Review Article

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Educational Effectiveness of Telementoring as a Continuing Professional Development Intervention for Surgeons in Practice

A Systematic Review

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Objective: We performed a systematic review to determine the educational effectiveness of telementoring as a continuing professional development (CPD) intervention for surgeons in practice.

Background: Surgeons can mentor their peers in remote locations using videoconferencing communication, referred to as telementoring.

Methods: We searched MEDLINE and EMBASE and included studies assessing the educational effectiveness of telementoring interventions used by surgeons in practice. We excluded studies involving only trainees and those not evaluating educational effectiveness. Two reviewers independently screened, extracted data, and assessed study quality using the Medical Education Research Study Quality Instrument (MERSQI; maximum score 18). Educational outcomes were categorized using Moore's Outcomes Framework.

Results: We retrieved a total of 1351 records, and 252 studies were selected for full-text review. Twenty-eight studies were included with 1 randomized controlled trial, 19 cohort studies, 5 qualitative studies, and 3 case studies, totaling 178 surgeons and 499 cases. The average MERSQI score was 10.21 ± 2.2 out of 18. Educational outcomes included surgeons' satisfaction with telementoring interventions (Moore's Level 2) in 12 studies, improvement in surgeons' procedural knowledge (Level 3b) in 3 studies, improvements in surgeons' procedural competence in an educational setting (Level 4) in 4 studies, performance in a workplace-based setting (Level 5) in 23 studies, and patient outcomes (Level 6) in 3 studies. No studies reported community health outcomes (Level 7).

Conclusions: Moderate-level evidence demonstrates the use of telementoring as effective in changing surgeons' knowledge and competence in both educational and workplace-based settings. Its use is also associated with changes in patient outcomes.

Keywords: attending surgeons, continuing professional development, CPD, distance learning, E-coaching, electronic learning, practicing surgeons, remote learning, telementoring

INTRODUCTION

With the constant growth of new technologies and advancements in surgical techniques, surgeons frequently seek additional training while in practice. This is often carried out by participating in continuing professional development (CPD) activities that aim to address learning gaps and lead to the development of new content knowledge, technical and nontechnical skills, and competencies.[1] The documentation of attendance at CPD activities has historically been sufficient to demonstrate learning for certification and credentialing purposes.[2] However, such passive learning is known to be generally ineffective at changing physician behavior in practice,[3] which is necessary for improvements in patient health status and outcomes. Moore's Expanded Outcomes Framework[4] was developed for planning and evaluating the impact of CPD educational activities. Specifically, it recommends the evaluation of CPD activities that go beyond passive learning, such as attendance, participant satisfaction, and changes in knowledge, to also include changes in workplace-based performance and changes to the health of patients and communities.[4]

According to the Society of American Gastrointestinal and Endoscopic Surgeons, surgical telementoring is defined as a relationship in which an expert provides guidance to a less experienced learner from a remote location facilitated by telecommunication technology.[5,6] Advantages of telementoring include its usefulness for training in highly specialized fields, reduced time detracted from the expert surgeon's practice in the absence of travel, and its ability to deliver training in rural and international communities.[5,7] Surgical coaching, defined as a one-on-one coach-coachee relationship, is a different type of CPD intervention that has been used to address higher-level educational outcomes on Moore's framework by helping to identify performance gaps, offer individualized feedback, and provide ongoing mentorship.[8,9] Surgical coaching requires an

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established coach-coachee relationship, which can be resource- and time-intensive. Telementoring is less resource-intensive, does not require an established relationship between surgeons, and can be used for one or many operative cases. With ongoing advancements in telecommunication technology over the last decade, it is important to evaluate the educational effectiveness of telementoring educational interventions before their widespread adoption.

Previous systematic reviews have examined the use of telementoring in surgeons. A 2017 systematic review compared the effectiveness of telementoring to onsite mentoring interventions in the trainee and surgeon population and organized outcomes based on a modified Kirkpatrick Model.[10] The review reported 4 studies with mentor-mentee satisfaction, 1 study reporting increased learning, and no studies reporting evidence related to behavior change or patient outcomes.[10] Studies without an onsite mentoring comparison group were excluded; however, this is not always practical for practicing surgeons, in particular, with mentorships between rural and international surgeons. A separate systematic review published in 2019, with literature searched up to July 2017, reviewed the technological capabilities of telementoring systems in addition to the clinical outcomes and educational benefits of telementoring for surgeons.[11] Included studies were all observational in nature and contained feasibility studies and studies with trainees.[11] Moreover, the field of telementoring has grown substantially, with several experimental studies published since 2017 that detail the experiences of surgeons with telementoring and currently available technology. Additionally, educational outcomes from this review were not examined using an established educational framework. A 2020 systematic review assessed if surgical coaching could serve as a method for the advancement of surgical skills in low- or middle-income countries (LMIC).[12] The review examined both trainees and practicing surgeons, with only 6 studies exclusively examining the remote delivery of surgical coaching.[12] Included studies from this review discussed skill acquisition for both technical and nontechnical skills, and no studies evaluated changes in patient outcomes or examined coaching in LMICs.[12]

The objective of our study was to conduct a systematic review to examine the educational effectiveness of telementoring as a continuing professional development intervention for surgeons in practice.

