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Overcoming the Impact of COVID-19 on Surgical Mentorship: A Scoping Review of Long-distance Mentorship in Surgery

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BACKGROUND: Mentorship in the surgical field has been increasingly recognized as a crucial component of career success. Distance mentorship models may be utilized to overcome geographic limitations, increase mentorship access, and strengthen mentoring relationships in surgery.

OBJECTIVE: This review aimed to identify the scope of literature on distance mentoring in surgery, the range of its application, its effectiveness, and any gaps in the literature that should be addressed in order to enhance mentorship in the surgical field.

DESIGN: A comprehensive PubMed review was performed in January 2021 on distance mentorship of students, trainees, and surgeons in the surgical field. Reviews, replies, and non-English articles were excluded. Data was extracted regarding publication year, author’s country, specialty, subjects, aim of mentorship model, and efficacy.

RESULTS: 134 total studies met inclusion and exclusion criteria. Most studies were published in 2020, written by authors in the United States, from general surgery, and featured an expert surgeon paired with a more junior fully trained surgeon. In all, 93.3% of studies utilized distance mentorship to enhance surgical skill through telementoring and only 4.5% were focused on mentorship to enhance careers through professional development. The remaining studies utilized distance mentorship models to increase surgical research (0.7%) and clinical knowledge (1.5%).

CONCLUSION: The results of this review suggest successful implementation of distance mentoring in surgery through telementoring, but a lack of professionally aimed distance mentorship programs. Amidst COVID-19, distance mentorship is particularly important because of decreased face-to-face opportunity. Future studies in the surgical field should investigate distance mentoring as a means of increasing mentorship for professional development. (J Surg Ed 78:1948–1964. © 2021 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: e-mentor, telementor, training, remote, virtual, education

COMPETENCIES: Medical Knowledge, Professionalism, Interpersonal and Communication Skills

INTRODUCTION

Mentorship in surgery has significant benefits to both the mentor and mentee. The mentor-mentee relationship has been defined as “a dynamic reciprocal relationship in a work environment between a career incumbent (mentor) and a beginner protégé (mentee), aimed at promoting development of both.”1 Mentorship in surgery has been shown to increase academic productivity, funding, leadership roles, job retention, and advance mentees’ careers, while reducing burnout.1-12 Mentors benefit by learning from the mentee, validating their knowledge and accomplishments, and through increased job satisfaction.7,13 Mentorship in surgery should be optimized to increase the overall professional and personal well-being of students and surgeons at all career stages.

Distance mentorship, meaning the mentor and mentee are located in different geographic areas, utilizes technology to create a boundaryless, egalitarian, and qualitatively different mentoring relationship.14 Distance mentorship models have been successfully implemented in the fields of academic medicine,15-19 nursing,20-22 medical research,23-25 and business.26,27 These models can increase mentorship of individuals with few local mentors and diversify mentorship networks.14,28-30 Distance...
Mentorship in medicine can take many forms, focusing on education, skill achievement, research productivity, or professional and personal development. The focus of this review included students, trainees, and surgeons within the surgical field, the implementation of distance mentorship in their training and careers, and its impact on skill acquisition, research, and professional development compared to in-person and no mentorship.

**METHODS**

A scoping review of the literature was performed in January 2021. Peer-reviewed articles were identified by a single author (L.N.R) using PubMed. Search terms that related to distance mentorship were used with Boolean operators, listed in Table 1. The authors’ personal saved files were also searched for relevant publications.

| Term                               | Search Phrase                                                                 | Number of Publications |
|------------------------------------|-----------------------------------------------------------------------------|------------------------|
| Distance mentor in surgery         | ("distance"[All Fields] OR "distances"[All Fields]) AND ("mentor s"[All Fields] OR "mentored"[All Fields] OR "mentoring"[MeSH Terms] OR "mentors"[All Fields] OR "mentoring"[MeSH Terms] OR "mentors"[MeSH Terms] OR "mentors"[All Fields] OR "mentor"[All Fields] AND "surgery"[MeSH Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "general surgery" OR (general[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields] OR "surgery s"[All Fields] OR "surgeries"[All Fields] OR "surgery s"[All Fields] OR "surgerys"[All Fields] OR "surgeries"[All Fields]) | 59                     |
| Telementor in surgery              | ("telementor"[All Fields] OR "telementored"[All Fields] OR "telementorin- g"[All Fields]) AND ("surgery"[MeSH Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "general surgery"[MeSH Terms] OR (general[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields] OR "surgery s"[All Fields] OR "surgeries"[All Fields] OR "surgery s"[All Fields] OR "surgerys"[All Fields] OR "surgeries"[All Fields]) | 238                    |
| E-mentor in surgery                | ("e-mentoring"[All Fields] AND ("surgery"[MeSH Subheading] OR "surgery" OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "general surgery"[MeSH Terms] OR (general[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields] OR "surgery s"[All Fields] OR "surgeries"[All Fields]) OR "surgery s"[All Fields] OR "surgerys"[All Fields] OR "surgeries"[All Fields]) | 2                     |
| Virtual mentor in surgery          | ("virtual"[All Fields] OR "virtuality"[All Fields] OR "virtualization"[All Fields] OR ("virtualized"[All Fields] OR "virtualizing"[All Fields] OR "virtuals"[All Fields] OR "virtual"[All Fields] OR "mentoring"[MeSH Terms] OR "mentoring"[All Fields] OR "mentors"[MeSH Terms] OR "mentors"[All Fields] OR "mentor"[All Fields] AND "surgery"[MeSH Subheading] OR "surgery"[All Fields] OR ("operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR (general[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields] OR "surgery s"[All Fields] OR "surgeries"[All Fields])) | 257                    |
Articles were screened by title and abstract, using inclusion and exclusion criteria listed in Table 2. Full-text review was performed on remaining articles. Inclusion criteria included reports of geographically distant mentorship within surgery. No limitation was placed on year or publication status. Articles that were duplicates, non-English, reviews, or replies were excluded due to the native language of the authors and so that duplicates would not be reported. Also, articles in which the mentor and/or mentee was not a premedical or medical student, surgical trainee (resident or fellow), or fully trained surgeon were excluded. Published abstracts were excluded. Data was manually extracted, as available, and stored using a standardized spreadsheet. A full-text review was conducted for all but 2 included articles, for which full-text access was unavailable, so data was extracted from the abstract. The categories of data extracted from each study are listed in Table 3.

Several presumptions were made during data collection. Country of authors was assumed to be the same, if only the first author’s country was published. Surgical specialty was determined by the text or journal and categorized as general surgery, if not specified. In telementored cases, the operation, if specified, was used to confirm that categorization into general surgery was acceptable. When sorting articles into types of mentorship, including educational, professional, telementoring, or research, the prevailing theme was selected, although some articles had mixed aspects. The career stage of the mentees was determined by the text, but if not explicitly stated, the context of the publication was used. If this was still unclear, the mentee was categorized as “unspecified” training level.

### RESULTS

#### Selection of Studies

PubMed search yielded 556 publications. Of these, 464 were screened by the title and abstract and 194 were reviewed via the full text (Fig. 1). Additionally, the lead author (L.N.R.) found 4 articles relevant to the study in her files. Following screening, 134 articles met inclusion and exclusion criteria. 426 articles were excluded because they were duplicates (N = 53), did not meet inclusion criteria (N = 241), were not in the English language (N = 39), were published abstracts (N = 4), review articles (N = 62), or replies (N = 2), and because the mentor and/or mentee was not a student, surgical trainee, or surgeon (N = 25).

