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Evaluating the use of telemedicine in gynaecological practice: a systematic review

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ABSTRACT

Objectives The aim of this systematic review is to examine the use of telemedicine in the delivery and teaching of gynaecological clinical practice. To our knowledge, no other systematic review has assessed this broad topic.

Design Systematic review of all studies investigating the use of telemedicine in the provision of gynaecological care and education. The search for eligible studies followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and focused on three online databases: PubMed, Science Direct and SciFinder.

Eligibility criteria Only studies within gynaecology were considered for this review. Studies covering only obstetrics and with minimal information on gynaecology, or clinical medicine in general were excluded. All English language, peer-reviewed human studies were included. Relevant studies published up to the date of final submission of this review were considered with no restrictions to the publication year.

Data extractions and synthesis Data extracted included author details, year of publication and country of the study, study aim, sample size, methodology, sample characteristics, outcome measures and a summary of findings. Data extraction and qualitative assessment were performed by the first author and crossed checked by the second author. Quality assessment for each study was assessed using the Newcastle-Ottawa scale.

Results A literature search carried out in August 2020 yielded 313 records published between 1992 and 2018. Following a rigorous selection process, only 39 studies were included for this review published between 2000 and 2018. Of these, 19 assessed gynaecological clinical practice, eight assessed gynaecological education, one both, and 11 investigated the feasibility of telemedicine within gynaecological practice. 19 studies were classified as good, 12 fair and eight poor using the Newcastle-Ottawa scale. Telecolposcopy and abortion care were two areas where telemedicine was found to be effective in potentially speeding up diagnosis as well as providing patients with a wide range of management options. Studies focusing on education demonstrated that telementoring could improve teaching in a range of scenarios such as live surgery and international teleconferencing.

Conclusions The results of this review are promising and demonstrate that telemedicine has a role to play in improving clinical effectiveness and education within gynaecology. Its applications have been shown to be safe and effective in providing remote care and training. In the future, randomised controlled studies involving larger numbers of patients and operators with measurable outcomes are required in order to be able to draw reliable conclusions.

Strengths and limitations of this study

- ► The review addresses the delivery of gynaecological clinical care and education remotely (telemedicine), a topic of immense importance as we are undergoing a period of global pandemic.
- ► To our knowledge, no other systematic review has assessed this broad topic.
- ► Large proportion of studies were observational in nature, without clear quantitative outcomes for statistical analysis.

INTRODUCTION

Moving into the 21st century, the exponential development of technology is driving change in the teaching and practice of gynaecology.[1] The potential to reach a wider audience via targeted cost-effective innovation is almost inevitable, with an avenue opening up to improve access to healthcare and patient outcomes.[2] Telemedicine (TM) can be defined as 'the use of medical information exchanged from one site to another via electronic communications to improve a patient's clinical health status'.[3] It can be used for clinical care directly and as a method of educating trainees.

Within gynaecology, advocates of TM stress its potential role to aid diagnosis, treatment, follow-up and long-term care. Inadequate access to overall medical care has been reported as being related to a range of factors including

poverty, the requirement of health insurance, geographic isolation from healthcare providers and lack of education.[4–6] Difficult access to healthcare providers is not just an issue facing low-income countries. With the centralisation of tertiary services, which has shown to improve patient outcomes, access and availability can also be an issue in patients living in rural areas of high-income countries, as well as certain patients living in urban areas with mobility issues.[7]

Advocates of TM believe in the potential of providing more efficient care when compared with traditional means of care provision. This could be achieved by relatively cheap means using devices and programmes that are easily accessible, by minimising travel costs and reaching large numbers of patients. The need for effective and safe patient care through TM is ever more urgent in the current climax with the pandemic of COVID-19 necessitating delivery of care without exposing the patients and care providers. Indeed, during the pandemic, virtual gynaecology clinics have been taking place and there may be a place for such clinics to continue in the future for selected patients.

The aim of this systematic review is to assess the current evidence for the application of TM within gynaecology in terms of its impact and value on clinical care, education and feasibility. No such review has been performed in the literature to date.

METHODS

Search strategy

The systematic search followed Preferred Reporting Items for Systematic Reviews andMeta-Analyses guidelines.[8] A bibliographic search of English language publications in three computerised databases (PubMed, Science Direct and SciFinder) was conducted. A bibliographic search of English language publications in the computerised database PubMed was conducted. PubMed was our primary database where controlled vocabulary (Medical Subject Headings (MeSH) words) was used separately and in combination.[9] Free text words were also used on PubMed and on the supplementary databases: Scifinder and Science Direct.

The search terms, MeSH words and combinations of searches used are listed in table 1. Various combinations of "gynaecology" or "gynecology" with other relevant MeSH words such as "telementoring", "telemedicine", "teleconferencing", "mobile health", "telehealth", "ehealth" and "mhealth" were used for the literature search. Finally, the search was augmented by a snowball strategy, examining the references cited in primary sources and review manuscripts. The screening and selection process of the relevant studies conducted are shown on the figure 1.

Table 1 Search and selection strategy

Database searched	PubMed, Scifinder and Science Direct
Search keywords	[gynaecology*] AND [telementoring] [gynaecology] AND [telemedicine] [gynaecology] AND [teleconferencing] [gynaecology] AND [telemonitoring] [gynaecology] AND [telepresence] [gynaecology] AND [interoperability] [gynaecology] AND [teleconsultation] [gynaecology] AND [remote care] [gynaecology] AND [distancelearning] [gynaecology] AND [mobile health] [gynaecology] AND [telehealth] [gynaecology] AND [ehealth] [gynaecology] AND [mhealth] [abortion care] AND [All above] [colposcopy] AND [All above]
Other sources	Additional studies were identified through references of included studies and reviews
Inclusion criteria	1. Published in English in peer-reviewed journals 2. Studies focusing on gynaecology only 3. Studies investigating human clinical practice
Exclusion criteria	1. Papers not in English 2. Full article not available 3. Studies investigating animals
Categories of studies	1. Gynaecology telemedicine studies focused on education 2. Gynaecology telemedicine studies focused on clinical practice 3. Gynaecology telemedicine studies focused on education and clinical practice 4. Gynaecology telemedicine studies focused on feasibility

*All the above combinations which contained "gynaecology" were also repeated with the word "gynecology".

Study selection

Only studies within gynaecology were considered for this review. Studies covering only obstetrics and with minimal information on gynaecology, or clinical medicine in general were excluded. All English language, peer-reviewed human studies were included. Relevant studies published up to August 2020 were considered with no restrictions to the publication year.

Study screening

The initial search for the relevant studies was performed by the first author (SM) and was independently repeated by the second author (NG). An overview of the search results and screening process is summarised in the study flow diagram (figure 1). The screening process was cross-checked by a senior author (SS). Disagreement between the reviewers was resolved by discussion until consensus was reached.

Data extraction and analysis

A data extraction spreadsheet was developed and agreed between the authors. The selected studies were

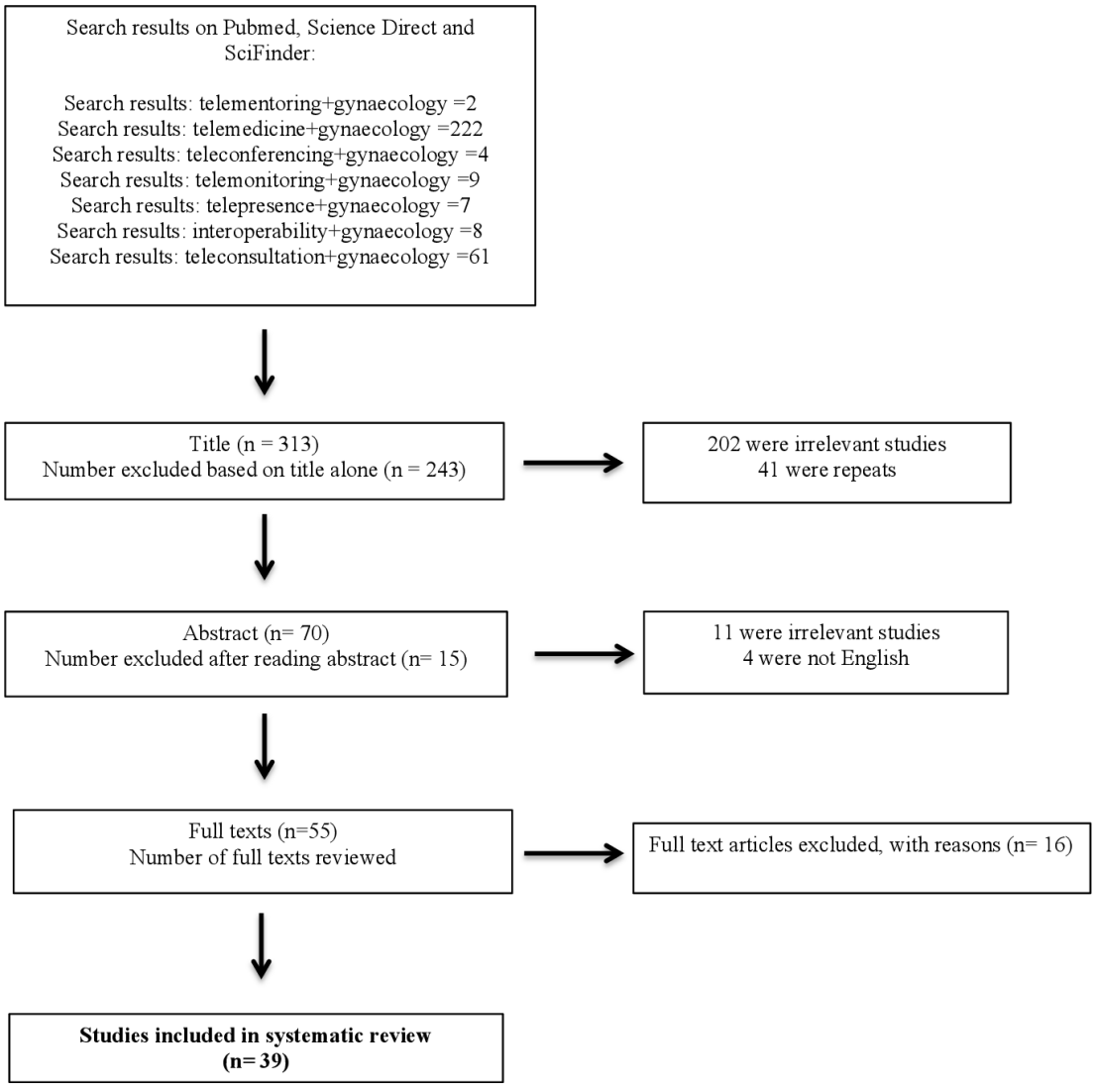

Figure 1 Preferred Reporting Items for Systematic Reviews andMeta-Analyses information flow chart.

comprehensively examined. Relevant data were extracted for each paper and inputted to the spreadsheet by the first author (SM) and subsequently crosschecked by the second author (NG). Data were then analysed qualitatively and summarised in the Results section. Because of the heterogeneity of the studies describing different modes of TM on different clinical topics within gynaecology, it was not possible to pool data together and perform a meta-analysis. The authors of the selected studies were not contacted to provide any information other than what was presented in the studies.