METHODS

Data Sources and Search

Three researchers (R.D.F., E.W., and K.C.) carried out the literature search under the guidance of a health sciences librarian. We adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guidelines[3] and registered our protocol with PROSPERO (ID: CRD42022333523). We searched EMBASE, MEDLINE, MEDLINE Daily, and Epub ahead of print from January 1, 1946 to August 4, 2022. Search terms included both medical subject headers and keywords relating to surgeons as the population and telementoring as the educational or CPD intervention. Search terms relating to surgeons as the population were "surgeon," "community surgeons," "surgery," "surgical technique," "surgical procedures," "general surgery," or "orthopedic/ transplant/ pediatric/ cardiac/ trauma/ plastic/ thoracic/ vascular surgeon." Search terms relating to education included "surgical training," "medical education," "surgical education," "continuing education/medical education/professional development," "continuous medical education," or "educational technology." Search terms relating to telementoring were "telemedicine," "telesurgery," "telesimulation," "telecommunication," "telementoring," "tele-education," "teleoperation," "telestration," "e-coach," or "teleproctoring," (Supplemental Table S1, http://links.lww.com/AOSO/A265 for the full search strategy). We applied language limitations to English. We also searched the gray literature, conference proceedings, published dissertations, and the reference lists of the reviewed full-text articles.

Inclusion and Exclusion Criteria

We included studies that (1) described a telementoring CPD intervention delivered remotely, (2) involved surgeons in practice as the population of interest, including mixed populations studies with separate data reported for surgeons in practice, and (3) evaluated the educational effectiveness of that telementoring intervention and reported outcomes at Level 2 or higher on Moore's Expanded Outcomes Framework (as outlined below).[4] We excluded studies that (1) were not original research studies (eg, commentaries, letters, and reviews); (2) did not study surgeons in practice (eg, residents and medical students as the only study participants); (3) did not evaluate educational outcomes [eg, only reported technical outcomes or participants' participation (Moore's Level 1 as outlined below)]; or (4) involved any in-person component between the mentor and mentee (eg, in-person coaching, observations, or the installation of technical equipment).

Conceptual Framework and Outcomes Definition

We used Moore's Expanded Outcomes Framework for planning and assessing learning in continuing education activities[4] to categorize the educational outcomes of each described telementoring intervention. Moore's Expanded Outcomes Framework and our process of systematic categorization of learning outcomes are described in Supplemental Table S2, http://links.lww.com/AOSO/A265. Moore's framework has 7 levels, with Level 1 (L1)—measuring participants' participation in the educational intervention; L2—measuring participants' satisfaction with the intervention; L3A—measuring participants' declarative knowledge; L3B—measuring participants' procedural knowledge; L4—measuring participants' competence in an educational setting; L5—measuring participants' performance in practice/workplace; L6—measuring a change in health status of patients; and L7—measuring a change in the health status of a community (Supplemental Table S2, http://links.lww.com/AOSO/A265). Telementoring was defined as guidance by expert surgeons to other surgeons from a remote location facilitated by videoconferencing communication.[5]

Selection of Studies

We imported identified citations into Covidence software. Each title and abstract were reviewed by 2 independent reviewers (either R.D.F., A.G., F.S.M., E.W., or K.C.) to determine if they met inclusion criteria. Two independent reviewers (either R.D.F., A.G., or F.S.M.) then performed a full-text review of the included articles. Any disagreements at any of the stages were resolved by a third reviewer during a consensus meeting with an opportunity for discussion among reviewers. Inter-rater agreement between reviewers was calculated for each stage of the screening process using Cohen's kappa coefficient.

Data Extraction and Quality Assessment

Data extraction from each study was performed independently by 2 reviewers (either R.D.F., A.G., or F.S.M.). The following data were extracted: study design, number and demographics of study participants, number and types of cases, description of the CPD telementoring intervention, description of the technical equipment used, educational outcomes measured, and the type of assessment tools used to measure the educational outcomes.

The methodological quality of each study was assessed independently by two reviewers (either R.D.F., A.G., or F.S.M.) using the Medical Education Research Study Quality Instrument (MERSQI)[14] (Supplemental Table S3, http://links.lww.com/

AOSO/A265). The MERSQI is a 10-item instrument (minimum score of 5 and maximum score of 18) specifically developed to evaluate the methodological quality of educational studies by evaluating the type of study design, type of data collected, validity of the evaluation instrument, data analysis, outcomes measured, and the number of sampling institutions and sampling response rates. Sampling institutions were scored based on the origin of mentees receiving the telementoring intervention. The sampling response rate was defined as the proportion of survey responders for survey studies and the proportion of surgeons with outcomes data in cohort studies. Any disagreements between reviewers were again resolved by a third independent reviewer during a consensus meeting.

RESULTS

Study Characteristics

Our search of MEDLINE and EMBASE yielded 1347 abstracts, and 96 duplicates were removed. A total of 1255 records were screened for titles and abstracts, and 249 were deemed eligible for full-text review. Of these, 116 were not original research studies (commentaries, letters, and reviews), 16 were conference abstracts, 43 did not have surgeons in practice as the study population, 27 did not report educational outcomes, and 22 had a supplementary in-person component to the telementoring intervention. The inter-rater agreement was moderate for title and abstract screening across reviewers [range 84.3%–85.2% (Cohen's kappa = 0.585–0.636)] and moderate to very strong agreement for full-text review across reviewers [range 92.3%–94.1% (Cohen's kappa = 0.570–0.755)]. Four additional studies were identified from reference lists and were added to the screening process. In total, 28 studies satisfied the inclusion and exclusion criteria of this review. Figure 1 shows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guidelines flow diagram for study selection. Table 1 summarizes the evidence and Supplemental Table S4, http://links.lww.com/AOSO/A265 details the characteristics of all included studies.

