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Recruiting trainees to surgery in the United States and Canadian system – What strategies are effective?

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ABSTRACT

Background: There has been increasing concerns regarding the declining number of medical students entering surgical residencies. The aim of this study is to analyze strategies and outcomes to enhance recruitment to the surgical specialties.
Methods: A systematic literature PRISMA-based search was performed. Study quality and bias were assessed. Meta-analysis was performed using DerSimonian Laird method.
Results: Of 3288 unique titles identified, 73 studies met inclusion criteria. Median study unique sample size was 84 participants (range 15–910). Subjective interest was reported in 59 studies, while objective match rate was reported by only 21 studies. The cumulative odds of students interested in the studied specialty was 1.98 (95% CI 1.47–2.67, $I^2 = 0\%$) and in any surgical specialty was 1.40 (95% 1.01–1.95, $I^2 = 37\%$) after an intervention compared to baseline.
Conclusion: While studies show increased odds of “interested in” a surgical specialty, the results may be subject to high selective and confounding biases.

Introduction

The percentage of US medical students matching into general surgery has dropped from 11% in 1984 to 6.5% in 2014.[1,2] This has led to increasing concerns regarding future workforce shortages in surgical specialties with reports estimating an 18% decline in the surgical workforce between 2009 to 2028.[3] Other models have estimated a shortage of 2000 cardiothoracic surgeons and 330–399 vascular surgeons by 2030.[4,5] Concerns on this shortfall in surgeons has led to numerous studies seeking to identify the contributing factors behind medical student career decisions, timing of those decisions, and strategies to recruit medical students into surgical specialties.[1,2,6,7]

In a recent review to determine reasons behind the decreased interest in surgical specialties, the lack of interest was attributed to a lack of exposure to surgeons, lifestyle considerations due to perceptions of surgeons' work schedules, lack of mentorship within the specialties, personality stereotypes associated with surgery, and lack of diversity and inclusivity within surgery.[6] Numerous medical schools have sought to recruit medical students to surgery by developing new programs that provide early or increased exposure to surgeons and surgical specialties to spark interest and clarify potential misconceptions.[8,9] Surgical leaders and their respective societies have embraced action plans to build diversity and inclusivity and correct stereotypic views of surgeons among medical students. These measures include clinical preceptorships or clerkships, simulation sessions, outreach specialty discussions or lectures, research opportunities, or a combination of measures.[2,10–13] However, there is currently no review that evaluates these recruitment techniques and their effectiveness. The aim of this meta-analysis is to evaluate the effectiveness of various

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recruitment strategies to surgical specialties in the United States and Canadian medical education system.

Methods

Study question

Which recruitment strategy is most effective in recruiting medical students to a surgical specialty, as measured by objective higher match rate into and/or subjective increased interest in the specialty in the United States or Canadian medical educational systems?

Study identification and inclusion

A systematic literature review was performed from database inception to December 2, 2020 in accordance with PRISMA guidelines on 5 databases (PubMed, EMBASE, CINAHL-Cumulative Index to Nursing and Allied Health Literature, Scopus, and ERIC-Education Resources Information Center).[14] The search strategy (Table 1) was developed with the help of an institutional librarian. “Student*” was used as search term alone to select for medical student as it was able to capture all studies identified through the MeSH term “medical students”. Inclusion criteria were original studies examining at least one recruiting intervention reporting quantitative data of either medical student interest or match into one or more surgical specialties. Exclusion criteria include: 1) foreign language studies or countries other than United States or Canada; 2) studies that did not include subjects after 2000; 3) studies that were unrelated to residency recruitment; 4) studies that were not recruiting to a surgical specialty; 5) studies that were not an original study; 6) studies that had a lack of a recruitment methods or lack of studied outcome – self reported interest (reporting of effect on interest without the direction of impact was not sufficient) or match result; 7) studies that were a duplication (including partial duplication of data); 8) conference abstract only. Two independent reviewers performed title and abstract screening. A study was excluded only when the decision to exclude was unanimous, otherwise it underwent full text screening which was also performed by two independent reviewers. The reference lists of included articles were screened manually as a secondary strategy. Disagreements after full text screening were resolved by consensus. Studies where intervention involved multiple specialties, but outcome focused on a single surgical subspecialty were excluded from meta-analysis of subspecialty specific outcome.

Study outcomes

The outcomes of this meta-analysis were: 1) subjective interest - students reported interest and increased interest in matching to a surgical field; 2) match result - the students matched into a surgical residency.

Study quality and bias

The quality of the included studies was assessed using the Medical Education Research Study Quality Instrument (MERSQI)[15] and Newcastle-Ottawa scale (NOS).[16] MERSQI is a validated tool designed specifically for medical education research that evaluates the quality of a study in 6 domains - study design, sampling, type of data, validity of evaluation instrument, data analysis, and outcomes - with a possible maximum score of 3 for each domain for a maximum possible MERSQI score of 18[15]. The total MERSQI score is calculated as the percentage of the total achievable score. For studies with multiple components such as skill proficiency, only components related to our study outcome were included for quality evaluation. NOS is designed to assess quality for case control or cohort studies in terms of selection, comparability, and outcome. The maximum score is 9[16]. The NOS is adapted for observational studies by removing items not applicable for a total score of 6. Similar adjustment of the total score was made for NOS. Publication bias was evaluated using contour-enhanced funnel plots and asymmetry was evaluated using Egger test for standardized mean difference and Peters test for odds ratio as recommended by Sterne *et al*[17]

Interrater reliability

MERSQI and NOS rating were performed by two independent reviewers and inter-rater reliability was quantified by calculating weighted Kappa and absolute agreement.[18] Absolute agreement between two raters was 89.7% and weighted Kappa was 0.89.

Meta-analysis

10-point Likert scale results were converted to 5-point for comparison. Missing standard deviation (SD) was filled with the mean of available SD. Studies with subgroups were combined within the study before pooling results across studies. Observational studies were not included in the meta-analysis due to either no reporting of baseline interest or recall bias from assessing baseline interest after the intervention. Only outcomes reported by 5 studies or more were used in the meta-analysis. We grouped “very interested” and “somewhat interested” together into “interested” because most studies did not report these measures separately. Pooled odds ratio and pooled standardized mean difference was calculated using random effects model DerSimonian Laird method in RevMan.[19] DerSimonian Laird is a random effects model using an inverse variance method.[20] Results were confirmed using Mantel-Haenszel method with Hartung-Knapp adjustment in R Studio.[20–22] Mantel-Haenszel is a fixed effects method that calculates the study weight differently for odds ratio, risk ratio, and risk difference and is considered to have better statistical properties when there are few events.[22] The random effect variant of the Mantel-Haenszel model is available in both R and RevMan.[19,23] The Hartung-Knapp-Sidikk-Jonkman is a random effects method that introduces an adjusted confidence interval and test statistics.[23] Hartung-Knapp-Sidikk-Jonkman has been shown to outperform DerSimonian Laird method when the included the number of studies is small and studies have unequal sample sizes.[21] Sensitivity analysis was performed with only studies scoring $\geq$4.5 on NOS. Heterogeneity between studies was assessed using I^2 statistics with P values. I^2 represent the percentage of variability in effect estimates that is due to heterogeneity rather than sampling error.[20]

Table 1
Search strategy used on Pubmed.

(Surgical specialties [MESH] OR colorectal surgery [tw] OR general surgery [tw] OR cardiovascular surgery [tw] OR gynecology [tw] OR neurosurgery [tw] OR obstetrics [tw] OR ophthalmology [tw] OR orthognathic surgery [tw] OR orthopedic* [tw] OR orthopaedic* [tw] OR otolaryngology [tw] OR plastic surgery [tw] OR thoracic surgery [tw] OR cardiothoracic surgery [tw] OR cardiac surgery [tw] OR trauma [tw] OR urology [tw] OR endocrine surgery [tw] OR surgical career [tw] OR surgical careers [tw] OR surgical specialty [tw] OR surgical specialties [tw] OR vascular surgery [tw]) AND (career choice [tw] OR recruit* [tw]) AND (student*[tw]).

Definitions

For historic cohort studies, study period was reported as the years the intervention occurred and sample size was reported as only the number of participants in the intervention. For studies not utilizing historic cohorts, sample size reported was the total number of students evaluated, including the control group. In this meta-analysis, surgical specialties include: general surgery, colorectal surgery, vascular surgery, obstetrics and gynecology, neurosurgery, ophthalmologic surgery, orthopedic surgery, otolaryngology, orthognathic surgery, neurosurgery, plastic surgery, cardiothoracic surgery, trauma surgery, urology, and endocrine surgery. Recruitment strategy was categorized as clinical exposure, one-time program, simulation/skills, research, multimodal, or other. Third- or fourth-year clerkship and shadowing in the operating room or inpatient and outpatient setting was considered clinical exposure. Interventions that occurred only once were all categorized into one-time program. Skill labs and simulations with lectures regarding the same topics were grouped into simulation/skills. Research included attendance of research meeting or participating in research activities. Multimodal included the use of two or more recruitment strategies; didactics with simulation/skills where didactic was an independent component was considered as a multimodal strategy. Participation in an intervention was considered elective unless if it was part of the mandatory curriculum.

Results

Study description

Of 3,288 unique titles identified, 73 studies met inclusion criteria (see PRISMA diagram, Fig. 1, reference list Appendix 1). Most studies (34) focused on preclinical medical students, 26 engaged with clinical students, and 13 intervened on both preclinical and clinical medical students. The median study sample size was 84 unique participants (range 15–910, total 9595). Thirty studies utilized a repeated measures design with pre- and post-intervention surveys, 15 studies were non-randomized cohorts, 6 were randomized control trials (RCT), and 22 were observational. Most studies looked at surgical specialties in general (33), followed by general surgery specifically (10), cardiothoracic surgery (6), neurosurgery (6), obstetrics/gynecology (OB/GYN) (6), vascular surgery (3), orthopedic surgery (3), head and neck surgery (3), trauma surgery (1), hand surgery (1), and ophthalmologic surgery (1). Recruitment strategies utilized included 18 clinical exposures, 11 one-time programs, 8 simulations, 3 research, 27 multimodal approaches, and 6 other designs. In most studies, subject participation was elective (63.0%). A summary of included studies is provided in Table 2; detailed methods and interventions are provided in Appendix 2.