Quality assessment for each study was assessed using the Newcastle-Ottawa scale proforma.[10] Using this quality assessment tool, each study is judged on eight items, categorised into three groups: the selection of the study groups; the comparability of the groups; and the ascertainment of either the exposure or outcome of interest for case-control or cohort studies, respectively.[10] Disagreement regarding extracted data were resolved by discussion and deliberated on by a more senior author (SS).

Patient and public involvement

Patients were not involved in the design or required for recruitment in this systematic review.

RESULTS

The results are presented in the following tables: table 2 lists the topic and aim of the study, results and conclusions; table 3 contains descriptive factors related to technology such as the distance between the subjects and the tele-healthcare provider, the bandwidth and the device/technology used; table 4 consists of more study characteristics including the duration of the study, the subjects (eg, cadavers, simulation, etc) and number of operators/clinicians. The studies have also divided into four broad categories according to their topic: clinical, education, clinical and education and feasibility.

Selected studies

After the initial search though PubMed, a total of 313 records were screened. The publications dated from

Table 2 Summary of study results

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Clinical					
Bouwsma *et al* (2018) Netherlands[11]	Gynaecological surgery for benign disease	Stepped-wedge cluster randomised controlled trial	Randomised control trial for patients scheduled for hysterectomy and/or adnexal surgery, to assess impact of an internet-based personalised care programme on return to work (RTW)	Median time until RTW was 49 days (IQR 27–76) in the intervention group and 62 days (42–85) in the control group. In the first 85 days after surgery, patients receiving the intervention returned to work faster than patients in the control group (HR 2.66, 95% CI 1.88 to 3.77).	Implementation of an internet-based care programme has a large potential to lead to accelerated recovery and improved RTW rates following different types of gynaecological surgeries.
Grindlay and Grossman (2017) USA[12]	TM: medical abortion	Qualitative: 8 in-depth interviews with clinic providers and staff involved with the provision of medical abortion using TM	To evaluate providers' experiences with TM provision of medical abortion in Alaska using qualitative methods	Providers reported that TM provision of medical abortion facilitated a more patient-centred approach to care where women were able to be seen sooner, have greater choice in abortion procedure type, and could be seen closer to their home. Providers felt that it was easy to integrate the new technology into clinic operations, and that a TM visit largely required the same overall processes and clinic flow as an in-person visit.	These findings indicate high acceptability among providers and the appropriateness for TM application to this healthcare service.
Shehata *et al* (2016) Canada[13]	General obstetrics and gynaecology	Retrospective electronic chart review study	Aim to analyse all the obstetrics and gynaecology eConsults: to estimate the effectiveness of the eConsult service by number of traditional referrals that were avoided as a result of the eConsult service and healthcare provider satisfaction	In 34.3% of eConsults, primary care providers indicated that a traditional consult was avoided. Pregnancy issues and gynecological cancer screening issues were the most common queries. Primary care providers highly valued the eConsult and the majority of eConsults were completed within 15 min (98.8%).	Electronic consultations were effective at reducing the number of traditional consults requested over 3.5 years. This initiative has potential to reduce current waiting times for traditional consultation in Canada and to make the consultation process more effective. The service was feasible and well received by primary care providers.

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Hitt *et al* (2016) USA[14]	Telecolposcopy	Cohort study	To use telecolposcopy to improve patient outcomes related to cervical cancer in rural settings	Over a 15-month time period, 940 unique patients were seen using telecolposcopy. Telecolposcopy was done at 8 remote sites across Arkansas representing patients from 72 of the 75 counties. After being seen through telecolposcopy. each patient was given an impression based on the assessment by the hub-site clinician. The mean transportation cost per patient saved was US$33.25±13.15 and the mean driving distance saved was 109±43.0 miles.	Telecolposcopy should be further explored and used in rural settings as a way to reduce patient costs and improve cervical cancer outcomes.
Jefferis *et al* (2016) UK[15]	Urogynaecology	Cohort simple observational study.	To assess the use of TM follow-up after day case TVT insertion	262 TVT cases were initially followed up via telephone, of which 10% then required review in outpatient clinic.	By using TM, 234 patients (90%) who would normally be seen in clinic were followed up remotely, saving valuable clinic time for patients with greater clinical need.
Ricard-Gauthier *et al* (2015) Switzerland[16]	Gynaeoncology	Cohort study	To evaluate the feasibility and performance of smartphone digital images for the detection of CIN 2 or worse as an adjunct to a conventional visual inspection approach with acetic acid (VIA) and Lugol's iodine (VILI), in comparison with detection by histopathological examination	87 HPV-positive women were screened for cervical cancer. Overall, 7 cases of CIN2+ (8.0%) were diagnosed using biopsy specimens. The on-site physician obtained a sensitivity of 28.6% (95% CI 3.7% to 71%) and a specificity of 87.2% (95% CI 77.7% to 93.7%). The off-site physicians obtained a sensitivity ranging between 42.9% (95% CI 9.9% to 81.6%; p=1) and 85.7% (95% CI 42.1% to 99.6%; p=0.13) and a specificity between 48.1% (95% CI 36.5% to 59.7%; p<0.001) and 79.2% (95% CI 68.5% to 87.6%; p=0.10). Comparison between observers did not reach significance. Observers assessed 95.6% of all images as very good or acceptable for interpretation purpose.	Smartphone images may be a useful adjunct to conventional VIA and VILI for the detection of CIN2+ and improve cervical cancer screening in low-resource settings.

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Catarino *et al* (2015) Switzerland[17]	Gynaeoncology	Cohort study	To evaluate the use of a smartphone for on-site and off-site VIA diagnosis	Of the 332 women recruited, 137 (41.2%) were HPV-positive and recalled for VIA triage; compliance with this invitation was 69.3% (n=95). CIN was detected in 17.7% and 21.7% of digital images by on-site and off-site physicians, respectively. The on-site physician had a sensitivity of 66.7% (95% CI 30.0% to 90.3%) and a specificity of 85.7% (95% CI 76.7% to 91.6%); the off-site physician consensus sensitivity was 66.7% (95% CI 30.0% to 90.3%) with a specificity of 82.3% (95% CI 72.4% to 89.1%).	This pilot study supports the use of TM for off-site diagnosis of CIN, with diagnostic performance similar to those achieved on-site.
Stratton *et al* (2015) USA[18]	Gynaeoncology	Cohort study	To identify strategies and factors effective in recruitment and retention of study participants	37 participants were enrolled. The largest proportion of participants (46%) was enrolled from the telecolposcopy network. Others were enrolled through outside institutions (43%), in-house referrals (8%), or direct advertisement (3%). Most participants were motivated to join the study to take care of their health issues. Only 2 participants joined the Facebook private page. Of 24 participants who qualified for vaccination, only 1 terminated early due to an unanticipated move.	The availability of a large number of potential participants from the telecolposcopy network increased recruitment to this clinical trial by 85% over other traditional means of recruitment. The telecolposcopy network is not only a means of providing a gynaecological service to women who otherwise would forego care, but also a novel and valuable resource in recruiting participants for a clinical trial.
Vonk Noordegraaf *et al* (2014) Netherlands[19]	Gynaecology	Randomised, single-blinded, controlled trial	To evaluate the effectiveness of an eHealth intervention on recovery and return to work, after gynaecological surgery	In intention-to-treat analysis, the eHealth intervention was effective on time to return to work (HR 1.43; 95% CI 1.003 to 2.040; p=0.048). The median duration of sick leave until a full sustainable return to work was 39 days (IQR 20–67 days) in the intervention group and 48 days (IQR 21–69 days) in the control group. After 26 weeks pain intensity was lower (VAS, cumulative OR 1.84; 95% CI 1.04 to 3.25; p=0.035) and quality of life was higher (Rand-36 health survey, between-group difference 30, 95% CI 4 to 57; p=0.024) in the intervention group, compared with the control group.	The use of the eHealth intervention by women after gynaecological surgery results in a faster return to work, with a higher quality of life and less pain.

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Gomperts *et al* (2014) Netherlands[20]	Early pregnancy, medical termination	Cohort study	To evaluate the need for and outcome of self-administered medical abortion with mifepristone and misoprostol in Brazil, provided through Women on Web, a global TM abortion service	The women on web website had 109 779 unique visitors from Brazil, 2104 women contacted the helpdesk by email. Of the 1401 women who completed the online consultation, 602 women continued their request for a medical abortion. Of the 370 women who used the medicines, 307 women gave follow-up information about the outcome of the medical abortion. Of these, 207 (67.4%) women were 9 weeks or less pregnant, 71 (23.1%) were 10, 11 or 12 weeks pregnant, and 29 (9.5%) women were 13 weeks or more pregnant. There was a significant difference in surgical intervention rates after the medical abortion (19.3% at 9 weeks, 15.5% at 11–12 weeks and 44.8% at N13 weeks, p=0.06). However, 42.2% of the women who had a surgical intervention had no symptoms of a complication.	There is large need for medical abortion in Brazil. Home use of mifepristone and misoprostol provided through TM is safe and effective. However, after 13 weeks gestation, there is an increased risk of surgical intervention that may be due to the regimen used and local clinical practices in Brazil.
Hitt *et al* (2013) USA[21]	Gynaeoncology	Cohort study	To provide needed care to an at-risk population. Second, to test the validity of providing care by pairing local examiners with only limited experience in colposcopy with distant experts provided by TM, and therefore provide a model that could be duplicated in other medically underserved areas.	The programme scheduled 1812 visits involving 1504 unduplicated patient referrals from 68 of the 75 counties in Arkansas and performed 1298 colposcopic examinations.	This project provides complex specialty gynaecological services using TM technology to overcome geographical barriers while producing results comparable to traditional examinations. It is cost effective and well received by patients and can be used as a model for improving access to care among vulnerable populations.