A total of 178 surgeons in 21 studies participated in telementoring interventions.[6,15,17–28,34–36,38–41] Seven studies did not report the number of surgeons that participated.[16,29–33,37] A total of 499 cases were completed, with 348 of these cases performed under the telementoring intervention. Telementoring was delivered internationally in 11 studies,[6,15,17,18,22,23,28,30,35,36,40] nationally in 12 studies,[16,19,21,24–26,29,33,34,38,39,41] locally (within the same city or hospital) in 4 studies,[20,27,32,37] and from the mainland to a ship in 1 study.[31] Telementoring was used in various surgical specialties, including urology,[27–30,32,34–36,40] pediatric surgery,[15,18,24,41] general surgery,[19,25,31] vascular surgery,[16] ophthalmology,[17] bariatric surgery,[22,33] trauma surgery,[20] neurosurgery,[21] obstetrics and gynecology,[23] endoscopy,[38] endocrine surgery,[39] and colorectal surgery.[26] Surgeons who participated as mentees were less experienced and/or performed fewer procedures for which they were being mentored than the mentor surgeons. They often practiced in a rural or remote community site and/or were not previously formally trained in a surgical technique or procedure they were learning through telementoring. Only 1 out of 28 studies reported surgeons' motivation to participate in the telementoring intervention.[15] This motivation was to improve their skills. Additionally, only 1 out of 28 studies specified whether participants were financially compensated, and participants in this study were not financially compensated.[22] No studies reported administrative mandates or other motivating factors for participation in telementoring interventions.

Telementoring Interventions

Technology to implement telementoring involved two-way audio communication and a video component in all 28 studies (Supplemental Table S4, http://links.lww.com/AOSO/A265). Telementoring during minimally invasive surgery (MIS) involved video communication of the MIS laparoscope or endoscope view and an external view of the operating room in 18 (64.3%) studies.[4,15,21,22,24–33,35,36,38,40,41] Seventeen (60.7%) MIS studies and 1 (3.6%) simulated open study reported the use of telestration to enable drawing on video or pictures to highlight relevant anatomy. Ten (35.7%) studies allowed remote control of either the laparoscope or endoscope position, laparoscopic robot, and/or electrocautery during the procedure. Eight (28.6%) studies combined the telementoring intervention with remote didactic material and/or virtual meetings for presurgical planning and ongoing management.[6,18,19,22,23,25,26,33]

Risk-of-Bias Assessment of Study Quality

The MERSQI score for each included study is detailed in Table 2. The average MERSQI score of included studies was 10.21 ± 2.2 (mean ± SD) with the range between 7 and 14.5 out of 18. Eight out of 28 (29%) studies compared a group of surgeons who received telementoring to a group of surgeons who received in-person mentoring, to a group of surgeons who were not mentored, or to a group of surgeons with combinations of telementoring interventions such as telementoring with telesurgery. The remaining 20 out of 28 (71%) studies involved a single group or a single surgeon undergoing the telementoring intervention. While there were 10 multicenter studies, the majority of studies (18/28) included participant surgeons from a single institution. All studies reported outcomes for a minimum of 75% of surgeons who received the telementoring intervention. Sixteen out of 28 (57%) studies reported objective outcome data, such as estimated blood loss or operative time, while 12 out of 28 (43%) studies only reported subjective assessments by surgeons, such as self-reported skills gained or described complications. Three studies used evaluation instruments with validity evidence to measure educational outcomes, including a survey based on the American Association for the Surgery of Trauma) scaling system,[20] Global Operative Assessment of Laparoscopic Skills (GOALS),[18] and Fundamental Laparoscopic Skills certification.[6] In terms of data analysis, 8/28 studies performed statistical inferences beyond descriptive analyses, and all data analyses were deemed appropriate (Table 2).

Educational Outcomes of Telementoring Interventions

The educational outcomes for Moore's Levels 2 and 3 were assessed using surveys or qualitative reports from study participants, for Level 4 using expert evaluators and tests with valid evidence, and for Levels 5 and 6 using patient health records or clinical observation by participants. The educational outcomes of telementoring interventions are summarized in Table 1 and detailed in Supplemental Table S4, http://links.lww.com/AOSO/A265.