Study quality

Studies scored a median of 4.5 (interquartile range, 3–6) out of 9 for NOS and median 9 (interquartile range, 8.5–11.0) out of 18 for MERSQI. Median score out of 3 for each domain for MERSQI was 1.5 for study design, 2 for sampling, 1 for type of data, 0 for validity of evaluation instrument, 3 for data analysis, and 1 for outcomes. For NOS, most studies did well on establishing baseline interest at the start of the study (77%). All studies adequately ascertained exposure to the intervention. Many also adequately followed up cohorts (73%). However, only 37% of studies had a representative exposed group. For cohort studies, only 22% had adequate selection of controls and had comparable cohorts based on design. Only a minority of studies reported match results (31%) and were considered to have sufficient length of follow-up.

Study interventions

Clinical: Out of 18 studies that used a clinical intervention, 17 focused on 3rd or 4th year medical students, while only 1 study focused on 1st year medical students. In the study that focused on preclinical students, students volunteered to participate in a trauma shadowing program. Of 17 studies on clinical medical students, 10 studies surveyed medical students about mandatory clerkships during their clinical years, 5 studies studied different practice setting and clerkship models, 1 study compared surgical subspecialty rotation versus general surgery clerkship, and lastly 1 study evaluated the addition of a new musculoskeletal medicine clerkship.

Simulation: Eight studies evaluated simulation as a means to increase surgical interest. Two included both pre-clinical and clinical students, while 6 included only pre-clinical students. In 2 studies, the simulation course was part of an anatomy curriculum and one study included the simulation course as part of the surgical clerkship. In the remaining studies, the simulation course was offered electively for interested students.

Research: Three studies evaluated the effect of research-related endeavors on matching into surgical careers including participation in an 8-week summer research experience, reception of a research grant, and reception of a scholarship to attend a society meeting.

Multi-modal: Twenty-seven studies used a multi-modal approach for recruiting medical students, 18 targeted preclinical students, 3 focused on clinical students, and 6 targeted both clinical and pre-clinical students. Twelve studies assessed multi-modal elective courses, 7 evaluated student interest groups, 5 studied summer programs, 3 made modifications to existing clerkships or preclinical courses, and 1 was a pipeline program by a national non-profit organization founded by physicians. Two institutions evaluated the effect of multiple programs together. Components of the multimodal interventions included simulation/skills labs (20 studies), clinical exposures (19), academic didactics (13), outreach efforts (11), research participation (6), journal clubs (4), research conference attendance (2), and miscellaneous (3).

One-time program: Of 11 one-time programs, 7 were simulation or skills courses, 3 were outreach efforts, and 1 included both.

Other: Other interventions evaluated included scholarships for clinical or research activities, a mobile web-based reporting module for medical students to report clerkship experiences in real time, increased surgeon participation in an anatomy laboratory course for 1st year medical students, addition of vascular didactics, and using reversed class room didactics instead of traditional didactics.

Outcome of study: There was considerable heterogeneity in study design and outcome reporting among the studies. The two most reported outcomes were the subjective outcome of increased interest in entering surgery and the objective outcome of match rate into surgery. Other less commonly reported outcomes included subjective interest in selecting a particular elective, the number of students enrolled in a particular elective, and the number of students that applied to a certain specialty. Further heterogeneity was created by differences in study design (the choice and number of cohorts, the use of cross-over design, use of post-intervention survey only or both pre- and post-intervention survey alone or in combination with cohorts), the studied specialty (a specific specialty versus surgery in general), and the type of data reported (interest as a percentage before and after intervention, baseline interest and change in interest, or numeric score based on Likert

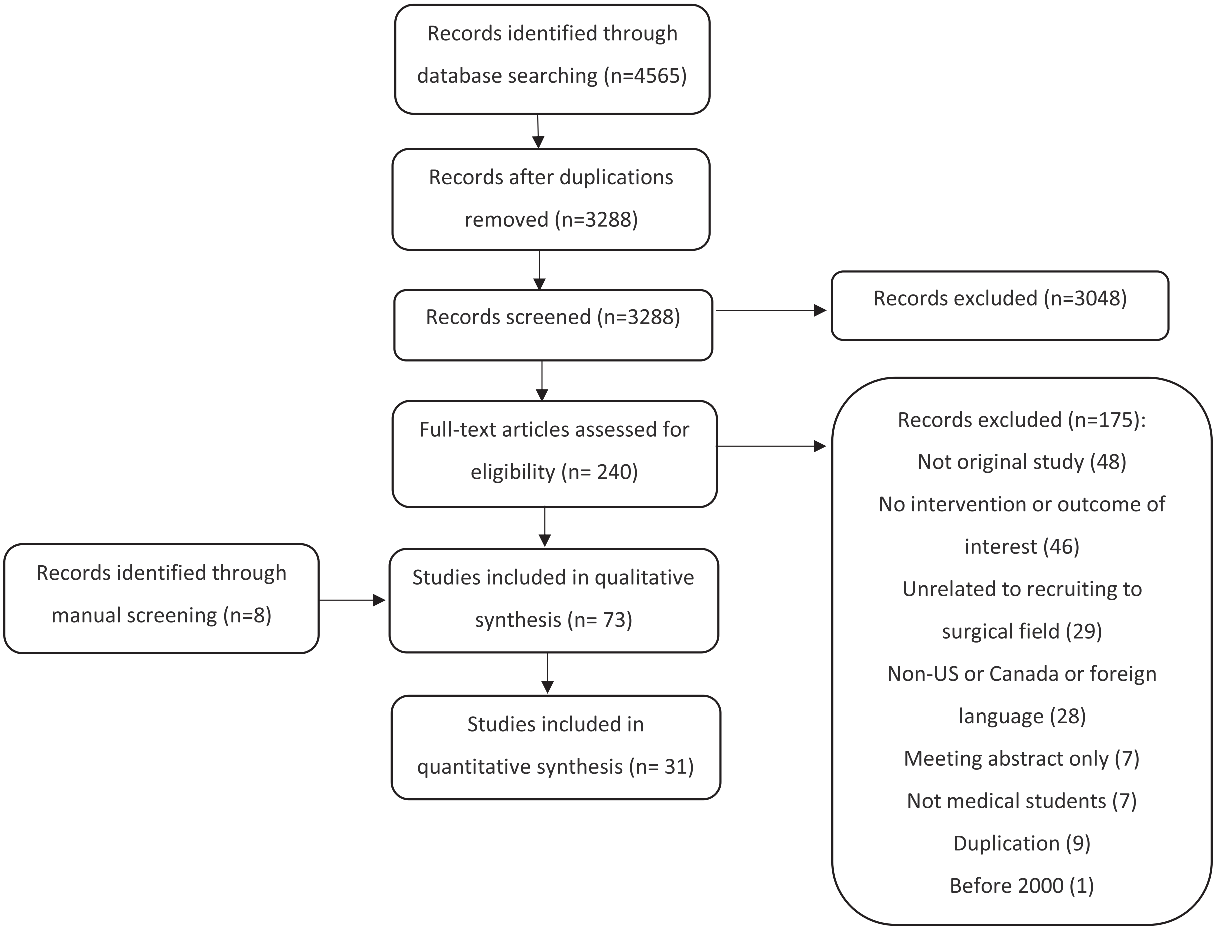


Fig. 1. PRISMA flow diagram for search and selection process.

scale before and after intervention).

Interest: Subjective interest was reported as an outcome by 59 studies, 10 of which also reported match data. Thirty-three studies reported interest result as percentage, 11 studies reported numeric score based on Likert scale, 9 reported both, and 6 studies either did not report specific numbers or reported interests in another way. Thirty-two studies used pre- and post-intervention surveys to assess interest, 23 of which reported interest before and after intervention, 6 reported baseline interest with change of interest, and 3 studies reported interest differently. Twelve studies were observational with only post-intervention survey. Fifteen studies were cohort studies (6 nonrandomized contemporary cohorts, 4 historic cohorts, and 5 randomized controlled trials). Due to the low number of cohort studies with additional variation in design and reporting of outcomes, cohort studies were not included in the meta-analysis. Meta-analysis could not be performed for baseline interest and change of interest due to the low number of studies.

Nine studies reported percentage of students interested in the studied specialty after the intervention compared to baseline with a cumulative odds ratio of 1.98 ($P < .001$, 95% CI 1.47–2.67; heterogeneity, $I^2 = 0\%$, $P = .86$), Fig. 2, reference lists for meta-analysis outcomes are presented in Appendix 1. Nine studies reported percentage of students interested in any surgical specialty after the intervention compared to baseline with a cumulative odds ratio of 1.40 ($P = .04$, 95% CI 1.01–1.95; heterogeneity, $I^2 = 37\%$, $P = .12$), Fig. 3. Eight studies reported interest in studied specialty as a numeric score based on 5-point Likert scale. Students rated interest higher after the intervention, pooled standard mean difference of 0.21 ($P = .004$, 95% CI 0.07–0.35; heterogeneity, $I^2 = 18\%$, $P = .29$), Fig. 4. Eight studies reported interest in any surgical specialty as a numeric score based on a Likert scale. Students rated interest higher after the intervention, pooled standard mean difference of 0.22 ($P = .001$, 95%CI 0.09–0.35; heterogeneity, $I^2 = 0\%$, $P = .65$), Fig. 5.