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Gomperts *et al* (2012) Netherlands[22]	Early pregnancy, medical termination	Cohort study	Analysis of factors influencing surgical intervention rate after home medical TOP by women in countries without access to safe services using the TM service 'Women on Web'	Of the 2323 women who did the medical TOP and had no ongoing pregnancy, 289 (12.4%) received a surgical intervention. High rates were found in Eastern Europe (14.8%), Latin America (14.4%) and Asia/Oceania (11.0%) and low rates in Western Europe (5.8%), the Middle East (4.7%) and Africa (6.1%; p<0.001). More interventions occurred with longer gestational age (p<0.001). Women without a surgical intervention more frequently reported satisfaction with the treatment (p<0.001).	The large regional differences in the rates of reported surgical interventions after medical TOP provided by TM cannot be explained by demographic factors or differences in gestational age. It is likely that these differences reflect different clinical practice and local guidelines on (incomplete) abortion rather than complications that genuinely needed surgical intervention. Surgical interventions significantly influenced womens' views on the acceptability of the TOP.
Kldiashvili and Schrader (2010) Georgia[23]	Gynaecological cytology	Case-control study	To evaluate the effectiveness of digital images for telecytology diagnosis and compare it with routine cytology diagnosis	There was 94% concordance in average between routine vs digital images diagnostic. Intracytologists concordance averaged 95.5%. Image sharpness and quality were rated 'good' and 'excellent' in 97% cases. With respect to image colour, 96% of the images were rated as 'excellent' or 'good'.	Digital images for cytology diagnostic are of adequate quality, with diagnostic concordance rates.
Radley *et al* (2006) UK[24]	Urogynaecology	Cross-sectional study	To develop and evaluate a Web-based, electronic pelvic floor symptoms assessment questionnaire (e-PAQ) for women	In secondary care, factor analysis identified 14 domains within the four dimensions (urinary, bowel, vaginal and sexual symptoms) with internal consistency (Cronbach's alpha)≥0.7 in 11 of these. In primary care, alpha values were all ≥0.7 and test–retest analysis found acceptable intraclass correlations of 0.50–0.95 (p<0.001) for all domains. A measure of face validity and utility was gained using a nine-item questionnaire, which yielded strongly positive patient views on relevance and acceptability.	The e-PAQ offers a user-friendly clinical tool, which provides valid and reliable data. The system offers comprehensive symptoms and quality of life evaluation and may enhance the clinical episode as well as the quality of care for women with pelvic floor disorders.

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Perisic, Rasic, Raznatovic (2006) Serbia and Montenegro[25]	Gynaeoncology	Cohort study	To test the performance of telecolposcopy in the diagnosis of various squamous intraepithelial lesions	The findings were identical for group 1 (15 gynaecologists who were not trained in colposcopy) and group 2 (six experienced colposcopists) in 219 cases, that is, an interobserver agreement of 88%; Cohen's kappa was 0.81. The findings were identical for group 1 and group 3 (supervising team consisting of three experts) in 208 cases, that is, an interobserver agreement of 83%; Cohen's kappa was 0.74. The findings were identical for groups 2 and 3 in 239 cases, that is, an interobserver agreement of 96%; Cohen's kappa was 0.93. There was high interobserver agreement between all participants. However, there were also significant differences in some cases. In the cases of suspected invasive carcinoma, the results showed a significant difference (I=4.8, p<0.005) because gynaecologists from group 1 were not sure of their diagnosis and they wanted to obtain a second opinion by referring the decision to a higher level.	Beginning TM in Serbia is difficult because of the limiting factors such as insufficient computer equipment in the healthcare system and, as its consequence, the insufficient computer training of physicians, but investigations like this one show the efficacy of using new technologies for getting an accurate diagnosis, cutting travel to the specialised secondary healthcare institutions, a greater use of second opinions and continuing education of a larger circle of medical staff. The long-term goal is to transfer colposcopy screening to a lower level (eg, nurses, technicians), but to retain the same efficacy.
Etherington *et al* (2002) UK[26]	Cervical screening	Cohort study	A pilot study to see whether the telecolposcopy system could record images of sufficient quality for diagnosis	Based on a diagnosis only of normal or abnormal, telecolposcopy had a sensitiviy of 89% and a specificity of 93%, a positive predictive value of 91% and a negative predictive value of 91%. The level of agreement between the telescreener and the colposcopist was good (kappa^0.70). Furthermore, telecolposcopy screening did not erroneously grade any cases of colposcopic highgrade CIN as normal.	Telecolposcopy, which is designed to be used by nurses in primary care, can be used reliably to make diagnoses. The technology is easily adaptable for real-time teleconsultation.
Allen-Davis *et al* (2002) USA[27]	Gynaecology: vulvovaginitis	Cohort study	To examine the agreement between telephone and office management of vulvovaginal complaints and to assess the accuracy of diagnosis of vulvovaginitis	A total of 485 patients underwent telephone interviews, and 253 (52%) completed the study protocol. Values showed poor agreement between nurses and practitioners for bacterial vaginosis (0.12), candidiasis (0.22), and trichomoniasis (0.05). There was also poor agreement between telephone nurses and practitioners regarding the necessity of an office visit (0.14).	This prospective study challenges the notion that the telephone is an effective tool to diagnose and treat vulvovaginal problems.

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Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Atlas *et al* (2000) Israel[28]	Gynaeoncology	Case series	To improve the care of gynaecological cancer patients and to exchange medical knowledge between multidisciplinary groups in Providence, Rhode Island, USA, and in Safed, Israel.	In the first 9 months of its operation, more than 450 patients were discussed by the International Tumour Board (ITB). During the 20 videoconferences, major technical difficulties were infrequent and easily resolved.	Collaboration via the ITB also shares expensive healthcare resources (eg, medical expertise) which are only occasionally needed for making the optimum recommendations within the vast domain of oncology. The prospective, multidisciplinary, realtime, teleconferenced ITB process could be a model for the management of other (ie, non-oncological) yet complex healthcare questions.
Tates *et al* (2016) Netherlands[29]	Urogynaecology	Case series	To examine the impact of a consultation medium on doctors' and patients' communicative behaviour in terms of information exchange, interpersonal relationship building, and shared decision-making	Satisfaction, perceived information exchange, interpersonal relationship building, and perceived shared decision-making showed no significant differences between face-to-face and screen-to-screen consultations. Patients' attitude toward Web-based communication (b=−0.249, p=0.02) and patients' perceived time and attention (b=0.271, p=0.03) significantly predicted patients' perceived interpersonal relationship building. Patients' perceived shared decision-making was positively related to their satisfaction with the consultation (b=0.254, p=0.005). Overall, patients experienced significantly greater shared decision-making with a female doctor (mean 4.21, SD 0.49) than with a male doctor (mean 3.66(SD 0.73); b=0.401, p=0.009).	The quality of doctor–patient communication did not differ significantly between web-based and face-to-face consultations. Doctors and simulated patients were equally satisfied with both types of consultation medium, and no differences were found in the manner in which participants perceived communicative behaviour during these consultations. The findings suggest that worries about a negative impact of web-based video consultation on the quality of patient–provider consultations seem unwarranted.
Education					

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Gambadauro and Magos (2007) UK[30]	Gynaecology surgery	Case series	Develop a Network-Enhanced Surgical Training (NEST) system around standard hardware and free software	Successfully developed a NEST telementoring system based on two standard personal computers connected by an Ethernet cable. Technology successfully used during a range of gynaecological interventions: abdominal, vaginal and laparoscopic surgery. Also used during pelvic-trainer sessions in skills laboratory. NEST seems reliable as mentor's instructions, both vocal and visual, always followed on time by surgeon during tests.	NEST system could be an ideal tool for studies on telementoring in safe environments, with the supervisor potentially just next door. Developed a potential new strategy to enhance rate of trainee's supervision. NEST is affordable and reproducible with readily available and relatively inexpensive technology.
Katz *et al* (2017) Israel[31]	General obstetrics and gynaecology	Case-control quantitative study	Quantitative study to assess the effectiveness of a computerised interactive simulator coupled with an instructor who monitored students' progress and provided web-based immediate feedback (WOZ training). In comparison to an automated e-learning module.	A significant advantage (p=0.01) was found in favour of the WOZ training approach.	Involvement of a web-based instructor in the simulation-based training process provided better learning outcomes that varied training content and trainee populations did not affect the overall learning gains.
Yoost *et al* (2017) USA[32]	Reproductive health	Prospective cohort Study	To evaluate the use of telehealth to teach reproductive health to rural areas with high rates of teen pregnancy	Reported condom use increased from 20% (10/50) at baseline to 40% (15/37) at 6 months (p=0.04). Hormonal contraception use increased from 22% (11/50) to 38% (14/37) (p=0.12). Report of HPV vaccination increased from 38% (10/26) to 70% (26/37) (p=0.001) among all subjects. At 6 months, 91.8% (34/37) reported the use of telehealth was 'very effective' as a means to teach the material.	Telehealth is an effective tool to teach reproductive health to rural areas. This model could be used to reach other rural counties with limited resources.

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Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Chekerov *et al* (2008) Germany[33]	Gynaecology oncology	Qualitative study	To develop specific web-based software to organise and conduct online tumour board meetings of gynaecologists, surgeons, radiologists, oncologists and pathologists from different hospitals and gynaecological practitioners, discussing individual patient's cases, defining therapy options and exchanging clinical experience	84% of the participants reported to be satisfied with the information content. 72% were satisfied with the technical support. 98% of the individual therapy recommendations were accepted and implemented. 92% agreed that the tumour board conference presents an optimal possibility for extensive scientific discussions and exchange. 81% agreed that the online tumour conference improves advanced educational training.	The online tumour conference is feasible and represents a time-saving possibility for gynaecological oncologist to receive a treatment recommendation based on the best available clinical and scientific evidence.
Haller and Gabathuler (2003) Switzerland[34]	General obstetrics and gynaecology	Case study	To transmit advanced training sessions externally	Teleconferencing organised between 1997 to 2001 from Zurich to Basel and Brig.	Advantages: 1. Cost-efficient technology 2. Internationally widespread technology 3. Guaranteed bandwidth Disadvantages: 1. Limited resolution 2. Adaptation of movements dependent on the amount of ISDN lines 3. Mixed use of multipoint 128/384 kbit/s is error sensitive 4. Interactivity with use of multipoint is hardly used.
Chaves *et al* (2017) Brazil[35]	Gynaecology surgery	Qualitative prospective study	To engage trainees to use the TM features of surgery on their own smartphones and tablets as an educational tool.	94% of the answered items were in agreement, 4.1% were neutral answers, and only 1.7% corresponded to negative impressions about the system. Cronbach's α was 0.82, which represents a good reliability level. Spearman's coefficients were highly significant in 4 comparisons and moderately significant in the other 20 comparisons.	This study presents a local streaming video system of live surgeries to smartphones and tablets and shows its educational utility, low cost and simple usage, which offers convenience and satisfactory image resolution, thus being potentially applicable in surgical teaching.