Moore's Level 2—Surgeons' satisfaction with telementoring interventions

Twelve studies reported surgeons' satisfaction with telementoring interventions (Moore's Level 2) (Table 1 and Supplemental Table S4, http://links.lww.com/AOSO/A265). Telementoring provided comfort, reassurance, and assistance during pediatric surgery and advanced laparoscopic general surgery cases[15,24,26] and was reported to be useful by surgeons.[21,23,25,26] Surgeons reported satisfaction with telementoring with respect to its efficiency of transmission, safety while performing the procedure, and teaching so that anatomy was easily identified.[17] Most participating surgeons agreed that telementoring exceeded or

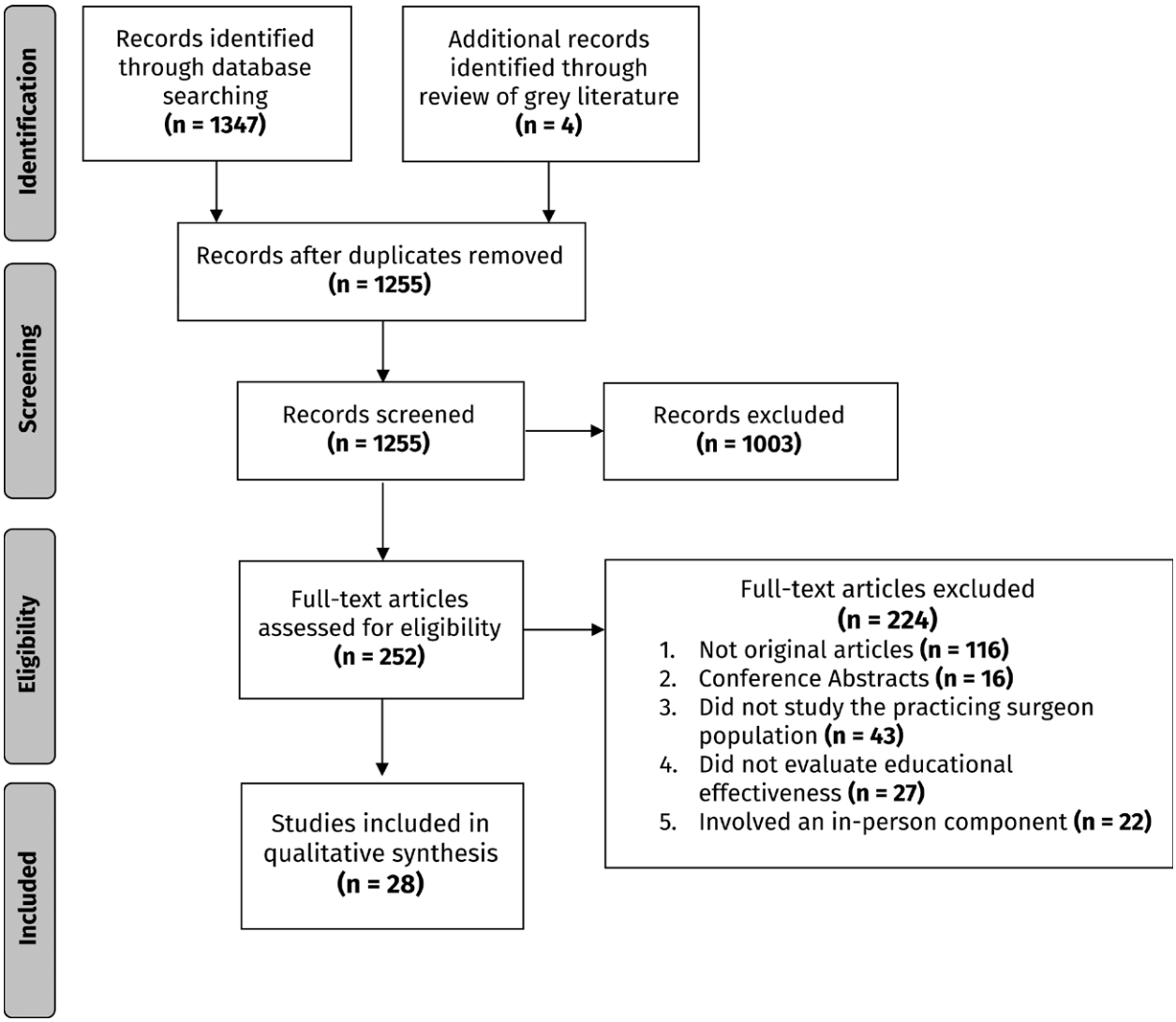

FIGURE 1. PRISMA[13] flow diagram for study selection.

met their expectations[22] and they would recommend it to their colleagues.[17–19,23]

One study evaluated the satisfaction of an at-home CPD telementoring program combined with structured remote learning.[19] The Hernia@Home program by Society of American Gastrointestinal and Endoscopic Surgeons involved remote telementoring instruction combined with didactic virtual lectures and videos, virtual meetings for goal setting, and monthly webinars for 1 year. Porcine model kits were delivered to surgeons who received telementoring by expert surgeons. All participating surgeons found the telementoring course valuable, and conducive to their professional development and would recommend it to a colleague.[19]

In comparison studies, vascular surgeons reported that telementoring during endovascular aortic graft procedures was as good as or better than live support.[16] Ninety-eight percent of pediatric surgeons reported that they would achieve the same objectives as traditional training in the development of MIS skills.[18] Additionally, all trauma surgeons in 1 study agreed that having access to a remote expert through telementoring is beneficial and more effective than an intraoperative consultation by telephone.[20] The reasons for dissatisfaction with telementoring included internet connectivity issues and overcrowding in the operating room, leading to obstructed vision during open trauma surgeries.[20]