![PRISMA Flowchart](image)

**FIGURE 1.** PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart.
**Study Characteristics**

The distribution of publications spanned from 1996 to 2021, peaking in 2020 (N = 16, 11.9%) (Fig. 2). Publications were primarily written by United States (N = 64, 47.8%),
25,33-95 internationally collaborating (N = 31, 23.1%),
96-126 and Canadian authors (N = 13, 9.7%) (Fig. 3). The United Kingdom140-143 and Japan144-147 each had 4 publications (3.0% each). France,148-150 India,151-153 and Norway154-156 had 3 publications (2.2% each). Italy157,158 and Switzerland159,160 had 2 publications (1.5% each). Africa,161 Austria,162 the Caribbean,163 Iran,164 and Spain165 each had 1 publication (0.8% each). Publications in General Surgery (N = 75, 56.0%)25,34-40,42,43,46,47,51-53, 55-58,60-64,68,69,71,74,76,80,81,84,86,89-91,93-96,98,102,105,109,116-119, 121-123,125-132,134,137-139,141,142,145,147-151, 153-156 and Urology (N = 13, 9.7%)50,59,67,77,88,97,99,107,108,112,120,144,164 were most prevalent (Fig. 4). Cardiovascular had 5 publications,70,72,110,111,160 Endocrine,79,113,152,157 Neurosurgery,45,54,92,135 Ophthalmology,48,66,83,143 and Pediatric Surgery49,65,87,100 had 4 publications. Obstetrics and Gynecology had 3 publications,73,104,114 along with Orthopedics,82,156,161 and Trauma.85,106,155 Colorectal,103,115 Otolaryngology,33,44 Oral and Maxillofacial Surgery,158,162 and Plastic and Reconstructive Surgery,11,146 each had 2 publications. Bariatric,165 Endovascular,140 Hepatobiliary,163 Transplant,101 and Vascular159 each had 1 publication. In combined specialty publications, there were 2 that were Otolaryngology and Neurosurgery,75,124 and 1 publication that was Trauma, Vascular, and Orthopedics.78

**Distance Mentorship Models**

Distance mentorship models mentioned in the literature aimed to increase the mentee’s knowledge, skill, research productivity, and professional development (Fig. 5). Models of distance mentoring most frequently utilized or proposed telementoring (N = 125, 93.3%). Telementoring is a technique through which an experienced physician guides a lesser experienced physician or healthcare professional in a remote location.166 If this occurs intra-operatively, it is termed telesurgical telementoring.166 Telesurgical telementoring was discussed
in 123 publications. Telesurgical telementoring has been primarily used to increase a mentee’s surgical skill. Amparore et al., however, suggested that telesurgery could be utilized to increase urology residents’ operative exposure during COVID-19 after identifying a decrease in their surgical and clinical training activities. Similarly, Redleaf et al. suggested that telesurgery could be used to increase medical students’ surgical experience during COVID-19 despite sub-internships and in-person surgical participation limitations. Telementoring can also be used to provide physicians with clinical advice. This was used in the literature to guide community physicians through orthopedic fracture treatment and perimyscular hematoma management. Overall, most distance mentorship models centered around telesurgical telementoring.

Models seeking to improve clinical knowledge, but not centered around a specific patient were categorized as educational (N = 2, 1.5%). Project Extension for Community Healthcare Outcomes (ECHO), a didactic and discussion-based platform, was used to improve gynecologic oncology outcomes in Mozambique. A mentorship model that emphasized self-assessment and discussion was proposed by Agrawal, et al., aiming to enhance resident surgical education despite decreased surgical participation opportunities during COVID-19.

Only 1 publication (0.7%) utilized a research driven distance mentorship model. Through the Surgical Education Research Fellowship, trainees were paired with mentors in various locations based on common interest. Mentees optimized academic productivity without distance limitations.

Six publications (4.5%) implemented distance mentorship models for professional development. Guadix et al. surveyed medical students interested in neurosurgery and identified several concerns related to COVID-19, including a perceived loss of networking opportunities, clinical experiences, and decreased board scores. Several solutions were proposed with the highest rated among medical students being virtual mentorships and skills workshops. Farlow et al. discussed an experiential void that could diminish otolaryngology interested senior medical students’ chances of matching due to COVID-19 restrictions. They suggested that a 1-day virtual event with educational sessions, residency application advice, and opportunities to meet and form mentorship relationships with faculty and residents could be utilized to overcome this challenge. Moreno et al. cautioned against the potential for COVID-19 to diminish mentorship opportunities for underrepresented minority medical students and proposed a surgery department sponsored distance mentorship model through which minority medical students could seek career advice, increase their network, and research opportunity. Luc et al. demonstrated the utility of social media to broaden the female surgical mentorship network and the effectivity of its use. Weber and Khosravani, medical students interested in plastic surgery, used social media to gain a global network of plastic surgery mentors. Jaffer et al. presented surgical trainees with a virtual mentorship world centered, called MentorSL, which was well received. The scope of literature surrounding the professional distance mentorship model in surgery was limited, but its utility in compensating for COVID-19 related changes was recognized.

Distance Mentorship Participants: Students, Surgical Trainees, and Surgeons

The subjects of these distance mentorship models included all levels from students to fully trained surgeons. Mentors, being more experienced, were typically fully trained physicians, but surgical trainees, meaning residents and fellows, were used in 2 publications. Mentees were frequently fully trained but less experienced physicians (N = 59, 44%) (Fig. 6). Only 1 publication (0.7%) utilized a research driven distance mentorship model. Through the Surgical Education Research Fellowship, trainees were paired with mentors in various locations based on common interest. Mentees optimized academic productivity without distance limitations.

In other distance mentorship models, the mentees were students (N = 14, 10%), who either completed a telesurgical task or were interested in pursuing a surgical career. In remaining articles, mentees were of more than one of these forementioned categories, while some articles did not specify the training.
or career level of the mentee (N = 23, 17%). Subgroup populations included mentees internationally based, rural or community based, military affiliated, females, or affected by COVID-19, each of which needed to increase their mentorship network beyond their local community. International distance mentorship was a theme in 25 publications, utilized frequently in telementoring to decreasing cost and time required by mentee to gain a new skill and improve patient care in an underserved country.

Similarly, rural and community based physicians relied on distance mentorship to improve access to surgical specialist guidance. Military physicians utilized distance mentorship to rapidly provide trauma care in austere environments. Two distance mentorship models aimed to increase female- and minority mentorship. Several publications sought to increase educational and professional opportunity for students and trainees amidst COVID-19 via telementoring, virtual courses, and networking opportunities. Each subgroup focused on the lack of local available mentors and articulated the need to increase the quality of surgical care, knowledge, and professional guidance.

Outcomes, Benefits, and Support

The efficacy and safety of distance mentorship was discussed in literature by comparing distance-mentored groups to those with in-person mentoring and those with no mentoring. These studies primarily centered around telementoring. Telementored surgeons performed significantly higher on skill assessments than non-mentored groups and performed better on their own after telementored training. Ereso et al compared the performance of surgical residents using an Operative Performance Scale, with and without telementoring for 3 procedures. Residents scored significantly higher on overall performance with telementoring (4.30 +/- 0.25 versus 2.43 +/- 0.20; p < 0.001) and on individual metrics, including tissue and instrument handling, procedure speed, and anatomy knowledge were also superior (p < 0.001). Ladd et al. showed that with telementored guidance medical students could improve their identification of anatomic structures from a baseline of 50% ± 10% to 100%, could conduct a craniotomy with no prior procedural knowledge, and that a resident could successfully expose the anterior circulation for the first time. Okrainec et al. showed that telementored surgeons learning laparoscopic skills scored significantly higher on skill assessments (440 +/- 56 versus 272 +/- 95, p = 0.001) and were more likely to achieve a certification passing score on the laparoscopic simulator (p = 0.03) that those utilizing an instructional DVD.

