
6. To what degree do men receive more recognition based on their work compared to women?
7. To what degree are others willing to help men compared to women?
8. To what degree are men offered more professional development opportunities compared to women?

Gender Stigma Consciousness and Gender Identity subscales from Social Identity and Attitudes Scale (SIAS)

9. My gender affects how people act towards me.
10. Members of the opposite sex interpret my behavior based on my gender.
11. My gender affects how people treat me.
12. Most people judge me on the basis of my gender.
13. My gender influences how teachers interpret my behavior.
14. My gender is central to defining who I am.
15. My gender contributes to defining who I am.
16. My gender contributes to my self-confidence.
17. My identity is strongly tied to my gender.

Sense of belonging from the SOBI-P subscale

18. I wonder if I really fit in with other surgeons.
19. People accept me.

- 20. What I offer is valued by the surgical community.
- 21. I feel like an outsider.
- 22. My background and experiences are different than those of other surgeons.
- 23. I feel left out.
- 24. I am not valued or important.

Identification with the domain of surgery from the Domain Identification Measure (DIM)

- 25. How much do you value being a surgical resident?
- 26. Do you think that being a surgeon is an important and/or necessary part of your life?
- 27. How important is it to you to do well in residency?
- 28. How much do you enjoy academic surgery?
- 29. How much do you enjoy operating?
- 30. How much is surgery to the sense of who you are?
- 31. How important is being a surgeon?

Resilience from the Connor-Davidson Resilience Scale (CD-RISC)

- 32. I am able to adapt to change.
- 33. I can deal with whatever comes.
- 34. I try to see the humorous side of problems.
- 35. Coping with stress can strengthen me.
- 36. I tend to bounce back after hardship.
- 37. I can achieve goals despite obstacles.
- 38. I can stay focused under pressure.
- 39. I am not easily discouraged by failure.
- 40. I think of myself as a strong person
- 41. I can handle unpleasant feelings.

Career engagement from the Career Engagement Scale (CES):

To what extent have you:

- 42. Actively sought out to design your research agenda?
- 43. Undertook activities to achieve your research goals?
- 44. Cared about developing your research agenda?
- 45. Developed plans and goals for your future research?
- 46. Sincerely thought about your personal values, interests, abilities, and weaknesses as an academic surgeon?
- 47. Collected information about research projects and opportunities?
- 48. Established or maintained contacts with individuals who can help you develop research projects?
- 49. Voluntarily participated in research?
- 50. Assumed activities that will help you progress professionally as an academic surgeon?

Appendix B Intervention A Abstracts

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DOI 10.1

REVIEW



Received: 1

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Abstract

Background. Females are less attracted than males to surgical specialties, which may be due to differences in the acquisition of skills. The aim of this study was to systematically review studies that investigate gender differences in the acquisition of surgical skills.

Methods. We performed a comprehensive database search using relevant search phrases and MeSH terms. We included studies that investigated the role of gender in the acquisition of surgical skills.

Results. Our search yielded 247 studies, 18 of which were found to be eligible and were therefore included. These studies included a total of 2,106 study participants. The studies were qualitatively synthesized in five categories (studies on medical students, studies on both medical students and residents, studies on residents, studies on gender differences in needed physical strength, and studies on other gender-related training conditions). Male medical students tended to outperform females. Similar gender differences were found among residents. Gaming experience and interest in surgery correlated with better acquisition of

surgical skills among men but not women. One-on-one training and instructor feedback worked better on males and further contributed to differences in the acquisition of surgical skills among residents. Women performed worse than their male counterparts on technical skills assessments including the Fundamentals of Laparoscopic Surgery exam. Female physicians possess the required physical strength for surgical procedures, but may face gender-related challenges in daily clinical practice.

Conclusion. Medical students are a heterogeneous group with a range of interests and experiences, while surgical residents are more homogeneous perhaps due to selection bias. Despite this, gender-related differences are present among medical students and residents. Future surgical curricula should consider tailoring personalized programs that give female physicians more practice opportunities in order to increase the output of surgical training and acquisition of surgical skills.