Moore's Level 3—Declarative and Procedural Knowledge

Three studies reported improvements in procedural knowledge (Level 3B) (Table 1 and Supplemental Table S4, http://links.lww.com/AOSO/A265). A qualitative study of pediatric surgeons receiving MIS training via telementoring reported that it was helpful for identifying anatomy and providing strategies to facilitate the procedure.[15] Nieto et al[23] reported a reduction in the difficulty of gynecological surgery to avoid a hysterectomy in patients with placenta accreta after telementoring and virtual meetings with an expert.[23] Bariatric surgeons reported an increase in confidence and quality of surgery after receiving telementoring.[22]

Moore's Level 4—Procedural Competence in an Educational Setting

Four studies evaluated surgeons' procedural competence in an educational setting (Level 4) (Table 1 and Supplemental Table S4, http://links.lww.com/AOSO/A265). Telementoring delivered to corneal ophthalmologists led to the successful transplantation of a novel keratoprosthesis in all cases using a cadaver model.[17] Telementors wore a virtual reality headset that live-streamed video from a 3D microscope used by ophthalmologists. Likewise, all cases of telementored laparoscopic nephrectomy in

TABLE 1.

Summary of Evidence

Educational Outcome by Moore's Expanded Outcomes Framework[4]	Number of Studies Assessing Educational Outcomes		Number of Studies in each Specialty	Number of Study Types
Level 2—Surgeons' satisfaction with telementoring interventions	12 Studies: Bruns et al., 2016[15] Deaton et al., 1999[16] Din et al., 2022[17] Falcioni et al., 2022[18] Greenberg et al., 2021[19] Marttos et al., 2012[20]	Mendez et al., 2005[21] Nguyen et al., 2018[22] Nieto-Calvache et al., 2022[23] Ponsky et al., 2014[24] Sebajang et al., 2005[25] Sebajang et al., 2006[26]	5 General surgery 1 Pediatric surgery 1 Bariatric surgery 1 Trauma surgery 1 Vascular surgery 1 Ophthalmology 1 Neurosurgery 1 Obstetrics and Gynecology	8 Cohort studies 4 Qualitative studies
Level 3—(A) declarative knowledge and (B) procedural knowledge	3 Studies: Bruns et al., 2016[15] Nieto-Calvache et al., 2022[23] Nguyen et al., 2018[22]		1 Pediatric surgery 1 Obstetrics and Gynecology 1 Bariatric surgery	2 Cohort studies 1 Qualitative study
Level 4—Procedural competence in an educational setting.	4 Studies: Din et al., 2022[17] Falcioni et al., 2022[18] Kavoussi et al., 1994[27] Okrainec et al., 2010[6]		2 General surgery 1 Ophthalmology 1 Urology	4 Cohort studies
Level 5—Competence in a workplace/practice setting	23 Studies: Bove et al., 2003[28] Bruns et al., 2016[15] Bruschi et al., 2005[29] Challacombe et al., 2005[30] Cubano et al., 1999[31] Deaton et al., 1999[16] Docimo et al., 1997[32] Fuertes-Guiro et al., 2016[33] Hinata et al., 2014[34] Kavoussi et al., 1994[27] Lee et al., 1998[35] Mendez et al., 2005[21]	Micali et al., 2000[36] Moore et al., 1996[37] Nguyen et al., 2018[22] Nieto-Calvache et al., 2022[23] Påhlsson et al., 2013[38] Ponsky et al., 2014[24] Pradeep et al., 2006[39] Rodrigues Netto N Jr et al., 2003[40] Rothenberg et al., 2009[41] Sebajang et al., 2005[25] Sebajang et al., 2006[26]	10 Urology 2 General surgery 3 Pediatric surgery 2 Bariatric surgery 1 Colorectal surgery 1 Endoscopy 1 Vascular surgery 1 Neurosurgery 1 Obstetrics and Gynecology 1 ENT - Endocrine surgery	1 RCT 16 Cohort studies 3 Qualitative studies 3 Case studies
Level 6—Patient outcomes	3 Studies: Hinata et al., 2014[34] Sebajang et al., 2005[25] Nieto-Calvache et al., 2022[23]		1 Urology 1 General surgery 1 Obstetrics & Gynecology	3 Cohort studies
Level 7—Outcomes on community health	0 Studies		No studies	No studies

a porcine model were performed successfully, defined as the lack of complications.[27]

Two studies evaluated the delivery of telementored laparoscopic simulation training.[6,18] There were significant improvements in laparoscopic skills compared with baseline[18] and compared to a self-practice group.[6] Specifically, virtual didactic resources combined with 2 telementored sessions resulted in improvements in stereotaxic skills and intracorporeal circle pattern cutting for precision.[18] Telementoring from Canada to Botswana over 8 weeks led to Fundamental Laparoscopic Skills certification of all (8/8) surgeons in the telementored group, compared with 37.5% (3/8) of surgeons in the self-practice group.[6]

Moore's Level 5–Competence in a Workplace/Practice Setting

Twenty-three out of 28 studies evaluated the educational outcomes of telementoring in a workplace/practice setting (Level 5) (Table 1 and Supplemental Table S4, http://links.lww.com/AOSO/A265). Twenty studies delivered telementoring during MIS procedures, and 3 studies delivered telementoring for open procedures. Of the 20 studies describing telementoring in MIS, 18 investigated laparoscopic surgeries, 10 of which were urologic procedures,[4,27–30,32,34–36,40] and 8 of which were advanced general subspecialty procedures.[15,22,24–26,31,33,41] The remaining 2 studies in MIS evaluated telementoring in endovascular surgery[16] and diagnostic endoscopy.[38]