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Boatin *et al* (2015) USA[36]	General obstetrics and gynaecology	Qualitative study	To develop a teaching conference between two institutions, one based in Boston, USA and the other in Mbarara Uganda	Over 30 months, 30 lectures were given using teleconferencing between USA and Uganda. A number of conferencing tools were tried: direct telephone connection, Ventrilo conferencing system and Skype via personal computer or smart phone. PowerPoint lectures were stored in a collective Dropbox that could be accessed and downloaded prior to lecture dates.	A successful collaboration in medical education via teleconference is sustainable, low cost, and beneficial to both resource-rich and resource-poor institutions. Expertise can be shared bilaterally and internationally by individuals who are potentially unable travel.
Browne *et al* (2000) USA[37]	General obstetrics and gynaecology	Qualitative study	To use video teleconferencing to improve the continuity of curricula among geographically dispersed clerkships	Describes the use of interactive video teleconferencing as a tool to link and improve a multisite undergraduate core clerkship in obstetrics and gynaecology. The site coordinators, clerkship director, and administrative personnel from the parent institution meet approximately 3 weeks after the completion of each core clerkshipfor live, real time and interactive broadcast to complete student evaluations, review curricula, and discuss problems with current students and other pertinent educational issues.	Video teleconferencing provides a mechanism to ensure consistency in curriculum and student evaluations and provides administrative support to distant sites.
Clinical and education					
Cordasco *et al* (2015) USA[38]	Veteran women's health	Qualitative study	A women's health focused educational and virtual consultation programme using televideo conferencing. The study aimed to perform a formative evaluation of the programme's development and implementation.	In 53 post session surveys received, 89% agreed with the statement 'The information provided in the session would influence my patient care'. Among 18 interviewees, all found the programme useful for building and maintaining women's health knowledge. All interviewees also reported that sessions being conducted during their lunch hour limited consistent participation.	This women's health education and virtual consultation programme is a promising modality for building and maintain primary care provider knowledge of women's health, and influencing patient care.
Feasibility					

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Van Dongen *et al* (2016) Netherlands[39]	Reproductive medicine	Randomised controlled trial	To evaluate a personalised e-therapy programme (Internet based) for women during fertility treatment aimed to reduce the chance of having clinically relevant symptoms of anxiety and/or depression after unsuccessful ART treatment.	The acceptability was good, as was the integration within current clinical guidelines and care. However, the demand reflected by a participation rate of 44% was low, since most women declined participation because they felt no need for support at that moment. The practicality of the intervention was moderate illustrated by a relatively high dropout rate (30%) due to practical concerns. The intervention was effective, shown by a reduction in the percentage women having clinically relevant symptoms of anxiety and/or depression in the compliant intervention group compared with the control group 3 months after the first ART cycle; risk difference of 24% (95% CI 2% to 46%; p=0.03).	In clinical fertility care, personalising an e-therapy programme to the patients' risk profile is promising and feasible.
Grossman and Grindlay (2017) USA[40]	Early pregnancy, medical termination	Retrospective cohort study	To compare the proportion of medical abortions with a clinically significant adverse event among TM and in-person patients at a clinic system in Iowa during the first 7 years of the service	During the study period, 8765 TM and 10405 in-person medical abortions were performed. Forty-nine clinically significant adverse events were reported (no deaths or surgery; 0.18% of TM patients with any adverse event(95% CI 0.11% to 0.29%)and 0.32% of in-person patients(95% CI 0.23% to 0.45%)). The difference in adverse event prevalence was 0.13% (95% CI 20.01% to 0.28%). 42 emergency departments responded to the survey (35% response rate) none reported treating a woman with an adverse event after medical abortion.	Adverse events are rare with medical abortion, and TM provision is non-inferior to in-person provision with regard to clinically significant adverse events.

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Mammas *et al* (2016) Greece[41]	Gynaecology: uterine transplant	Simulation cohort study	To assess the TRE of the uterus graft (UG) on TM systems, in uterus transplant (UT). Studied by diagnostic sensitivity-specificity analysis based on simulation of TRE of the UG on 10 MRI sets of female pelvic digital images by two radiologists, assessing the vascular variations of the grafts and the inflammatory and neoplastic lesions of the UG.	The pregrafting TRE of the UG showed: Diagnostic unreliability for vascular variations and a high diagnostic reliability for inflammatory and neoplastic diseases of the UG (100%)	MRI-based TRE of the UG in UT is feasible and highly reliable for the remote pregrafting diagnosis of UG pathological lesions, but unreliable for integrated vascular anatomic and pathological UG remote evaluation for pregrafting and pretransplant decision support and planning.
Kim *et al* (2016) South Korea[42]	Gynaeoncology	Prospective cohort study	To develop web-based digital cervicography system, and validate it compared with conventional film cervicography.	63 cases were finally analysed after excluding technically defective cases that cannot be evaluable on analogue images. The generalised kappa for analogue versus digital image was 0.83, for analogue versus scanned image 0.72, and for digital versus scanned image was 0.71; all were in excellent consensus.	Digitalised cervicography system can be substituted for the film cervicography very reliably, and can be used as a promising telemedicine (TM) tool for cervical cancer screening.
Barlow *et al* (2012) USA[43]	Paediatric and adolescent gynaecology	Qualitative study	To assess whether Telehealth would be appropriate for paediatric and adolescent gynaecological services in a tertiary care centre and to determine patient/family interest.	Of the 1533 patient visits, 469 (30.6%) were potentially appropriate for telehealth based on geography. According to clinic physicians, only 51 of these 469 visits (10.9%) were appropriate for telehealth. The main reasons for being inappropriate were the need for physical examination (n=238, 57.0%), imaging (n=57, 13.6%), or issues regarding sexuality/privacy (n=45, 10.8%). Of the 51 appropriate visits, 28 patients/families (55.0%) expressed interest in telehealth.	Currently, telehealth appears to be appropriate for only a small subset of patients/families.

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Schadel *et al* (2005) Germany[44]	Gynaeoncology	Prospective cohort study	To evaluate the diagnostic reliability of cervical examination using digital colposcopy compared with conventional binocular colposcopy.	A total of 315 patients were examined and diagnosed by a colposcopist onsite. During the colposcopic examination, digital camera images were stored on a PC (median five pictures per patient). A second physician, experienced in colposcopy, re-evaluated the initial diagnostic findings using the stored digital images. The primary and secondary findings in each patient were categorised according to the Rome classification system. There was agreement between the primary and secondary examiners in 69% of cases (k.0.60). There was no systematic bias in terms of under-rating or over-rating. The proportion of non-assessable colposcopic examinations was 9%.	Digital colposcopy was reliable and provided advantages in terms of a better follow-up examination and internal quality control of the diagnosis. The pilot study suggests that telecolposcopy may provide better training and further education for physicians and students, and may also improve the diagnostic possibilities in gynaecology.
Etherington (2002) UK[45]	Gynaeoncology	Prospective cohort study	Aim to investigate the negative predictive value of colposcopy and to demonstrate the use of TM to develop a secondary screening technique for use in primary care.	81 out of 97 women were studied by both techniques. Using a diagnosis of normal or abnormal, telecolposcopy had a sensitivity of 88.9% and a specificity of 93.3%. There was very good agreement between the telecolposcopy screener and the colposcopist (Cohen's kappa statistic=O. 70). Furthermore, telecolposcopy screening did not grade any cases of colposcopic high-grade CIN as normal.	The pilot study has established the validity of diagnosing from transmitted computerised video clips.
Stewart *et al* (2001) UK[46]	Fertility	Randomised controlled trial	To compare patient satisfaction with telephone discussions versus clinic appointments, in couples after unsuccessful IVF/ICSI treatment	Couples were separated into those undergoing their first treatment cycle (100 couples) and those undergoing their second or subsequent treatment cycle (85 couples) and then randomised to either a telephone or appointment follow-up. Satisfaction was assessed by a postal questionnaire and analysis conducted on an 'intention-to-treat' basis. An overall response rate of 91% was achieved.	Analysis indicated no statistically significant difference between telephone and appointment groups with regard to the degree of satisfaction. However, there was an association between the type of follow-up and the duration of discussion; telephone follow-up discussions were significantly shorter than appointment follow-ups.

Continued

Table 2 Continued

Authors (year)	Subspecialty	Study design	Aim	Results	Conclusion
Harper *et al* (2000) USA[47]	Gynaeoncology	Retrospective cohort study	To demonstrate the technical performance and clinical feasibility of a telecolposcopic system through assessment of image transmission veracity, ease of office system implementation and the patient's acceptance of the electronic image transmission.	79 women participated in the trial. 3 to 20 images were captured for each woman, documenting cervical squamous intraepithelial lesions and vaginal and vulvar diseases. With complete visualisation of the squamocolumnar junction, there was an 86% agreement between the remote and review sites (k=0.533, p=0.019). The interobserver agreement for colposcopic impressions was 86% (k=0.684, p<0.001), and for colposcopic impressions with histology within one level of disease severity, 86% (k=0.78, p<0.001). Colposcopists' and patients' satisfaction with telecolposcopy was excellent.	The telecolposcopic system described in our study is technically feasible, can be implemented in an office system with limited technical support, and is preferred by women who have to travel many miles to receive referral healthcare.
Quercia *et al* (2017) Switzerland[48]	Cervical cancer screening	Prospective cohort study	To assess the feasibility of a mobile health (m-Health) data collection system to facilitate monitoring of women participating to cervical cancer screening campaign.	A total of 151 women were recruited in the study. Technical problems, including transmission of photos, HPV test results and pelvic examination data, have subsequently been solved through a system update.	The quality of the data was satisfactory and allowed monitoring of cervical cancer screening data of participants.
Haggerty *et al* (2016) Romania[49]	Gynaeoncology	Prospective cohort study	To assess the feasibility of two technology-based weight loss interventions in obese women with endometrial hyperplasia and cancer	20 women were randomised (TM: n=10, Text4Diet: n=10), and 90% lost weight. Many were early stage (70%) and grade (43.8%) disease with a median age of 60.5 years. A statistically greater weight loss was observed in the TM arm (median loss: 9.7 kg (range: 1.6–22.9 kg)) versus 3.9 kg (range: 0.3–11.4 kg) in the Text4Diet arm (p=0.0231). Similarly, weight loss was greater in the TM (7.6%) as compared with the Text4Diet arm (4.1%, p=0.014). Mean serum levels of IL-2 were significantly (27.15 pg/mL vs 5.18 pg/mL, p=0.0495) lower at intervention end as compared with baseline.	A technology-based weight loss intervention is feasible in women with Type I endometrial cancer/hyperplasia. Both interventions produced weight loss, although more person-to-person contact produced more significant outcomes. Reductions in expression of IL-2 were related to weight loss.

ART, assisted reproductive technology; CIN, Cervical intraepithelial neoplasia; HPV, Human Papillomavirus; IL, interleukin; ISDN, Integrated Services Digital Network; TRE, Tele-Radiological Evaluation; TVT, Tension-free Vaginal Tape.

Table 3 Descriptive factors related to technology

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Clinical						
Bouwsma *et al* (2018) Netherlands[11]	Not specified	An interactive web portal facilitated self-management through the entire surgical pathway, by providing individual tailored convalescence advice preoperatively. Postoperatively, the web portal contained an interactive self-assessment tool to monitor recovery.	The intervention group was associated with cost savings of €56 compared with usual care.	Not specified.	Not specified.	No factors related to technology were specified.
Grindlay and Grossman (2017) USA[12]	Not specified	TM: A remote physician who is licensed in Alaska electronically reviews the patient's history and ultrasound images, and meets with the patient using a Health Insurance Portability and Accountability Act-compliant video teleconference platform.	Not specified.	Not specified.	Not specified.	Few areas of improvement suggested: 1. Video shows both doctor and patient on screen, one suggestion was to change the display for the patient so that only physician is seen, as some patients feel shy seeing themselves on-screen and thus distracted. 2. One physician noted at times, they were unsure who else was in the room, this could be resolved with a wider angle camera. 3. 5 participants note that on rare occasions there were minor technical issues such as setting up the camera or adjusting the volume, but these were typically resolved quickly.