Match: Twenty-four studies reported match results as an outcome, of which 10 also reported interest data. Seven studies were nonrandomized cohort studies, one of which used historic cohorts. One was a randomized cohort study. The remaining 16 studies were observational.

Six studies reported match rate to any surgical specialty in the intervention group compared to control with a cumulative odds ratio of 1.56 ($P = .14$, 95%CI 0.86–2.84; heterogeneity, $I^2 = 70\%$, $P = .005$), Fig. 6.

Study heterogeneity, publication bias, and subgroup analysis: Despite heterogenous study designs and interventions used, 3 of the interest outcomes had very low heterogeneity (interest based on Likert scale for specific specialties $I^2 = 18\%$, interest based on Likert scale for any surgical specialties $I^2 = 0\%$, percentage of students interested in specific specialties $I^2 = 0\%$). Only the percentage of students interested in any surgical specialties displayed a moderate heterogeneity, I^2 of 37%, which was not statistically significant ($P = .12$). However, the match outcome had substantial heterogeneity ($I^2 = 70$, $P = .005$). There is asymmetry in the funnel plots on visual inspection suggesting there may be publication or reporting bias, however, the Egger test and Peters test for funnel plot asymmetry were nonsignificant for all five outcomes (Figs. 2–7).

Table 2
Overview of included studies.

Author, Year	Participant	Specialty	Study period	N	RR or % follow-up	Method	Participation in intervention	Intervention group	Outcome	MERSQI	NOS
Cochran, 2003	MS3	Surgical	2001–2002	98	95%	Pre- and post- intervention survey	Mandatory	Clinical	Interest	8.5	6
Kozar, 2003	MS1	GS	NR	210	58%	Pre- and post- intervention survey	Selective	One-time program	Interest	9	3
Dunn, 2004	MS3	OB/GYN	2001–2002	60	NR	Historic Cohort	Mandatory	Multimodal	Interest	7.2	2
O'Herrin, 2004	MS3	GS	2001–2002	84	98%	Pre- and post- intervention survey + Observational	Mandatory	Clinical	Interest + Match rate	12.5	9
Arnold, 2005	MS3	Surgical	2003–2004	108	98.6%	Pre- and post- intervention survey	Mandatory	Clinical	Interest	8.5	6
Carter, 2005	MS3	Surgical	2002	135	95%	Post- intervention survey	Mandatory	Clinical	Interest	7	4.5
Madan, 2005	MS1, MS2	GS	NR	59	100%	Pre- and post- intervention survey	Selective	Simulation	Interest	8.5	4.5
Glasgow, 2006	MS1	GS	2003–2004	67	67%	Pre- and post- intervention survey	Selective	One-time program	Interest	8	3
Hammoud, 2006	MS3	OB/GYN	NR	487	55.5%	Pre- and post- intervention survey + Observational	Mandatory	Clinical	Interest + Match rate	13	7.5
Nguyen, 2007	MS3	Surgical	2004–2005	117	91%	Post- intervention survey	Mandatory	Clinical	Interest	10	4.5
Riboh, 2007	MS1, MS2	Surgical	NR	40	Pre: 28% Post: 63%	Pre- and post- intervention survey	Selective	Multimodal	Interest	8	3
Sammann, 2007	MS1 MS2	Surgical	NR	86	87.2%	Cohort	Selective	Multimodal	Interest	8	2
Smith, 2007	MS1	Hand surgery	NR	72	100%	Pre- and post- intervention survey	Selective	One-time program	Interest	9.5	4.5
Abdessamad, 2008	MS3	OB/GYN	2006–2007	76	92.10%	RCT	Mandatory	Clinical	Interest	10	6
Berman, 2008	MS3	Surgical	2006–2007	131	89%	Post- intervention survey	Mandatory	Clinical	Interest	9	4.5
Rayburn, 2009	MS3	OG/GYN	2003–2008	70	100% interest, 60% match	Post- intervention survey + Observational	Selective	One-time program	Interest + Match rate	9	7.5
Sandquist, 2009	MS3	GS	2004–2006	403	100%	Cohort	Mandatory	Clinical	Match rate	14.4	6
Are, 2010	MS1	Surgical	2008–2009	234	69%	Post- intervention survey	Mandatory	One-time program	Interest	8.5	3
Chang, 2010	MS3	OB/GYN	2006–2007	91	89%	Post- intervention survey	Mandatory	Clinical	Interest	8	4.5
Godshall, 2010	MS2 (I), MS3 (c)	VS	2008–2009	112	I = 93% C = 95%	Historic cohort	Mandatory	Other	Interest	12	5
Tesche, 2010	MS1, MS2	CTS	NR	44	100%	Pre- and post- intervention survey	Selective	One-time program	Interest	11.5	4.5
Zaid, 2010	MS1	Surgical	2006	144	63%	Post- intervention survey	Mandatory	Simulation	Interest	5.5	3
Cahan, 2011	MS3	Surgical	2007–2010	39	NR	Post- intervention survey	Mandatory	Multimodal	Interest	7	3
Haubert, 2011	MS2	Surgical	2008–2010	361	NR	Cohort	Selective	Multimodal	Interest	8.5	1
Lee, 2011	MS1, MS2	VS	2007–2009	52	100%	Pre- and post- intervention survey + Observational	Selective	Simulation	Interest + Match rate	8.5	4.5
Zarebczan, 2011	MS3	Surgical	2001–2006	506	100%	Pre- and post- intervention survey	Mandatory	Clinical	Interest	9.5	6
Al-Heeti, 2012	MS4	GS	2008–2009	61	100%	Pre- and post- intervention survey	Mandatory	Clinical	Interest	10.5	6
Goldin, 2012	MS3	Surgical	2005–2008	345	74%	Pre- and post- intervention survey	Mandatory	Clinical	Interest	9	4.5
Markovic, 2012	MS1-4	VS	NR	80	94.7%	RCT, crossover	Selective	One-time program	Interest	9	6
Agarwal, 2013	MS1-4	NSG	2000–2012	NR	100%	Observational	Selective	Multimodal	Match rate	10.8	7.5
Galiñanes, 2013	MS3	Surgical	2010–2011	53	100%	RCT	Mandatory	One-time program	Interest	10	6
Gawad, 2013	MS1	Surgical	NR	20	95%	Pre- and post- intervention survey	Selective	Multimodal	Interest	8.5	4.5
Lou, 2013	MS1-4	CTS	NR	45	100%	RCT	Selective	Simulation	Interest	11	6
Patel, 2013	MS1 MS2	Surgical	NR	33	100%	Pre- and post- intervention survey	Selective	One-time program	Interest	8.5	4.5
Stroh, 2013	MS1	Trauma	NR	126	54%	Historic Cohort	Selective	Clinical	Interest	8.5	2
Drolet, 2014	MS1, MS2	GS	2011–2012	171	I = 100% C = 67%	Cohort	Selective	Multimodal	Interest	8.5	3
Haggerty, 2014	MS4	CTS	2003–2013	30	100%	Observational	Selective	Research	Match rate	10.8	7.5
Li, 2014	MS1, MS2	Surgical	2010	56	89%	Cohort	Selective	Multimodal	Interest	8	2
	MS3	GYN		59	100%		Mandatory		Interest	8.5	6

Table 2 (*continued*)