Technology for Mentorship

Technology utilized in distance mentorship models varied based on the type of distance mentorship model discussed. Surgical telementoring models incorporated two-way audio and real-time video images, as well as telestration which the mentor could use to guide the mentee visually through the surgery. Other technology that could be controlled remotely by the mentor includes and electrocautery, laser pointers, ghost controls, and robotics like the Karl Storz Endoscopy-America, Inc. VisitOR1 (Karl Storz; Tuttingen, Germany) or the RemotePresence-7 robot (Intouch Health; Santa Barbara, Calif.) New virtual reality technology like the System for Telementoring with Augmented Reality (STAR), has been used to provide instruction within the mentee’s visual field while even newer technology, called the coaxial projective imaging system can be used to project 3D images. iPhones, tablets and small displays have also been incorporated into telementoring to increase convenience. Among these lines, apps have been used and developed to give on demand mentoring. Popular videoconferencing software includes Skype, NetMeeting, Google Hangout, and FaceTime. Social media has been utilized in professional distance mentorship models. The importance of this technology is that it can enhance the virtual presence and communication methods of the mentor in the remote environment.
Studies which compared distance mentorship with in-person mentorship also yielded favorable results. Telementored groups generally performed comparably or significantly higher on skills assessments. \(^\text{165}\) Vera et al. showed that telementored medical students using a virtual environment demonstrated faster laparoscopic suturing and knot-tying skill acquisition, faster procedure times (mean 167.4 versus 242.4 s, \(p = 0.014\)), and fewer failures than in-person mentored medical students.\(^\text{36}\) Robotic surgery trainees yielded similar skill assessment scores when telementored trainees were compared to in-person mentored trainees by Shin et al.\(^\text{59}\) Altieri et al. compared performance of in-person versus videoconference mentored electrosurgery course participants, finding no significant difference in exam scores immediately following the course or after 6 months.\(^\text{96}\) Panait et al. assessed laparoscopic skill acquisition of telementored and in-person mentored medical students, finding both improved on right- and left-hand path length and time for grasping, cutting, and suturing with no significant difference between groups.\(^\text{117}\) Only in 1 study did the telementored group have a lower performance. Students learning the FAST trauma assessment had lower scores in the Debriefing Assessment for Simulation in Healthcare Student Version Assessment if telementored, but showed a greater improvement from baseline than the in-person mentored group.\(^\text{89}\)

There was generally no increase risk to the patient or documented complications because of telementoring. Di Valentino et al. compared endovascular procedures performed by an experienced interventionalist (group A) to procedures performed by a telementored team with a mentor in the same hospital (group B) and with a mentor at a tertiary center (group C). There was no significant difference in duration, time in ICU, or mortality, but the hospital stay was longer for group A than group C.\(^\text{160}\) Fuertes-Guiró et al. showed that in laparoscopic bariatric surgery procedures, hospital stay and procedure time was shorter for telementored cases and the only complications (bleeding of surgical wounds, urological infection, and conversions) occurred in non-mentored cases.\(^\text{165}\) No significant difference in operative time and blood loss was found for robotic telementored versus in-person mentored procedures by Shin et al.\(^\text{59}\) Sawyer et al. demonstrated no significant difference for telementored versus in-person mentored operative time for laparoscopic cholecystectomy and no complications.\(^\text{14}\) Hira et al. identified no significant differences in operative times, complication rates, early continence status, and positive margin rate for telementored versus in-person mentored radical prostatectomy procedures.\(^\text{144}\) Mean operative times, blood loss, and postoperative morbidity for telementored laparoscopic adrenalectomies were comparable to standard outcomes for Bruschi et al.\(^\text{157}\) Several instances of open con

Publications that examined mentor and mentee outlook on distance mentorship showed overall positive support for this method, while those that investigated mentee perspective showed a perceived effectiveness.\(^\text{49,51,69,71,116,124,133,135,137,149,158}\) Interestingly, in a study that taught surgeons through both on-site and telementoring methods, on-site mentoring was evaluated as statistically superior to robotic telementoring with significantly more interaction of the mentee with the expert and perceived higher quality of teaching, but only if on-site mentoring was conducted \textit{prior to} telementoring and not if on-site mentoring was conducted \textit{after} telementoring.\(^\text{149}\) Generally, the use of distance mentorship was well received.

In the limited number of reports that discussed the effectiveness of distance mentorship outside of telementoring, there also seemed to be success. Distance mentorship of surgical researchers demonstrated successful mentor pairs with no significant difference found in program completion rate based on time zone differences, and found that mean distance between pairs who completed the program was greater than for pairs who did not complete the program, though not statistically significant.\(^\text{25}\) Social media was supported by female surgeons as a means of increasing access to female mentors and by medical students as a means of increasing their network in surgery.\(^\text{41,110}\)

### Disadvantages

Confidentiality is an important consideration for all forms of distance mentorship because electronics leave a digital footprint. In telementoring, the patient may be at risk of health information breach if proper measures are not taken to secure their information.\(^\text{65,91,128,161}\) Software that is free and easy to access, such as Skype, may also be the least confidential.\(^\text{128}\) Steps should be taken to securely share patient information if telementoring is utilized. This can be done with de-identification, phone calls, and password protection of devices.\(^\text{161}\) Even when mentorship is aimed towards professional development, mentees have rated the acknowledgement of confidentiality in exchanges as important.\(^\text{110}\)
Additional disadvantages to distance mentorship that are specific to telementoring include technologic glitches, liability issues, and decreased cost have led to a steady rise in the development of distance mentorship models in the surgical field suggests in-person mentorship, however the overall support for distance mentorship include a higher likelihood of technologic glitches and breached confidentiality when compared to in-person mentorship, however the overall support for distance mentorship models in the surgical field suggests these barriers can be overcome.

Although distance mentorship models may focus on professional, educational, or skill development, the current literature in surgery particularly focused on skill development through telementoring. Advancements in technology and decreased cost have led to a steady rise in publications since the mid-1990s. Since its development, novel techniques have been distributed globally through increased access to expert mentors. Despite this strong-suit, the surgical field lacks literature on the use of distance mentorship for professional development.

The suggested utility of distance mentorship models with a professional aim is that they can be used to increase mentorship of those with decreased local mentor options that fit their needs, including females and minorities. The issue of suboptimal access to mentorship targeting personal and professional growth has recently gained attention in the surgical field. Particular groups affected by this include trainees, females, and minorities in surgery. Several studies showed high rates of stress and burnout in surgical trainees, correlating with suboptimal mentorship. Female surgeons in training and early career often lack female mentorship, possibly due to a limited number of females in senior positions. Surgeons of racial and ethnic minorities have faced a similar challenge. We included 1 study which showed that that social media could increase access to female mentors in surgery, however future studies in surgery implementing this type of mentorship are needed. Without optimization of professional mentorship for these groups, their interest in the surgical field and academic careers may decline along with retention, productivity, and career trajectory.

The impact of the COVID-19 pandemic has heightened the risk of suboptimal mentorship in surgery amongst the previously discussed groups and additionally impacted medical students who have fewer opportunities to establish mentorship relationships in-person. New personal and professional challenges prompted by COVID-19 have made mentorship of trainees more important than ever to reduce fatigue and burnout. Additionally, medical students now have decreased face-to-face opportunities to develop mentorship relationships.

We demonstrated that in surgery, the largest peak of distance mentorship publications occurred in 2020, the year of COVID-19. Several publications in our findings proposed the utility of virtual mentorship models to compensate for COVID-19 related changes in training. Structured mentorship programs sponsored by the surgical department and opportunities to increase networking opportunities were commonly proposed, some of which included virtual conferences, skills workshops, webinars, research pairings, and social medial connectivity. It is plausible that COVID-19 has increased people’s comfort with virtual relationships, making distanced mentorship more convenient than ever. Refining distance mentorship models in light of COVID-19 and optimizing their effectiveness may be an effective way to improve mentorship in these groups.

Our review has a number of limitations. The studies selected typically were observational or had low numbers of subjects, thus may feature selection bias. The quality of research on this topic as a whole was lacking, with very few randomized control trials. We made the inclusion criteria broad, however, to incorporate recently published articles set during COVID-19 and to develop a comprehensive review. Several presumptions made during data collection had the potential to skew our findings. Our assumption that authors were from the United States. The peak year of publication was 2020. Over 93.3% focused on the use of telementoring and 56.0% were categorized as general surgery related. Mentorship pairs typically featured an expert surgeon matched with a fully trained, but less experienced surgeon. Overall, distance mentorship enhanced learning opportunities for mentees and did not seem to negatively impact performance. Disadvantages of distance mentorship include a higher likelihood of technologic glitches and breached confidentiality when compared to in-person mentorship, however the overall support for distance mentorship models in the surgical field suggests these barriers can be overcome.

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studies. Our choice to categorize unspecified surgical specialty publications into general surgery may have inflated this number; however, its high prevalence is consistent with other reviews on telementoring.\textsuperscript{200,201} Lastly, the level in training/career was not specified for some mentor-mentee pairs, having the potential to skew our distribution assessment; however, these were largely publications that spoke about telementoring broadly and not comparative studies.

**CONCLUSION**

Distance mentorship in the surgical field primarily takes the form of telementoring, which increases the mentee’s opportunities to enhance surgical skill. COVID-19 has increased personal and professional mentorship needs for students, trainees, recent graduates, females, and minorities. Future studies should propose distance mentorship models with this aim and test their efficacy so that mentorship in the surgical field can be optimized.