Keywords Gender differences • Surgical skills • Surgical career • Surgical simulation • Medical education

Received:

Abstract

Background: The impact of gender and hand dominance on operative performance may be a subject of prejudice among surgeons, reportedly leading to discrimination and lack of professional promotion. However, very little objective evidence is available yet on the matter. This study was conducted to identify factors that influence surgeons' performance, as measured by the Fundamentals of Laparoscopic Surgery (FLS) skills assessment.

Methods: This study included 25 surgical residents who had experience with laparoscopic surgery. The participants were registered according to their gender and hand dominance. All of the participants performed 10 repetitions of the five FLS tasks within 1 month. Assessment of laparoscopic skills was based on three parameters measured by the simulator: time, errors, and economy of hand movement.

Results: Differences in performance existed between the compared groups. Men completed the tasks in less time than women ($p = 0.01$, Mann-Whitney test). Women had a higher number of errors and unnecessary movements ($p = 0.03$, Mann-Whitney test). There was no significant difference in unnecessary movements, time, or errors among residents with right hand dominance compared to those with left dominance. Users of computer games did not make fewer errors than non- users.

Conclusions: The study provides objective evidence of a difference in laparoscopic skills between surgeons differing by gender. These results may influence the future development of training programs for laparoscopic surgery. They also pose a challenge to individuals responsible for the selection and training of the residents.

Key words: Surgical training — Assessment — Gender — Hand dominance — Virtual reality — Minimally invasive surgery