Author, Year	Participant	Specialty	Study period	N	RR or % follow-up	Method	Participation in intervention	Intervention group	Outcome	MERSQI	NOS
Nitschmann, 2014			2010–2011			Pre- and post- intervention survey		One-time program			
Reid, 2014	MS3	Surgical	2011–2012	106	99%	Cohort	Selective	Clinical	Interest	9	2
Abbas, 2015	MS2, MS3	Surgical	2013–2014	129	38.80%	Pre- and post- intervention survey	Mandatory	Simulation	Interest	7.5	4.5
Cook, 2015	MS3	GS	2008–2009	258	63%	Pre- and post- intervention survey + Cohort	Selective	Clinical	Interest + Match rate	11.5	4
Greene, 2015	MS1	Head and neck	2012–2014	18	100%	Pre- and post- intervention survey	Selective	Multimodal	Interest	9.5	4.5
Saberski, 2015	MS1	Surgical	2009–2010	NR	NR	Pre- and post- intervention survey	Mandatory	Simulation	Interest	6.5	4.5
Trehan, 2015	Scholarship recipients	CTS	1999–2014	45	80%	Post- intervention survey, retrospective + Observational	Selective	Other	Interest + Match rate	10.8	7.5
Wagner, 2015	MS3	Surgical	2013	187	C = 41%, I= Pre: (99%) Post: (84%)	Historic Cohort	Mandatory	Other	Interest	9	3
Awad, 2016	Grant recipients	NSG	2007–2016	158	96.80%	Observational	Selective	Research	Match rate	12	7.5
Day, 2016	MS1, MS2	Surgical	NR	26	100%	Cohorts	Selective	Multimodal	Match rate	12	5
Grover, 2016	MS1-4	GS	2004–2013	372	100%	Observational	Selective	Multimodal	Match rate	10.8	7.5
Lattanza, 2016	MS1, MS2 Female	Orthopedic	2012–2014	318	64%	Pre- and post- intervention survey + Observational	Selective	One-time program	Interest + Match rate	12	6
Liebert, 2016	MS3	Surgical	2014–2015	89	79%	Pre- and post- intervention survey	Mandatory	Other	Interest	8.5	3
London, 2016	MS3	Orthopedic	2006–2012	715	100%	Historic cohort	Mandatory	Clinical	Match rate	14.4	6
Nellis, 2016	MS1-4	Head and neck	2009–2015	15	86.7%	Post- intervention survey + Observational	Selective	Other	Interest + Match rate	11	7.5
Pulcrano, 2016	MS1	Surgical	2014–2015	190	31.6%	Pre- and post- intervention survey	Mandatory	Other	Interest	9.5	4.5
Salna, 2016	MS1, MS2	GS	1984–2014	NR	100%	Observational	Selective	Multimodal	Match rate	10.8	7.5
Wu, 2016	MS1, MS2	Ophthalmology	2013–2014	22	81.80%	Pre- and post- intervention survey	Selective	Multimodal	Interest	6.5	4.5
Zuccato, 2016	MS1	NSG	2012–2014	40	93%	Pre- and post- intervention survey	Selective	Multimodal	Interest	9.5	4.5
Zuckerman, 2016	MS1, MS2	NSG	2012–2013	35	100%	Pre- and post- intervention survey	Selective	Multimodal	Interest	8.5	4.5
Kashkoush, 2017	MS1-4	NSG	2014–2016	234	100%	Observational	Selective	Multimodal	Match rate	10.8	7.5
Mason, 2017	MS3	Surgical	2005–2012	118	94.90%	Observational	Selective	Multimodal	Match rate	13.2	7.5
Shipper, 2017	MS1, MS2	Surgical	NR	30	Pre: 100% Post: 93.3%	Pre- and post- intervention survey	Selective	Multimodal	Interest	8.5	4.5
Karmali, 2018	MS2	Surgical	NR	18	100%	Post- intervention survey	Selective	Simulation	Interest	8	3
Coyan, 2019	MS1, MS2	CTS	2019	22	Pre: 100%, Post: 86.4%	Pre- and post- intervention survey	Selective	Simulation	Interest	8.5	4.5
Dallas, 2019	MS1-3	NSG	2017–2019	32	100%	Pre- and post- intervention survey	Selective	Multimodal	Interest	9	4.5
Davis, 2019	MS1, MS2	CTS	2015–2017	101	72%	Pre- and post- intervention survey	Selective	Multimodal	Interest	9	3
DeBolle, 2019	MS1-4	Surgical	2010–2014	NR	100%	Observational	Selective	Multimodal	Match rate	10.8	7.5
Garstka, 2019	MS3	Surgical	2012–2016	910	100%	RCT	Mandatory	Clinical	Match rate	15.6	9
Hicks, 2019	MS1	Surgical	NR	59	100%	RCT	Selective	Multimodal	Interest	11	3
Lazow, 2019	MS1	Surgical	2013–2017	54	Pre: 94.4%, Post: 27.8%	Pre- and post- intervention survey + Cohort	Selective	Multimodal	Interest + Match rate	11.5	4
Song, 2019	MS1-4	Surgical	2016–2017	127	NR	Post- intervention survey	Selective	Multimodal	Interest	5	1.5
Vajapey, 2019	Scholarship recipients	Orthopedic	2003–2016	130	100%	Cohort	Selective	Research	Match rate	12	5
Head, 2020	MS1	Surgical	NR	36	100%	Cohort	Selective	Multimodal	Interest + Match rate	12	5
Sethia, 2020	MS1	Head and neck	2015–2018	36	97%	Observational	Selective	Multimodal	Match rate	12	7.5

Abbreviations: RR: response rate, MERSQI: Medical Education Research Study Quality Instrument, NOS: Newcastle-Ottawa scale, MS: medical student, GS: general surgery, OB/GYN: obstetrics/gynecology, VS: vascular surgery, CTS: cardiothoracic surgery, NSG: neurosurgery, ENT: ear, nose, and throat, NR: not reported, RCT: randomized controlled trial. Reference list see Appendix 1.

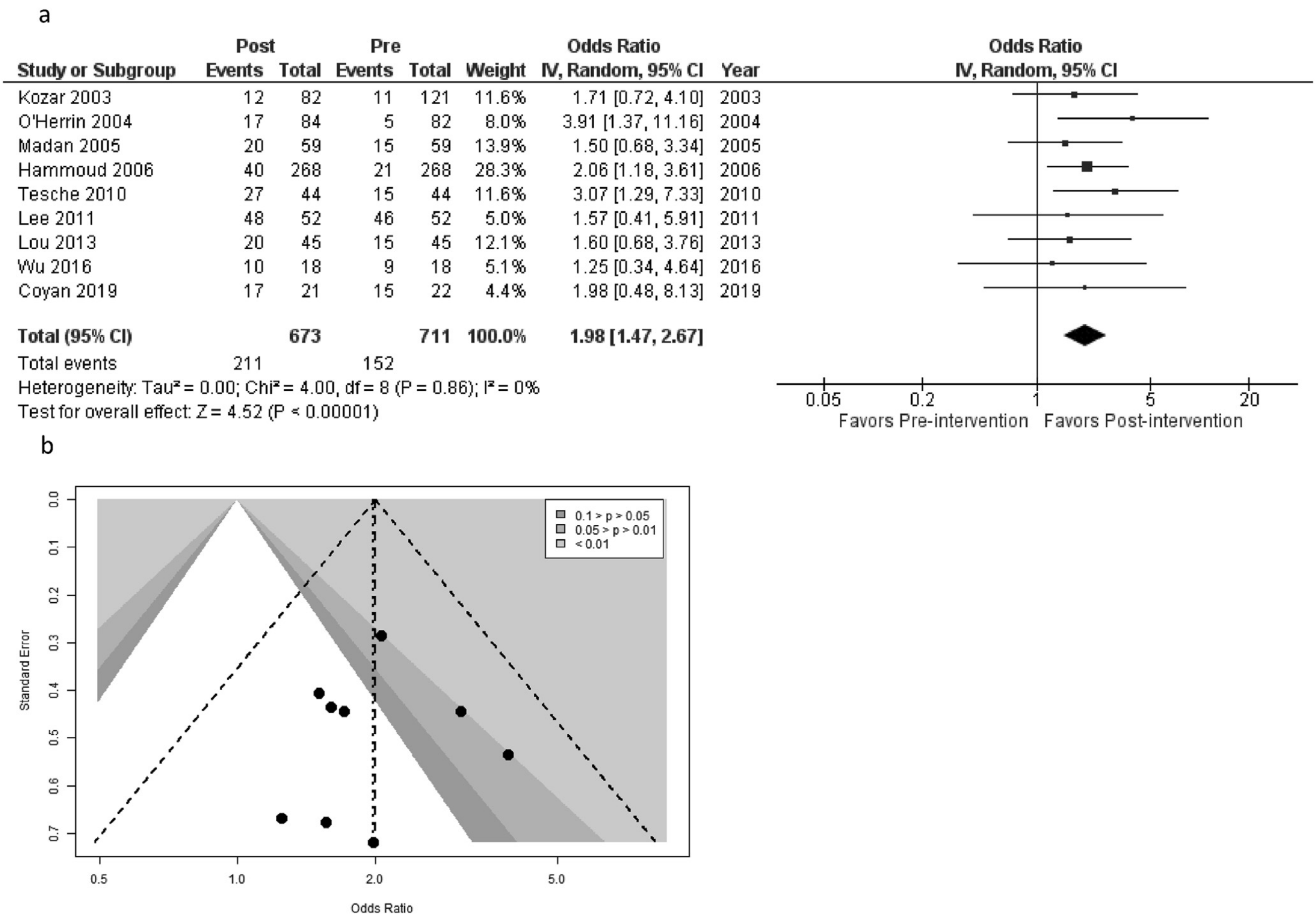


Fig. 2. Forest plot (2a) and funnel plot (2b) of cumulative odds ratio for percentage of students reporting interest in studied specialty after the intervention compared to baseline. Interest was assessed as categorical data. Events were students reporting being "somewhat interested" or "very interested" in the studied specialty. Shaded area of the contoured enhanced funnel plot show P < .001, P < .05 and P < .10 from the darkest gray to lightest gray.

Interpretation of funnel plots and asymmetry testing must be guarded because the number of studies is low. Removal of low-quality studies with subgroup analysis of only studies that scored 4.5 or higher on NOS showed similar results for all four interest outcomes (Appendix 3-6). However, the outcome percentage of students interested in any surgical specialties pre- and post-intervention was not statistically significant ($P = .09$) and displayed greater heterogeneity ($I^2 = 44\%$) (Figs. 2–5, Appendix 3-6). All studies used in the single match outcome had moderate-high quality. Subgroups analysis by timing of the intervention and intervention type were performed, however, due to small number of studies in each group, we were not able to draw conclusions from these analyses (Figs. 7 and 8, and Appendices 7-9). When interest in specific specialties is examined, the increase in interest is greater than when interest in surgical specialties in general is evaluated, indicating interest in specific specialties may be a better marker (Figs. 7 and 8). Subgroup analysis of match result showed lower heterogeneity (Multimodal/Preclinical students $I^2 = 46$, $P = .16$, Clinical/Clinical students $I^2 = 65\%$, $P = .06$, Appendix 9). Results were confirmed using the Mantel-Haenszel method with Hartung-Knapp adjustment are presented in Appendices 10-14 and were similar to DerSimonian Laird method.

Discussion

In this meta-analysis of interventions to enhance recruitment into surgery, we found the odds of a participant being interested in a studied specialty and any surgical specialty were 2.0 and 1.4, respectively, after a recruitment intervention compared to baseline. While match results are more objective, the pooled result had significant heterogeneity and was not statistically significant. Based on this analysis, there was not enough evidence to recommend one recruitment strategy over another or specific timing of recruitment intervention. The question we posed cannot be answered with the current data available because of heterogeneity of study methodology, outcome reported, and the soft endpoints of most studies.