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**AUTHOR CONTRIBUTIONS**

Conceptualization LR, JJ; Data curation LR; Formal analysis LR, JJ; Methodology LR, JJ; Project administration JJ; Resources JJ; Supervision JJ; Writing original draft LR; Writing review & editing JJ.

**REFERENCES**

1. Barker JC, Rendon J, Janis JE. Medical student mentorship in plastic surgery: the mentee’s perspective. *Plast Reconstr Surg*. 2016;137:1934–1942.

2. Ramanadham SR, Rohrich RJ. Mentorship: a pathway to succeed in plastic surgery. *Plast Reconstr Surg*. 2019;143:353–355.

3. DeLong MR, Hughes DB, Tandon VJ, Choi BD, Zenn MR. Factors influencing fellowship selection, career trajectory, and academic productivity among plastic surgeons. *Plast Reconstr Surg*. 2014: 133.

4. Rudnicki PA, Liang F, Prince NH, Lipsitz S, May Jr JW, Guo L. What made them successful: An introspective survey of AAPS members. *Plast Reconstr Surg Glob Open*. 2015;3.

5. Sambunjak D, Straus SE, Marušić A. Mentoring in academic medicine: a systematic review. *Jama*. 2006;296:1103–1115.

6. Zetrenne E, Wirth GA, Kosins AM, Evans GR, Wells JH. Profiling the association of academic chairmen of plastic surgery. *Plast Reconstr Surg*. 2008;121:328e–332e.

7. Janis JE, Barker JC. Medical student mentorship in plastic surgery: the mentor’s perspective. *Plast Reconstr Surg*. 2016: 138.

8. Franzblau LE, Kotsis SV, Chung KC. Mentorship: concepts and application to plastic surgery training programs. *Plast Reconstr Surg*. 2013;131:837e–843e.

9. Odom EB, Janis JE, Gosain A, Barker JC, Buck DW 2nd. Education for the future: what the residents want. *Plast Reconstr Surg*. 2017;140:646e–647e.

10. Khansa I, Janis JE. A growing epidemic: plastic surgeons and burnout—a literature review. *Plast Reconstr Surg*. 2019;144:298e–305e.

11. Hart AM, Crowley C, Janis JE, Losken A. Survey based assessment of burnout rates among US plastic surgery residents. *Ann Plast Surg*. 2020;85:215–220.

12. Carrau D, Janis JE. Physician burnout: solutions for individuals and organizations. *Plast Reconstr Surg Glob Open*. 2021;9.

13. Rohrich RJ. Mentors in medicine. *Plast Reconstr Surg*. 2003;112:1087–1088.

14. Bierema LL, Merriam SB. E-mentoring: using computer mediated communication to enhance the mentoring process. *Innov High Educ*. 2002;26: 211–227.

15. Coates WC, Ankel F, Birnbaum A, Kosiak D, Broderick KB, Thomas S, et al. The virtual advisor program: linking students to mentors via the world wide web. *Acad Emerg Med*. 2004;11:255–255.

16. Kim Ej. Working effectively with long-distance mentors. *Int J Womens Dermatol*. 2020;6:68–69.

17. Kim CC, Kim Ej, Curiel-Lewandrowski C, Marks V, Maloney M, Frieden IJ. A model in dermatology for long-distance mentoring. *J Am Acad Dermatol*. 2013;68:860–862.

18. Macafee DA. Is there a role for mentoring in Surgical Specialty training? *Med Teach*. 2008;30:e55–e59.

19. Chong JY, Ching AH, Renganathan Y, Lim WQ, Toh YP, Mason S, et al. Enhancing mentoring...
experiences through e-mentoring: a systematic scoping review of e-mentoring programs between 2000 and 2017. *Adv Health Sci Educ Theory Pract.* 2020;25:195–226.

20. Harris R, Birk SB, Sherman J. E-mentoring for doctor of nursing practice students: a pilot program. *J Nurs Educ.* 2016;55:458–462.

21. Parsons L, Brennan J, Bowen D, Mahara MS, Crawford L, Gomez L. Sharing with the land of the dancing lights. *The Canadian Nurse.* 2005;101:22–25.

22. Welch S. Virtual Mentoring Program within an Online Doctoral Nursing Education Program: A Phenomenological Study. *Int J Nurs Educ Scholar.* 2017;14:20160049.

23. Kupfer DJ, Schatzberg AF, Dunn LO, Schneider AK, Moore TL, DeRosier M. Career development institute with enhanced mentoring: a revisit. *Acad Psychiatry.* 2016;40:424–428.

24. Sorkness CA, Pfund C, Ofili EO, Okuyemi KS, Vishwanath JK, Zavala ME, et al. A new approach to mentoring for research careers: the National Research Mentoring Network. *BMC Proc.* 2017;11:22.

25. Falcone JL, Croteau AJ, Schenarts KD. The role of gender and distance mentoring in the surgical education research fellowship. *J Surg Educ.* 2015;72:330–337.

26. Headlam-Wells J, Gosland J, Craig J. Beyond the organisation: The design and management of E-mentoring systems. *Int J Inf Manage.* 2006;26:372–385.

27. Schichtel M. Core-competence skills in e-mentoring for medical educators: a conceptual exploration. *Med Teach.* 2010;32:e248–e262.

28. Editorial. Long-distance relationships. *Nat Neurosci.* 2007;10:1223.

29. Edwards J-A. Mentorship of underrepresented minorities and women in surgery. *Am J Surg.* 2020.

30. Corsini EM, Boeck M, Hughes KA, Logghe HJ, Pitt SC, Stamp N, et al. Global Impact of Social Media on Women in Surgery. *Am Surg.* 2020;86:152–157.

31. Lewellen-Williams C, Johnson VA, Deloney LA, Thomas BR, Goyol A, Henry-Tillman R. The POD: a new model for mentoring underrepresented minority faculty. *Acad Med.* 2006;81:275–279.

32. Chong JY, Ching AH, Renganathan Y, Lim WQ, Toh YP, Mason S, et al. Enhancing mentoring experiences through e-mentoring: a systematic scoping review of e-mentoring programs between 2000 and 2017. *Advances in Health Sciences Education.* 2020;25:195–226.

33. Farlow JL, Marchiano EJ, Fischer IP, Moyer JS, Thorne MC, Bohn LA. Addressing the Impact of COVID-19 on the Residency Application Process Through a Virtual Subinternship. *Otolaryngol Head Neck Surg.* 2020;165:926–928.

34. Rafiq A, Moore JA, Doarn CR, Merrell RC. Asynchronous confirmation of anatomical landmarks by optical capture in open surgery. *Arch Surg.* 2003;138:792–795.

35. Andersen DS, Cabrera ME, Rojas-Muñoz EJ, Popescu VS, Gonzalez GT, Mullis B, et al. Augmented Reality Future Step Visualization for Robust Surgical Telementoring. *Simulation in Healthcare.* 2019;14:59–66.

36. Vera AM, Russo M, Mohsin A, Tsuda S. Augmented reality telementoring (ART) platform: a randomized controlled trial to assess the efficacy of a new surgical education technology. *Surg Endosc.* 2014;28:3467–3472.

37. Andersen D, Popescu V, Cabrera ME, Shanghavi A, Mullis B, Marley S, et al. An augmented reality-based approach for surgical telementoring in austere environments. *Military medicine.* 2017;182:310–315.

38. Andersen D, Popescu V, Cabrera ME, Shanghavi A, Gómez G, Marley S, et al. Avoiding Focus Shifts in Surgical Telementoring Using an Augmented Reality Transparent Display. *MMVR.* 2016;220:9–14.

39. Hashimoto DA, Phitayakorn R, Fernandez-del Castillo C, Meireles O. A blinded assessment of video quality in wearable technology for telementoring in open surgery: the Google Glass experience. *Surg Endosc.* 2016;30:372–378.

40. Foo JL, Martinez-Escobar M, Peloquin C, Lobe T, Winer E. A collaborative interaction and visualization multi-modal environment for surgical planning. *Stud Health Technol Inform.* 2009;142:30–30.