Of the 10 studies evaluating telementoring interventions for urologic procedures, there were 153 telementored patient cases. One hundred and forty-four out of 153 (94.1%) of telementored cases were completed successfully and/or reported no intraoperative complications or differences in parameters compared with in-person mentoring, such as operative time, estimated blood loss, blood transfusion, complication rate, surgical margins, and/or postoperative recovery.[29,30,32,34,37,40] Seven out of 153 (4.6%) cases were considered telementoring failures due to connection or hardware issues.[28,36,37] Two out of 153 (1.3%) cases were converted to open due to intraoperative complications.[28]

TABLE 2.

The Medical Education Research Study Quality Instrument (MERSQI) Score[14] for Included Studies

Study no.	Source	Study Design Score/3	Sampling: Institution/1.5	Sampling: Response Rate/1.5	Type of Data/3	Validity Evidence for Evaluation Instrument Scores/3	Data Analysis: Sophistica-tion/2	Data Analysis: Appropriate/1	Outcome/3	MERSQI Score/18
1	Bove et al., 2003[28]	1	0.5	1.5	1	0	1	0	2	7
2	Bruns et al., 2016[15]	1	0.5	1.5	1	0	1	1	2	8
3	Bruschi et al., 2005[29]	1	0.5	1.5	3	0	1	1	2	10
4	Challacombe et al., 2005[30]	2	0.5	1.5	3	0	2	1	2	12
5	Cubano et al., 1999[31]	2	0.5	1.5	1	0	1	1	2	9
6	Deaton et al., 1999[16]	2	0.5	1.5	3	0	2	1	2	12
7	Din et al., 2022[17]	1	0.5	1.5	1	0	1	1	1.5	7.5
8	Docimo et al., 1997[32]	1	0.5	1.5	3	0	2	1	2	11
9	Falcioni et al., 2022[18]	1.5	1.5	1.5	3	3	2	1	1.5	15
10	Fuertes-Guiro et al., 2016[33]	3	1.5	1.5	3	0	2	1	1.5	13.5
11	Greenberg et al., 2021[19]	1	1.5	1.5	1	0	1	1	1.5	8.5
12	Hinata et al., 2014[34]	2	1	1.5	3	0	2	1	1.5	12
13	Kavoussi et al., 1994[27]	1	0.5	1.5	3	0	1	1	1.5	9.5
14	Lee et al., 1998[35]	1	1	1.5	1	0	1	1	2	8.5
15	Marttos et al., 2012[20]	1.5	0.5	1.5	3	3	1	1	2	13.5
16	Mendez et al., 2005[21]	1	0.5	1.5	1	0	1	1	2	8
17	Micali et al., 2000[36]	1	0.5	1.5	1	0	1	1	2	8
18	Moore et al., 1996[37]	2	1	1.5	3	0	2	1	2	12.5
19	Nguyen et al., 2018[22]	1	1.5	1.5	1	0	1	1	2	9
20	Nieto-Calvache et al., 2022[23]	1	1.5	1.5	1	0	1	1	2	9
21	Okrainec et al., 2010[6]	2	0.5	1.5	3	3	2	1	1.5	14.5
22	Påhlsson et al., 2013[38]	1	0.5	1.5	1	0	1	1	2	8
23	Ponsky et al., 2014[24]	1	0.5	1.5	3	0	1	1	2	10
24	Pradeep et al., 2006[39]	1	0.5	1.5	1	0	1	1	2	8
25	Rodrigues Netto N Jr et al., 2003[40]	1	0.5	1.5	3	0	1	1	2	10
26	Rothenberg et al., 2009[41]	1	0.5	1.5	3	0	1	1	2	10
27	Sebajang et al., 2005[25]	1	1	1.5	3	0	1	1	2	10.5
28	Sebajang et al., 2006[26]	2	1	1.5	3	0	1	1	2	11.5

Of the eight studies evaluating telementoring interventions for subspecialties of general surgery, 3 studies involved pediatric surgeries,[15,24,41] 2 studies described general and advanced laparoscopic surgeries,[25,31] 2 studies involved bariatric surgeries,[22,33] and 1 study included colorectal surgeries,[26] totaling 96 telementored cases. In studies with no comparator group, all 76 telementored patient cases were performed successfully and were described as having no intraoperative or postoperative complications.[25,28,30,36,38,40,41] One randomized controlled trial (RCT) by Fuertes-Guiro[33] delivered telementoring during bariatric surgery in 20 patient cases, which led to shorter operative time, shorter postoperative stay, and less postoperative complications compared with 16 patient cases performed by surgeons receiving no telementoring.[32] In 2 cohort studies delivering telementoring during advanced general surgery procedures, 4 telementored cases required conversion from MIS to open surgery.[25,41] The 4 cases involved anterior resections for rectal prolapse and carcinoma and were converted due to the mentee's inability to find appropriate planes of dissection despite guidance from the mentor.[25,41]