Continued

Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Shehata *et al* (2016) Canada[13]	Not specified.	Using a secure, web-based tool, primary care providers direct specific patient questions to obstetrics and gynaecology. The primary care provider has the opportunity to append diagnostic images, reports, pictures, or any other information that can aid the specialist in understanding the problem or the reason for consultation. The case is then assigned to the single ob-gyn participating who was participating in the project at the time, resulting in a notification email to that specialist with the expectation that it will be completed within 7 days.	Not specified.	Not specified.	Not specified.	No technical issues identified.
Hitt *et al* (2016) USA[14]	Telecolposcopy done at eight remote sites in Arkansas sending data to a clinician in central Arkansas. Distance not specified	Not specified.	Start-up costs US$44 000 per site or US$352 000 for all eight remote sites. Additional costs can be incurred such as clinic personnel time spent at both the remote site and UAMS, clinical space to perform the procedures and other supplies.	Not specified.	Not specified.	Not specified.
Jefferis *et al* (2016) UK[15]	Not specified.	Telemedical review, telephone communication.	Not specified.	Not specified.	Not specified.	No technical issues identified.

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Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Ricard-Gauthier *et al* (2015) Switzerland[16]	Images from Madagascar analysed by physicians in Geneva.	A minimum of 3 pictures were taken for all participants with a smartphone during the examination: one of the native cervix, one after application of acetic acid (1 min after application) and one after application of Lugol's iodine.	Not specified.	Not specified.	Not specified.	No technical issues identified.
Catarino *et al* (2015) Switzerland[17]	Images from Madagascar analysed by physicians in Geneva	Photos were taken at a distance of about 15 cm from the cervix, with 2 Å~optical zoom. Image capture was conducted by using a smartphone (Samsung Galaxy S5), which has a 16 megapixels camera, with an aperture size of F2.2, focal length of 31 mm and a pixel size of 1.12 µ m. All photographs were taken by a medical student, with no previous experience for VIA/VILI, who was trained for cervical image capture and assisted the physician during the examination.	Not specified.	Not specified.	Not specified.	No technical issues identified.
Stratton *et al* (2015) USA[18]	Not specified	Recruitment tools: telecolpscopy network, direct advertising and private facebook page	Not specified.	Not specified.	Not specified.	No technical issues identified.
Noordegraaf *et al* (2014) Netherlands[19]	Not specified	The intervention group had access to an eHealth intervention, with detailed tailored preoperative and postoperative instructions on the resumption of work and daily activities, and with tools (eg, a video) to improve self-empowerment, communication with care providers and employer, and to identify recovery problems.	Not specified.	Not specified.	Not specified.	No technical issues identified.
Gomperts *et al* (2014) Netherlands[20]	Not specified	Patients from Brazil who contacted 'Women on Web' online TM service	Not specified.	Not specified.	Not specified.	No technical issues identified.

Continued

Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Hitt *et al* (2013) USA[21]	Telecolposcopy done at eight remote sites in Arkansas sending data to a clinician in central Arkansas. Distance not specified	During each weekly 3 hours clinic, an advanced practice nurse/ nurse practitioner at each of the four remote sites, who has been trained in the mechanics of colposcopy, performs the exams and collects biopsy specimens under the real-time interactive supervision of an experienced Obstetrics-Gynaecology Faculty member at the central hub site in Little Rock.	The study model of using one physician with four nurse practitioner examiners and four assistants produced an hourly cost of US$321.00, or a cost of US$40 per exam. This compares with a traditional model incorporating four doctor examiners with four assistants producing an hourly cost of US$416.00 or a cost per exam of US$52.	Not specified.	Not specified.	Complications with the telecolposcopic method were rare during the study period. Two patients required referral to the hub site due to the presence of very large endocervical polyps that required removal with the patient under anaesthesia. Another two patients were referred to the hub site because of anxiety states requiring intravenous sedation for the examination.
Gomperts *et al* (2012) Netherlands[22]	Not specified. Women from 88 different countries enrolled online	'Women on Web' TM tool: interactive online consultation and follow-up.	Not specified.	Not specified.	Not specified.	No technical issues identified.
Kldiashvili and Schrader (2010) Georgia[23]	The images reviewed in the same location 100 days later.	Cases photographed with the 2.0 universal serial bus (USB) digital eyepiece microscope camera with a resolution of 2048×1536 pixels.	Not specified.	Not specified.	Not specified.	No technical issues identified.

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Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Radley *et al* (2006) UK[24]	Not specified	The electronic pelvic floor symptoms assessment questionnaire was located on a portable workstation in each clinic. Data were transferred on a weekly basis to the secure central inhospital server. Once this transfer had been carried out, all data on the portable workstations were erased.	The costs of computer hardware relate to the units currently in use. The computers used were Dell Optiplex GX270 PCs with 2.8 GHz Pentium processors installed with the Windows XP operating system (total cost £600). A-frame TS15LBREI001 screens (cost £590). The installation, networking and maintenance of touchscreen computers are dependent on local IT department costs. In this unit, this amounts to £200 per unit.	Not specified	Not specified	No technical issues identified.
Perisic and Rasic (2006) Serbia and Montenegro[25]	Not specified	The images were acquired using a videocolposcope (I SO-FC, Carl Zeiss), a videorecorder (SLV-E 180E, Sony).	Not specified	Not specified	Not specified	No technical issues identified.
Etherington *et al* (2002) UK[26]	Not specified	Not specified	Not specified	Not specified	Not specified	The pilot study identified 97 women who were suitable for inclusion. Full data were available from 81 cases: five defaulted. Telescreening appointments, six had telecolposcopy images that were unable to be interpreted and five did not attend their colposcopy appointments.
Allen-Davis *et al* (2002) USA[27]	Not specified	Telephone consultation, Device—NS	Not specified	Not specified	Not specified	No technical issues identified.

Continued

Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Atlas *et al* (2000) Israel[28]	Videoconferencing and analysis of cancer cases between two units from the USA and Israel	A videoconferencing unit with a 32 in (81 cm) monitor and several microphones was used in each location. The units were linked by ISDN, usually three lines. A radiograph viewing box and a microscope with an attached video-camera were employed.	Not specified	Not specified	Not specified	No technical issues identified.
Tates *et al* (2016) Netherlands[29]	Same building, different rooms	Laptop and a webcam with a built-in microphone. The intern and patient interacted through Skype. The intern would initiate a video call with the patient and the consultation began.	Not specified	Not specified	Not specified	No technical issues identified.
Education						
Gambadauro and Magos (2007) UK[30]	Video and audio interaction between computers in operating room (OR) and a remote computer via internet or intranet. Distance not specified.	Software to connect operating room computer and mentor's computer: Ethernet cable to connect two personal computers. Video UltraVNC and Audio Microsoft NetMeeting.	OR computer: £600 Mentor's computer: £700 Video converter: £50 Bluetooth: £30 Cables: £20 Softwarre video: Free, audio: free Total: £1400	Not specified	UltraVNC with enhanced video driver reduced the problem to a minimum. Audio latency slightly longer when using a wireless Bluetooth headset than with a hard-wired system.	Main technical issues: quality and the latency of the video and audio material. However, latency did not seem to interfere with the overall interaction between surgeons

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Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Katz *et al* (2017) Israel[31]	Web-based instructor feedback, physical distance not specified.	TM simulator, developed at the Technion—Israel Institute of Technology, Haifa, Israel—was used; the technology involves a Wizard of Oz (WOZ) simulator. The simulator used for training is a low-fidelity, Web-based application that was developed using Microsoft SharePoint 2010 technology. The computerised interactive simulator was coupled with an instructor who monitored students' progress and provided web-based immediate feedback	The simulator is described as a low cost and globally accessible	Not specified	Not specified	Not specified
Yoost *et al* (2017) USA[32]	Clinicians were more than 3 hours away from the students' location.	Sessions involved the use of high-definition teleconferencing equipment. All presentations occurred in real time and were interactive. Throughout the programme, an online portal was present for students to ask anonymous questions of the presenters, which were answered during the following session.	Not specified	Not specified	Not specified	Not specified
Chekerov *et al* (2008) Germany[33]	Not specified	Special web-based software was developed for this project in cooperation with a professional contract research organisation (Alcedis GmbH).	Not specified	Not specified	Not specified	Not specified
Haller and Gabathuler (2003) Switzerland[34]	Teleconference between three different cities in Switzerland	Transmission organised with an ISDN line	Not specified	Transmission was organised with an ISDN line (128kbits/s), upgraded to 384lbit/s in 2000	Not specified	Disadvantages: 1. Limited resolution, 2. Adaptation of movements dependent on the amount of ISDN lines, 3. Presentations sometimes have to be filmed, 4. Mixed use of multipoint 128/384 kbit/s is error sensitive 5. Interactivity with use of multipoint is hardly used.

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Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Chaves *et al* (2017) Brazil[35]	Outside the operating room, 5–10 m away	Hardware involved in streaming system: ► One Webcam Logitech C270 ► One Raspberry Pi two model B ► One wireless adaptor TP-LINK TL-WN722N ► One 5600 mAh battery The live streaming was performed with a local wireless network created by the streaming system itself. The smartphones and tablets were property of the medical students/ residents and were able to connect to this local wireless network through an access password, so that they could watch the surgery's camera video streaming in real time on a web browser.	Hardware: Raspberry Pi 2: US$39.50 Webcam Logitech C270: US$22.00 Wireless adapter TP-LINK model TL-WN722N: US$12.50 Internal support of a construction hardhat: US$50 cents; Battery 5600 mAh: US$10.00	A wireless adapter TP-LINK, model TL-WN722N, with an external 4dBi antenna was included in the streaming system to perform the transmission with a better signal.	Not specified	Improvements suggested included adding audio transmission simultaneously with the video transmission, which could allow the surgery to be narrated. Another suggestion would be to incorporate recording for use in a video library.
Boatin *et al* (2015) USA[36]	Between Boston and Uganda	Communication via web conferencing was the primary mode of teleconferencing. Each planned conference would begin with an international phone call between organisers on each end to establish contact prior to web conferencing. Web conferencing tools used included Ventrilo and Skype, through a number of interfaces: personal and hospital computer and smart phones.	The programme was introduced on a budget of under US$500.	In Boston, free Wi-Fi connections were available through network systems. In Mbarara, no Wi-Fi networks were available. Internet access was obtained by purchasing cellular data through established commercial networks. Approximately 100 MB and 300–500 MB of data is typically required for an hour of continuous audio and web conferencing, respectively.	Not specified	6 of 30 lectures had to be cancelled due to problems with internet connectivity