Clinical exposure was a popular topic of investigation, with many studies assessing effectiveness of clerkships during clinical years in attracting students to surgical specialties. Students consider clerkship experience as the most important factor in making career decision.[24] The 3rd year of medical school is when students develop the strongest perception about specialties and most frequently alter career paths, thus making it a good target time for recruitment.[10,24] Clerkship in the 3rd or 4th years were shown to increase subjective interest of medical students in targeted specialties and improve opinions towards surgeons.[7,10,25,26] Active participation in patient care or the operating room was associated with a higher interest in surgery.[27] However, most of these studies focused on a pre-existing curriculum rather than a new intervention which would not further improve recruitment.

Only five studies looked at whether exposure to a preceptorship-based model or private practice setting would increase student interest.[11,28–31] Abdessamad et al. showed higher interest in students with clinical experiences in private offices and

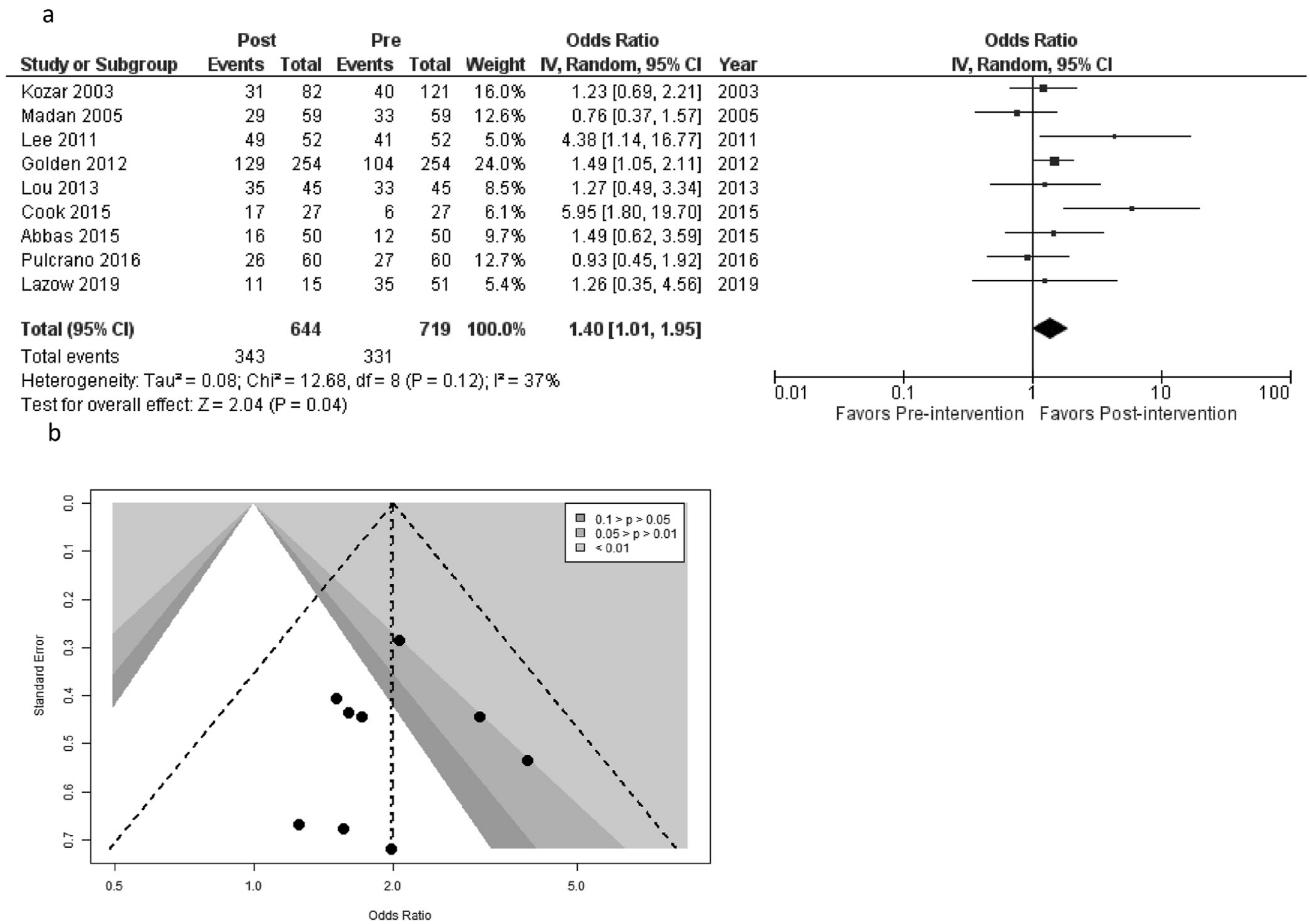


Fig. 3. Forest plot (3a) and funnel plot (3b) of cumulative odds ratio for percentage of students reporting interest in any Surgical specialty after the intervention compared to baseline. Events were students reporting being "somewhat interested" or "very interested" in any surgical specialty. Shaded area of the contoured enhanced funnel plot show P < .001, P < .05 and P < .10 from the darkest gray to lightest gray.

Cook et al. showed a higher match rate to general surgery after non-metropolitan clerkships.[11,28] Private practice settings allow closer interaction between medical students and attending physicians and may portray better lifestyle and stronger patient-physician relationships, likely contributing to the improved student interest.[11,29] Reid et al. did not show any difference in student interest in groups who underwent different clerkship models, but showed that students who underwent a preceptorship model had better opinions of surgeons and their lifestyle and felt that they participated more actively in clinical care.[30] Garstka et al. showed that students that were exposed to both academic and community practice settings had 1.36 odds of matching into a surgical specialty.[31] Remodeling the 3rd year clerkship to include different practice settings and team models may be a valid strategy to improve recruitment to surgery.

Timing of the intervention appears to be important and efforts may be needed prior to clinical years of medical school. Seventy percent of students that matched into a surgical specialty had chosen surgery as their first preference when they started 2nd year of medical school.[32] Students that focused on a career path early have more chance to conduct research, network, attend conferences, and participate in relevant extracurricular activities.[26] Additionally, negative 3rd year clerkship experiences can adversely impact interest in surgery.[33] Students that participated in a clerkship during pre-clinical years felt more prepared for their 3rd year clerkship, had better clerkship grades, and had higher match rates into surgery.[1] In addition, many specialties are not included in the required 3rd year core clerkships. Students may only be able to have further exposure to surgical subspecialties like vascular surgery or orthopedic surgery if they select these specialties as electives, making exposure in preclinical years crucial to stimulate interest.

Exposure to surgical simulations are frequently offered as voluntary courses for preclinical students with the goals of early exposure to surgical specialties, increasing knowledge, improving skills, creating mentorship opportunities, and improving student interest.[8,34] Although many studies reported a high percentage of students stating increased interest in studied specialty, few found statistical difference.[8,24,34–36] Madan et al. speculated that this could be related to a high level of pre-course interest from selection bias.[35] Other studies attributed lack of statistical significance to a lack of power in the study.[8,34,35] Simulation and skills course can help medical students understand how theoretical knowledge is applied to clinical situations and raise awareness about surgical subspecialties.[24] Karmali et al. showed that 72% of students reconsidered their choice of electives due to simulation and that elective choice highly influences subspecialty choice.[36] More importantly, most studies demonstrated improvement in technical skills and increased confidence which could contribute to positive clinical experience.[8,24,36] Li et al. found more positive perceptions of 3rd year clerkships from those that participated in simulation and skills programs during preclinical years.[34] However, it is important