41. Weber L, Khosravani N. Connecting with the next generation: a medical student’s perspective on social media use and plastic surgery. *Plast Reconstr Surg.* 2018;142:247e–248e.

42. Rosser JC, Fleming JP, Legare TB, Choi KM, Naga-giri J, Griffith E. Design and development of a novel distance learning telementoring system using off-the-shelf materials and software. *Surg Technol Int.* 2017;31:41–49.
43. Rafiq A, Moore JA, Zhao X, Doarn CR, Merrell RC. Digital video capture and synchronous consultation in open surgery. *Ann Surg*. 2004;239:567–573.

44. Redleaf MI, Welling DB, Wackym PA. Expanded use of teleservices in otology and neurotology in response to the COVID-19 (SARS-Cov-2) pandemic. *Laryngoscope Investig Otolaryngol*. 2020;5:950–953.

45. Ladd BM, Tackla RD, Gupte A, Darrow D, Sorenson J, Zuccarello M, et al. Feasibility of Telementoring for Microneurosurgical Procedures Using a Microscope: A Proof-of-Concept Study. *World Neurosurg*. 2017;99:680–686.

46. Dort J, Trickey A, Paige J, Schwarz E, Dunkin B. Hands-on 2.0: improving transfer of training via the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) Acquisition of Data for Outcomes and Procedure Transfer (ADOPT) program. *Surg Endosc.* 2017;31:3326–3332.

47. Auzu O, Sen A, Ilan R, Shah N, Parker A, Blyden D, et al. HERalding new ringtones of patient safety: Blackberry-based clinical communication and telementoring in laparoscopic surgery. *AMIA Annu Symp Proc*. 2009;2009:23.

48. Richa R, Vágvölgyi B, Balicki M, Hager GD, Taylor RH. Hybrid tracking and mosaicking for information augmentation in retinal surgery. *Med Image Comput Comput Assist Interv.* 2012;15:397–404.

49. Rothenberg SS, Yoder S, Kay S, Ponsky T. Initial experience with surgical telementoring in pediatric laparoscopic surgery using remote presence technology. *J Laparoendosc Adv Surg Tech A*. 2009;19(Suppl 1):S219–S222.

50. Lee BR, Moore R. International telementoring: a feasible method of instruction. *World J Urol*. 2000;18:296–298.

51. Gandsas A, Draper K, Chekan E, Garcia-Oria M, McMahon RL, Clary EM, et al. Laparoscopy and the internet. A surgeon survey. *Surg Endosc*. 2001;15:1044–1048.

52. Ereso AQ, Garcia P, Tseng E, Gauger G, Kim H, Dua MM, et al. Live transference of surgical subspecialty skills using telerobotic proctoring to remote general surgeons. *J Am Coll Surg*. 2010;211:400–411.

53. Cubano M, Pouloue B, Talamini M, Stewart R, Antossek L, Lentz R, et al. Long distance telementoring. *Surgical endoscopy*. 1999;13:673–678.

54. Guadix SW, Winston GM, Chae JK, Haghdel A, Chen J, Younus I, et al. Medical Student Concerns Relating to Neurosurgery Education During COVID-19. *World Neurosurg.* 2020;139:e836–e847.

55. Andersen D, Popescu V, Cabrera ME, Shanghavi A, Gomez G, Marley S, et al. Medical telementoring using an augmented reality transparent display. *Surger*. 2016;159:1646–1653.

56. Moreno NA, Dimick JB, Newman EA. Mentorship strategies to foster inclusivity in surgery during a virtual era. *Am J Surg*. 2020;220:1536–1538.

57. Rosser JC Jr., Murayama M, Gabriel NH. Minimally invasive surgical training solutions for the twenty-first century. *Surg Clin North Am*. 2000;80:1607–1624.

58. Wood D. No surgeon should operate alone: how telementoring could change operations. *Telemed J E Health*. 2011;17:150–152.

59. Shin DH, Dalag L, Azhar RA, Santomauro M, Satkunasivam R, Metcalfe C, et al. A novel interface for the telementoring of robotic surgery. *BJU Int*. 2015;116:302–308.

60. Ibrahim AM, Varban OA, Dimick JB. Novel uses of video to accelerate the surgical learning curve. *J Laparoendosc Adv Surg Tech A*. 2016;26:240–242.

61. Dawson DL. On the practicality of emergency surgery during long-duration space missions. *Aviat Space Environ Med*. 2008;79:712–713.

62. Gandsas A, McIntire K, Montgomery K, Bumgardner C, Rice L. The personal digital assistant (PDA) as a tool for telementoring endoscopic procedures. *Stud Health Technol Inform*. 2004;98:99–103.

63. Darrow DP, Spano A, Grande A. The potential for undue patient exposure during the use of telementoring technology. *Cureus*. 2020;12:e7594.

64. Jarc AM, Stanley AA, Clifford T, Gill IS, Hung AJ. Proctors exploit three-dimensional ghost tools during clinical-like training scenarios: a preliminary study. *World J Urol*. 2017;35:957–965.

65. Abdulhai S, Glenn IC, McNinch NL, Craner D, Chou E, Ponsky TA. Public perception of telemedicine and surgical telementoring in the pediatric population: results of a parental survey. *J Laparoendosc Adv Surg Tech A*. 2018;28:215–217.

66. Camara JG, Rodriguez RE. Real-time telementoring in ophthalmology. *Telemed J*. 1998;4:375–377.
67. Agarwal R, Levinson AW, Allaf M, Makarov DV, Nason A, Su L-M. The RoboConsultant: telementoring and remote presence in the operating room during minimally invasive urologic surgeries using a novel mobile robotic interface. *Urology*. 2007;70:970–974.

68. Prince SW, Kang C, Simonelli J, Lee YH, Gerber MJ, Lim C, et al. A robotic system for telementoring and training in laparoscopic surgery. *Int J Med Robot*. 2020;16:e2040.

69. Glenn IC, Bruns NE, Hayek D, Hughes T, Ponsky TA. Rural surgeons would embrace surgical telementoring for help with difficult cases and acquisition of new skills. *Surg endos*. 2017;31:1264–1268.

70. Harris G, Berdusis K. Surgical telementoring across the Atlantic. *Telemed. Today*. 2000;8:23–24.

71. Rojas-Muñoz E, Cabrera ME, Lin C, Andersen D, Popescu V, Anderson K, et al. The System for Telementoring with Augmented Reality (STAR): A head-mounted display to improve surgical coaching and confidence in remote areas. *Surgery*. 2020;167:724–731.

72. Assad-Kottner C, Hakeem A, Fontenot E, Uretsky BF. "Tele-mentoring": an interventional procedure using a wearable computer: first-in-man. *J Am Coll Cardiol*. 2014;63:1022.

73. Senapati S, Advincula AP. Telemedicine and robotics: paving the way to the globalization of surgery. *Int J Gynaecol Obstet*. 2005;91:210–216.

74. Sawyer MA, Lim RB, Wong SY, Cirangle PT, Birkmire-Peters D. Telementored laparoscopic cholecystectomy: a pilot study. *Stud Health Technol Inform*. 2000;70:302–308.

75. Snyderman C. Telementoring at UPMC. Interview by Mark Hagland. *Healthc Inform*. 2012;29:32–34.

76. Rojas-Muñoz E, Cabrera ME, Lin C, Sánchez-Tamayo N, Andersen D, Popescu V, et al. Telementoring in Leg Fasciotomies via Mixed-Reality: Clinical Evaluation of the STAR Platform. *Mil Med*. 2020;185:513–520.

77. Moore RG, Adams JB, Partin AW, Docimo SG, Kavoussi LR. Telementoring of laparoscopic procedures: initial clinical experience. *Surg Endosc*. 1996;10:107–110.

78. Wachs JP, Gomez G. Telementoring systems in the operating room: a new approach in medical training. *Medicina (B Aires)*. 2015;73:539–542.

79. Treter S, Perrier N, Sosa JA, Roman S. Telementoring: a multi-institutional experience with the introduction of a novel surgical approach for adrenalectomy. *Ann Surg Oncol*. 2013;20:2754–2758.

80. Rosser JC Jr., Young SM, Klonsky J. Telementoring: an application whose time has come. *Surg Endosc*. 2007;21:1458–1463.