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Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Browne *et al* (2000) USA[37]	Teleconferencing between medical educators from six different sites of the same City	Video teleconferencing: a video teleconference, liquid-display crystal projector, and video and audio recorders are used.	Not specified	Not specified	Not specified	Data security arose as a major concern, including possible effect on student privacy and confidentiality issues. Occasional hardware problems (details not published).
Clinical and education						
Cordasco *et al* (2015) USA[38]	Telemedicine education programme organised by an organisation from Los Angeles for healthcare providers within Greater Los Angeles	Videoconference group discussions, device used in each location not specified.	Not specified	Not specified	Not specified	Not specified
Feasibility						
Van Dongen *et al* (2016) Netherlands[39]	Not specified	The e-therapy programme consisted of digital psychoeducation and CBT. Online text providing psychoeducation as well as exercises that were presented as 'home work' were offered and aimed to support more adaptive coping behaviour and more helpful cognitions regarding treatment and its outcome. Participants logged in at home, weekly, at the time that suited them best.	Not specified	Not specified	Not specified	Not specified
Grossman and Grindlay (2017) USA[40]	Not specified	TM abortion care involves video discussion, device not specified.	Not specified	Not specified	Not specified	Not specified

Continued

Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Mammas *et al* (2016) Greece[41]	Not specified	Pelvic MRI sets of digital images taken by ACS-NT GYROSCAN MRO POWERTRACK 6000 to 1.5T (by Phillips) and projected on the electronic space of the DICOM workstation of the intranet of the department of radiology.	Not specified	Not specified	Not specified	Not specified
Kim *et al* (2016) South Korea[42]	Not specified	First, analogue images were obtained by conventional cervicography system (Cerviscope, National Testing Lab World-wide, Fenton, Missouri, USA) that has been used to take a 35 mm film photograph of the cervix after applying 5% acetic acid to the cervix. Second, digital images of each patient were also taken at the same time by digital camera (Dr. Cervicam, National Testing Lab, Seoul, South Korea). The films were transferred to a central processing facility for the development of analogue images. Digital images made by digital camera were transmitted online.	Not specified	Not specified	Not specified	Not specified
Barlow *et al* (2012) USA[43]	Average distance 75.8 km to clinic.	Not specified	Not specified	Not specified	Not specified	Not specified

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Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Schadel *et al* (2005) Germany[44]	Not specified	The digital colposcopy system consisted of a standard binocular colposcope (ZEP 505, M/s. Zeiss, Germany) supplemented with a CCD camera (MediLive, M/s. Zeiss, Germany) for imaging, a PC with frame-grabber card (LC1, M/s. DBS, Germany) for storing static images and specially developed software (ColpoData, M/s. LMTB, Germany) to archive patient data and images.	Not specified	Not specified	Not specified	Not specified
Etherington (2002) UK[45]	Examination and images of patients in inner city Birmingham GP practice, images transferred to hospital colposcopy clinic for analysis—exact distance not specified.	The TM system was based on a standard PC with a video-capture card and an ISDN connection. Numerous video clips or still images could be captured for each patient. Still images were captured as JPEG files and video clips as AVI files.	Not specified	Not specified	Not specified	6 cases from early in the study could not be included due to poor image quality or inadequate images.
Stewart *et al* (2001) UK[46]	84 couples living <50 miles from clinic and 75 couples living >50 miles from clinic	Telephone consultation, device not specified	Not specified	Not specified	Not specified	Not specified
Harper *et al* (2000) USA[47]	Review site: Dartmouth Hitchcock Medical Center. Two remote sites (exact distance not specified)	Not specified	Not specified	Not specified	Not specified	Not specified

Continued

Table 3 Continued

Authors (year)	Distance	Type of device	Cost	Bandwidth	Latency	Troubleshooting
Quercia *et al* (2017) Switzerland[48]	Data from rural Madagascar to Switzerland	Medical consultations were performed with a Samsung Galaxy S5 using the m-Health application. Data collected by the application were automatically sent in real time to a central database. Therefore, the patient's file could be consulted at any time and any place.	Not specified	Not specified	Not specified	Reversible errors: Resolved with application update included: 1. Transmission of the photos 2. Transmissions of the GeneXpert results 3. Transmission of the pelvic examination data
Haggerty *et al* (2016) Romania[49]	Not specified	The TM arm participated in weekly telephone counselling sessions with weights being recorded via aWiFi scale fromWithings. The texting arm received a text messaging programme called Text4Diet that delivered 3–5 personalised text messages daily on various monthly themes.	Not specified	Not specified	Not specified	The main limitation in internet access for this urban population was the restriction that participants frequently did not have 'private' WiFi access that was required by the scale model used for this study (ie, participants were using public internet and could not sign into the network to connect with the scale).

CBT, Cognitive Behavioural Therapy ; UAMS, University of Arkansas for MedicalSciences; VIA, Visual Inspection after Acteic acid; VILI, Visual Inspection with Lugol's Iodine.

Table 4 Study characteristics

Authors (year)	Duration of study	Setting (animal model, simulation, patients, cadavers)	Variable number (operation, USS)	No. of participants	No. of operators
Bouwsma *et al* (2018) Netherlands[11]	2011–2014	Patients	Operation: benign gynaecological surgery—hysterectomy and/or laparoscopic adnexal surgery Usual care n=206 Care programme n=227	Usual care n=206 Care programme n=227	Secondary care 9 different hospitals
Grindlay and Grossman (2017) USA[12]	October–Nov 2013	Provider's experience	8 in-depth interviews	8 providers, eligibility criteria: physician, advanced practice clinician, nurse, medical assistant/ patient care coordinator, clinic manager, or counsellor on staff at a clinic providing medical abortion via TM.	8 clinic providers involved with medical abortion using telemedicine
Shehata *et al* (2016) Canada[13]	July 2011–January 2015	E-Consults directed to obstetrics and gynaecology	394 e-consults directed to Ob-Gyn	E-Consults were submitted by 151 primary care providers—126 medical doctors and 25 nurse practitioners—91% with urban practices and 9% with rural practices.	All eConsults were answered by a single Royal College of Surgeons of Canada–certified obstetrician–gynaecologist (ob-gyn) who had been in independent practice for 7 years at the start of the project.
Hitt *et al* (2016) USA[14]	15 months January 2014–April 2015	Patients	940 unique patients seen via telecolposcopy	940 patients had telecolposcopy performed at 8 remote sites, each given an impression based on the assessment by the hub-site clinician in UAMS located in central Arkansas.	Number of doctors involved not specified.
Jefferis *et al* (2016) UK[15]	5 years: 1 January 2010–31 December 2014	Patient requiring follow-up after tension-free vaginal tape insertion.	262 patients who underwent day case tension-free vaginal tape insertion were followed up via telemedicine.	262 patients	All cases of primary retropubic TVT slings performed by one unit over a 5-year period. No. operators not specified.
Ricard-Gauthier *et al* (2015) Switzerland[16]	5 months: July 2013–November 2013	Patients	88 HPV-positive women were screened for cervical cancer.	88 patients had cervical smartphone images taken for remote analysis.	One on-site physician in Madagascar, and three physicians in Geneva analysing the smartphone images.
Catarino *et al* (2015) Switzerland[17]	8 months; January 2014–August 2014	Patients	95 HPV-positive women were screened for cervical cancer	95 patients had cervical smartphone images taken for remote analysis.	One on-site expert in Madagascar, and three physicians in Geneva analysing the smartphone images.

Continued

Table 4 Continued

Authors (year)	Duration of study	Setting (animal model, simulation, patients, cadavers)	Variable number (operation, USS)	No. of participants	No. of operators
Stratton *et al* (2015) USA[18]	19 months: September 2012–March 2014	Trial participants	37 participants were enrolled over the 19-month time period.	The largest proportion of participants (46%) was enrolled from the telecolposcopy network. Others were enrolled through outside institutions (43%), in-house referrals (8%), or direct advertisement (3%). Most participants were motivated to join the study to take care of their health issues. Only 2 participants joined the Facebook private page.	The availability of a large number of potential participants from the telecolposcopy network increased recruitment to this clinical trial by 85% over other traditional means of recruitment.
Noordegraaf *et al* (2014) Netherlands[19]	18 months: March 2010–September 2011	Patients	Women were randomly assigned to the intervention group (n=110) or the control group (n=105). The intervention group received an eHealth programme that provided personalised tailor-made preoperative and postoperative instructions on the resumption of daily activities, including work. The control group was provided with access to a control website.	A cohort of 215 women (aged 18–65 years) who had a hysterectomy and/or laparoscopic adnexal surgery for a benign indication.	The trial was carried out in 6 general and/or teaching hospitals and one university hospital.
Gomperts *et al* (2014) Netherlands[20]	This study analyses the data of women from Brazil who contacted Women on Web from 1 January through 31 December 2011 and performed a medical abortion provided through Women on Web's TM service.	Patients	307 women who received and used the medication, and the outcome of the abortion was reported back.	307 women	NS

Continued

Table 4 Continued

Authors (year)	Duration of study	Setting (animal model, simulation, patients, cadavers)	Variable number (operation, USS)	No. of participants	No. of operators
Hitt *et al* (2013) USA[21]	18 months: January 2010–June 2011	Patients	1298 telescopic exams	1298 patients underwent examination using telemedicine	Colposcopy services via interactive TM were set up at 4 separate spoke sites. During each weekly 3 hours clinic, an advanced nurse practitioner at each of the spoke sites performed the exams and collected biopsy specimens under the real-time, interactive supervision of an experienced faculty member at the hub site. Exact number of operators not specified.
Gomperts *et al* (2011) Netherlands[22]	20 months: February 2007–September 2008	Patients	2585 women from 88 countries where access to TOP is restricted, who received medication for a TOP and provided follow-up information.	2585 women	NS
Kldiashvili and Schrader (2010) Georgia[23]	100 days	Cytology slides	420 gynaecological cytology cases	420 cases	4 cytologists
Radley *et al* (2006) UK[24]	8 months: June 2003 to January 2004	Patients	432 women (204 in primary care and 228 in secondary care urogynaecology clinic)	432 women	Two general practices, two community health clinics and a secondary care urogynaecology clinic.
Perisic *et al* (2006) Serbia and Montenegro[25]	NS	Patients	250 colpographs	250 patients	Group 1 consisted of 15 gynaecologists who were not trained in colposcopy and were from primary healthcare. Group 2 consisted of six experienced colposcopists (specialists). Group 3 was a supervising team consisting of three experts (colposcopists who had more than 15 years' colposcopy experience).