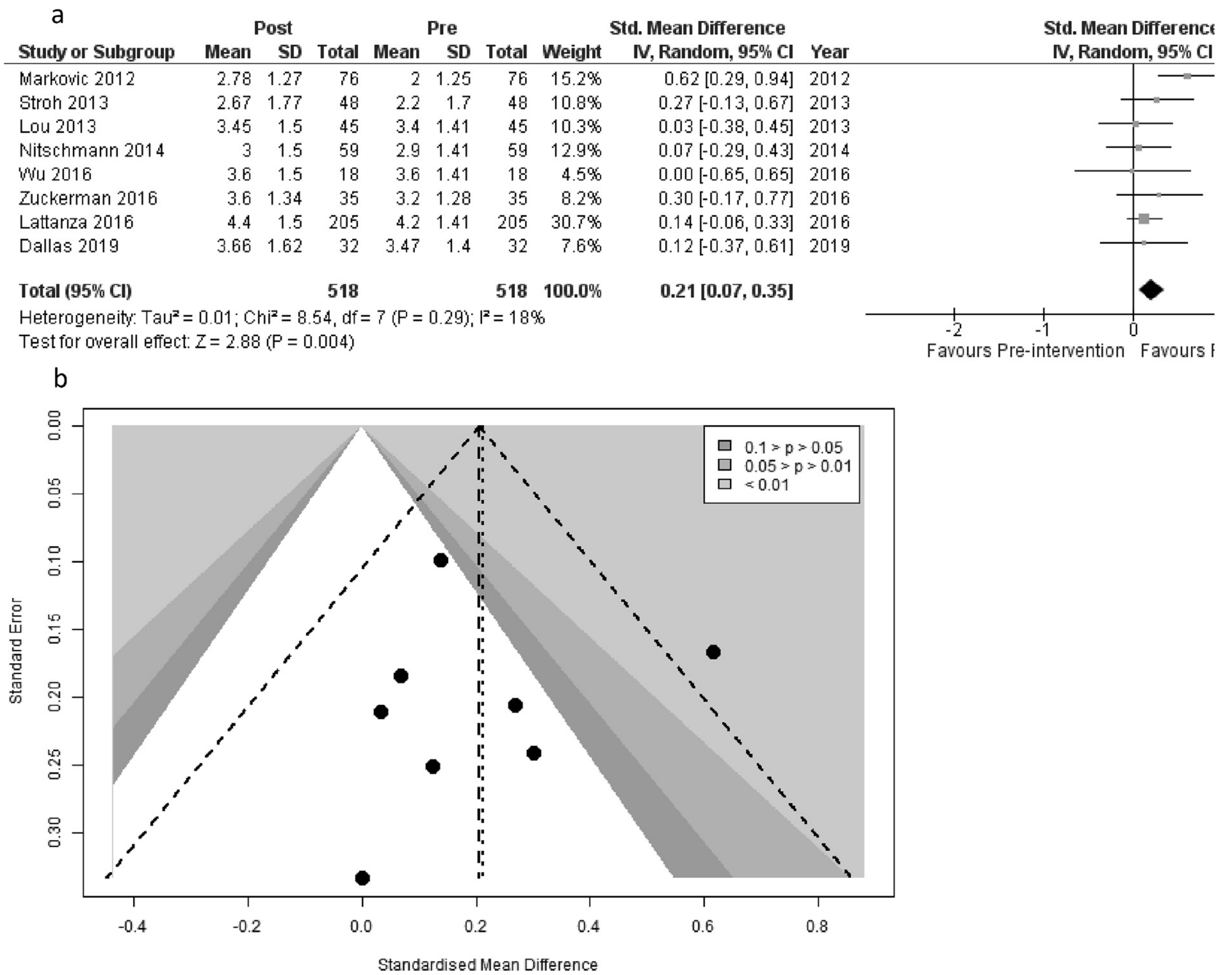


Fig. 4. Forest plot (4a) and funnel plot (4b) of pooled standard mean difference of reported interest in studied specialty based on 5-point Likert Scale after the intervention compared to baseline. Interest was assessed as continuous data by calculation of standard mean difference. Shaded area of the contoured enhanced funnel plot show P < .001, P < .05 and P < .10 from the darkest gray to lightest gray.

to note that supervised simulation/skills practice is more effective than self-directed practice, which may even have a negative impact on student interest due to frustrations.[12]

One-time programs consist of one or a combination of the following interventions: simulation or skills labs, academic didactics, outreach efforts such as networking lunches or dinners, and career-related didactics or panel discussions. Outreach didactics, panel discussions, lunches, or dinners appeared to be effective ways for students to gain accurate perceptions of the specialty and clarify misperceptions.[9] For specialties not included in the core curriculum, such as hand surgery, otolaryngology, or cardiothoracic surgery; these outreach activities allow medical students to consider these specialties as a career option. However, increased interest resulting from a single exposure is likely not sustained. Markovic et al. showed that in as little as one month, there was a significant decline in student interest compared to immediately after the simulation course; though it was still slightly higher than baseline.[13] Thus, these short programs are suitable as an introduction to the specialty, especially for preclinical students and for specialties with minimal student exposure but likely require follow up with other interventions to maintain interest over time.

Only three studies looked at research as a recruitment intervention, including one that studied research meeting attendance.[37–39] Haggerty et al. found that 8.7% of students matched into cardiothoracic surgery and an additional 43.5% matched into other surgical specialties.[37] In the remaining studies, over 50% of the participants matched into the specialty of the interventions.[38,39] Vajapey et al. found significantly higher match rates to the studied specialty in participants of the program compared to applicants who were not accepted in to the program.[39] However, applicants who did not participate in the program also had a high match rate. This suggests that students applying for these research opportunities already have a heightened interest in the specialty. The higher match rate in participants could be due to higher academic achievement at baseline, increased competitiveness for the specialty because of the program, or a combination of the two.[39] Despite these biases, research program participation is effective in nurturing potential candidates of the specialty.

Lastly, almost a third of the studies looked at multimodal strategies. Some studies looked at clerkships or elective courses with additional components, some at interest groups, and some studies looked at trends in match rate after implementation of multiple independent programs at a single institution. Interest groups can have a wide reach – Salna et al. reported over 50% of the student body had participated in at least one event sponsored by the interest group– and can spark interest in those who initially had not considered pursuing a surgical field.[2] Regardless of the type of event, they all increased student exposure to

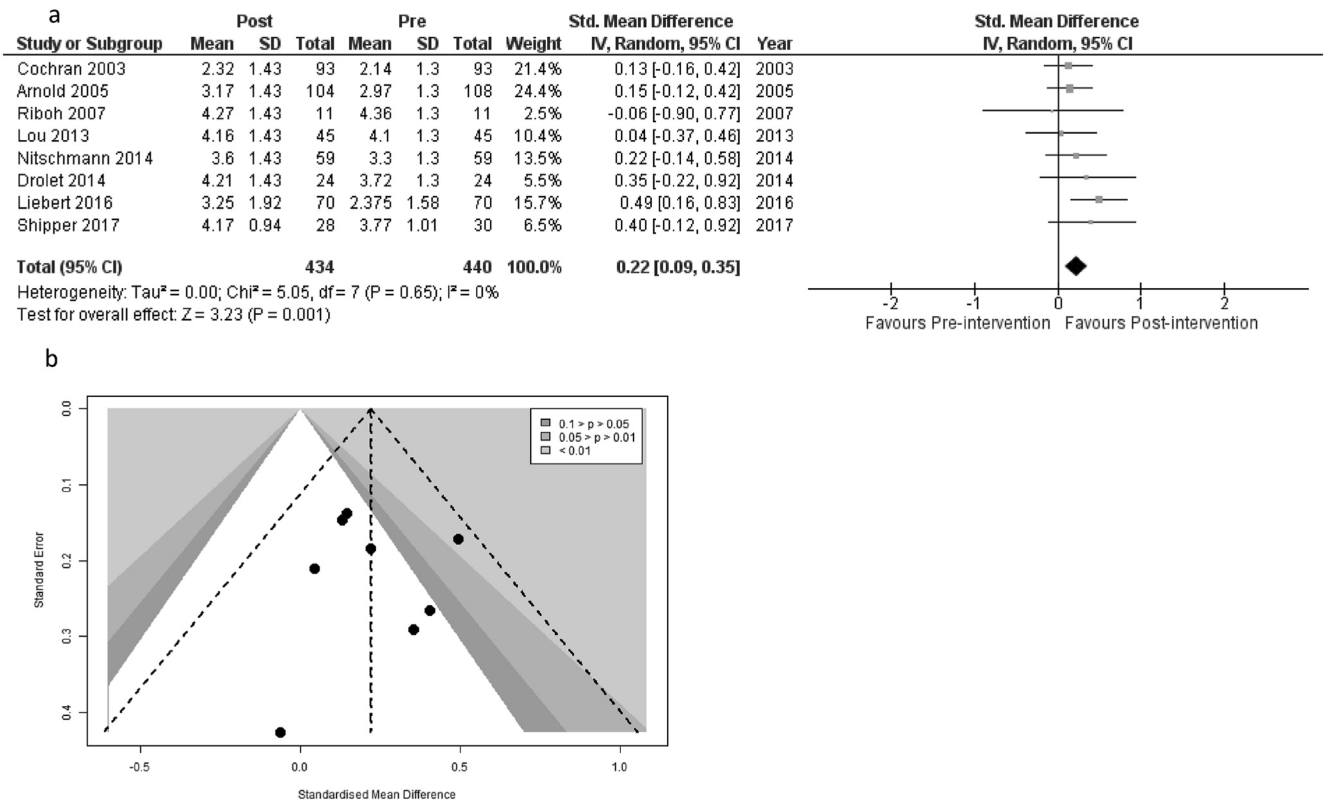


Fig. 5. Forest plot (5a) and funnel plot (5b) of pooled standard mean difference of reported interest in any Surgical specialty based on 5-point Likert Scale after the intervention compared to baseline. Interest was assessed as continuous data by calculation of standard mean difference. Shaded area of the contoured enhanced funnel plot show P < .001, P < .05 and P < .10 from the darkest gray to lightest gray.

surgeons and improved understanding of the field. For those already interested in surgical specialties, these events provided opportunities to seek research opportunities or establish mentorship. The additional advantage of interest groups is that they can maintain consistent contact throughout the year to sustain interest and can design events according to student needs.[40] Multiple studies have reported increased match rate to surgical fields after establishment of interest groups.[2] The Surgical Exploration and Discovery (SEAD) program is a two-week program founded by the University of Toronto in 2012 that introduces students to seven surgical specialties through half-day operating room observerships in each of the seven specialties, 1-h career discussion sessions with question and answer hosted by each division, and 3-hr simulation workshops hosted by each division.[12] Students were more knowledgeable about these different specialties and were able to either find new specialties of interest or rule out specialties they initially were interested in. However, all the students were interested in surgery at baseline and the sample size was only 18. This program may be more appropriate with assisting the medical students with finding the right surgical specialty than inspiring interest in those who were not considering surgery. As most medical school curricula in the US allow only 8–12 weeks of surgical clerkship in the 3rd year of medical school, the most critical year, this allows exposure to a very limited number of specialties. The SEAD program can be ideal for preclinical students to familiarize themselves with all of their options and identify those most suitable to explore in depth during their clinical years.[12]

Studies on this topic have a high potential for bias. Quality of studies varied widely with the median study scoring 50% of the total score for both MERSQI and NOS. Interest is a very popular outcome; however, it is highly subjective and at risk for observer bias. If pre- and post-intervention interest levels were completed on a single survey post-intervention, there is an additional risk for recall bias. Very few studies used randomized controlled trial design and only one study used a cross-over design that allowed comparison of interest change in the control group while the intervention group underwent the course, allowing for truly comparable cohorts.[13] However, the aforementioned study is still subject to selection bias because students that volunteered to be in the study likely had higher baseline interest than those not participating.[13] Recruitment efforts are unlikely to be effective on those who have already ruled out surgery, thus the target population may be similar to this selective group. Randomized controlled trials with a cross-over design are recommended for future studies assessing student interest. Cohort studies using contemporary cohorts are at a higher risk of selection bias compared to historic cohorts. This is especially important for studies that report match rate since it would not be possible to use randomized controlled trial design for this outcome. Historic cohorts showing improvement in match rate into surgical specialties after implementation of recruitment efforts may be the most convincing evidence if evaluated in comparison to national trends, although all changes to the curriculum occurring during that period need to be accounted for. Match rate is a more objective outcome not subject to observer or recall bias but can, however, be subject to confounding bias. The earlier the year a recruitment intervention targets in medical school, the more room there is for confounding bias. Despite the risk for confounding bias, match rate as an outcome provides a higher level of intervention effectiveness and thus should be included in future studies on recruitment efforts.