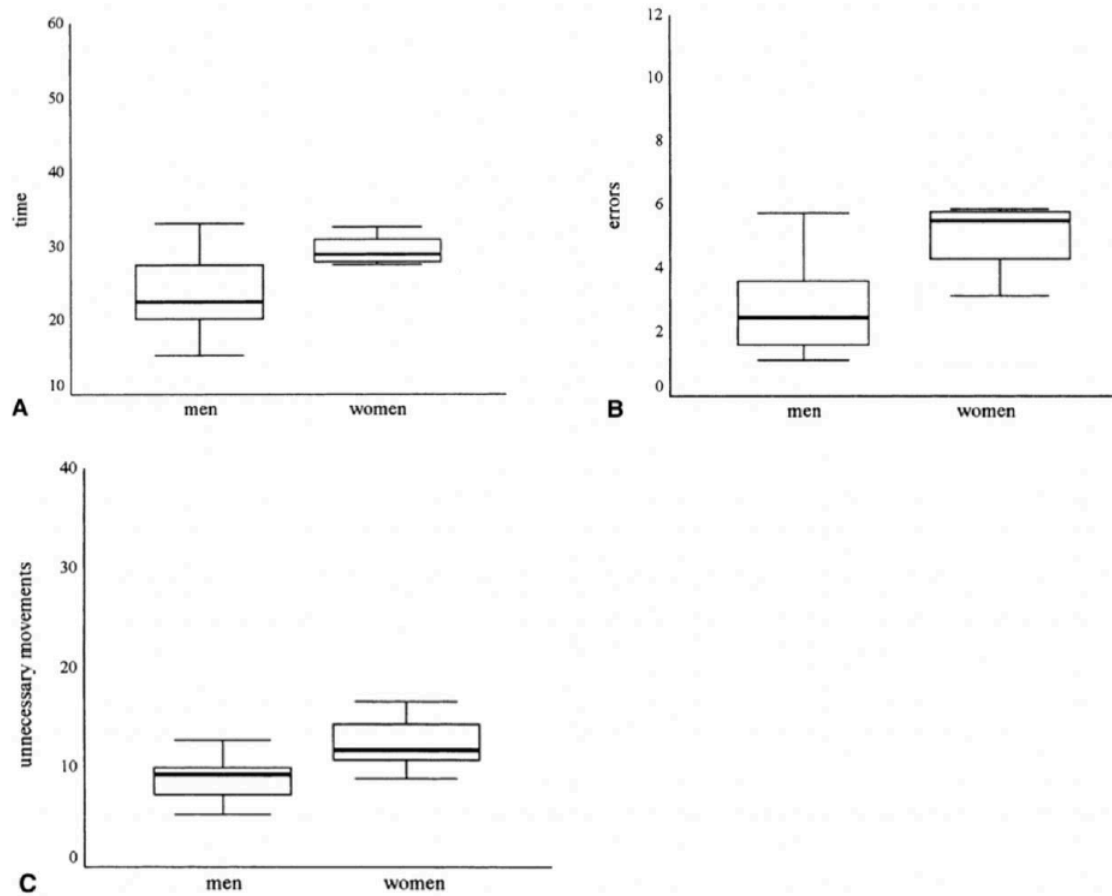


Fig. 1. Male vs female surgeons. **A** Time (s) to complete the task. **B** Error scores. **C** Economy of motion scores. Horizontal bands indicate the medians; boxes denote the 25th and 75th percentiles; and whisker lines represent the largest and lowest values. The statistics are given in the text.

Appendix C Intervention B Abstracts

3065–3073

DOI 10.1007



CrossMark

REVIEW

Received: 1
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Abstract

Background. Females are less attracted than males to surgical specialties. It is unknown whether this may be due to differences in the acquisition of skills. The aim of this study was to systematically review studies that investigate gender differences in the acquisition of surgical skills.

Methods. We performed a comprehensive database search using relevant search phrases and MeSH terms. We included studies that investigated the role of gender in the acquisition of surgical skills.

Results. Our search yielded 247 studies, 18 of which were found to be eligible and were therefore included. These studies included a total of 2,106 study participants. The studies were qualitatively synthesized in five categories (studies on medical students, studies on both medical students and residents, studies on residents, studies on gender differences in needed physical strength, and studies on other gender-related training conditions). Male medical students performed similarly to females. There were no gender differences in technical skill performance among residents. Gaming

experience and interest in surgery correlated with better acquisition of surgical skills among men and women. One-on-one training and instructor feedback worked equally well for males and females. Women performed equally to their male counterparts on technical skills assessments including the Fundamentals of Laparoscopic Surgery exam. Female physicians possess the required physical strength for surgical procedures. Instructors should note there are no gender-related challenges in skill acquisition.

Conclusion. Medical students are a heterogeneous group with a range of interests and experiences, while surgical residents are more homogeneous perhaps due to selection bias. Despite this, there are no gender-related differences in technical skill among medical students or residents. Future surgical curricula should consider the benefit of one-on-one training and instructor feedback for residents in order to increase the output of surgical training and acquisition of surgical skills.

Keywords Gender differences • Surgical skills • Surgical career • Surgical simulation • Medical education

Received: 1

Abstract

Background: The impact of gender and hand dominance on operative performance may be a subject of prejudice among surgeons, reportedly leading to discrimination and lack of professional promotion. However, very little objective evidence is available yet on the matter. This study was conducted to identify factors that influence surgeons' performance, as measured by the Fundamentals of Laparoscopic Surgery (FLS) skills assessment.

Methods: This study included 25 surgical residents who had experience with laparoscopic surgery. The participants were registered according to their gender and hand dominance. All of the participants performed 10 repetitions of the five FLS tasks within 1 month. Assessment of laparoscopic skills was based on three parameters measured by the simulator: time, errors, and economy of hand movement.

Results: No differences in performance existed between the compared groups. Men completed the tasks in similar time compared to women ($p = 0.68$, Mann-Whitney test). Women and men had a similar number of errors and unnecessary movements ($p = 0.73$, Mann-Whitney test). There was no significant difference in unnecessary movements, time, or errors among residents with right hand dominance compared to those with left dominance. Users of computer games did not make fewer errors than non- users.