81. Rosser J Jr., Wood M, Payne J, Fullum T, Lisehora G, Rosser L, et al. Telementoring: pushing the telemedicine envelope. *J Assoc Acad Minor Phys*. 1997;8:11–15.

82. Ponce BA, Jennings JK, Clay TB, May MB, Huisingsh C, Sheppard ED. Telementoring: use of augmented reality in orthopaedic education: AAOS exhibit selection. *J Bone Joint Surg Am*. 2014;96:e84.

83. Camara JG, Zabala RA, Henson RD, Sheft SH. Teleophthalmology: the use of real-time telementoring to remove an orbital tumor. *Opthalmol. Imag*. 2000;107:1468–1471.

84. Kaufmann C, Rhee P, Burris D. Telepresence surgery system enhances medical student surgery training. *Stud Health Technol Inform*. 1999;62:174–178.

85. Poland S, Frey JA, Khoabrini A, Ondrejka JE, Ruhlin MU, George RL, et al. Telepresent Focused Assessment With Sonography for Trauma Examination Training Versus Traditional Training for Medical Students: A Simulation-Based Pilot Study. *Journal of Ultrasound in Medicine*. 2018;37:1985–1992.

86. Allen D, Bowersox J, Jones GG. Telesurgery. Telepresence. Telementoring. Telerobotics. *Telemed Today*. 1997;5:18–20. 25.

87. Ponsky TA, Bobanga ID, Schwachter M, Stathos TH, Rosen M, Parry R, et al. Transcontinental telementoring with pediatric surgeons: proof of concept and technical considerations. *J Laparoendosc Adv Surg Tech A*. 2014;24:892–896.

88. Sterbis JR, Hanly EJ, Herman BC, Marohn MR, Broderick TJ, Shih SP, et al. Transcontinental telesurgical nephrectomy using the da Vinci robot in a porcine model. *Urology*. 2008;71:971–975.

89. Marohn MR, Hanly EJ. Twenty-first century surgery using twenty-first century technology: surgical robotics. *Curr Surg*. 2004;61:466–473.

90. Drasin T, Dutilson E, Gracia C. Use of a robotic system as surgical first assistant in advanced laparoscopic surgery. *J Am Coll Surg*. 2004;199:368–373.
91. St Julien J, Perrier ND. Video telementoring to accelerate learning of new surgical techniques. JAMA Surg. 2016;151:671–672.
92. Shenai MB, Tubbs RS, Guthrie BL, Cohen-Gadol AA. Virtual interactive presence for real-time, long-distance surgical collaboration during complex microsurgical procedures. J Neurosurg. 2014;121:277–284.
93. Moore AM, Carter NH, Wagner JP, Filipi CJ, Chen DC. Web-Based Video Assessments of Operative Performance for Remote Telementoring. Surg Technol Int. 2017;30:25–30.
94. Parker A, Rubinfeld I, Azuh O, Blyden D, Falvo A, Horst M, et al. What ring tone should be used for patient safety? Early results with a Blackberry-based telementoring safety solution. Am J Surg. 2010;199:336–340. discussion 340–331.
95. Gandsas A, McIntire K, George IM, Witzke W, Hoskins JD. Park A. Wireless live streaming video of laparoscopic surgery: a bandwidth analysis for handheld computers. Stud Health Technol Inform. 2002;85:150–154.
96. Altieri MS, Carmichael H, Jones E, Robinson T, Pryor A, Madani A. Educational value of telementoring for a simulation-based fundamental use of surgical energy™ (FUSE) curriculum: a randomized controlled trial in surgical trainees. Surg Endosc. 2020;34:3650–3655.
97. Amparore D, Claps F, Cacciamani GE, Esperto F, Fiori C, Liguori G, et al. Impact of the COVID-19 pandemic on urology residency training in Italy. Minerva Urol Nefrol. 2020;72:505–509.
98. Bogen EM, Schlachta CM, Ponsky T. White paper: technology for surgical telementoring—SAGES Project 6 Technology Working Group. Surg Endosc. 2019;33:684–690.
99. Bove P, Stoianovici D, Micali S, Patriciu A, Grassi N, Jarrett TW, et al. Is telesurgery a new reality? Our experience with laparoscopic and percutaneous procedures. J Endourol. 2003;17:137–142.
100. Bruns NE, Irtan S, Rothenberg SS, Bogen EM, Kotobi H, Ponsky TA. Trans-atlantic telementoring with pediatric surgeons: technical considerations and lessons learned. J Laparoendosc Adv Surg Tech A. 2016;26:75–78.
101. Challacombe B, Kandaswamy R, Dasgupta P, Mamode N. Telementoring facilitates independent hand-assisted laparoscopic living donor nephrectomy. Transplant Proc. 2005;37:613–616.
102. Datta N, MacQueen IT, Schroeder AD, Wilson JJ, Espinoza JC, Wagner JP, et al. Wearable technology for global surgical telementoring. Journal of Surgical Education. 2015;72:1290–1295.
103. Forgione A, Kislov V, Guraya SY, Kasakevich E, Pugliese R. Safe introduction of laparoscopic colorectal surgery even in remote areas of the world: the value of a comprehensive telementoring training program. J Laparoendosc Adv Surg Tech. 2015;25:37–42.
104. Gambadauro P, Magos A. NEST (network enhanced surgical training): a PC-based system for telementoring in gynaecological surgery. Eur J Obstet Gynecol Reprod Biol. 2008;139:222–225.
105. Kirkpatrick AW, Blaivas M, Sargsyan AE, McBeth PB, Patel C, Xiao Z, et al. Enabling the mission through trans-atlantic remote mentored musculoskeletal ultrasound: case report of a portable hand-carried tele-ultrasound system for medical relief missions. Telemed J E Health. 2013;19:530–534.
106. Kirkpatrick AW, Hamilton D, Beckett A, LaPorta A, Brien S, Glassberg E, et al. The need for a robust 24/7 subspecialty “clearing house” response for telementored trauma care. Can J Surg. 2015;58:S85–S87.
107. Lee BR, Bishoff JT, Janetschek G, Bunyaratavej P, Kamolpronwijit W, Cadeddu JA, et al. A novel method of surgical instruction: international telementoring. World journal of urology. 1998;16:367–370.
108. Lee BR, Cadeddu JA, Janetschek G, Schulam P, Docimo SG, Moore RG, et al. International surgical telementoring: our initial experience. Stud Health Technol Inform. 1998;50:41–47.
109. Liu P, Li C, Xiao C, Zhang Z, Ma J, Gao J, et al. A Wearable Augmented Reality Navigation System for Surgical Telementoring Based on Microsoft Hololens. Ann Biomed Eng. 2021;49:287–298.
110. Luc JGY, Stamp NL, Antonoff MB. Social media as a means of networking and mentorship: role for women in cardiothoracic surgery. Semin Thorac Cardiovasc Surg. 2018;30:487–495.
111. Menkis AH, Kodera K, Kiaii B, Swinamer SA, Rayman R, Boyd WD. Robotic surgery, the first 100 cases: where do we go from here? Heart Surg Forum. 2004;7:1–4.
112. Micali S, Virgili G, Vannozzi E, Grassi N, Jarrett T, Bauer J, et al. Feasibility of telementoring between Baltimore (USA) and Rome (Italy): the first five cases. Journal of endourology. 2000;14:493–496.
113. Miller JA, Kwon DS, Dkeidek A, Yew M, Hisham Abdullah A, Walz MK, et al. Safe introduction of a new surgical technique: remote telementoring for posterior retroperitoneoscopic adrenalectomy. *ANZ J Surg*. 2012;82:813–816.

114. Moretti-Marques R, Salcedo MP, Callegaro Filho D, Lopes A, Vieira M, Fontes Cintra G, et al. Telementoring in gynecologic oncology training: changing lives in Mozambique. *Int J Gynecol Cancer*. 2020;30:150–151.

115. Neary PC, Boyle E, Delaney CP, Senagore AJ, Keane FB, Gallagher AG. Construct validation of a novel hybrid virtual-reality simulator for training and assessing laparoscopic colectomy; results from the first course for experienced senior laparoscopic surgeons. *Surg Endosc*. 2008;22:2301–2309.