Additionally, telementoring during endoscopic retrograde cholangiopancreatography facilitated successful common bile duct canulation in 26 patient cases.[38] Local endoscopists scored telementoring as crucial for the successful outcome in 8/26, important in a further eight cases, and less important in the remaining 10 cases. In endovascular surgery, operative times and clinical courses were equivalent between patient cases with telementoring and in-person mentoring for aortic grafts in the management of abdominal aortic aneurysms.[16]

Three studies delivered telementoring for open procedures performed by neurosurgeons (craniotomies, carotid endarterectomy, and lumbar laminectomy),[21] obstetricians and gynecologists (one-step conservative surgery for patients with placenta accrete spectrum),[23] and endocrine general surgeons (exploratory parathyroid adenoma resection).[39] All 13 open surgeries were performed uneventfully, and telementoring was noted to contribute to their outcomes.

After receiving the telementoring intervention, 1 study reported that the participating surgeon was able to perform thymectomies independently months after,[15] and another study reported that the operating surgeon independently operated on 31 living donor nephrectomy cases.[30]

Moore's Level 6—Patient Outcomes

Three studies reported long-term health outcomes of patients (Level 6) after surgery with a telementoring intervention (Table 1 and Supplemental Table S4, http://links.lww.com/AOSO/A265).[23,25,34] In a study evaluating telementoring in robot-assisted radical prostatectomy, there were no rectal injuries and no deaths during follow-up.[34] With the use of telementoring to instruct one-step conservative surgery in patients with placenta accreta spectrum, hysterectomy was avoided in all 6 cases that would have otherwise been performed.[23] A negative outcome occurred in 1 study, in which 1 patient with a Hartmann reversal under telementoring was subsequently readmitted with a small bowel obstruction requiring reoperation.[25]

Moore's Level 7—Outcomes on Community Health

No studies reported outcomes for this level.

DISCUSSION

In this systematic review, we identified 28 studies with 178 surgeons in practice that examined the learning outcomes and educational effectiveness of telementoring CPD educational interventions. Telementoring was delivered in a variety of forms, including internationally, nationally, locally, and from the mainland to a ship. We described the use of telementoring CPD interventions across various surgical specialties. Most notably, we demonstrated that participation in telementoring was associated with changes in Moore's Levels 2 to 6 learning outcomes, with paucity of literature evaluating changes to the health of the community (Level 7). Based on the critical appraisal of the included studies using the MERSQI score, the overall methodological quality of the studies was moderate, with most studies involving a single group undergoing a telementoring intervention, approximately a third of studies having a comparator group for the telementoring intervention, and there was only 1 RCT.

Overall, surgeons in practice reported high satisfaction with telementoring CPD interventions in both educational and practice-based settings, with improvements in Moore's Level 2 outcomes. Previous reviews reported similar findings of generally positive experiences with telementoring among surgeons and trainees,[42] as well as positive attitudes towards in-person coaching among surgeons in both technical and nontechnical skills training.[43] Developing a positive attitude toward an educational intervention has been noted as an initial step toward an effective CPD program.[4] Yet, only 1 study directly stated that the participating surgeons' motivation to participate was to improve their skills.[15] Since practicing surgeons' motivation to learn is expected to have an impact on the effectiveness of the CPD program and the eventual transfer of acquired skills into practice, future studies should clearly report surgeons' reasons for participating in telementoring interventions.

The framework by Merrill et al.[44] is an approach for developing CPD activities to address physician learning of Moore's Levels 3 and higher and includes the following components: presentation, demonstration/example, practice, feedback, and reinforcement.[4,44] Presentation methods are useful for conveying declarative knowledge, and demonstration/example methods are useful for procedural knowledge, Level 3A and 3B outcomes, respectively.[4] Studies in our review used demonstration methods via telementoring interventions with the use of telestration and telesurgery to demonstrate procedural knowledge during surgery training. Surgeons subsequently developed confidence in identifying anatomy and strategies to perform procedures, associated with improved Level 3B outcomes.

Practice and feedback are essential for improvements in Level 4 outcomes, in which surgeons practice their skills in a setting that resembles their practice and receive feedback to develop competence before implementing their skills in practice.[4,44] Our study demonstrates improvements in Moore's Level 4 outcomes using laparoscopic simulation training, cadaver models, and animal models. Similarly, an RCT in medical students investigating the effectiveness of in-person surgical coaching on simulated laparoscopic cholecystectomies found improvements in procedural knowledge.[45] Feedback and reinforcement are critical for improvements in Level 5 outcomes, in which surgeons receive ongoing feedback and reinforce what they have learned during patient encounters.[4,44] In our review, telementoring was delivered to practicing surgeons during MIS and open procedures, and over 95% of telementored cases were completed successfully or reported no intraoperative complications or differences in operative parameters compared with in-person mentoring (Level 5). Comparable operative outcomes were noted in a study comparing telementoring with onsite mentoring.[10]