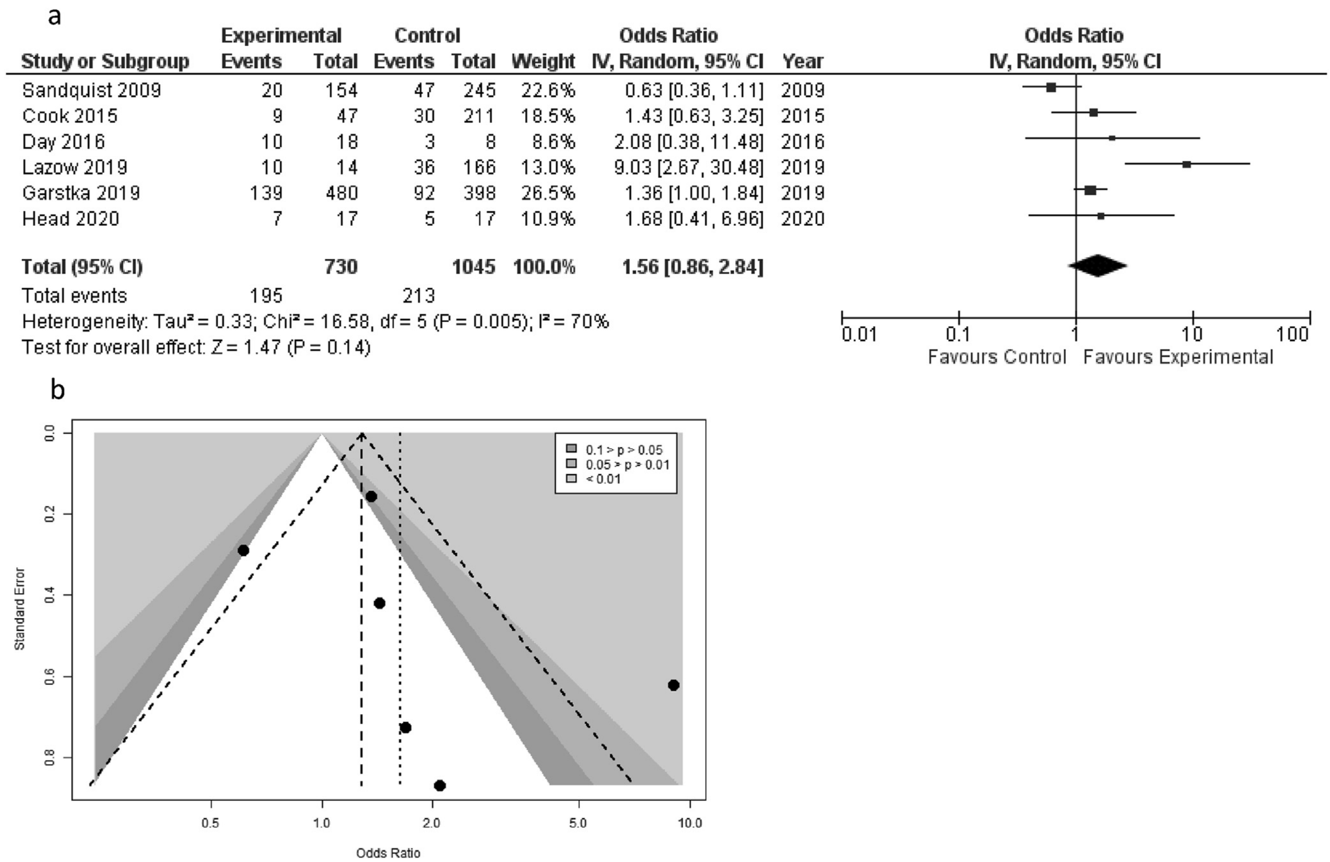


Fig. 6. Forest plot (6a) and funnel plot (6b) of cumulative odds ratio for matching into any surgical specialty. Events were students matched into any surgical specialty. Shaded area of the contoured enhanced funnel plot show P < .001, P < .05 and P < .10 from the darkest gray to lightest gray.

Limitations

The quality of this review is limited by the quality of individual studies. The heterogeneous nature of the studies in print and the soft endpoints of most published studies limit the validity of combining these published data. Additionally, most studies on this topic are subjective to recall bias, selection bias, or confounding bias. For studies using interest as the outcome, it is important to note interest does not always translate to matching into a specialty, especially if there is a longer gap between intervention and match. Eight percent of students considered OB/GYN in Hammoud et al. prior to clerkship, and 15% by the end, however, only 5% matched into OB/GYN.[25] Match result may also have limitations as an outcome due to increased opportunity for confounding bias from the long gap between the intervention and match, as well as significant selection bias between cohorts. In addition, application was not a commonly reported outcome, which is likely a more accurate reflection of student interest than match outcome. Academic achievement and competitiveness of the program need to be considered when viewing match rate, especially for specialties like neurosurgery, orthopedic surgery, etc. An additional limitation to our study is that we were not able to perform meta-analysis for some of the outcomes reported due to significant differences in study design and small number of studies. Although match is a more objective outcome, our meta-analysis indicated significant heterogeneity likely due to differences in the choice of control group, type of intervention, and timing of the intervention. More studies reporting match data would allow better subgroup analyses with more homogeneous data and allow for comparisons of timing and intervention. We were not able to identify superiority of one recruitment method over another or the timing of intervention objectively based on the current data available.

Conclusion

In conclusion, there are numerous studies evaluating recruitment into surgical specialties that show improved interest and match rate. However, there is significant heterogeneity in the design, reporting of outcome, and quality of the studies. Results from this meta-analysis should be interpreted with caution. Recruitment strategies can improve subjective interest immediately following the intervention; however, this may not translate to matching into the specialty. We recommend assessing the effectiveness of recruitment efforts with cross-over randomized trials with historic cohorts that utilize pre- and post-intervention interest surveys as well as reporting of both application to and match rate into the studied specialty if possible. While increased interest is a valid intermediate measure, studies should report both application and match rates as this is an objective assessment of the success of their intervention.

Declaration of competing interest

This research received no specific grant support from any funding agency in the public, commercial, or not-for-profit sectors. Authors have no conflict of interest to disclose.

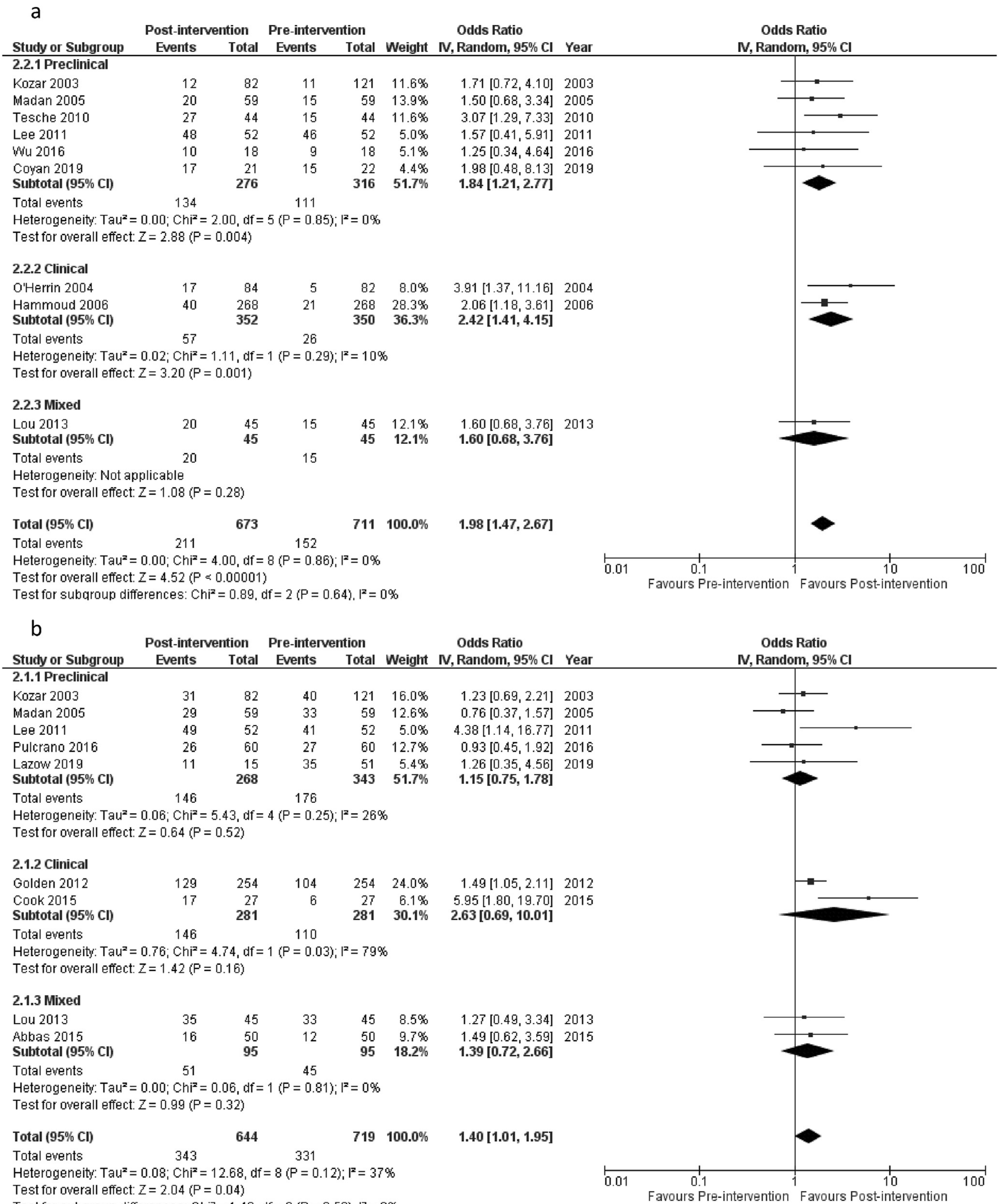
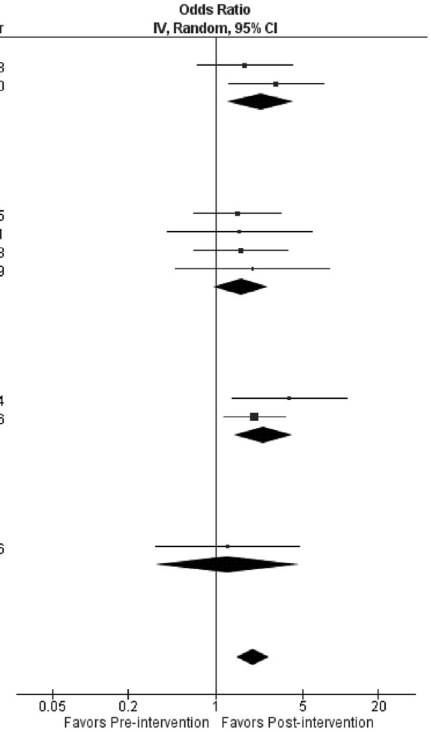