116. Nguyen NT, Okrainec A, Anvari M, Smith B, Meieres O, Gee D, et al. Sleeve gastrectomy telementoring: a SAGES multi-institutional quality improvement initiative. *Surg Endosc*. 2018;32:682–687.

117. Panait L, Rafiq A, Tomulescu V, et al. Telementoring versus on-site mentoring in virtual reality-based surgical training. *Surg Endosc*. 2006;20:113–118.

118. Quezada J, Achurra P, Jarry C, Asbun D, Tejos R, Inzunza M, et al. Minimally invasive tele-mentoring opportunity—the mito project. *Surg Endosc*. 2020;34:2585–2592.

119. Rodas E, Vicuna A, Rodas EB. Telemedicine and mobile surgery in extreme conditions: the Ecuadorean experience. *Stud Health Technol Inform*. 2004;104:168–177.

120. Rodrigues Netto Jr N, Mitre AI, Lima SVC, Fugita OE, Lopes Lima M, Stoianovici D, et al. Telementoring between Brazil and the United States: initial experience. *Journal of endourology*. 2003;17:217–220.

121. Rosser JC Jr., Bell RL, Harnett B, Rodas E, Murayama M, Merrell R. Use of mobile low-bandwith telemedical techniques for extreme telemedicine applications. *J Am Coll Surg*. 1999;189:397–404.

122. Schlacht CM, Lefebvre KL, Sorsdal AK, Jayaraman S. Mentoring and telementoring leads to effective incorporation of laparoscopic colon surgery. *Surg endosc*. 2010;24:841–844.

123. Schlacht CM, Nguyen NT, Ponsky T, Dunkin B. Project 6 Summit: SAGES telementoring initiative. *Surg Endosc*. 2016;30:3665–3672.

124. Snyderman CH, Gardner PA, Lanisnik B, Ravnik J. Surgical telementoring: a new model for surgical training. *Laryngoscope*. 2016;126:1334–1338.

125. Talbot M, Harvey E, Berry G, Reindl R, Tien H, Stinner D, et al. A pilot study of surgical telementoring for lcg fasciotomy. *BMJ Military Health*. 2018;164:83–86.

126. Zhang F, Zhu X, Gao J, Wu B, Liu P, Shao P, et al. Coaxial projective imaging system for surgical navigation and telementoring. *J Biomed Opt*. 2019;24:1–9.

127. Durst L. The Centre for Minimal Access Surgery—teaching for tomorrow. *J Telemed Telecare*. 2000;6(2):S14–S15. Suppl.

128. Guo Y, Henao O, Jackson T, Quereshy F, Okrainec A. Commercial videoconferencing for use in telementoring laparoscopic surgery. *Stud Health Technol Inform*. 2014;196:147–149.

129. Anvari M, Durst L. Development of a new telementoring program. *Hosp Q*. 2000;3:26–30.

130. Gagliardi AR, Wright FC. Exploratory evaluation of surgical skills mentorship program design and outcomes. *J Contin Educ Health Prof*. 2010;30:51–56.

131. Schlacht CM, Kent SA, Lefebvre KL, McCune ML, Jayaraman S. A model for longitudinal mentoring and telementoring of laparoscopic colon surgery. *Surg endosc*. 2009;23:1654–1658.

132. Choy I, Fecso A, Kwong J, Jackson T, Okrainec A. Remote evaluation of laparoscopic performance using the global operative assessment of laparoscopic skills. *Surg Endosc*. 2013;27:378–383.

133. Mendez I, Hill R, Clarke D, Kolyvas G, Walling S. Robotic long-distance telementoring in neurosurgery. *Neurosurgery*. 2005;56:434–440.

134. Sebajang H, Trudeau P, Dougall A, Hegge S, McKinley C, Anvari M. The role of telementoring and telerobotic assistance in the provision of laparoscopic colorectal surgery in rural areas. *Surg Endosc*. 2006;20:1389–1393.

135. Dawe P, Kirkpatrick A, Talbot M, Beckett A, Garraway N, Wong H, et al. Tele-mentored damage-control and emergency trauma surgery: A feasibility study using live-tissue models. *Am J Surg*. 2018;215:927–929.

136. Park JP, Montreuil J, Nooh A, Martineau PA. Telemedicine-guided forearm emergency decompressive fasciotomy for compartment syndrome. *J
137. Sebajang H, Trudeau P, Dougall A, Hegge S, McKinley C, Anvari M. Telementoring: an important enabling tool for the community surgeon. *Surg Innov*. 2005;12:327–331.

138. Okrainec A, Henao O, Azzie G. Telesimulation: an effective method for teaching the fundamentals of laparoscopic surgery in resource-restricted countries. *Surg Endosc*. 2010;24:417–422.

139. Anvari M. Telesurgery: remote knowledge translation in clinical surgery. *World J Surg*. 2007;31:1545–1550.

140. Antoniou SA, Antoniou GA. Surgical telementoring as a means to disseminate vascular expertise around the world. *J Endovasc Ther*. 2017;24:859–860.

141. Jaffer U, John NW, Standfield N. Surgical trainee opinions in the United Kingdom regarding a three-dimensional virtual mentoring environment (MentorSL) in second life: pilot study. *JMIR Serious Games*. 2013;1:e2.

142. Byrne JP, Mughal MM. Telementoring as an adjunct to training and competence-based assessment in laparoscopic cholecystectomy. *Surg Endosc*. 2000;14:1159–1161.

143. Ho DK. Using smartphone-delivered stereoscopic vision in microsurgery: a feasibility study. *Eye (Lond)*. 2019;33:953–956.

144. Hinata N, Miyake H, Kurahashi T, Ando M, Furukawa J, Ishimura T, et al. Novel telementoring system for robot-assisted radical prostatectomy: impact on the learning curve. *Urology*. 2014;83:1088–1092.

145. Mizota T, Kurashima Y, Poudel S, Watanabe Y, Shichinohe T, Hirano S. Step-by-step training in basic laparoscopic skills using two-way web conferencing software for remote coaching: A multicenter randomized controlled study. *Am J Surg*. 2018;216:88–92.

146. Mitsuno D, Hirota Y, Akamatsu J, Kino H, Okamoto T, Ueda K. Telementoring demonstration in craniofacial surgery with hololens, skype, and three-layer facial models. *J Craniofac Surg*. 2019;30:28–32.

147. Taniguchi E, Ohashi S. Construction of a regional telementoring network for endoscopic surgery in Japan. *IEEE Trans Inf Technol Biomed*. 2000;4:195–199.

148. Malassagne B, Mutter D, Leroy J, Smith M, Soler L, Marescaux J. Teleeducation in surgery: European Institute for Telesurgery experience. *World J Surg*. 2001;25:1490–1494.

149. Sereno S, Mutter D, Dallemagne B, Smith CD, Marescaux J. Telementoring for minimally invasive surgical training by wireless robot. *Surg Innov*. 2007;14:184–191.

150. Marescaux J, Soler L, Leroy J, Vix M, Kochl C, et al. Virtual university applied to telesurgery: from teleeducation to telementration. *Studies in health technology and informatics*. 2000;70:195–201.

151. Agrawal V, Yadav SK, Agarwal P, Sharma D. “GRASP” module of self-assessment with virtual mentoring for uninterrupted surgical training during COVID-19 pandemic. *Indian J Surg*. 2020:1–2.

152. Pradeep P, Mishra S, Vaidyanathan S, Nair CG, Ramalingam K, Basnet R. Telementoring in endocrine surgery: preliminary Indian experience. *Telemed J E Health*. 2006;12:73–77.

153. Singh S, Sharma V, Patel P, Anuragi G, Sharma RG. Telementoring: an overview and our preliminary experience in the setting up of a cost-effective telementoring facility. *Indian J Surg*. 2016;78:70–73.

154. Budrionis A, Hasvold P, Hartzvigen G, Bellika JG. Assessing the impact of telestration on surgical telementoring: A randomized controlled trial. *J Telemed Telecare*. 2016;22:12–17.

155. Andrccassen HK, Warth LL. The Impact of Telementoring. *Stud Health Technol Inform*. 2018;255:127–131.

156. Budrionis A, Hartzvigen G, Lindsetmo RO, Bellika JG. What device should be used for telementoring? Randomized controlled trial. *Int J Med Inform*. 2015;84:715–723.