Conclusions: The study provides objective evidence that there is no difference in laparoscopic skills between surgeons differing by gender, hand dominance, or experience with computer games.

Key words: Surgical training — Assessment — Gender — Hand dominance — Virtual reality — Minimally invasive surgery

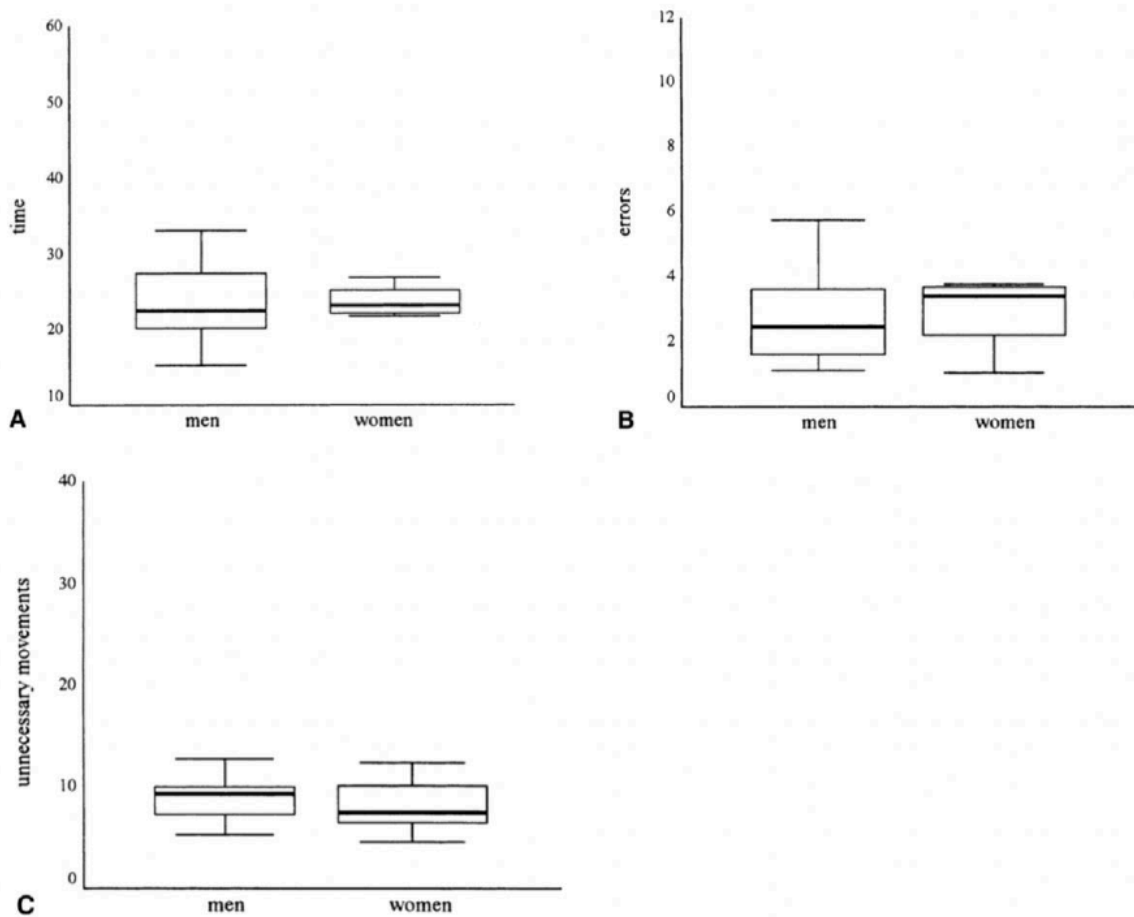


Fig. 1. Male vs female surgeons. **A** Time (s) to complete the task. **B** Error scores. **C** Economy of motion scores. Horizontal bands indicate the medians; boxes denote the 25th and 75th percentiles; and whisker lines represent the largest and lowest values. The statistics are given in the text.

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