Fig. 7. Forest plots of subgroup analysis of cumulative odds ratio for percentage of students reporting interest in studied specialty (7a) and surgical specialties in general (7b) after the intervention compared to baseline grouped by intervention timing. Events were students reporting being "somewhat interested" or "very interested" in the studied specialty in 7a and any surgical specialty in 7b. Intervention timing was grouped into "preclinical" for 1st and 2nd year medical students, clinical for 3rd and 4th year medical students, and mixed for those that accepted all students.

a

Study or Subgroup	Post Events	Post Total	Pre Events	Pre Total	Weight	Odds Ratio IV, Random, 95% CI	Year
3.1.1 One-time Program							
Kozar 2003	12	82	11	121	11.6%	1.71 [0.72, 4.10]	2003
Tesche 2010	27	44	15	44	11.6%	3.07 [1.29, 7.33]	2010
Subtotal (95% CI)		**126**		**165**	**23.2%**	**2.30 [1.24, 4.25]**	
Total events	39		26				
Heterogeneity: Tau² = 0.00; Chi² = 0.86, df = 1 (P = 0.35); I² = 0%							
Test for overall effect: Z = 2.65 (P = 0.008)							
3.1.2 Simulation							
Madan 2005	20	59	15	59	13.9%	1.50 [0.68, 3.34]	2005
Lee 2011	48	52	46	52	5.0%	1.57 [0.41, 5.91]	2011
Lou 2013	20	45	15	45	12.1%	1.60 [0.68, 3.76]	2013
Coyan 2019	17	21	15	22	4.4%	1.98 [0.48, 8.13]	2019
Subtotal (95% CI)		**177**		**178**	**35.4%**	**1.60 [0.97, 2.63]**	
Total events	105		91				
Heterogeneity: Tau² = 0.00; Chi² = 0.11, df = 3 (P = 0.99); I² = 0%							
Test for overall effect: Z = 1.84 (P = 0.07)							
3.1.3 Clinical							
O'Herrin 2004	17	84	5	82	8.0%	3.91 [1.37, 11.16]	2004
Hammoud 2006	40	268	21	268	28.3%	2.06 [1.18, 3.61]	2006
Subtotal (95% CI)		**352**		**350**	**36.3%**	**2.42 [1.41, 4.15]**	
Total events	57		26				
Heterogeneity: Tau² = 0.02; Chi² = 1.11, df = 1 (P = 0.29); I² = 10%							
Test for overall effect: Z = 3.20 (P = 0.001)							
3.1.4 Multimodal							
Wu 2016	10	18	9	18	5.1%	1.25 [0.34, 4.64]	2016
Subtotal (95% CI)		**18**		**18**	**5.1%**	**1.25 [0.34, 4.64]**	
Total events	10		9				
Heterogeneity: Not applicable							
Test for overall effect: Z = 0.33 (P = 0.74)							
Total (95% CI)		**673**		**711**	**100.0%**	**1.98 [1.47, 2.67]**	
Total events	211		152				
Heterogeneity: Tau² = 0.00; Chi² = 4.00, df = 8 (P = 0.86); I² = 0%							
Test for overall effect: Z = 4.52 (P < 0.00001)							
Test for subgroup differences: Chi² = 1.92, df = 3 (P = 0.59), I² = 0%							



b

Study or Subgroup	Post Events	Post Total	Pre Events	Pre Total	Weight	Odds Ratio IV, Random, 95% CI	Year
3.2.1 Simulation							
Madan 2005	29	59	33	59	12.6%	0.76 [0.37, 1.57]	2005
Lee 2011	49	52	41	52	5.0%	4.38 [1.14, 16.77]	2011
Lou 2013	35	45	33	45	8.5%	1.27 [0.49, 3.34]	2013
Abbas 2015	16	50	12	50	9.7%	1.49 [0.62, 3.59]	2015
Subtotal (95% CI)		**206**		**206**	**35.8%**	**1.37 [0.73, 2.55]**	
Total events	129		119				
Heterogeneity: Tau² = 0.18; Chi² = 5.31, df = 3 (P = 0.15); I² = 43%							
Test for overall effect: Z = 0.98 (P = 0.33)							
3.2.2 Clinical							
Golden 2012	129	254	104	254	24.0%	1.49 [1.05, 2.11]	2012
Cook 2015	17	27	6	27	6.1%	5.95 [1.80, 19.70]	2015
Subtotal (95% CI)		**281**		**281**	**30.1%**	**2.63 [0.69, 10.01]**	
Total events	146		110				
Heterogeneity: Tau² = 0.76; Chi² = 4.74, df = 1 (P = 0.03); I² = 79%							
Test for overall effect: Z = 1.42 (P = 0.16)							
3.2.3 One-time Program							
Kozar 2003	31	82	40	121	16.0%	1.23 [0.69, 2.21]	2003
Subtotal (95% CI)		**82**		**121**	**16.0%**	**1.23 [0.69, 2.21]**	
Total events	31		40				
Heterogeneity: Not applicable							
Test for overall effect: Z = 0.70 (P = 0.49)							
3.2.4 Multimodal							
Lazow 2019	11	15	35	51	5.4%	1.26 [0.35, 4.56]	2019
Subtotal (95% CI)		**15**		**51**	**5.4%**	**1.26 [0.35, 4.56]**	
Total events	11		35				
Heterogeneity: Not applicable							
Test for overall effect: Z = 0.35 (P = 0.73)							
3.2.5 Other							
Pulcrano 2016	26	60	27	60	12.7%	0.93 [0.45, 1.92]	2016
Subtotal (95% CI)		**60**		**60**	**12.7%**	**0.93 [0.45, 1.92]**	
Total events	26		27				
Heterogeneity: Not applicable							
Test for overall effect: Z = 0.18 (P = 0.85)							
Total (95% CI)		**644**		**719**	**100.0%**	**1.40 [1.01, 1.95]**	
Total events	343		331				
Heterogeneity: Tau² = 0.08; Chi² = 12.68, df = 8 (P = 0.12); I² = 37%							
Test for overall effect: Z = 2.04 (P = 0.04)							
Test for subgroup differences: Chi² = 1.90, df = 4 (P = 0.75), I² = 0%							

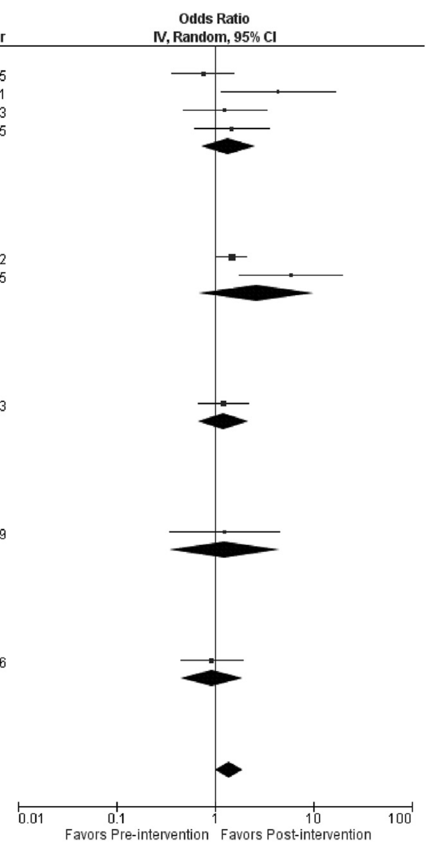


Fig. 8. Forest plots of subgroup analysis of cumulative odds ratio for percentage of students reporting interest in studied specialty (8a) and surgical specialties in general (8b) after the intervention compared to baseline grouped by intervention type. Events were students reporting being "somewhat interested" or "very interested" in the studied specialty in 8a and any surgical specialty in 8b. Intervention type was grouped into "one-time program", "simulation", "clinical", "multimodal", and "other". Intervention was considered multimodal if two type or more of intervention was performed. Intervention was considered "one-time program" if the event occurred only once.

Acknowledgements

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2020.12.006.

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