157. Bruschi M, Micali S, Porpiglia F, Celia A, De Stefani S, Grande M, et al. Laparoscopic telementored adrenalectomy: the Italian experience. *Surg Endosc*. 2005;19:836–840.

158. Tel A, Bortuzzo F, Fascolo P, Costa F, Sembronio S, Bresadola V, et al. Maxillofacial Surgery 5.0: a new paradigm in teledistance for distance surgery, remote assistance and webinar. *Minerva stomatologica*. 2020.

159. Porretta AP, Alerci M, Wytenbach R, Antonucci F, Cattaneo M, Bogen M, et al. Long-term outcomes of a telementoring program for distant teaching of
160. Di Valentino M, Alerci M, Bogen M, Tutta P, Sartori F, Marty B, et al. Telementoring during endovascular treatment of abdominal aortic aneurysms: a prospective study. *J Endovasc Ther.* 2005;12:200–205.

161. Kauta NJ, Groenewald J, Arnolds D, Blankson B, Omar A, Naidu P, et al. WhatsApp Mobile Health Platform to Support Fracture Management by Non-Specialists in South Africa. *J Am Coll Surg.* 2020;230:37–42.

162. Scemann R, Guevara G, Undt G, Ewers R, Schicho K. Clinical evaluation of tele-endoscopy using UMTS cellphones. *Surg Endosc.* 2010;24:2855–2859.

163. Fuertes-Guiró F, Vitali-Erion E, Rodriguez-Franco A. A program of telementoring in laparoscopic bariatric surgery. *Minim Invasive Ther Allied Technol.* 2016;25:8–14.

164. Challacombe B, Wheatstone S. Telementoring and Telerobotics in Urological Surgery. *Curr Urol Rep.* 2010;11:22–28.

165. Budrionis A, Hasvold P, Hartvigsen G, Bellika JG. Assessing the impact of telestration on surgical telementoring: A randomized controlled trial. *J Telemed Telecare.* 2016;22:12–17.

166. Andersen D, Popescu V, Cabrera ME, Shanghavi A, Mullis B, Marley S, et al. Avoiding Focus Shifts in Surgical Telementoring Using An Augmented Reality Transparent Display. *Stud Health Technol Inform.* 2016;220:9–14.

167. Tel A, Bortuzzo F, Pascolo P, Costa F, Sembroni S, Bresadola V, et al. Maxillofacial Surgery 5.0: a new paradigm in telemedicine for distance surgery, remote assistance, and webinars. *Minerva Stomatol.* 2020;69:191–202.

168. Chalacombe B, Wheatstone S. Telementoring and Telerobotics in Urological Surgery. *Curr Urol Rep.* 2010;11:22–28.

169. Andersen D, Popescu V, Cabrera ME, Shanghavi A, Mullis B, Marley S, et al. An Augmented Reality-Based Approach for Surgical Telementoring in Austere Environments. *Mil Med.* 2017;182:310–315.

170. Vera AM, Russo M, Mohsin A, Tsuda S. Augmented reality telementoring (ART) platform: a randomized controlled trial to assess the efficacy of a new surgical education technology. *Surg Endosc.* 2014;28:3467–3472.

171. Augestad KM, Bellika JG, Budrionis A, Chomutare T, Lindsetmo R-O, Patel H, et al. Surgical telementoring in knowledge translation—clinical outcomes and educational benefits: a comprehensive review. *Surgical innovation.* 2013;20:273–281.

172. Daar DA, Abdou SA, Wilson SC, Hazen A, Saadeh PB. A call to action for male surgeons in the wake of the #metoo movement: mentor female surgeons. *Ann Surg.* 2019;270:26–28.

173. Blood EA, Ullrich NJ, Hirshfeld-Becker DR, Seely EW, Connelly MT, Warfield CA, et al. Academic women faculty: are they finding the mentoring they need? *J Female Health Care.* 2012;21:1201–1208.

174. Butkus R, Serchen J, Moyer DV, Bornstein SS, Hingle ST. Achieving gender equity in physician compensation and career advancement: a position paper of the American College of Physicians. *Ann Intern Med.* 2018;168:721–723.

175. Luc JGY, Stamp NL, Antonoff MB. Social media in the mentorship and networking of physicians: Important role for women in surgical specialties. *Am J Surg.* 2018;215:752–760.
181. Stephens EH, Heisler CA, Temkin SM, Miller P. The current status of women in surgery: how to affect the future. JAMA surgery. 2020;155:876–885.

182. Bucknor A, Kamali P, Phillips N, Mathijssen I, Rakhorst H, Lin SJ, et al. Gender Inequality for Women in Plastic Surgery: A Systematic Scoping Review. Plast Reconstr Surg. 2018;141:1561–1577.

183. Capek L, Edwards DE, Mackinnon SE. Plastic surgeons: a gender comparison. Plast Reconstr Surg. 1997;99:289–299.

184. Roberts SE, Nehemiah A, Butler PD, Terhune K, Aarons CB. Mentoring residents underrepresented in medicine: strategies to ensure success. J Surg Educ. 2020.

185. Fell M, Staruch R, Baker BG, Nicholas R, Howes R. Plastic surgery training in the UK: Results from a national survey of trainee experiences. JPRAS Open. 2020;25:72–82.

186. Khajuria A. Modern plastic surgical practice: technical competence alone is not enough. World J Plast Surg. 2020;9:119–127.

187. Sinclair P, Fitzgerald JE, Hornby ST, Shalhoub J. Mentorship in surgical training: current status and a needs assessment for future mentoring programs in surgery. World J Surg. 2015;39:303–313.

188. Hernandez JA, Mullens CL. Paging all academic plastic surgeons: a call to action for medical student mentorship. Plast Reconstr Surg. 2019;143:1132e–1133e.

189. Roberts SE, Shea JA, Sellers M, Butler PD, Kelz RR. Pursing a career in academic surgery among African American medical students. Am J Surg. 2020;219:598–603.

190. Burgos CM, Josephson A. Gender differences in the learning and teaching of surgery: a literature review. Int J Med Educ. 2014;5:110.

191. Butkus R, Serchen J, Moyer D, Bornstein S, Hingle S. Health and public policy committee of the american college of physicians. achieving gender equity in physician compensation and career advancement: a position paper of the american college of physicians. Ann Intern Med. 2018;168:721–723.

192. Gotian R. Mentoring during the COVID-19 pandemic. Nature. 2020. https://doi.org/10.1038/d41586-020-01028-x. Epub ahead of print.

193. Rastegar Kazerooni A, Amini M, Tabari P, Moosavi M. Peer mentoring for medical students during the COVID-19 pandemic via a social media platform. Med Educ. 2020;54:762–763.

194. Rodoni BM, Eyrich NW, Fessell DP. COVID-19 & the Residency Match: The Added Importance of Mentoring. Ann Surg. 2020;272:e151–e152.

195. Badawy L, Oza P, Shankarghatta R, Merli E. Social network dynamics throughout clinical training - distance matters. Med Educ. 2020.

196. Woitowich NC, Jain S, Arora VM, Joffe H. COVID-19 threatens progress toward gender equity within academic medicine. Academic Medicine. 2020. https://doi.org/10.1097/ACM.0000000000003782.

197. Moreno NA, Dimick JB, Newman EA. Mentorship strategies to foster inclusivity in surgery during a virtual era. Am J Surg. 2020;220:1536–1538.

198. Antonoff MB. Commentary: Mentoring trainees when the going gets tough. J Thorac Cardiovasc Surg. 2020;160:1131–1132.

199. Boskovski MT, Hirji SA, Brescia AA, Chang AC, Kaneko T. Enhancing thoracic surgical trainee competence in the coronavirus disease 2019 (COVID-19) era: Challenges and opportunities for mentorship. J Thorac Cardiovasc Surg. 2020;160:1126–1129.

200. Augestad KM, Bellika JG, Budrionis A, Chomutare T, Lindsetmo RO, Patel H, et al. Surgical telementoring in knowledge translation-clinical outcomes and educational benefits: a comprehensive review. Surg Innov. 2013;20:273–281.

201. Huang EY, Knight S, Guetter CR, Davis CH, Moller M, Slama E, et al. Telemedicine and telementoring in the surgical specialties: a narrative review. The American Journal of Surgery. 2019;218:760–766.