Continued

Table 4 Continued

Authors (year)	Duration of study	Setting (animal model, simulation, patients, cadavers)	Variable number (operation, USS)	No. of participants	No. of operators
Etherington *et al* (2002) UK[26]	NS	Patients	81 cases	81 patients included for diagnosis comparison between telecolposcopic and colposcopic images	NS
Allen-Davis *et al* (2002) USA[27]	June 1996 to August 1996	Patients	485 patients underwent telephone evaluation followed by same day appointment with physician, nurse midwife or physicians assistant	485 patients	NS
Atlas *et al* (2000) Israel[28]	9 months	International Tumour Board (ITB): Multidisciplinary team discussion of patient cases	20 videoconferences, discussing 450 patients. Three key cases described.	450 patient cases	The ITB consists of doctors trained in cancer surgery, chemotherapy, radiation oncology, diagnostic radiology and tumour pathology, as well as nurses, nutritionists and oncology social workers. Exact numbers not specified.
Tates *et al* (2016) Netherlands[29]	NS	Simulated patients	48 simulated doctor–patient consultations	6 certified simulated patients	12 medical students
Gambadauro and Magos (2007) UK[30]	6 months	Patients: range of gynaecological interventions including abdominal, vaginal and laparoscopic surgery. Simulation: pelvi-trainer sessions in endoscopy skills laboratory.	20 operations	NS	NS

Continued

Table 4 Continued

Authors (year)	Duration of study	Setting (animal model, simulation, patients, cadavers)	Variable number (operation, USS)	No. of participants	No. of operators
Katz *et al* (2017) Israel[31]	Two separate sessions with groups of participants	E-learning simulation	Two training sessions, where participants were divided into those receiving an automated, self-assessment computerised case and an intervention group (WOZ) received the same computerised case accompanied by a human trainer supplying web-based immediate feedback and clarifications for each question.	First experiment: 10 control, 8 intervention subjects Second experiment: 7 control, 7 intervention subjects	NS
Yoost *et al* (2017) USA[32]	Eight hours long telehealth sessions were offered over a course of 4 weeks in the spring of 2015	Computer e-learning	8 teaching sessions	55 students	8 teaching sessions
Chekerov *et al* (2008) Germany[33]	20 months December 2004 to August 2006	Online Gynaecological Cancer Conference	39 Tumour Board Conferences 144 patients' cases presented	667 participants	121 peer-reviewed second opinions were sought
Haller and Gabathuler (2003) Switzerland[34]	1997–2001	Lecture hall—videoconferencing	NS	NS	NS
Chaves *et al* (2017) Brazil[35]	4 weeks June–July 2016	Patients	5 operations (4 total abdominal hysterectomies and 1 oophoroplasty)	21 medical students/residents	5 operations observed
Boatin *et al* (2015) Boston, USA[36]	30 months: June 2012 to January 2015	Lectures	30 lectures	30 lectures with approximately 20 attendees per session	NS
Browne *et al* (2000) USA[37]	Two years: 6-week rotation with video teleconference occurring across sites half way through clerkship	Video teleconference	20–22 studemts between 5 clerkship sites every 6 weeks	20–22 students, site coordinators, clerkship director, administrative staff and occasionally department chairperson between 5 clerkship sites.	NS

Continued

Table 4 Continued

Authors (year)	Duration of study	Setting (animal model, simulation, patients, cadavers)	Variable number (operation, USS)	No. of participants	No. of operators
Cordasco *et al* (2015) California, USA[38]	14 months: October 2012–December 2013	Specialist at a 'hub' facility and primary care providers at multiple 'spoke' sites.	14 1 hour monthly sessions	Interviews conducted with 18 primary care providers	Number of specialists delivering sessions not specified.
Van Dongen *et al* (2016) Netherlands[39]	28 months: February 2011–June 2013	Patients	120 women starting their first ART cycle were randomised, 48% in the intervention group were compliant.	120 women	Women in the control group received care as usual, whereas women in the intervention group received in addition to their usual care access to a personalised e-therapy programme. Number of e-therapists involved not specified.
Grossman and Grindlay (2017) USA[40]	7 years: July 2008–June 2015	Patients—adverse events	During the study period, 8765 TM and 10405 in-person medical abortions were performed.	Total: 19170 medical abortions, 49 clinically significant events reported (0.18% telemedicine patients, 0.32% in-person patients)	NS
Mammas *et al* (2016) Greece[41]	NS	Pelvic MRI sets of digital images	10 sets of pelvic MRI digital images	10 sets of pelvic MRI digital images	2 consultant radiologists
Kim *et al* (2016) South Korea[42]	1 year: January 2013–December 2013	Patients	100 cases from 5 centres were collected prospectively, of which 63 cases were valid to be included in the study.	Total 63 cases and associated 567 images were finally analysed to assess intraobserver consensus.	Nine certified specialists belonging to Korean Cervicography Research Group evaluated the digital images on DCS, 35 mm analogue slides, and scanned images without patient information.
Barlow *et al* (2012) USA[43]	1 year: July 2008–July 2009	Patients	51 patient visits considered appropriate for telehealth, of which 28 patients/families expressed interest in telehealth.	51 patient visits	NS
Schadel *et al* (2005) Germany[44]	NS	Patients	286 patients, average 5 images per patient.	315 patients participated in study, of which 286 patients were valid for re-evaluation by a second physician.	NS

Continued

Table 4 Continued

Authors (year)	Duration of study	Setting (animal model, simulation, patients, cadavers)	Variable number (operation, USS)	No. of participants	No. of operators
Etherington (2002) UK[45]	NS	Patients	81 patients had full data available	97 invited, 10 declined/did not attend all appointments, 6 had inadequate images, thus 81 women had full data for analysis.	One experienced colposcopist
Stewart *et al* (2001) UK[46]	January 1998 to December 1999	Patients	159 couples returned the questionnaire within 2 weeks of their follow-up discussion	159 couples	One clinic, number of clinicians involved in follow-up not specified
Harper *et al* (2000) USA[47]	October 1997 to May 1998	Patients	79 women, number of images captured for each patient varied from 3 to 20	79 women	NS
Quercia *et al* (2017) Switzerland[48]	July and August 2016	Patients	151 patients	151 patients recruited, application collected 44 items of information per patient	NS
Haggerty *et al* (2016) Romania[49]	Recruitment: August 2012–May 2013 Weight loss programme 6 months	Patients	20 patients	10 patients: TM arm 10 patients: Texting arm	NS

1992 to 2018. Following the initial screen, 243 studies were excluded due to the title alone and 70 abstracts were retained and examined. Of those, 15 were excluded because they were not relevant to the research questions (ie, not focused on TM), focused on other specialties, were not available in English or were duplicate studies. By duplicate studies, we refer to the retrieval of the same study through different the databases. Of the remaining 55 full-text publications that were examined, 16 were review or opinion articles and one focused on antenatal care. They were therefore excluded, leaving 39 studies for inclusion in the review.[11–49] An overview of the search results and screening process is summarised in the study flow diagram (figure 1).

Study characteristics

Data from the 39 studies included in this review demonstrated considerable variation regarding the research question, methodology, study design, sample size and outcome measures. Of the 39 studies, 19 assessed gynaecological clinical practice; eight investigated gynaecological education, while one assessed the preceding pair concomitantly. 11 studies investigated the feasibility of TM within gynaecological practice. The majority of the studies were level IV evidence, as they were either case series, case-control or cohort studies. On the Newcastle-Ottawa quality assessment scale, 19 studies were classified as good, 12 fair and eight poor[10] (table 5).

Sample sizes ranged from 6 to 19 170, although not all studies specified sample size. Of the 39 studies, the highest number were conducted in the USA (n=13), followed by the Netherlands (n=6), UK (n=6), Switzerland (n=4), Israel (n=2), Germany (n=2), Romania (n=1), Canada (n=1) Serbia and Montenegro (n=1), Brazil (n=1), Greece (n=1) and South Korea (n=1). Therefore, the majority originated from Europe and North America. One study was from Brazil published in 2017,[34] one from South Korea published in 2016,[41] one from Georgia published in 2010[22] and two from Israel published in 2000 and 2017.[27 30] No obvious association is observed between the year of publication and the geographical region.

Various subspecialties of O&G were investigated the most common being cervical pathology/cytology in 13 studies[14 16–18 21 23 25 26 42 44 45 47 48] followed by benign gynaecology in five studies,[11 19 30 35 43] early pregnancy and medical abortion in four studies,[12 20 22 40] fertility and reproductive medicine in three studies,[32 39 46] urogynaecology in three studies[15 24 29] and gynaecological oncology in three studies.[28 33 49]

Different modes of TM have been used and reported in the different studies ranging from interactive and personalised web-based programmes giving preoperative and postoperative advice,[11 19 39] video teleconferences,[12 40] online/internet consultations[20 22] and telephone consultations.[15 27 29 43 46 48 49] Moreover, 11 studies investigated the effectiveness of telecolposcopy where an experienced clinician had made decisions and diagnosis remotely.[14 16 17 21 25 26 42 44 45 47] TM has also been used for collaboration and training between clinicians and medical students; for example, e-consultations between primary and secondary care clinicians discussing the care of patients[23] and in teleconferences providing expert and multidisciplinary input in oncological cases.[28 33 41] Furthermore, the role of TM in medical education has been assessed in three studies where trainees were provided feedback from an experienced surgeon remotely, during real-time surgery.[30 31 35] Studies on clinical outcomes did not report any adverse effects to the patients.

Colposcopy and cervical cytology

Hitt *et al*[14] demonstrated the feasibility of telecolposcopy in 940 patients from rural areas. The assessment was done effectively by the hub-site clinician and the authors estimated mean transportation costs per patient saved to be S$33.25.[14] Another study evaluated the feasibility of using smartphone digital images for the detection of Cervical Intraepithelial Neoplasia (CIN2)+in 87 HPV-positive cases.[16] There was no statistical difference in the sensitivity and specificity of the detection of CIN2+ between on-site and off-site physicians. Moreover, 95.6% of all images were deemed to be very good or acceptable for diagnostic purposes.[16] Similarly, Catarino *et al*[17] involving 332 patients demonstrated that off-site diagnosis of CIN was at least similar to that reached on-site.[17]

Hitt *et al*[21] performed 1298 telecolposcopies whereby a nurse practitioner who has been trained in the mechanics of colposcopy performed the examination under real-time interactive supervision of an experienced colposcopist at the hub site.[22] The study model of using one physician with four nurse practitioner examiners and four assistants produced an hourly cost of US$321.00, or a cost of US$40 per exam. This compared with a traditional model incorporating four doctor examiners with four assistants producing an hourly cost of US$416.00 or a cost per exam of US$52.[21] The authors thus concluded that this method was cost effective and well received by patients.