Most studies in our review (20/23) assessed Level 5 outcomes during minimally invasive surgery, likely due to the ease of video capture and transmission. While 23/28 studies in our review examined learning outcomes in a workplace setting, only 2 studies[15,30] reported on surgeons' ability to independently perform the surgical procedures after the telementoring intervention, and 1 other study[38] evaluated endoscopists' decreasing dependency on telementoring overtime. Because most studies (21/23) involved surgeons who simultaneously received the

telementoring interventions at the same time they were being assessed on their learning outcomes, there is limited evidence to support the transfer of competence acquired during telementoring interventions into surgeons' independent practice. Previous studies have evaluated long-term coaching in surgery trainees and demonstrated improvements in procedural skills compared with conventional residency training.[46–48] An RCT evaluated a structured, in-person surgical coaching program comprised of opportunities for performance analysis, debriefing, feedback, and behavior modeling in trainees performing a jejunojejunostomy.[46] Conventional learning was defined as teaching in the operating room, attending scheduled teaching sessions, and looking after patients on the ward.[46] The coaching program involved performance analysis with the use of video recording playbacks, debriefing, feedback, and behavior modeling.[46] After 2 months, trainees developed significantly higher procedure-specific skills and fewer technical errors compared with participants in a conventional learning group without coaching.[46] Future studies should assess surgeons' competence in practice to demonstrate the transfer of skills acquired during a telementoring intervention (Level 5).

The use of telementoring for CPD activities has been implemented successfully in specialties outside of surgery. One nationwide example includes project extension for community healthcare outcomes,[49] a telementoring network designed for CPD among primary care physicians specifically aimed at improving patient outcomes. This project has demonstrated the ability to fulfill all 7 levels of Moore's expanded outcomes framework using weekly condition-specific videoconferencing sessions among specialists and primary care clinicians in the United States and globally, including Canada and Ireland. This project was designed based on Moore's framework and national reports that include broad recommendations for redesigning CPD to improve healthcare.[49] Several recommendations were developed as a result of this project that aligns with the results of our study, including the need to address relevance to practice, an emphasis on flexibility and easy accessibility, personalized learning, and support from interprofessional collaboration.

In the design of a remote surgical coaching curriculum for CPD activities, the use of established frameworks can be considered along with the findings from our review. Previous studies in surgical coaching have evaluated the Problem identification, Realistic goals, Alternative solutions, Consideration of consequences, Target feasible solutions, Implementation of Chosen solutions, and Evaluation framework,[46] Goal, Reality, Options, Will framework,[50] and Wisconsin Surgical Coaching Rubric[51] and have developed a set of criteria for coaching. These models all generally include the concepts of goal setting, performance review, individualized feedback, and ongoing support and reassessment. In our review, only 8/28 studies reported opportunities for goal setting, performance review, and feedback outside of the telementored cases. Additionally, less than half (12/28) of the included studies involved 10 or more cases and/or a long-term coach-coachee relationship to provide ongoing support and reassessment, which are important for meaningful changes to surgeons' practice. The absence of long-term follow-up data for most telementoring interventions may reflect the challenge of implementing this type of educational intervention in practice.

Future studies in telementoring can aim to incorporate concepts from Moore's Expanded Outcomes Framework, Merrill's Framework, and the Wisconsin Surgical Coaching Rubric.[51] Demonstration with the use of telestration and other visual aids can help surgeons with their Level 3B outcomes. Practice and feedback in an educational setting can be incorporated using cadavers or simulation models to develop Level 4 outcomes. Additionally, these components, combined with goal setting, performance reviews, and feedback in a long-term coaching relationship, can help optimize surgeons learning and establish changes to their practice.

According to the 2015 Lancet Global Health Commission assessment of global surgery,[52] the human and economic consequences of untreated surgical conditions in LMICs are large and have gone unrecognized. The reasons for unmet needs were attributed to lack of access to safe and affordable surgical care, inadequate surgical resources, low specialist surgical workforce density, and poor sustainability of care.[52,53] A systematic review of in-person educational initiatives explored if surgical coaching could serve as an effective method of continuing education and advancement of surgical skills in low-resource settings; however, the search failed to identify any studies discussing or evaluating coaching in LMICs.[12] In our review, we identified 4 studies that successfully delivered telementoring internationally to surgeons practicing in LMICs with improvements in Moore's Levels 2, 3B, 4, 5, and 6 outcomes.[6,18,22,23] Future research should investigate the use of telementoring CPD interventions to help address the need for an increased workforce density of specialist surgeons in LMICs.

Limitations

First, most studies in this systematic review involved a single-group analysis of surgeons undergoing the telementoring intervention. The paucity of RCTs with a comparator group limits our ability to make causal inferences regarding the effectiveness of telementoring interventions. Our work creates a starting point/needs assessment for further higher-quality studies. Second, the systematic review is limited by the heterogeneity between the cases of surgeries performed, the methodologies used, the assessments made, and the study outcomes reported in the included studies as is unfortunately inherent in surgical education.

CONCLUSION

Our study demonstrated that telementoring CPD interventions for surgeons in practice are associated with high participant satisfaction (Moore's Level 2), improvements in procedural knowledge (Level 3), and improvements in skill acquisition and procedural competence in an educational setting (Level 4). Additionally, we demonstrated evidence for short-term improvements in surgeons' practice (Level 5) and subsequent impacts on patient health (Level 6). Future studies should examine higher-level educational outcomes of telementoring CPD interventions, the transferability of competencies acquired during telementoring into independent practice, and the impact of telementoring on the training of surgeons in LMICs. Future studies should include RCTs to develop evidence for the use of telementoring in the education of surgeons in practice.

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