Kldiashvili *et al*[23] evaluated 'telecytology' whereby 420 cytological images were assessed by on-site and off-site cytologists.[23] The study found a 94% concordance between routine versus digital images and 97% of digital images were rated as 'good' or 'excellent'.[23] Another study by Etherington *et al* on telecolposcopy demonstrated a high sensitivity and specificity of 89% and 93% respectively on the basis of diagnosis of 'normal' and 'abnormal'.[24] The images produced were of sufficient quality for diagnosis.[26] Harper *et al*[47] performed colposcopies in 79 women whereby the images were sent to a hub site for further assessment and comparison.[47] The interobserver agreement was as high as 86% (k=0.68) and the colposcopists' and patients' satisfaction was rated as 'excellent'. The study concluded that the telecolposcopic system is technically feasibile and is preferred by women as it cuts down travel costs.[47]

Perisic *et al* performed videocolpocopy in 250 patients.[25] The diagnostic accuracy of three different groups was

Table 5 Newcastle-Ottawa quality assessment table

Authors (year)	Selection	Comparability	Outcome	Quality
Clinical				
Bouwsma *et al* (2018) Netherlands[11]	****	*	**	Good
Grindlay and Grossman (2017) USA[12]	**	*	**	Fair
Shehata *et al* (2016) Canada[13]	**	*	**	Fair
Hitt *et al* (2016) USA[14]	**	*	**	Fair
Jefferis *et al* (2016) UK[15]	**		**	Poor
Ricard-Gauthier *et al* (2015) Switzerland[16]	**	*	**	Fair
Catarino *et al* (2015) Switzerland[17]	***	*	**	Good
Stratton *et al* (2015) USA[18]	**	*	**	Fair
Noordegraaf *et al* (2014) Netherlands[19]	****	*	**	Good
Gomperts *et al* (2014) Netherlands[20]	**	*	**	Fair
Hitt *et al* (2013) USA[21]	****	*	***	Good
Gomperts *et al* (2011) Netherlands[22]	**	*	**	Fair
Kldiashvili, and Schrader (2010) Georgia[23]	***	*	**	Good
Radley *et al* (2006) UK[24]	***	*	**	Good
Perisic *et al* (2006) Serbia and Montenegro[25]	**	*	**	Fair
Etherington *et al* (2002) UK[26]	***	**	**	Good
Allen-Davis *et al* (2002) USA[27]	***	**	**	Good
Atlas *et al* (2000) Israel[28]	*		**.	Poor
Tates *et al* (2016) Netherlands[29]	***	*	**	Good
Education				
Gambadauro and Magos (2007) UK[30]	*		**.	Poor
Katz *et al* (2017) Israel[31]	***	*	**	Good
Yoost *et al* (2017) USA[32]	**	*	**	Fair

Continued

Table 5 Continued

Authors (year)	Selection	Comparability	Outcome	Quality
Chekerov *et al* (2008) Germany[33]	*		**.	Poor
Haller and Gabathuler (2003) Switzerland[34]	*		**.	Poor
Chaves *et al* (2017) Brazil[35]	*		**.	Poor
Boatin *et al* (2015) Boston, USA[36]	**	*	**	Fair
Browne *et al* (2000) USA[37]	*		*	Poor
Clinical and education				
Cordasco *et al* (2015) USA[38]	**	*	**	Fair
Feasibility				
Van Dongen *et al* (2016) Netherlands[39]	***	*	**	Good
Grossman and Grindlay (2017) USA[40]	***	*	**	Good
Mammas *et al* (2016) Greece[41]	*		*	Poor
Kim *et al* (2016) South Korea[42]	***	*	**	Good
Barlow *et al* (2012) USA[43]	**	*	**	Fair
Schadel *et al* (2005) Germany[44]	***	*	**	Good
Etherington (2002) UK[45]	***	*	**	Good
Stewart *et al* (2001) UK[46]	***	*	**	Good
Harper *et al* (2000) USA[47]	***	*	**	Good
Quercia *et al* (2017) Switzerland[48]	***	*	**	Good
Haggerty *et al* (2016) Romania[49]	***	*	**	Good

assessed (inexperienced, experienced and expert colposcopists) which showed high interobserver agreement. The authors concluded that videocolposcopy can provide an accurate diagnosis, reduced travel distance and can enable training of healthcare staff.[25] Schadel *et al*[44] evaluated the use of digital colposcopy against conventional binocular colposcopy.[44] Three hundred and fifteen patients had a colposcopic assessment onsite and had their images saved which were reviewed by another colposcopist. There was agreement between the examiners in 69% of cases (k=0.60). The authors concluded that digital colposcopy was reliable and provided advantages in terms of a better follow-up examination and internal quality control of the diagnosis.[44]

Abortion care

An Alaskan study evaluated the feasibility of a TM abortion care service.[12] Eight providers had in-depth

interviews about the quality of the service, which involved access to patient notes, scan images and patient video teleconference. The healthcare providers felt that the patients were assessed sooner and that the service was feasible.[12] Gomperts *et al*[20] evaluated the outcome of self-administered mifepristone and misoprostol for medical abortion in 602 Brazilian women.[20] The surgical intervention rate after medical abortion was 19%, 15.5% and 45% at 9, 10–12 and 13 weeks gestation, respectively. The study concluded that home use of the above medication in women before 13 weeks gestation through a TM service is safe and effective.[20] The same group performed a study involving 2323 women from 88 different countries to analyse the factors influencing surgical intervention after medical abortion.[22] These women were assessed by TM with interactive online consultation and follow-up. There were regional differences in the rates of surgical intervention, which may reflect different clinical practice and local guidelines.[22]

Grossman *et al*[40] compared outcomes between TM and in person management of medical abortion. This was a large study with 8765 women who had abortion management via TM and 10 405 women who had in person management. The complication rates were low at 0.18% and 0.32%, respectively, and this difference was non-significant.[40]

Gynaecological surgery

Bouwsma *et al*[11] performed a randomised-controlled trial where 227 women underwent an internet-based personalised care programme after gynaecological surgery and 206 women had the usual postoperative care.[11] The study demonstrated an accelerated recovery and reduced time to return to work in the intervention group which were both statistically significant.[11] Moreover, the authors reported an estimated 54 euros savings per patient with the intervention group.[11] A similar study by the same group recruited 110 patients who were randomly allocated to an eHealth intervention with tailored preoperative and postoperative instructions with regards to resumption of work and daily activities.[19] Compared with the control group, the eHealth intervention was associated with reduced time to return to work (p=0.048). Furthermore, at 26 weeks post operation, the intervention group reported improved quality of life score compared with the control group (p=0.024).

Gambadauro *et al* (2007) developed a network-enhanced surgical training (NEST) telementoring system consisting of audio–visual interaction of the trainer with the trainee during gynaecological surgery.[30] The authors concluded that NEST was a reliable and affordable learning tool.[30] Chaves *et al*[35] evaluated the effectiveness of a telementoring programme whereby gynaecology residents and medical students received education on their smartphones connected to a wireless network though live surgery.[35] 94% reported that the streaming video system was an effective educational tool.[35]

DISCUSSION

This systematic review is an analysis of where we stand with the use of TM at present; the COVID-19 pandemic has provided a catalyst for change, as it has forced us all to consider methods of remote care. The incorporation of TM into daily practice became a priority to help limit the spread of disease by limiting face-to-face contact. Our review presents the evidence of the promising role of TM within gynaecological practice and education. Of note, the majority of the selected studies were classified as good or fair using the Newcastle-Ottawa methodological assessment tool. The applications of TM to date have been shown to be safe and effective in providing remote care and training. This is in line with a recent review conducted in the field of general surgery.[50]

Clinical potential

Particular fields within gynaecology inherently lend themselves to TM approaches. This is evident by the number of studies focused on particular areas; of the 22 clinically focused studies, eight were within colposcopy[13 15–17 20 22 24 25] with seven of them being classified as good and fair methodological quality. Moreover, the studies analysed in this review clearly demonstrate that telementoring can improve the education of medical professionals within gynaecology and may occupy a niche in surgical education by enabling the education of surgeons within and between hospitals. It has been shown in some settings to be a safe and effective method of implementing remote mentoring. Furthermore, Boatin *et al*[36], a study of fair methodological quality, demonstrated that successful video conferencing can result in expertise being shared bilaterally and internationally across individuals who potentially are unable to travel. It could therefore be beneficial to both resource-rich and resource-poor institutions.[36]

The most consistent finding was that digital colposcopy was reliable and provided advantages with a better follow-up examination and quality control of the diagnosis. The cost varied depending on the particular use of TM and only a few studies explicitly outlined the cost of implementation of their TM systems. The initial cost must be weighed against potential saving such as reduced travel time, improved access to expert healthcare and thus potentially earlier diagnosis, and the long-term benefit of increased healthcare expertise via a wider education audience. This is a complex cost–benefit analysis, which will vary with type and setting of TM implementation and is certainly something to be considered in future studies.

Telementoring value

Robotic surgery has been demonstrated to have a role in telementoring in general surgery.[51] No studies focusing on the use of robotic surgery for telementoring in gynaecology are currently available. One study compared clinical outcomes between telementoring and on-site mentoring of robotic assisted laparoscopic radical prostatectomy found no significant difference between the

two.[52] This finding suggests there may be a further role for telementoring in gynaecological cases using robotic surgery as this technology becomes more widespread. Another emerging technology to consider is Google Glass, a wearable device that provides users hands-free access to computer functions. The potential benefit of this technology in telementoring has been demonstrated in both surgical and non-surgical medical settings.[53 54] Moreover, more recent telecommunication technologies would certainly help to improve the perception of telementoring, particularly the advent of augmented and virtual reality.[55 56] Again, there are no studies identified specific to gynaecology, however, based on the studies available from other specialties, it could well be piloted within gynaecology.

TM is unlikely to ever supersede on-site mentoring completely but should be used as an adjunct to traditional clinical practice and training. At present, there may be technical limitations to its widespread implementation owing to suboptimal internet penetration particularly in low-income countries and the fact that internet connectivity is concentrated within cities globally.[50] In addition, the necessary infrastructure including telecommunications, specific electrical appliances and technical expertise of the personnel including the clinicians may be suboptimal in developing countries. Furthermore, highly motivated individuals are required to implement TM programmes whether that might be for clinical or educational purposes. Moreover, when it comes to telementoring, bandwidth should be over 521 kb/s and none of the selected studies reported such figure.[3] Security will also play a crucial role in developing TM programmes in the future as this involves sharing and handling sensitive patient information. Therefore, the development of agreed frameworks to ensure that personal and sensitive information is encrypted appropriately is essential.

Limitations of the current evidence

The majority of studies included were observational in nature, without clear quantitative outcomes for statistical analysis and were classified as level IV evidence according to the Oxford Centre for Evidence-based Medicine preform.[10] In a number of studies, the variable was low and thus the conclusion of the study was based on a single operator demonstrating a TM application within gynaecology. Therefore, there is the potential for a number of the included studies to be subject to selection bias, with certain patients, practitioners or students more amenable to the technology as it was more likely to be involved in the study resulting in positive outcomes with TM.

On the other hand, some studies included thousands of patients, in particular those focused on telecolposcopy and TM abortion care. These studies indicate the wide-reaching nature of these applications. In these cases, one must consider that often low numbers of operators were involved and thus again selection bias may apply. In the future, randomised controlled studies involving larger numbers of patients and operators with measurable outcomes are required in order to be able to draw reliable conclusions.

CONCLUSION

This review is to our knowledge the only such review on the topic. The range of studies demonstrates the wide potential role of TM within gynaecology. However, this variety translates to broad conclusions based mostly on self-reported data. Reassuringly, the methodological quality of the majority of the reviewed studies were classified as good or fair. While some promising studies have been conducted, there is yet insufficient evidence to support the clinical or cost effectiveness of TM in gynaecology. The role of TM has more than ever become more obvious as we are undergoing the COVID-19 pandemic where effective TM strategies need to be implemented to provide safe and effective care to patients, without putting patients, doctors and the community at risk of the infection.

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